

Fiscal Year:	FY 2021	Task Last Updated:	FY 09/08/2022
PI Name:	Gaidica, Matthew Ph.D.		
Project Title:	Manipulating Sleep Architecture as an Operational Countermeasure		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	TRISH--TRISH		
Joint Agency Name:		TechPort:	No
Human Research Program Elements:	None		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:			
Project Type:	GROUND	Solicitation / Funding Source:	2020 TRISH-RFA-2001-PD: Translational Research Institute for Space Health (TRISH) Postdoctoral Fellowships
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No. of PhD Candidates:		No. of Master' Degrees:	
No. of Master's Candidates:		No. of Bachelor's Degrees:	
No. of Bachelor's Candidates:		Monitoring Center:	TRISH
Contact Monitor:		Contact Phone:	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 7/31/2023 per TRISH (Ed., 8/4/22) NOTE: End date changed to 7/31/2022 (originally 7/31/2021) per TRISH (Ed., 11/2/20)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Dantzer, Ben (MENTOR: University of Michigan, Ann Arbor)		
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Task Description:	<p>POSTDOCTORAL FELLOWSHIP</p> <p>Space exploration exposes humans to unique stressors that, if not addressed, compromise physical and psychological health and performance. Sleep is known to promote physiologic resilience making it paramount in challenging circumstances, but all sleep is not the same. Progressive, stereotyped sleep stages are common in mammals and form a basic structure known as “sleep architecture.” High homeostatic value has been placed on slow-wave sleep (SWS), which is the deepest state of sleep characterized synchronous 1–4 Hz brain oscillations. SWS co-occurs with important fluid rhythms and changes in neural microstructure that promote waste clearing, potentially underlying the important findings that SWS enhances memory and performance. This proposal aims to identify critical conditions for which enhancing SWS through non-invasive audio stimulation may mitigate the influence of stressors or augment performance. I propose a novel translational analog in the wild red squirrel as it is a freely behaving, tractable rodent model that exhibits human sleep patterns. The extreme northern latitude of the field site for this study provides an opportunity to investigate how a SWS countermeasure fares under varying, long-duration changes in circadian cueing. I will measure neural, cardiac, and accelerometry data to analytically describe how sleep architecture, autonomic markers of stress, and cognitive/physical performance interact. A major goal of this project is to concurrently refine the SWS countermeasure into a configurable, autonomous tool capable of being deployed towards long-duration human space missions. The perceived significance of the proposed work is to span evidence to products that bridge fundamental research towards understanding the foundations of performance and resilience while providing an operational toolset alongside empirically derived implementation strategy.</p>
Rationale for HRP Directed Research:	<p>Research Impact/Earth Benefits:</p> <p>Bio-logger development: A low-cost solution for closed-loop brain wave stimulation does not currently exist, limiting the exploration of brain rhythm manipulation to enhance health and performance. The bio-loggers developed in my first year solve this dilemma as they are miniature, low-power, wireless-enabled, and can effectively perform “real-time” computation on incoming physiological data. Because understanding human sleep requires suitable animal models as well as technological innovations to approach new hypotheses, my project represents a significant impact on advancing current state-of-the-art techniques in animal tracking and monitoring pertinent to sleep studies. Techniques for sterilization, encapsulation, electrode fabrication, and software implementation are also considerable intellectual achievements that can be shared with the scientific community.</p> <p>Analytical tools for sleep data: We developed a novel method to classify sleep-wake behavior from accelerometer data alone. The data opens new possibilities for analyzing these data, which are typically only appreciated as being useful to identify active, daytime behaviors (e.g., running, grooming, chewing). Additionally, we discovered new sleeping patterns in the red squirrel, which may serve to identify sleep architecture ideal for extreme environment/high performers, or be useful to future hypotheses concerning how sleep has evolved and translates to the human condition.</p>
Task Progress:	<p>Space exploration exposes humans to unique stressors that, if not addressed, compromise physical and psychological health and performance. Sleep is known to promote physiologic resilience making it paramount in challenging circumstances, but all sleep is not the same. Progressive, stereotyped sleep stages are common in mammals and form a basic structure known as “sleep architecture”. High homeostatic value has been placed on slow-wave sleep (SWS), which is the deepest state of sleep characterized by synchronous 1–4 Hz brain oscillations. SWS co-occurs with important fluid rhythms and changes in neural microstructure that promote waste clearing, potentially underlying the important findings that SWS enhances memory and performance. This proposal aims to identify critical conditions for which enhancing SWS through non-invasive audio stimulation may mitigate the influence of stressors or augment performance. I propose a novel translational analog in the wild red squirrel as it is a freely behaving, tractable rodent model. We recently characterized red squirrel sleep patterns using accelerometry finding that sleep is more efficient during times of high behavioral demand, such as in autumn when catching food is paramount to survival. If this particular sleep regimen was understood better, it may lead to a broader understanding of how sleep interplays with demanding environments and high performing individuals.</p> <p>In the first year, we also developed a miniaturized toolset to measure neural, cardiac, and accelerometry data to analytically describe how sleep architecture, autonomic markers of stress, and cognitive/physical performance interact. In the next year, we embark on a major goal to test whether closed-loop SWS enhancement is viable in a free-ranging species, while monitoring the physiological response to environmental and social interactions/conditions. This project concludes by connecting the SWS countermeasure as a configurable, autonomous tool capable of being deployed toward long-duration human space missions. The perceived significance of the proposed work is to span evidence to products that bridge fundamental research toward understanding the foundations of performance and resilience while providing an operational toolset alongside empirically derived implementation strategy.</p>
Bibliography Type:	Description: (Last Updated: 04/10/2024)