Fiscal Year:	FY 2022	**Task Last Updated:**	FY 01/07/2024
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		
PI Email:	mgaidica@umich.edu	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	650-963-6888
Organization Name:	University of Michigan, Ann Arbor		
PI Address 1:	Department of Neuroscience		
PI Address 2:			
PI Web Page:			
City:	Ann Arbor	**State:**	MI
Zip Code:	48109	**Congressional District:**	12
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2020 TRISH-RFA-2001-PD: Translational Research Institute for Space Health (TRISH) Postdoctoral Fellowships
Start Date:	08/01/2020	**End Date:**	07/30/2023
No. of Post Docs:	1	**No. of PhD Degrees:**	
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., 11/7/23) NOTE: End date changed to 2/29/2024 per TRISH (Ed., 9/12/23) 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)		
Grant/Contract No.:	NNX16AO69A-P0502		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	POSTDOCTORAL FELLOWSHIP 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.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Space exploration represents an artificial environment where sleep is altered and historical data suggests sleep will be sacrificed by astronauts during missions. Since sleep is not only a physiological necessity but required to fight against physical/mental fatigue and more broadly, maintain health and performance, it is important that we understand what sleep should look like and design appropriate, well-informed countermeasures. Wild animals (i.e., those that are free-living) represent an opportunity to understand how evolution has solved many problems related to coping and thriving in austere environments. From this viewpoint, we should not only be thinking about how to maintain and improve astronaut sleep but also investigate the universe of strategies that other animals use and consider how those could be worked into sleep/rest-wake/work strategies during low earth and deep space missions. In this project, we devised an approach using the North American Red Squirrel as an analog model because they are one of the few tractable (i.e., widely available) mammal species in North America that maintains a diurnal sleep schedule and sleeps within one large, nightly bout, like humans. Unlike ground squirrels—which are the focus of other NASA and TRISH studies—red squirrels do not use torpor or hibernation to address the challenges of extreme cold, suggesting that there is much to learn about how they manage energetic resources through modifying sleep-wake behavior. Our work specifically investigates these questions from both non-invasive and invasive methodologies. Firstly, we have gathered a massive amount of accelerometer data using non-invasive collaring (>7,000 total days) from red squirrels in the Yukon, where light and temperature drastically change across seasons. Although these data provide a wealth of information across many individuals (n > 200 squirrels), inertial data alone can not sufficiently identify sleep itself, let alone specific stages of sleep and its underlying architecture (e.g., REM-NREM). Therefore, a more invasive methodology was needed, albeit only possible to deploy on a smaller scale due to the relative complexity of the surgical implant procedure and required oversight. Such that, secondly, we have used the miniature neurophysiology platform we developed to record sleep in implanted, freely behaving red squirrels at the University of Michigan. The protocols we developed solve many outstanding issues related to the use of wild animals. Namely, humane anesthesia techniques that we developed through cross-institution conversations with domain experts, as well as technological advancements in performing real-time analysis of incoming neural data on our device. In sum, all of these directions build towards constructing better approaches to understanding sleep, its evolutionary importance and design, and compiling those ideas into testable countermeasure approaches to support astronaut – and more broadly, human – health.
Task Progress:	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. 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 caching food is paramount to survival. If this particular sleep regime was understood better, it may lead to a broader understanding of how sleep interplays with demanding environments and high performing individuals. 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 tested if 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 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.
Bibliography Type:	Description: (Last Updated: 04/10/2024)
Articles in Peer-reviewed Journals	Gaidica M, Dantzer B. "An implantable neurophysiology platform: Broadening research capabilities in free-living and non-traditional animals." Front Neural Circuits. 2022 Sep 23;16:940989. https://doi.org/10.3389/fncir.2022.940989 . PMID: 36213207; PMCID: PMC9537467 , Sep-2022

Awards	Gaidica, M. "Outstanding Postdoctoral Fellow Award, Nominee, August 2021." Aug-2021