THE ACUTE EFFECTS OF AEROBIC EXERCISE TYPES ON AFFECT AND COGNITION AFTER A STRESSOR

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Abstract

Aerobic exercise has benefits on both physical and mental health, including a reduction of stress. However, the differential effects of specific types of aerobic exercise are unclear. We compared the effects of two different types of aerobic exercise (high-intensity interval training; HIIT, and endurance training; ET) with an active control group (relaxation) on mood and cognition following a stressor. Participants were healthy undergraduates (aged 18-25). Physiological tests (e.g., heart rate; HR, and blood pressure; BP) were administered, followed by psychological tests of mood and cognition (e.g., Visual Analogue Scale; VAS, and Automated Neuropsychological Assessment Metrics; ANAM). Participants completed a negative mood-induction/stressor task (e.g. impromptu public speaking), and were then randomly assigned to complete one of three interventions (e.g. HIIT, ET, control). Physiological and psychological tests were then re-administered. We predict that the two forms of aerobic exercise (e.g. HIIT, ET) will have independent effects on mood and cognition, from the control and from each other. Our results will inform whether certain types of aerobic exercise (e.g. HIIT, ET) differentially impact mood and cognition and may promote the development of exercise-based interventions for stress-related emotional disorders (e.g. depression, anxiety, etc.).
INTRODUCTION

Emotional Disorders and Academic Difficulties of College Students

Depression and anxiety disorders are highly prevalent among college students, affecting nearly 16 percent of undergraduates (Eisenberg et. al, 2007). Past studies reveal that higher stress levels are associated with a greater prevalence of depression and anxiety disorders in adulthood (Arborelius et. al, 1999). Mental health disorders, like depression, have negative emotional and cognitive consequences on students’ academic abilities or experiences, as noted in a “Strategic Primer on College Student Mental Health” published by the American Council on Education (Douce et. al, 2014). For example, depressed students often reveal reduced positive mood states and impaired attention. Given today’s increasing importance of higher education, college students are expected to “be ready to learn – in a state of physical, psychological, emotional, intellectual, social and spiritual well-being” (Douce et. al, 2014). Thus, interventions are needed to improve students’ well-being, and thereby enhance academic performance. We need to better understand the mechanisms of depression, anxiety, and other emotional disorders that are linked to stress in order to develop improved treatment options. As described below, physical activity may be a type of low-cost and highly effective intervention that has positive effects on stress management and mental health, including enhanced mood and cognition (Daley, 2008; Hillman, Erickson, & Kramer, 2008). We describe the effects of aerobic exercise on stress, mood, and cognition in the following section.
Aerobic Exercise Effects on Stress, Mood and Cognition

Aerobic exercise is characterized as a form of physical activity that requires a high level of oxygen, which can be reached by using 50 to 70 percent of an individual’s maximum aerobic effort (Martinsen et. al, 1985). Aerobic exercise has been shown to reduce stress and negative affect based upon a meta-analysis review on the effects of exercise on mood (Landers et al, 2000). Another study suggests that a single bout of exercise (i.e. acute exercise) leads to improved vigor (i.e. increased arousal or alertness) and positive psychological well-being in individuals with depression (Bartholomew et. al, 2005). A meta-analysis of randomized controlled trials has demonstrated that aerobic exercise improves certain components of cognitive function, including attention and processing speed (Smith et al., 2010).

Despite the widespread amount of evidence for exercise’s positive effects on emotional and cognitive function as well as moderation of stress levels, there are several primary limitations of these previous findings. Firstly, past studies tend to focus on the effects of exercise on psychological traits in older-aged adults and/or clinical populations, and are often retrospective by nature (Dimeo et. al, 2001; Kavussanau & McAuley, 1995). Despite the high prevalence of mood disorders among young adults, little attention has been given to this population in terms of direct exercise intervention studies. Specifically, the impact of acute exercise interventions on emotional response and cognitive performance in this population is unclear. Such findings may expand upon the mechanisms by which exercise improves negative mood symptoms and/or enhances cognitive performance. Given the importance of cognitive function in young adult
populations, especially college students, it is essential to consider the potential use of exercise interventions as a mechanism of enhancing academic performance. Relatively little evidence exists to suggest that certain types of aerobic exercise have differential effects on emotional response or cognition. This unexplored area of research is important to consider as certain types of exercise become more popular and commercialized (e.g., CrossFit). The succeeding paragraphs describe two types of popular aerobic exercise techniques in addition to their differential effects on physiological outcomes.

**High-intensity Interval Training (HIIT)**

High-intensity interval training, or HIIT, is a form of aerobic exercise characterized by alternating periods of high and low intensity. Intensity refers to the amount of direct physical capacity of an individual to perform an exercise. The main focus of HIIT is to maximize effort during periods of high intensity (e.g., sprinting for 30 seconds) and to minimize effort during periods of low intensity (e.g., walking slowly for 1 minute). Periods of low intensity last longer than high intensity periods and are meant to provide rest or recovery. HIIT workouts may include one to three sets of different exercises that are often performed in less than 20 minutes, in addition to a warm-up and cool-down. HIIT provides a vigorous and short-lasting workout that should be performed two to three times per week to accelerate fat loss and/or improve aerobic capacity, cardiovascular health and muscular fitness (Herodek et al, 2014).

**Endurance Training (ET)**

Endurance training (ET) (also referred to as steady state training), is an alternate form of aerobic exercise that is distinguished from HIIT workouts by a longer lasting,
continuous period of moderately high intensity. Intensity for ET is set at more than 60 percent of an individual’s maximum aerobic effort (Kindermann et. al, 1979). The main goal of ET is to perform exercise at a moderately high intensity for a longer duration (e.g. running at a constant pace for at least 30 minutes). It should be noted that the intensity for ET is less than the ‘high intensity’ period of HIIT. Recovery or rest periods are often not included during ET workouts as the level of intensity is meant to remain relatively high and constant. ET workouts often involve repetition of different exercises for a greater number of sets (e.g. three to five) that are performed for a longer time period (e.g. 30 minutes or more). ET provides a moderate to high effort, long-lasting workout intended to be performed three to five times per week in order to improve aerobic capacity, cardiovascular health and muscular fitness (Jones & Carter, 2000).

**Different Physiological Impacts of HIIT and ET**

As expected from the above descriptions, HIIT and ET exercise forms are qualitatively different in their cardiovascular and metabolic profiles. In fact, studies comparing the impact of these two different aerobic exercises on body fat and skeletal muscle metabolism show distinct differences. Although both exercise forms have been shown to improve cardiovascular fitness, ET programs have been shown to result in higher overall energy expenditure while HIIT programs have shown greater fat loss (Boutcher, 2010; Tremblay, Simoneau, & Bouchard, 1994) as well as improvements in fasting plasma insulin levels (Trapp, Chisholm, Freund, & Boutcher, 2008). While the relationship between aerobic exercise and mental health has been studied extensively, it remains unknown as to whether specific types of aerobic exercise (i.e. HIIT or ET) have
different effects on psychological or cognitive function and whether these effects are mediated by exercise’s ability to improve stress. We speculate that different types of aerobic exercise can be used to cope with stress, thereby improving mood and enhancing cognition following a stressor; however, this idea has not yet been tested among young adults using validated stress task paradigms. Such findings may ultimately be useful in determining which specific types of exercise young adults can perform to reduce stress and improve emotional well-being and cognitive/academic success.

Present Study

The present study aims to address the gap in the literature by using a randomized control trial of exercise interventions in young adults to evaluate the comparative effects of high-intensity interval training (HIIT) and endurance training (ET) with a relaxation control group on emotional response and cognitive function following a validated stress task. The incorporation of a stress task was meant to illustrate the association between stress and negative mood states, which are often linked to emotional disorders such as depression or anxiety. Moreover, we were interested in whether exercise could modulate this relationship between stress and emotional response. We characterize emotional response as an individual’s affect (i.e. positive vs. negative feelings) and vigor reactivity (i.e. aroused vs. non-aroused). We characterize cognitive function as an individual’s attention (i.e. accuracy measured by percentage correct responses) and processing speed (i.e. simple reaction time). We predict that both exercise groups will have improved effects on emotional response and cognitive function, following the stressor, based upon previous findings of exercise on mental health (Taylor et. al, 1985). We also predict that
the two exercise groups will have different effects on emotional response and cognitive function, relative to each other, based upon the unique physiological effects of each type of exercise (Boutcher, 2010; Tremblay, Simoneau, & Bouchard, 1994). Given the gap in the literature and inconclusive past findings, we do not predict a specific direction for each exercise group’s effect on emotional response and cognitive function. In regards to the active control group, we predict that there will be improvements in both emotional response and cognitive function, based upon past findings of the benefits of relaxation on overall mental health (Smith et. al, 2007).

METHOD

Participants

Participants consisted of 43 undergraduate psychology students (20.3 ± 1.7 years old, 54.5% female) who were recruited through an online research pool system. To be eligible for the study, participants were required to be between the ages of 18 and 25, and be able to perform at least 20 minutes of vigorous exercise. Exclusion criteria were any exercise-related health conditions or pregnancy. The Institutional Review Board at Kent State University approved all study procedures.

Procedures

All participants were required to meet minimum physical eligibility requirements in order to participate in the study. If participants did not meet these eligibility requirements, they were immediately debriefed about the nature of the study and were asked to leave. Eligible participants were randomly assigned to one of three groups: high-
intensity interval training (HIIT), endurance training (ET), or control. A series of physiological measures were administered to ensure these physical eligibility requirements were met and to maximize participant safety before completing the exercise portion of the study. Maximum and target heart rates (based upon participant age) were also calculated for later use during the exercise intervention.

Eligible participants then completed a series of psychological measures, including the Automated Neuropsychological Assessment Metrics (ANAM) and the Visual Analogue Scale I (VASI) of emotional response (baseline period). Subsequently, participants completed a negative mood induction task that involved public speaking. Participants were asked to prepare and deliver a three minute impromptu speech based upon a pre-recorded given scenario while standing in front of a video camera and “being recorded.” Although no recording actually took place, participants were told their speech was being recorded for later evaluation in order to increase engagement in the task. Immediately following the speech task, participants completed the VAS II to assess their emotional response to the stressor (stressor-reactivity period).

Participants were then instructed to complete their assigned intervention. Participants in the HIIT or ET group completed different online exercise videos that were matched for length (each approximately 20 minutes, including a warm-up and cool-down) and required a high level of aerobic effort. Participants in the control group did not complete any form of exercise, but instead were instructed to watch an online relaxation video with scenic images and non-verbal background music that was also matched for the 20 minute duration of the HIIT and ET exercises.
For those in the exercise groups (HIIT or ET), the researcher verbally instructed participants about the nature of the online video. Participants were informed that they were allowed to take breaks or stop at any point if they felt shortness of breath, increased heart rate, dizziness, or any physical pain. Participants were provided with a water bottle and completed the exercise video in a private, well-ventilated lab room with adequate space. To monitor participant safety during exercise, participants were instructed to use a heart rate monitor halfway through completion of the video to assess their maximum and target heart rates. If the heart rate considerably exceeded the maximum heart rate, participants were instructed to stop exercise and inform the researcher immediately.

Upon completion of the intervention (post-intervention period), all participants completed a series of psychological measures (VAS III, ANAM), followed by final physiological measures (blood pressure and resting heart rate). Physiological measures were intended to ensure participant safety after completion of exercise. Participants were then debriefed about the nature of the study and informed that they were not actually recorded on video camera during the speech task. All study procedures were completed in approximately two hours or less.

**Measures**

*Physiological Measures.*

*Height analysis.* Participants were asked to stand on a standardized scale to record their accurate height that would be used to assess their weight and body fat percentage.

*TANITA Body Fat Analyzer.* The body fat analyzer was used to determine body weight and estimate body fat composition (percentage body fat) using electrical impulse
analysis. Prior to stepping on the scale, participants were asked if they had any previous implanted electrical devices or pacemaker that could trigger the scale. Participants were also asked to provide their age, sex, and athleticism (completion of at least 10 hours of moderate-vigorous exercise per week).

**Blood Pressure (BP) and Heart Rate (HR).** A standardized blood pressure cuff machine (Datascope Accutorr Plus) was used to determine participant’s systolic and diastolic BP as well as their resting HR. These measures were taken at the beginning of the study (pre-exercise) to determine participant eligibility for the exercise portion of the study, and were also taken at the conclusion of the study (post-exercise) for safety monitoring purposes. The numerical values obtained for BP and HR were then compared to the American Heart Association (AHA) “Blood Pressure & Heart Rate Chart” and were assessed based on appropriate age and gender (See Appendix for AHA BP&HR Chart). Participants were required to meet one of the following categories in order to be deemed eligible for the study: normal blood pressure or pre-hypertension (below 140/90). Those participants who were categorized as Stage 1 or 2 hypertension (at or above 140/90) were excluded from the study. Elevated blood pressure and/or poor aerobic capacity (i.e. recovery heart rate) have been shown to affect an individual’s ability to perform exercise safely (American College of Sports Medicine, 2013).

**Maximum heart rate (MHR) and target heart rate (THR).** MHR was calculated based on participant age using the following formula: MHR = 220-age; this numerical value indicates the number of beats per minute at which the heart is performing at maximum capacity (90 percent or greater aerobic effort). THR values were calculated
based on the obtained MHR value, using the following two formulas: \( \text{THR} = \text{MHR} \times 0.65 \) and \( \text{THR} = \text{MHR} \times 0.85 \); these numerical values indicate the number of beats per minute at which the heart is performing at 65% and 85% effort, respectively.

**YMCA Bench Step-Test for Cardiovascular Fitness.** The standardized YMCA Bench Step Test was used to assess participant’s level of cardiovascular fitness. This test determines how fast the heart is able to recover (i.e. return to normal, resting heart rate) after a brief three minute period of exercise. The test was performed using a standardized step stool that was able to hold up to 225 pounds (participants previously determined body weight was used to assess their eligibility for the bench test). A standardized online metronome was set at 96 beats per minute and participants were required to step to synchronized pattern (up-up-down-down) for three minutes. Immediately following, the researcher performed a manual pulse reading for 60 seconds and then compared the numerical value obtained to the “Age-adjusted standards based on guidelines published by YMCA.” Participants were required to have a heart rate that fell in the category of average (or above) for their age group and gender in order to be deemed eligible for the study. Those participants who fell in the category below average (or poor) were excluded from the study (See Appendix for YMCA Bench Step-Test and guidelines).

**Psychological Measures**

*Emotional Response.* The Visual Analogue Scale (VAS) (I, II, and III) was administered at separate points in the study in order to evaluate participants’ emotional responses (affect and vigor) during the different study periods (i.e., baseline, during stressor, and post-intervention). The VAS consists of 10 separate items that include a
horizontal line ranging from “Not very” to “Very much.” Participants are asked to mark the point on the line that indicates a given feeling for a certain state (e.g. how alert do you feel?) and reflect how they felt about a given task (e.g. how challenging did you find the task?). Each VAS (I, II, and III) asks participants how they felt during a specific time period (e.g. VAS I asks how they felt “during the last 10 minutes”). Scores are calculated using an establish algorithm and yields scores ranging from 0 to 100 (Monk, 1989). Higher affect scores indicate greater positive affect. Higher vigor scores indicate more arousal/alertness. *(See Appendix)*

*Automated Neuropsychological Assessment Metrics (ANAM).* ANAM consists of a series of online computerized tests that measure a broad range of cognitive processes (e.g. simple reaction time, attention, memory, etc.) (CSRC, 2013). Participants completed a simple series of ANAM tests (i.e. simple reaction-time, 2-choice reaction time) to measure simple reaction time and attention before and after exercise or relaxation. *(See Appendix)*

*Negative Mood Induction (Speech) Task.* The speech task used is a validated protocol known to induce negative affect (Egloff et. al, 2006). This task induces a negative mood by modeling a public speaking situation, which often provokes stress in individuals. Participants were required to prepare and deliver an impromptu speech in front of a video camera based upon a pre-recorded scenario voice that was presented via an audio player. Participants were not actually recorded, and were informed of this deception during the debriefing session. The video camera was used to induce a negative
mood and stress by making participants feel as if they were under pressure to perform well and be evaluated, similar to public speaking situations.

The speech task included the following components, which were verbally spoken by a pre-recording: the description of the task, the scenario and three speaking points, the three minute preparation period, the three minute speaking period, followed by the conclusion of the task. If participants failed to speak for the entire three minute period, they were prompted by the audio recording to continue speaking or summarize their main points. (See Appendix for detailed instructions of speech task)

Intervention Measures

*High-intensity Interval Training (HIIT).* Participants assigned to the HIIT group watched and completed the following online standardized HIIT workout video that was roughly 20 minutes in length and available at the following URL: http://youtu.be/VhdXXqcoco0. The video included a warm-up, main HIIT workout, and cool-down. No workout equipment was necessary for completing this video. The video was publicly available and was produced by Fitness Blender, a company that provides free online workout videos.

*Endurance Training (ET).* Participants assigned to the ET group watched and completed the following online standardized ET workout video that was roughly 20 minutes in length and available at the following URL: https://www.youtube.com/watch?v=5G7tYJ8xdMk. The ET video was also publicly available and was produced by Fitness Blender. A duct-taped water bottle was provided to participants to supplement the dumb-bell weights required in the ET video.
Participants completed the warm-up and cool-down of the HIIT video, in addition to the ET workout, since these components were not included in the ET video. Participants completed 3 of 5 total rounds in the ET video.

Control (relaxation group). Participants assigned to the control group watched an online relaxation video that required no physical activity. The video included scenic images of various landscapes, including canyons and waterfalls. Participants watched 20 minutes of the 50 minute length video. The video was produced by Healing Films. The video was publicly available at the following URL: https://www.youtube.com/watch?v=ibh2ZE77tCw.

RESULTS

Characteristics of Participants

A total of 48 undergraduate students consented to participate in the study. Of those participants, four were deemed ineligible due to failure to meet minimal physical requirements for the exercise component of the study. These participants (n=4) were excluded for the following reasons: (a) a resting blood pressure above 140/90 characterized as Stage 1 Hypertension (n=1), or (b) a below average or poor recovery heart rate based upon age-gender adjusted standards of the aerobic step test (n=3). Of the total eligible participants (n=44), three participants (n=3) were unable to complete the ANAM portion of the study due to computer technical difficulties. Therefore, data analyses involved those participants who were deemed eligible and completed all portions of the study (N=41). Descriptive demographics of these 41 participants and
baseline study variables are presented in Table 1. Chi-square analyses and Analysis of Variance tests (ANOVAs) of participants’ baseline characteristics did not reveal differences in age, sex, athleticism, body fat, resting HR, systolic BP, diastolic BP, vigor, affect, attention, or processing speed across the three randomly assigned groups (i.e. HIIT, ET, control); this statistical finding suggests that the groups were relatively similar at baseline (all p’s ≥ .055) (see Table 1).

**Physiological Changes from Baseline to Post-Intervention**

To evaluate whether our exercise and relaxation conditions elicited the expected physiological changes, we examined changes in BP and HR across groups. One-way ANOVAs were conducted with BP or HR change (from baseline to intervention) as the dependent variable and group (HIIT, ET, or control) as the independent variable (see Table 2). ANOVA results revealed that change in SBP and DBP was not significantly different across the three groups (SBP Δ, \( p = 0.57 \); DBP Δ, \( p = 0.09 \)) (see Figure 1). However, there was a significant group effect on change in HR [HR Δ: \( F(2,41) = 45.27, p < 0.001 \)] (see Figure 2). HR changes in the HIT, and ET exercise conditions were not significantly different from one another, but both exercise conditions exhibited greater HR increase compared to the control group. Paired samples t-test revealed that after the intervention the HIT [\( t(12) = 8.9, p < .001 \)] and ET groups [\( t(14) = 8.3, p < .001 \)] showed an average HR increase of 19.2 and 13.5 beats/min from baseline, respectively. In contrast, the control group showed an average HR decrease of 6.9 beats/min [\( t(15) = 3.0, p = .009 \)]. These results indicate that our exercise and relaxation control groups have expected effects on HR.
Affect Reactivity to Stressor and Intervention

To evaluate whether the stress task elicited equivalent affect changes across all groups, we examined changes in affect from baseline to post-stressor for each group. As expected, one-way ANOVAs indicated that change in affect after the stressor did not differ across conditions (Affect Δ after Stressor, p = 0.098) (see Table 2). Across groups, participants began at a baseline average affect of 52.23 points and then decreased to an average affect of 50.5 points following the stressor, which indicated that affect became significantly more negative during the stressor task. To determine whether affect recovery from the stressor differed based on intervention group, we examined changes in affect from baseline to post-intervention. Contrary to our hypotheses, there was no effect of intervention condition on emotional recovery from the stressor (Affect Δ after Intervention, p = 0.483) (see Table 2), which indicated that all interventions were effective at returning participants’ affect to baseline levels after the stressor (i.e., no between group differences were observed) (See Figure 3). After the intervention, participants’ affect returned to a near baseline average of 52.20 points.

Vigor Reactivity to Stressor and Intervention

To evaluate whether the stress task elicited equivalent changes in vigor across all conditions, we examined changes in vigor from baseline to post-stressor. As expected, changes in vigor in response to the stressor were equivalent across groups (p = .920) (see Table 2). Across intervention groups, participants’ baseline vigor began at an average of 74.0 points and then decreased to an average of 73.77 points following the stressor, but this change was not significant. To determine whether vigor change in response to the
intervention differed across groups, we examined changes in vigor from baseline to post-intervention for each group. Significant one-way ANOVA results revealed group differences in the change in vigor after the intervention \[Δ: F(2, 41) = 4.62, p = 0.02\] (see Figure 4). Specifically, participants in the control condition experienced a significant decrease in vigor (to an average of 73.2 points, \(p = 0.008\)) after the intervention, whereas participants in both exercise conditions (HIIT, ET) experienced non-significant increases in vigor to an average of 74.2 points after the intervention. This difference indicated that condition effects occurred for changes in vigor from baseline to post-intervention between the exercise and control groups (See Figure 4).

**Cognitive Function at Baseline and after Intervention**

To evaluate the effects of the stress intervention on cognitive function, we examined changes in attention accuracy (2-choice reaction time test) and reaction time (simple reaction time test) from baseline to post-intervention for each condition. One-way ANOVAs indicated that there were no significant effects of stress intervention on simple reaction time \(F(2,38) = 0.78, p = 0.47\). However, there were significant differences between groups for 2-choice reaction time \(F(2,37) = 5.44, p = 0.008\) (see Figure 5). Specifically, for the ET condition, participants attention accuracy increased significantly from baseline to post-intervention; this increase was the most dramatic change in attention and was significantly greater compared to the HIIT \(p = 0.002\) and control \(p = 0.008\) conditions. In comparison, the HIIT condition experienced a non-significant decrease in attention over the time period, whereas the control experienced a non-significant increase in attention from baseline to post-intervention.
Summary of Analyses Related to the Primary Objective

Multiple one-way ANOVA tests were conducted to test the two-part hypothesis of the study that a) exercise conditions will reveal differential effects on emotional response and cognitive function, relative to the control, and b) exercise conditions will have differential effects on emotional response and cognitive function, relative to each other. As can be seen in Tables 1-3, results indicate that this hypothesis received partial support. Emotional response based upon generalized affective response (positive vs. negative feelings) did not vary significantly across conditions. However, emotional response based upon vigor did vary significantly across conditions with individuals in the control condition experiencing a significant decrease in vigor. Results revealed that there were no significant differences between groups for cognition based upon simple reaction time measured in milliseconds. However, there was a significant difference between groups for cognition based upon attention accuracy measured by the percentage of correct responses. The ET condition was the only group that showed a significant change in attention, exhibiting an increase in accuracy from baseline.

DISCUSSION

The primary purpose of the present study was to compare the effects of two types of aerobic exercise (HIIT, ET) relative to a control on mood and cognition following a stressor. Related to this purpose, the first hypothesis was that HIIT and ET would improve emotional response and cognitive performance. A second hypothesis was that there would be differences between HIIT and ET, in terms of their effects on emotional
response and cognition, although we did not predict a directional effect between the two groups. A final hypothesis was that the active control (relaxation) group would lead to improvements in both emotional response and cognitive function. Our hypotheses were based upon previous findings regarding the effects of aerobic exercise and relaxation on physical and mental health.

In our study, we examined both physiological (i.e. heart rate, blood pressure) and psychological (i.e. affect, vigor, attention, processing speed) constructs for all three groups. In accordance with past research (Reidi et. al., 2001), we detected physiological differences (i.e. heart rate) between the exercise groups and control group from baseline to post-intervention. In relation to the control group, both exercise groups increased in heart rate across the given time period. Past evidence reveals that aerobic exercise, in general, reduces blood pressure in both healthy and non-healthy (e.g. hypertensive) adults (Whelton et. al., 2002). Our findings reveal that both the ET and control groups decreased in systolic blood pressure, while the HIIT group slightly increased in this physiological trait; however, these changes in systolic blood pressure were not significant and therefore need further investigation. Changes in diastolic blood pressure were non-significant between groups.

Additionally, our stress task was effective at producing the desired change in affect because we observed a significant increase in negative affect (i.e. negative feelings) and increase in vigor (i.e. alertness) across all three groups immediately following the stressor. Since the stressor occurred before the intervention, there were no differences observed between groups in terms of their response to the task. In contrast to
our hypothesis, all three groups recovered equally from the stressor by returning to baseline affect after the given intervention (i.e. all three interventions were effective at improving mood after the stressor, to baseline). In regards to vigor (alertness), the relaxation group did reveal a greater reduction in this trait (i.e. relaxation invoked feelings of fatigue, etc.) compared to the exercise conditions; vigor changes were not different between the two exercise groups. Finally, we found that endurance training (ET) yielded improvements in attention accuracy (i.e. percentage correct responses) as compared to the other groups. This effect was not observed in the change of our secondary measure of cognition (i.e. simple reaction time) from baseline to post-intervention between the three groups.

**Consistency with Previous Findings**

The finding of a positive association between aerobic exercise and improved mood (i.e. affect, vigor) following a stressor is in line with outcomes of previous studies that have found evidence to support the ability of aerobic exercise to reduce negative affect (Landers et al, 2000) and to improve vigor (Bartholomew et al, 2005). Landers and colleagues (2000) observed different forms of chronic exercise among primarily older adults and found that exercise may have long-term benefits on mental health. Bartholomew and colleagues (2005) observed the positive effects of a single bout of exercise (similar to the present study) in depressed individuals and noted that these effects are observed in both depressed and non-depressed individuals. The present study expanded upon previous findings by including a younger group of healthy individuals, incorporating a validated laboratory stressor task, and an active control group to compare
the relative effects of exercise to a previously established method of intervention (i.e. relaxation). Our finding regarding the correlation between endurance training (ET) and improved attention (i.e. percentage correct) also supports and expands upon previous research that aerobic exercise improves certain areas of cognition (Smith et al, 2010). To note, however, Smith and colleagues found that aerobic exercise in general enhances both attention and processing speed. We did not observe this same effect for processing speed in our study. We only observed the improvement in attention for ET and a non-significant decrease in attention (i.e. reduced attention) for HIIT, which suggests that exercise type may influence short-term cognitive benefits or deficits, respectively.

Implications of the Present Study

Findings from the present study have implications for psychological exercise-based interventions that include aerobic exercise as a potential form of improving mood and cognition. In regards to mood, our findings suggest that either exercise or relaxation is effective at improving mood after a stressful task. For college students, the present study may have implications for the type of exercise performed before an exam or lecture. In order to improve academic performance on a multiple-choice based exam (i.e. percentage correct responses), perhaps a long run (i.e. endurance training) may be more useful than a cross-fit class (i.e. high-intensity interval training).

Methodological Considerations of the Present Study

Several features of the current study warrant discussion. First is the choice of the stress task as an evaluated speaking task. Other tasks could have been used instead of the speech task (e.g. unsolvable Sudoku puzzles, watching sad films, writing a story about a
negative experience in life, etc.). We chose to incorporate the public speaking task in our study because it has been shown in previous studies to induce a negative affect (i.e. negative feelings); the task involves using a standardized protocol to ensure that every participant is engaging in the same stressor (i.e. same public speaking scenario). The speech task captures elements of anxiety and depression because it provokes feelings of anxiety (i.e. being overwhelmed) and rumination (i.e. dwelling on past thoughts or performance).

The second key feature of our study that deserves additional explanation is our use of an active control group, as opposed to a non-active group (i.e. a control group that does not engage in any pre-determined task, such as sitting in a chair and doing nothing for 20 minutes). We used an active control group because we wanted to compare our two exercise groups (i.e. HIIT, ET) with a group that performed an activity of relative positive impact on mental health (i.e. meditation). Essentially, we were interested in comparing exercise to an alternative health intervention that has been previously shown to alleviate stress and related mental health disorders (Grossman et. al, 2003).

The final feature of our study that needs further explanation is the potential occurrence of practice effects that may have occurred after repeated measures of cognition (i.e. performing better on the ANAM task the second time, after the intervention, simply due to prior exposure to the task at baseline). If practice effects had occurred, we would have observed the same pattern of change in cognition across all three groups (i.e. all three groups would have performed better the second time after practice from the first time). However, it is important to note that this effect did not occur
across the three groups; in fact, we observed opposing trends between groups. As noted in the results section, the endurance group experienced a significant increase in cognition from baseline to post-intervention, while the other two groups (HIIT, control) experienced non-significant changes in cognition. We would have expected the observed changes in cognition for the HIIT and control groups to be significant if we had used a larger sample size to observe greater respective trends between these groups and enhance the validity of our results.

Limitations of the Present Study

One of the major limitations of the present study was that it was acute by nature, and did not observe the long-term effects of aerobic exercise on physiological and psychological health. Another limitation was that it solely observed the effects of aerobic exercise in healthy, young adults. A third limitation of the present study was that it did not account for the time lapse between exercise performed and cognitive tasks (i.e. attention, processing speed); we allowed for a brief recovery period after exercise was performed (i.e. less than 10 minutes) and before cognitive tasks were given. In reality, most people who exercise have an extended duration of time (e.g. 30 minutes to 1 hour) between exercise and work due to post-exercise related activities (e.g. taking a shower, eating a meal, etc.). A fourth major limitation of the present study was that it did not measure baseline depression prevalence among participants; however, we did use the Profile of Moods States (POMS) to observe baseline affect and the Visual Analogue Scale (VAS) to measure baseline vigor, which are traits often linked to depression. These
methodological issues and limitations may have impacted our findings and should be considered in future studies.

Conclusions and Recommendations for Future Research

An area for future research will be to observe whether findings of the present study can extend to include long-term effects of exercise on mental health. Physical activity is a health behavior that must be maintained over the lifespan in order to receive long-lasting physical and mental health benefits. Future interventions need to determine if there is a relationship between the time at which exercise is performed (e.g. going to the gym) and the time at which cognitive resources are demanded (e.g. going to school or work). Finally, future studies need to extend our findings to address clinical populations suffering from acute or chronic illness, including children and older-aged adult populations.
REFERENCES


doi:10.1249/01.mss.0000178101.78322.dd


TABLES
Table 1. Characteristics of Participants at Baseline

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Total Sample (N = 43)</th>
<th>HIIT (N = 13)</th>
<th>ET (N = 15)</th>
<th>Control (N = 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>20.3 ± 1.7</td>
<td>20.0 ± 1.5</td>
<td>19.7 ± 1.5</td>
<td>21.0 ± 1.9</td>
</tr>
<tr>
<td>Female</td>
<td>24 (54.5)</td>
<td>7 (29.2)</td>
<td>9 (37.5)</td>
<td>8 (33.3)</td>
</tr>
<tr>
<td>Athlete</td>
<td>19 (43.2)</td>
<td>6 (31.6)</td>
<td>5 (26.3)</td>
<td>8 (42.1)</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>20.3 ± 7.6</td>
<td>17.3 ± 5.7</td>
<td>23.9 ± 8.7</td>
<td>19.4 ± 6.9</td>
</tr>
<tr>
<td>Height (in)</td>
<td>66.3 ± 4.1</td>
<td>66.9 ± 3.7</td>
<td>66.5 ± 4.1</td>
<td>65.7 ± 4.5</td>
</tr>
<tr>
<td>Resting HR (beats/min)</td>
<td>73.3 ± 12.1</td>
<td>72.0 ± 13.6</td>
<td>75.1 ± 9.9</td>
<td>72.8 ± 13.4</td>
</tr>
<tr>
<td>Resting SBP</td>
<td>113.7 ± 12.9</td>
<td>110.5 ± 14.0</td>
<td>115.1 ± 12.8</td>
<td>115.0 ± 12.6</td>
</tr>
<tr>
<td>Resting DBP</td>
<td>66.7 ± 7.1</td>
<td>64.8 ± 5.4</td>
<td>66.7 ± 8.6</td>
<td>68.3 ± 6.8</td>
</tr>
<tr>
<td>Affect</td>
<td>52.2 ± 1.6</td>
<td>52.5 ± 1.6</td>
<td>51.8 ± 1.3</td>
<td>52.4 ± 1.8</td>
</tr>
<tr>
<td>Vigor</td>
<td>74.0 ± 1.8</td>
<td>74.4 ± 1.3</td>
<td>73.3 ± 2.0</td>
<td>74.3 ± 1.9</td>
</tr>
<tr>
<td>Attention (% correct)</td>
<td>93.2 ± 9.0</td>
<td>95.6 ± 4.7</td>
<td>90.3 ± 13.4</td>
<td>94.0 ± 5.6</td>
</tr>
<tr>
<td>Reaction Time (ms)</td>
<td>346.1 ± 309.1</td>
<td>305.5 ± 42.0</td>
<td>296.6 ± 39.5</td>
<td>424.8 ± 509.6</td>
</tr>
</tbody>
</table>

Note: HR = Heart Rate. SBP = Systolic Blood Pressure. DBP = Diastolic Blood Pressure.

*p < .05 for chi-square or ANOVA comparing the three conditions.
Table 2. Analysis of Variance (ANOVA) Results for Group Differences in Physiological, Emotional, and Cognitive Change across Study Periods

<table>
<thead>
<tr>
<th>Variable</th>
<th>df between</th>
<th>df within</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physiological Changes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR change</td>
<td>2</td>
<td>41</td>
<td>45.27</td>
<td>.000*</td>
</tr>
<tr>
<td>BP change systolic</td>
<td>2</td>
<td>40</td>
<td>0.57</td>
<td>.571</td>
</tr>
<tr>
<td>BP change diastolic</td>
<td>2</td>
<td>40</td>
<td>2.54</td>
<td>.091</td>
</tr>
<tr>
<td><strong>Emotional Changes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigor change after stressor</td>
<td>2</td>
<td>41</td>
<td>0.08</td>
<td>.920</td>
</tr>
<tr>
<td>Vigor change after intervention</td>
<td>2</td>
<td>41</td>
<td>4.62</td>
<td>.016*</td>
</tr>
<tr>
<td>Affect change after stressor</td>
<td>2</td>
<td>41</td>
<td>2.46</td>
<td>.098</td>
</tr>
<tr>
<td>Affect change after intervention</td>
<td>2</td>
<td>41</td>
<td>0.74</td>
<td>.483</td>
</tr>
<tr>
<td><strong>Cognitive Changes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention change</td>
<td>2</td>
<td>37</td>
<td>5.44</td>
<td>.008*</td>
</tr>
<tr>
<td>Attention change reaction time</td>
<td>2</td>
<td>37</td>
<td>1.38</td>
<td>.265</td>
</tr>
<tr>
<td>Simple reaction time change</td>
<td>2</td>
<td>38</td>
<td>0.78</td>
<td>.466</td>
</tr>
</tbody>
</table>

Note: HR = Heart Rate. BP = Blood Pressure.
Table 3. Multiple Comparisons (LSD) Results for Significant ANOVA Results

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Condition</th>
<th>Mean Change from Baseline</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR Change After Intervention</td>
<td>HIIT to ET</td>
<td>5.76410</td>
<td>.061</td>
</tr>
<tr>
<td></td>
<td>Control to ET</td>
<td>-20.34167</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Control to HIIT</td>
<td>-26.10577</td>
<td>.000*</td>
</tr>
<tr>
<td>Vigor Change After Intervention</td>
<td>HIIT to ET</td>
<td>-0.20603</td>
<td>0.742</td>
</tr>
<tr>
<td></td>
<td>Control to ET</td>
<td>-1.64677</td>
<td>.008*</td>
</tr>
<tr>
<td></td>
<td>Control to HIIT</td>
<td>-1.44075</td>
<td>.023*</td>
</tr>
<tr>
<td>Attention Change After Intervention</td>
<td>HIIT to ET</td>
<td>-5.40128</td>
<td>.002*</td>
</tr>
<tr>
<td></td>
<td>Control to ET</td>
<td>-2.56795</td>
<td>.106</td>
</tr>
<tr>
<td></td>
<td>Control to HIIT</td>
<td>2.83333</td>
<td>.082</td>
</tr>
</tbody>
</table>

\*\( p < .05 \)
Figures
Figure 1. Change in Blood Pressure Across Time for Each Condition.
Figure 2. Change in Heart Rate Across Time for Each Condition.
Figure 3. Change in Affect Across Time for Each Condition
Figure 4. Change in Vigor Across Time for Each Condition.
Figure 5. Change in Attention Across Time for Each Condition.
APPENDIX

Blood Pressure & Heart Rate Chart

Patient Name: ____________________  Blood Pressure: ___________  Heart Rate: _________  Date: ____________

Resting Heart Rate Chart For Men

<table>
<thead>
<tr>
<th>Age</th>
<th>Athletes</th>
<th>Excellent</th>
<th>Good Above Ave.</th>
<th>Ave.</th>
<th>Below Ave.</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25</td>
<td>49-55</td>
<td>56-61</td>
<td>62-65</td>
<td>66-69</td>
<td>70-73</td>
<td>74-81</td>
</tr>
<tr>
<td>26-35</td>
<td>49-54</td>
<td>55-61</td>
<td>62-65</td>
<td>66-70</td>
<td>71-74</td>
<td>75-81</td>
</tr>
<tr>
<td>36-45</td>
<td>50-56</td>
<td>57-62</td>
<td>63-66</td>
<td>67-70</td>
<td>71-75</td>
<td>76-82</td>
</tr>
<tr>
<td>46-55</td>
<td>50-57</td>
<td>58-63</td>
<td>64-67</td>
<td>68-71</td>
<td>72-76</td>
<td>77-83</td>
</tr>
<tr>
<td>56-65</td>
<td>51-56</td>
<td>57-61</td>
<td>62-67</td>
<td>68-71</td>
<td>72-75</td>
<td>76-81</td>
</tr>
<tr>
<td>65+</td>
<td>50-55</td>
<td>56-61</td>
<td>62-65</td>
<td>66-69</td>
<td>70-73</td>
<td>74-79</td>
</tr>
</tbody>
</table>

Resting Heart Rate Chart For Women

<table>
<thead>
<tr>
<th>Age</th>
<th>Athletes</th>
<th>Excellent</th>
<th>Good Above Ave.</th>
<th>Ave.</th>
<th>Below Ave.</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25</td>
<td>54-60</td>
<td>61-65</td>
<td>66-69</td>
<td>70-73</td>
<td>74-78</td>
<td>79-84</td>
</tr>
<tr>
<td>26-35</td>
<td>54-59</td>
<td>60-64</td>
<td>65-68</td>
<td>69-72</td>
<td>73-76</td>
<td>77-82</td>
</tr>
<tr>
<td>36-45</td>
<td>54-59</td>
<td>60-64</td>
<td>65-69</td>
<td>70-73</td>
<td>74-78</td>
<td>79-84</td>
</tr>
<tr>
<td>46-55</td>
<td>54-60</td>
<td>61-65</td>
<td>66-69</td>
<td>70-73</td>
<td>74-77</td>
<td>78-83</td>
</tr>
<tr>
<td>56-65</td>
<td>54-59</td>
<td>60-64</td>
<td>65-68</td>
<td>69-73</td>
<td>74-77</td>
<td>78-83</td>
</tr>
<tr>
<td>65+</td>
<td>54-59</td>
<td>60-64</td>
<td>65-68</td>
<td>69-72</td>
<td>73-76</td>
<td>77-84</td>
</tr>
</tbody>
</table>

Blood Pressure Chart

<table>
<thead>
<tr>
<th>Top number (systolic) in mm Hg</th>
<th>Bottom number (diastolic) in mm Hg</th>
<th>Your category*</th>
<th>What to do**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 120</td>
<td>and</td>
<td>Normal blood pressure</td>
<td>Maintain or adopt a healthy lifestyle.</td>
</tr>
<tr>
<td>120-139</td>
<td>or</td>
<td>Pre-Hypertension</td>
<td>Maintain or adopt a healthy lifestyle.</td>
</tr>
<tr>
<td>140-159</td>
<td>or</td>
<td>Stage 1 Hypertension</td>
<td>Maintain or adopt a healthy lifestyle. If blood pressure goal isn't reached in about six months, talk to your doctor about taking one or more medications.</td>
</tr>
<tr>
<td>160 or more</td>
<td>or</td>
<td>Stage 2 Hypertension</td>
<td>Maintain or adopt a healthy lifestyle. Talk to your doctor about taking more than one medication.</td>
</tr>
</tbody>
</table>

1. If your readings fall into two different categories, your correct blood pressure category is the higher category. For example, if your blood pressure reading is 125/95 millimeters of mercury (mm Hg), you have stage 1 hypertension.
2. Ranges may be lower for children and teenagers. Talk to your child's doctor if you're concerned your child has high blood pressure.
3. These recommendations address high blood pressure as a single health condition. If you also have heart disease, diabetes, chronic kidney disease or certain other conditions, you'll need to treat your blood pressure more aggressively.

Doctor Recommendations:

ProArgi-9 Plus: ____________________

Cans/Boxes  Servings  Morning  Afternoon  Just before bed

Rev. 1, 11/24/2011
YMCA Bench Step Test for Cardiovascular Fitness

Testing for cardiovascular fitness can be costly, time consuming, and also require elaborate equipment. Luckily there is an easy Do-It-Yourself assessment that can easily be completed at home.

The YMCA 3-minute Bench Step Test is based on how quickly your heart rate recovers following a short bout of exercise.

Below are the essentials to perform the test on your own:

- 12-inch tall step, bench, or box (as close to 12 inches as you can find)
- Stopwatch, timer, or clock with a secondhand
- Metronome (free – www.metronomeonline.com)
- Heart rate monitor (optional)
- Partner to assist with cadence and form (optional)

Procedures:
1. Set the metronome to 96 beats per minute and turn the volume up loud enough that you can hear each beat.
2. Stand facing your step.
3. When ready to begin start the stopwatch or timer and begin stepping on and off the step to the metronome beat following a cadence of up, up, down, down.
4. Continue for 3 minutes.
5. As soon as you reach 3 minutes, stop immediately and sit down on your step.
6. Perform a manual pulse reading and count the number of beats for an entire 60 seconds - http://www.webmd.com/heart/taking-a-pulse-heart-rate - If wearing a heart rate monitor record your heart rate 1 minute from when you sit down.
7. Record your pulse when you have reached 1 minute and then locate your score on the rating scale below.

Results: Age-adjusted standards based on guidelines published by YMCA.

### Ratings for Women, Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>18-25</th>
<th>26-35</th>
<th>36-45</th>
<th>46-55</th>
<th>56-65</th>
<th>65+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>52-81</td>
<td>58-80</td>
<td>51-84</td>
<td>63-91</td>
<td>60-92</td>
<td>70-92</td>
</tr>
<tr>
<td>Good</td>
<td>85-93</td>
<td>85-92</td>
<td>89-96</td>
<td>95-101</td>
<td>97-103</td>
<td>96-101</td>
</tr>
<tr>
<td>Above Average</td>
<td>96-102</td>
<td>95-101</td>
<td>100-104</td>
<td>104-110</td>
<td>106-111</td>
<td>104-111</td>
</tr>
<tr>
<td>Average</td>
<td>104-110</td>
<td>104-110</td>
<td>107-112</td>
<td>113-118</td>
<td>113-118</td>
<td>116-121</td>
</tr>
<tr>
<td>Below Average</td>
<td>113-120</td>
<td>113-119</td>
<td>115-120</td>
<td>120-124</td>
<td>119-127</td>
<td>123-126</td>
</tr>
<tr>
<td>Very Poor</td>
<td>135-169</td>
<td>134-171</td>
<td>137-169</td>
<td>137-171</td>
<td>141-174</td>
<td>135-155</td>
</tr>
</tbody>
</table>

### Ratings for Men, Based on Age

<table>
<thead>
<tr>
<th>Age</th>
<th>18-25</th>
<th>26-35</th>
<th>36-45</th>
<th>46-55</th>
<th>56-65</th>
<th>65+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>50-76</td>
<td>51-76</td>
<td>49-76</td>
<td>56-82</td>
<td>60-77</td>
<td>59-81</td>
</tr>
<tr>
<td>Good</td>
<td>79-84</td>
<td>79-85</td>
<td>80-88</td>
<td>87-93</td>
<td>86-94</td>
<td>87-92</td>
</tr>
<tr>
<td>Above Average</td>
<td>88-93</td>
<td>88-94</td>
<td>92-88</td>
<td>95-101</td>
<td>97-100</td>
<td>94-102</td>
</tr>
<tr>
<td>Average</td>
<td>95-100</td>
<td>96-102</td>
<td>100-105</td>
<td>103-111</td>
<td>103-109</td>
<td>104-110</td>
</tr>
<tr>
<td>Below Average</td>
<td>102-107</td>
<td>104-110</td>
<td>108-113</td>
<td>113-119</td>
<td>111-117</td>
<td>114-118</td>
</tr>
<tr>
<td>Poor</td>
<td>111-119</td>
<td>114-121</td>
<td>116-124</td>
<td>121-126</td>
<td>119-128</td>
<td>121-126</td>
</tr>
<tr>
<td>Very Poor</td>
<td>124-157</td>
<td>126-161</td>
<td>130-163</td>
<td>131-159</td>
<td>131-154</td>
<td>130-151</td>
</tr>
</tbody>
</table>
VAS I

Please read each question carefully and rate how much you had that feeling during the last 10 minutes (your rest period). You may mark anywhere on each line with a perpendicular line (I). Be sure to mark each line only once.

How alert do you feel?

Not very

Very much

How sad do you feel?

Not very

Very much

How tense do you feel?

Not very

Very much

How much of an effort is it to do anything?

Not very

Very much

How happy do you feel?

Not very

Very much

How weary do you feel?

Not very

Very much

How calm do you feel?

Not very

Very much

How sleepy do you feel?

Not very

Very much

How challenging did you find the task?

Not at all

Extremely

How difficult did you find the task?

Not at all

Extremely
Speech Task

E: (Audiofile) "The following task is a public speaking task. We will give you a hypothetical situation in which you have been falsely accused. You will be asked to prepare and deliver a speech defending yourself. We will give you 3 minutes to mentally and silently prepare and we will then give you 3 minutes to speak. You will be required to speak continuously for the entire 3 minutes. We will be videotaping your speech so we can rate your performance at a later time. Please speak to the video camera directly in front of you. You will be rated on your poise, articulation, and persuasiveness of your speech.

The Scenario:

You are driving down a neighborhood street when you suddenly realize that there is a police officer behind you with his red light flashing. When you pull over, the officer gives you a ticket for failing to stop at a stop sign the block before. You are sure that no stop sign existed. When you finally talk him into going back, so you can show him there is no sign there, you realize that there is a stop sign, but it is almost totally hidden by the trees. The officer gives you a 50 dollar ticket. Tell a story about the incident as if you were arguing your case in traffic court and include the following:

1) The events that led up to the officer giving you a ticket.

2) Whether you think you should or should not have been given a ticket.

3) The extent of the city's responsibility in keeping road signs in good view.

PAUSE AUDIO

E: (Audiofile) "Now you will have three minutes to prepare your speech. Remember to organize your thoughts mentally so that you will be able to speak clearly and effectively as soon as you are directed to begin. We will be monitoring your cardiovascular activity during the preparation and the speech, so keep your arms resting on the arms of the chair, your back against the chair, and your feet flat on the floor. Please do not speak during the preparation period. The preparation period begins now."

PAUSE AUDIO

E: (Audiofile) "The preparation period is now over. It is time to begin the speech. Keep in mind that you will be evaluated on your poise, articulation, and the persuasiveness of your speech. Remain as still as possible. You must speak for the entire 3 minutes. You must continue talking until you are directed to stop. Once you have thoroughly covered the 3 points, you may repeat and summarize your arguments. Look at the camera. You may now begin."
If participant stops talking, prompt: “Please keep speaking until I tell you the task is completed.”

If PT is totally unable to keep talking, prompt: “Please repeat or summarize your main points.”

E: (Audiofile) “The task is now over. Please complete the next questionnaire (VAS 2) in the series, regarding your feelings during the preparation and delivery of your speech. Please return it to the marked folder when you are finished.”