The University of Scranton
Office of the Provost
FACULTY RESEARCH COMMITTEE – INTERNAL RESEARCH GRANTS

Please carefully read the Guidelines and Instructions before preparing your proposal. Proposals lacking requested details may be rejected.

I. APPLICATION FORM/COVER SHEET

APPLICANT(s):

Name: Andrew Venezia Dept: Health and Human Performance Signature: [signature]

Name: ____________ Dept: ____________ Signature: ____________

Name: ____________ Dept: ____________ Signature: ____________

TITLE OF PROPOSAL: The effect of acute exercise and cognitive work on affect, mood, and cardiovascular recovery

Total amount requested: $ 1300
Project Start date: February 2024 Project End date: February 2025

Approvals (if required)

IACUC	Date Reviewed		Date Approved	
IRB	Date Reviewed	October 24	Date Approved	Pending
IBC	Date Reviewed		Date Approved	

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ABSTRACT [Using only the space provided on this page, please enter your Abstract here. Use layman's language.]

Although research supports benefits of acute exercise on memory, questions remain concerning the optimal exercise protocol and timing of exercise relative to learning for memory improvements. Research suggests that high-intensity exercise is more effective than low intensity exercise for improving learning and memory, but prescribed high-intensity exercise can be less pleasurable and therefore less likely to be performed. How self-perceived “hard” exercise influences learning and memory is currently unkown. Moreover, although acute exercise is often associated with improved mood, the proposer recently showed that when acute exercise is immediately followed by cognitive work (cognitive testing), mood state and cardiovascular recovery from exercise can be negatively affected.

II. BUDGET

	Amount
A. Salaries and Wages *(students and other personnel paid through University payroll) – specify no. of hours and hourly wage*	$0
A. Total Salaries & Wages	
B. FICA *(0.0765 x total salaries and wages)* **B. Total FICA**	$0
C. Consultants and other Fee-for-Service Personnel *(personnel paid via check voucher) - specify no. of hours and hourly wage*	$0
C. Total Consultants	
D. Equipment: Automated Neuropsychological Assessment Metric (ANAM) cognitive testing and mood assessment battery	~$800
D. Total Equipment	
E. Supplies –	$0
E. Total Supplies	
F. Travel *(itemize mileage, per diem, hotel, airfare)*	$0
F. Total Travel	
G. Other - Payment of participants: Ten $50 Amazon gift cards to be raffled off.	$500
G. Total Other	
H. TOTAL PROJECT COST	
I. AMOUNT REQUESTED *(Max. $2000 individual; $3000 collaborative)*	$1300
J. Subtract I from H - ***If H is greater than I, explain in Budget Justification how the additional expense will be covered.***	

III. BUDGET JUSTIFICATION. The ANAM testing system will be used as the cognitive test battery and cognitive "stressor". The test battery also provides the mood assessment for the project. It is important for the proposer to use this system, as this was the system that was used in a previously published study demonstrating that cognitive testing immediately following high-intensity resistance exercise negatively affected mood in some individuals[1]. Using the same testing system will allow for a clear comparison between studies.

An incentive for participation in the study will assist in subject recruitment. Using a raffle will allow the proposer to save money yet still offer an incentive. A power analysis for a between-subjects fixed effects, one-way analysis of variance was conducted with G*Power using effect sizes (η^2partial = 0.22-0.23) from previously published research utilizing moderate-vigorous intensity acute exercise and the RAVLT [2,3]. The analysis showed that a total sample size of 60 subjects would be sufficient for a power of 0.95. We aim to recruit 70 participants to account for drop out and outliers. Using a raffle to provide ten $50 gift cards will be cheaper than providing all 70 participants with $10-$20.

IV. NARRATIVE

A. BACKGROUND AND SIGNIFICANCE: Regular and consistent physical activity and exercise are known to have beneficial effects on brain health[4]. While there is little doubt that physical activity has at least small to moderately positive effects on brain health[5,6], to truly optimize the benefits of physical activity, it is necessary to understand the optimal protocol for each bout of exercise, and how each bout can be utilized to improve different cognitive domains. Long-term memory is one such cognitive domain that appears to be sensitive to the characteristics of both the exercise protocol and the to-be remembered information[7–9]. Research suggests that high-intensity exercise is more effective at improving long-term memory compared to light-or moderate- intensity exercise, possibly due to the elevated noradrenergic activity and circulating catecholamines that accompany high-intensity exercise[3,9,10]. Indeed, high arousal that is associated with central noradrenergic activity and circulating catecholamines improves memory consolidation (stabilizing the memory trace)[11,12] and may reduce the threshold for encoding (forming the memory trace)[13]. The proposer recently published research demonstrating that self-perceived "hard" cycling increases central noradrenergic activity and improves memory for neutral and emotionally charged images[14,15]. How self-perceived hard cycling affects verbal learning and memory is not fully understood.

Although research supports a positive effect of exercise on mental health[16], the relationship is complex and research is needed to understand the characteristics of how different exercise protocols affect mood and affect. One concern with utilizing high-intensity exercise for improving long-term memory is the possible negative effect it can have on mood-state. Acute bouts of exercise are generally associated with improved mood and affect, though some studies suggest that high-intensity exercise can have negative effects on mood-state, especially during the exercise[17–19]. An important consideration for how acute exercise affects mood-state is what happens immediately post-exercise. **If acute exercise is to be used as a tool to improve learning and memory, the learning needs to occur during the time period when arousal is elevated, which is greatest immediately post exercise. Research recently published by the proposer has suggested that when exercise is immediately followed by cognitive work, cardiovascular recovery is attenuated and mood-state is negatively affected in some individuals[1].**

The recovery of the cardiovascular system post-exercise is important in many situations where intense exercise is followed by a period of rest before beginning another bout of intense exercise. This activity pattern is found in certain sports, such as boxing, mixed martial arts, and American football, and may be observed in tactical and first responder situations. Therefore, understanding if cognitive work negatively affects cardiovascular recovery may have implications for both sport and tactical performance. It has been well established that changes in heart rate (HR) occur during and after aerobic exercise, and are primarily due to alterations in autonomic nervous system (ANS) activity[20]. Acutely, there is a withdrawal of the parasympathetic nervous system (PNS) as exercise begins and then a reactivation of the PNS following the cessation of the exercise bout. This post-exercise recovery of the PNS is variable depending on the intensity, duration, and modality of the exercise. **How recovery of the PNS is influenced by cognitive work during the post-exercise period is currently unknown, but previous research from the proposer suggests a delayed PNS recovery [1], though this has not been systematically evaluated.** Heart rate variability (HRV) frequency domains have been used as a non-invasive method to evaluate HR regulation by the PNS and sympathetic nervous system (SNS) divisions of the ANS. Evaluation of HRV offers valuable insights into cardiac ANS modulation.

B. OBJECTIVES OF THE RESEARCH PROJECT:

Specific Aim 1: To determine the effect of 20 minutes of self-perceived "hard" cycling on verbal learning, recall (30 minute and 24 hour), and recognition (24 hour) with or without a post-exercise recovery period sufficient to allow heart rate to return to within 10% of resting prior to learning.

Specific Aim 2: To determine the effect of 20 minutes of self-perceived "hard" cycling followed by a cognitive test battery on affect & mood-state. Moreover, we will determine if a post-exercise recovery period between exercise and the cognitive test battery modulates the effect on affect & mood-state.

Specific Aim 3: To examine the interactive effect of acute exercise and cognitive work on post-exercise cardiovascular recovery dynamics.

The study will be conducted during the spring and fall of 2024, with the goal of submitting a manuscript in the spring of 2025.

C. METHODOLOGY:

Participants: Sixty to seventy participants aged 18-35 will be recruited through flyers, emails, and word of mouth to participate. For internal validity, participants will be excluded if they participate in organized endurance athletics (cross country, track, triathlons, etc.) or have a weekly aerobic training volume >150 minutes per week; are currently diagnosed with or taking medication for attention deficit hyperactivity disorder, anxiety, depression, or any cardiovascular condition that affects heart rate responses to exercise; any orthopedic limitation that prevents moderate-to-high-intensity cycling. If eligible to participate, participants will be instructed to refrain from exercise for 12 hours prior to testing, refrain from alcohol use for at least 24 hours prior to testing, and consume approximately 500 ml of water two hours prior to testing to ensure proper hydration.

Procedures: The current investigation will utilize a between-subjects research design. Experimental procedures are depicted in Figure 1. Participants will be randomly assigned to one of three experimental groups: no exercise (CON), acute cycling exercise (AE), acute cycling exercise with recovery (AER). On day one, participants will come to the laboratory and provide informed consent. Following informed consent, participants will complete the ParQ-Plus (standard health history questionnaire), the State-Trait Anxiety Inventory Forms Y1-Y2 (STAI-Y1, STAI-Y2 [21]), and the 7-Day Physical Activity Recall Interview[22], to characterize the study sample and ensure eligibility for participation. Upon completion of the questionnaires, participants will have their height and weight measured, along with body fat percentage via bioelectrical impedence. In addition, resting heart rate and heart rate variability (HRV) will be assessed. HRV will be assessed through R-R interval collection via a chest strap HR monitor (Polar, USA). Immediately prior to experimental intervention, participants will complete the Self-Assessment Manikin Valence (SAM-V) and Arousal (SAM-A) dimension scales[23] followed by a mood-state assessment using the Mood-Scale II of the Automated Neuropsychological Assessment Metrics (ANAM). Upon completion of this, participants will engage in a 20-minute bout of self-perceived "hard" cycling exercise[14,15] or seated rest on the stationary cycle. Upon completion of the exercise or rest, participants will either begin the cognitive test battery (Rey Auditory Verbal Learning Task (RAVLT) and ANAM test battery) or rest until heart rate has returned to within 10% of their resting heart rate before beginning the cognitive test battery. Upon completion of the cognitive test battery, participants will complete the same mood-state and affect assessment that was completed before the experimental conditions. On day two, which will take place 24 hours after day one, participants will complete the recall and recognition portions of the RAVLT [24].

Exercise Session: The exercise condition will consist of self-regulated high-intensity cycling on a mechanically braked cycle ergometer. Participants in the AE and AER groups will cycle for a total duration of 24 minutes comprising a 2-minute warm-up, 20-minute moderate-to-high-intensity cycling interval, and 2-minute cool down. During the warm-up and cool-down, participants will self-select their cycling speed and resistance. During the exercise interval, participants will be instructed to attain and maintain a rating of perceived exertion of 15 ("Hard") on the Borg Rating of Perceived Exertion (RPE) scale, a valid and reliable method for exercise prescription[25]. Pedaling cadence will be maintained between 60-70 revolutions per minute, while participants adjust the resistance on the cycle ergometer as needed to maintain the prescribed perception of exertion. The proposer has previously shown that this exercise protocol is effective at elevating salivary alpha amylase, indicating increased noradrenergic signaling[14,15].

Heart rate and RPE will be recorded at baseline, after the warm-up (0-minute time point), at 5-, 10-, 15-, and 20-minute time points during the exercise interval, and after the cool-down. At these time points, participants will provide ratings of affective experience on the SAM-V and SAM-A dimension scales[23]. During the rest condition(s), participants will sit quietly on the cycle ergometer for 20 minutes while identical measurements will be collected at 0-, 5-, 10-, 15-, and 20-minute time points. During both conditions, an experimenter will remain in the room and participants will be restricted from technology use, reading, and excessive talking.

RAVLT: The RAVLT is a brief test used to assess verbal learning and memory that is comprised of learning and recall trials and a recognition memory task [24]. Multiple versions of this test have been used to determine the influence of acute exercise on learning and short- and long-term memory [2,3]. The test will be administered according to published procedures [24]. For the learning and recall trials, participants will be read a list (List A) of 15 unrelated concrete nouns at a pace of one word per second. Participants will then be asked to recall as many of the 15 words as possible. This reading of words followed by recall will be repeated five times (learning trials). Then, a second list of words (List B) will be read and participants will be provided time to recall as many words from the new list as possible. After recall of this list is completed, participants will be asked to recall as many words as possible from the original list (List A; immediate recall). Approximately 30 minutes after the learning and immediate recall trials (immediately after ANAM test battery and Mood assessment), participants will be asked to recall as many words as possible from the original 15-word list to assess long-term recall. Twenty-four hours later, participants will again perform a recall trial and a recognition memory trial where participants will be given a list of 50 words and asked to mark any words that were included in the original 15 nouns (List A).

ANAM Test Battery: The ANAM test battery is a computer-based testing system that was developed by the US Department of Defense to assesses several cognitive domains (memory, executive function, reaction time, etc.). The test will take approximately 20-30 minutes to complete. This test system has been used to assess the influence of popular supplements [26] and physical activity/exercise [1,27] on cognitive function in college students, including by the proposer [1]. **Importantly, these tests are being used as a cognitive "stressor", and the results are not being used as primary dependent variables. Performance on these tests will be analyzed as an exploratory analysis, and all analyses will undergo a false discovery rate (FDR) correction.** The test battery also includes a Mood assessment that was recently used by the proposer to understand how acute exercise affects mood[1].

Statistics: Performance on all assessments will be analyzed using the appropriate repeated measures one-way analysis of variance (ANOVA) for the specific test (number of time points and measures will vary for each assessment). $p \leq 0.05$ will be considered statistically significant and a Tukey's post hoc analysis will be performed when the ANOVA is significant.

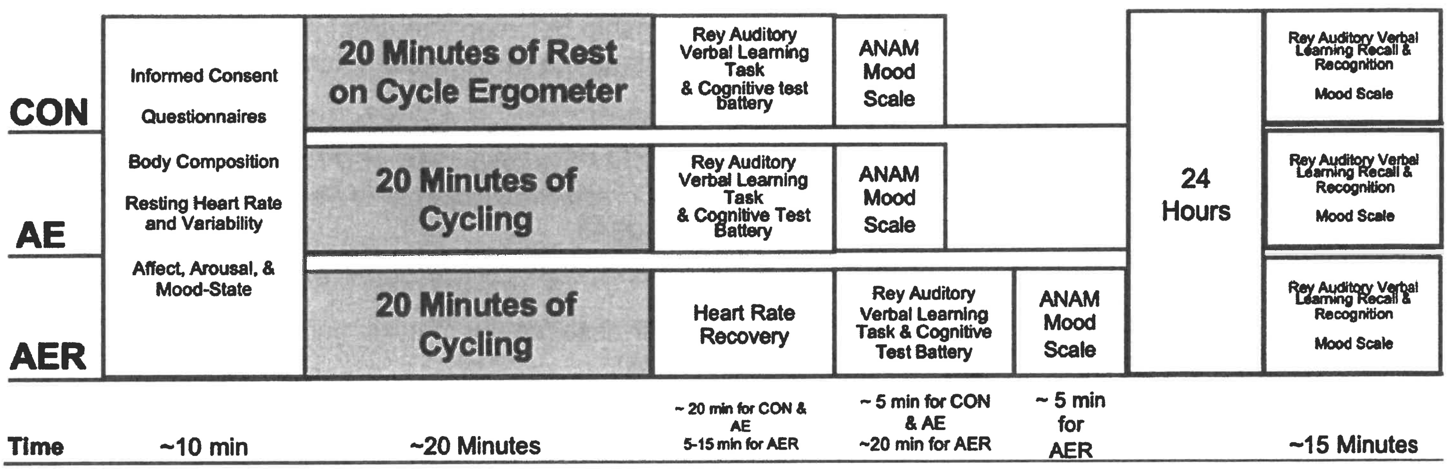

Figure 1.

D. REFERENCES:

1. Venezia, A. C. *et al.* The Effects of Acute Resistance Exercise on Memory, Processing Speed, and Mood State After a Cognitive Challenge. *J Strength Cond Res* **37**, 1738–1745 (2023).
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9. Loprinzi, P. D. *et al.* The temporal effects of acute exercise on episodic memory function: Systematic review with meta-analysis. *Brain Sciences* vol. 9 Preprint at https://doi.org/10.3390/brainsci9040087 (2019).
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14. Venezia, A. C., Weiss, L. R., Nielson, K. A. & Smith, J. C. Moderate-to-vigorous intensity cycling exercise immediately after visual learning enhances delayed recognition memory performance. *Psychol Sport Exerc* **69**, 102498 (2023).
15. Weiss, L. R., Venezia, A. C. & Smith, J. C. A single bout of hard RPE-based cycling exercise increases salivary alpha-amylase. *Physiol Behav* **208**, 112555 (2019).
16. Basso, J. C. & Suzuki, W. A. The Effects of Acute Exercise on Mood, Cognition, Neurophysiology, and Neurochemical Pathways: A Review. *Brain Plasticity* **2**, 127–152 (2017).
17. Zenko, Z., Ekkekakis, P. & Ariely, D. Can you have your vigorous exercise and enjoy it too? Ramping intensity down increases postexercise, remembered, and forecasted pleasure. *J Sport Exerc Psychol* **38**, 149–159 (2016).
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E. DISSEMINATION PLANS: Data from the proposed investigation will be presented at the national meeting of the American College of Sports Medicine and will be submitted for publication in the Journal of Sport and Exercise Psychology or Psychology of Sport and Exercise.

F. ADDITIONAL FUNDING SOURECES/PLANS FOR CONTINUATION OF FUNDING: The data obtained from this investigation will be used to pursue additional funding through The University of Scranton Internal Research Grants with the ultimate goal of pursuing the National Institutes of Health R15 grant mechanism.

V. BIOGRAPHICAL INFORMATION:

The overall goal of my research is to understand the most effective exercise strategies to enhance brain health and identify the mechanisms that mediate these adaptations. My undergraduate and graduate education provided me with formal training in exercise physiology, cellular biology, genetics, and neuroscience. As a master's student in Exercise Science, I was a research assistant on an NIH-funded project to examine the impact of creatine supplementation on cognitive function in older adults and completed a thesis examining how leisure time physical activity impacts cognitive processing in older adults. While completing my PhD in Neuroscience and Cognitive Science, I worked on projects examining the impact of long-term physical activity on hippocampal gene and protein expression in male and female mice, and the transgenerational effects of chronic voluntary physical activity. I then transitioned to examining the mechanisms of acute exercise-induced neuroplasticity in brain regions important for learning and memory. I was awarded an NIH predoctoral research fellowship to pursue a series of experiments aimed at understanding the influence of acute exercise intensity and noradrenergic signaling on markers of brain plasticity and behavior in rodents. Currently, at The University of Scranton, I am continuing my work investigating the influence of acute exercise and noradrenergic signaling on learning and memory, and following up my previous rodent research in human participants. Recently, I have been examining the effect of acute high-intensity exercise on affect and mood, since I have observed in both rodents and humans that cognitive testing immediately following high-intensity exercise appears to result in negative effects on mood. Moreover, I have observed that cardiovascular recovery is delayed when cognitive testing immediately follows acute high-intensity exercise, though I have not yet specifically investigated this phenomenon. Since starting at The University of Scranton, I have published five research articles related to the proposed project.

Selected Relevant Publications:

Refereed Research Articles:

1. **Venezia A. C.,** Weiss L. R., Nielson K.A., Smith J.C. (2023). Moderate-to vigorous intensity cycling exercise immediately after visual learning enhances delayed recognition memory performance. *Psychology of Sport & Exercise.* 69 102498
2. **Venezia A.C.,** Barney P., Spagnoli D., Greco-Hiranaka C., Piepmeier A.T., Smith J.C., Weiss L.R. (2023). The effects of acute resistance exercise on memory, processing speed, and mood state after a cognitive challenge. *The Journal of Strength and Conditioning Research.* 37 (9): 1738-1745.
3. **Venezia, A.C.**, Hyer, M.M., Glasper, E.R., Roth, S.M., Quinlan, E.M. (2020). Acute forced exercise increases Bdnf IV mRNA and reduces exploratory behavior in C57BL/6J mice. *Genes, Brain and Behavior* 19 (5)*:* e12617
4. Weiss, L.M., **Venezia, A.C.**, Smith, J.C. (2019). A single bout of hard RPE-based cycling exercise increases salivary alpha-amylase. *Physiology and Behavior* 208: 112555.
5. **Venezia, A.C.**, Quinlan, E.M., Roth S.M. (2017). A single bout of exercise increases hippocampal Bdnf: influence of chronic exercise and noradrenaline. *Genes, Brain and Behavior* 16 (8): 800-811.
6. **Venezia, A.C.**, Guth, L.M., Sapp R. M., Spangenburg, E.E., Roth, S.M. (2016) Sex-dependent and independent effects of long-term voluntary wheel running on hippocampal Bdnf expression. *Physiology and Behavior* 156: 8-15.
7. **Venezia A.C.**, Guth L.M., Spangenburg E.E., Roth S.M. (2015). Lifelong Parental Voluntary Wheel Running Increases Offspring Hippocampal *Pgc-1α* mRNA Expression but not Mitochondrial Content or *Bdnf* Expression. *Neuroreport* 26 (8): 467-472.
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PREVIOUS INTERNAL RESEARCH GRANTS: The applicant has not received any internal research funding

in the past three years.