Fiscal Year:	FY 2021	**Task Last Updated:**	FY 02/19/2021
PI Name:	Basner, Mathias M.D., Ph.D.		
Project Title:	Hybrid Training - A Sensory Stimulation Countermeasure for Long Duration Space Exploration Missions		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **Bmed**:Risk of Adverse Behavioral Conditions and Psychiatric Disorders		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	19104-4209	**Congressional District:**	2
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2014-15 HERO NNJ14ZSA001N-MIXEDTOPICS. Appendix E: Behavioral Health & Human Health Countermeasures Topics
Start Date:	04/19/2016	**End Date:**	11/30/2020
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 11/30/2020 per NSSC information (Ed., 10/22/20) NOTE: End date updated to 3/31/2020 per NSSC information (Ed., 11/12/19) NOTE: End date updated to 10/31/2019 per NSSC information (Ed., 5/8/19) NOTE: End date updated to 4/30/2019 per NSSC information (Ed., 1/23/19) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/17/17)		
Key Personnel Changes/Previous PI:	N/A		

COI Name (Institution):	Dinges, David Ph.D. (University of Pennsylvania) Gur, Ruben Ph.D. (University of Pennsylvania) Stahn, Alexander Ph.D. (University of Pennsylvania)
Grant/Contract No.:	NNX16AI53G
Performance Goal No.:	
Performance Goal Text:	
Task Description:	This proposal addresses the risk of Adverse Behavioral Conditions and Psychiatric Disorders, and the need to identify and validate countermeasures and effective methods for modifying the habitat/vehicle environment that promote individual behavioral health and performance during exploration class missions (BMed1, BMed7). We propose to investigate the efficacy of physical exercise (using a cycle ergometer) combined with an interactive virtual environment, i.e., Hybrid Training, as a countermeasure for augmenting sensory stimulation during long-duration space missions. This countermeasure will combine validated tools and VR (virtual reality) technologies in a new way to reveal the full potential of Hybrid Training, and take into account (a) key needs that fulfill sensory stimulation, (b) "hedonic adaptation," i.e., a reduced affective response to stimuli with continued or repeated exposure, (c) delivery schedule, and (d) size, mass, and volume requirements. We plan to investigate a crew of N=9 during two 12-14 month Antarctic winter-over missions in Neumayer station (total N=18). We will investigate both immediate and long-term benefits of Hybrid Training. Our primary outcomes are neurostructural and neurofunctional changes assessed with fMRI, and cognitive performance assessed with the Cognition test battery and a virtual maze. We will also assess biochemical markers of stress and neuroplasticity, objective measures of sleep-wake rhythmicity and sleep structure, subjective symptom reports, and group cohesion with unobtrusive proximity measurements as additional outcomes that will provide insights into mechanisms and consequences of the observed structural and functional brain changes, and their reversibility by Hybrid Training. These data will be compared to historic controls from Neumayer station and other Antarctic stations (Concordia, Halley), space analog environments (e.g., Mars500), and the International Space Station (ISS). At the end of the project, we will have a much clearer understanding whether and to what extent the detrimental effects of ICE (isolated, confined, and extreme) environments on neuroplasticity and behavioral health can be mitigated by Hybrid Training.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	With the proposed work we will relevantly contribute to the goal of the Human Research Program (HRP) to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration. More specifically, our findings, based on state-of-the-art neuroimaging technologies and on innovative, non-invasive, low burden, yet methodologically sound measurement technologies for cognitive, physiological, and crew cohesion outcomes, will relevantly contribute to the development of technologies to provide mission planners and system developers with strategies for monitoring and mitigating crew health and performance risks. These methodologies will also be useful for assessing subjects living in isolated, confined, and extreme environments on Earth.
Task Progress:	We accomplished the following: 1) Final results were presented at Human Research Program Investigators' Workshop in February 2021. 2) Actigraphy and HRV (hear rate variability) analyses were completed. 3) Biomarker analyses for inflammatory cytokines (IL) Il-1, IL-6, nerve growth factor (NGF), tumor necrosis factor-alpha (TNF-α), and Vit D were completed. 4) Final report was generated. This study addressed the risk of Adverse Behavioral Conditions and Psychiatric Disorders, and the need to identify and validate countermeasures and effective methods for modifying the habitat/vehicle environment that promote individual behavioral health and performance during exploration class missions (BMed1, BMed7). We investigated the efficacy of physical exercise (using a cycle ergometer) combined with an interactive virtual environment, i.e., Hybrid Training, as a countermeasure for augmenting sensory stimulation during long duration space missions. This countermeasure took into account (a) key needs that fulfill sensory stimulation, (b) "hedonic adaptation," i.e., a reduced affective response to stimuli with continued or repeated exposure, (c) delivery schedule, and (d) size, mass, and volume requirements. We investigated a crew of N=7-8 during two 12-14 month Antarctic winter-over missions in Neumayer III station (total N=15). We investigated both immediate and long-term benefits of Hybrid Training. Our primary outcomes were neurostructural and neurofunctional changes assessed with fMRI, and cognitive performance assessed with the Cognition test battery. We also assessed biochemical markers of stress and neuroplasticity, objective measures of sleep-wake rhythmicity and sleep structure, subjective symptom reports as additional outcomes that provided insights into mechanisms and consequences of the observed structural and functional brain changes, and their reversibility by Hybrid Training. These data were compared to historic controls from Neumayer III station.
Bibliography Type:	Description: (Last Updated: 12/22/2021)
Articles in Peer-reviewed Journals	Basner M, Moore TM, Nasrini J, Gur RC, Dinges DF. "Response speed measurements on the Psychomotor Vigilance Test: How precise is precise enough?" Sleep. 2021 Jan 21;44(1):zsaa121. Epub 2020 Jul 2. https:// ; PMID: 32556295 , Jan-2021
Articles in Peer-reviewed Journals	Smith MG, Kelley M, Basner M. "A brief history of spaceflight from 1961 to 2020: An analysis of missions and astronaut demographics." Acta Astronaut. 2020 Oct;175:290-9. Epub 2020 Jun 3. https:// ; PMID: 32801403; PMCID: PMC7422727 , Oct-2020

Articles in Peer-reviewed Journals	Basner M, Stahn AC, Nasrini J, Dinges DF, Moore TM, Gur RC, Mühl C, Macias BR, Laurie SS. "Effects of head-down tilt bed rest plus elevated CO2 on cognitive performance." J Appl Physiol (1985). 2021 Apr 1;130(4):1235-46. https:// ; PMID: 33630672 , Apr-2021