Fiscal Year:	FY 2019	**Task Last Updated:**	FY 05/21/2019
PI Name:	Dinges, David F. Ph.D.		
Project Title:	Standardized Behavioral Measures for Detecting Behavioral Health Risks during 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 Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **Team**:Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	dinges@pennmedicine.upenn.edu	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	215-898-9949
Organization Name:	University of Pennsylvania		
PI Address 1:	Department of Psychiatry		
PI Address 2:	423 Service Dr., 1013 Blockley Hall		
PI Web Page:			
City:	Philadelphia	**State:**	PA
Zip Code:	19104-4209	**Congressional District:**	2
Comments:			
Project Type:	Flight,Ground	**Solicitation / Funding Source:**	2013-14 HERO NNJ13ZSA002N-BMED Behavioral Health & Performance
Start Date:	07/21/2015	**End Date:**	02/28/2020
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**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:	Williams, Thomas	**Contact Phone:**	281-483-8773
Contact Email:	thomas.j.will1@nasa.gov		
Flight Program:	ISS		
Flight Assignment:	NOTE: End date changed to 2/28/2020 per NSSC information (Ed., 5/22/19) NOTE: End date changed to 7/20/2019 per NSSC information (Ed., 8/10/18) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		
Key Personnel Changes/Previous PI:			

COI Name (Institution):	Basner, Mathias M.D. (University of Pennsylvania) Mollicone, Daniel Ph.D. (Pulsar Informatics, Inc.) Stuster, Jack Ph.D. (Anacapa Sciences, Inc.) Strangman, Gary Ph.D. (Harvard Medical School) Stahn, Alexander Ph.D. (University of Pennsylvania) Roma, Peter Ph.D. (KBRwyle / NASA Johnson Space Center) Gur, Ruben Ph.D. (University of Pennsylvania)
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Task Description:	Isolated and confined environments anticipated during exploration missions will include stressors such as small teams living and working in extreme conditions for prolonged periods separated from family and friends; loss of the day/light cycle; loss or delay of communications with ground; partial gravity; and limited space, privacy, and food selection. NASA's Human Factors and Behavioral Performance Element seeks to maintain and enhance behavioral health and performance in such environments. The behavioral risk (Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders) is a high priority within the NASA Human Research Program (HRP) because it has face validity, but lacks sufficient evidence due to a deficiency in measurement of the risk. Thus, there is concern that the behavioral health of the crew will be challenged in a Mars mission, however there is no standardized method to detect and quantify the magnitude of the risk or its likelihood. The overarching goal of this project is to build on a successful record of software-based measurement of behavioral health indicators (e.g., mood, cognitive function, performance, physical and mental fatigue, sleep quality) to develop a complementary standardized suite of behavioral core measures (BCM) that would be quite feasible to implement within the constraints of spaceflight research, ground-based analogs (both short- and long-duration), and prolonged missions in isolated, confined, extreme environments lasting up to 12 months or longer. Achievement of this goal would permit a more rapid and reliable assessment and quantification of the Risk of Adverse Cognitive or Behavioral Conditions Psychiatric Outcomes for exploration class missions. The standardized behavioral medicine measures we are developing will be similar to the guidelines for standardization for bed rest studies. Defining standardized measures will not only allow for the systematic collection of data across multiple analogs, but it will also facilitate risk characterization for the Behavioral Medicine (BMed) risk. Without a standardized suite of behavioral health measures, the unknown BMed risk for exploration-class missions will continue to be estimated based on anecdote and conjecture. The elements of the BCM include the following: (1) The Cognition test battery (a suite of 10 brief neuropsychological tests specifically designed for astronauts), (2) actigraphy sleep/wake data, (3) visual analog scales and brief questionnaires with proven validity and utility in space and space analog environments, (4) Journals (Audio/Video and/or typed), (5) a robotic arm track-and-capture grappling task, (6) Team Measure Questionnaires designed to measure aspects of crew performance, team processes, team climate, and group living. Data acquisition feasibility and flexibility, and user acceptability of BCM has been assessed in a short-duration NASA analog (4 missions in the Human Exploration Research Analog [HERA], N=16 subjects), in a long-duration remote location analog (10 months of data collection during a 12-14 month winter-over in the Antarctic Neumayer station, N=7 subjects), and is currently being further assessed on the International Space Station (ISS) for feasibility and acceptability (during a 6 month mission, N=2 astronauts). Mission controllers completed a team performance questionnaire during HERA missions, and flight directors will be asked to complete this brief questionnaire during the ISS study during the 58/59 expeditions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This project will deliver a Behavioral Core Measures Tool (BCM) that will be tested for its feasibility, flexibility, and acceptability in research studies in both short and long duration space analog environments and on the ISS. With the BCM, it will be possible for NASA's HFBP (Human Factors & Behavioral Performance) program to much better assess and quantify the Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Outcomes for exploration class missions. With the proposed work we will relevantly contribute to HRP's goal to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration. More specifically, the BCM will constitute an important technology to provide mission planners and system developers with strategies for monitoring and mitigating crew health and performance risks. Additionally, Behavioral Core Measures could also be beneficial for monitoring behavioral health during Earth-based operations, especially those involving isolated, confined, and extreme environments (e.g., Antarctic research expeditions).
	Cognition: Data acquisition on the Cognition (neurobehavioral) test battery in NASA's HERA facility was finalized on 10/26/2016. A total of N=288 full Cognition test bouts (100% of expected) were successfully collected as well as N=270 surveys (93.75% of expected) in N=16 crewmembers. We deployed and collected data on N=8 crewmembers during two out of the four Campaign 3 missions in NASA's Human Exploration Research Analog (HERA) facility. In HERA research participants performed the Cognition test battery on the Apple iPad, however, through discussions with the International Space Station Medical Program (ISSMP) it was determined that the iPad is not a feasible platform for data collection on ISS. Thus a Windows PC version of the Cognition software was developed and is being used on-board the ISS and in the Antarctic Neumayer station. Data acquisition on Neumayer station was finalized in November 2017. We received 82 full Cognition batteries from N=7 crewmembers in total (Cognition was performed on a monthly basis). We also received N=59 Psychomotor Vigilance Test (PVT) tests (the PVT plus survey only was performed 2 weeks after each full Cognition battery). Post-mission data acquisition at Charité Berlin was performed on 3/22/2018. Data acquisition for the N=2 astronauts on ISS began on 11/9/2018 and is currently in progress. We have received 4 BCM Cognition test batteries with good data quality to date.

Task Progress:

Self Report and Visual Analog Scale Measures: A set of visual analog scales and brief questionnaires with proven validity and utility in space and space analog environments were chosen in order to evaluate several key aspects of behavioral health and crew interaction. These questionnaires include (a) the Reaction Self-Test (RST) Visual Analog Scales (VAS) to evaluate perceived mental (mentally sharp—mentally fatigued) and physical (energetic—physically exhausted) exhaustion, fatigue (tired—fresh, ready to go), sleepiness (not sleepy at all—very sleepy), stress (not stressed at all—very stressed), and workload (very low—very high); (b) the Social Desirability Scale (SDS-17) to measure self-desirability bias; (c) sleep diaries to evaluate sleep quality and duration; (d) the Profile of Mood States, Short Form (POMS-SF) to evaluate mood; (e) the Beck Depression Inventory (BDI-II) to evaluate depression; and (f) the Conflict Scale (CS) to evaluate perceived conflict among crewmembers and between crewmembers and mission control. The Visual Analog Scales and sleep diaries have already proven useful for measuring neurobehavioral health during 6-month missions on ISS and these data informed the need for a one-year mission.

During the 14-month Neumayer missions these surveys were deployed using the University of Pennsylvania's Qualtrics electronic web-based survey tool in order to accommodate offline data collection and storage. Data were successfully collected on N=7 Neumayer crewmembers, and self-report measures were successfully collected with 88.4% response adherence. A total of N=501 BCM questionnaires were completed: n=82 nighttime Visual Analog Scales; n=82 Conflict Scales; n=165 morning Visual Analog Scales and sleep diaries; n=84 POMS-SF, n=81 BDI-II, and n=7 SDS-17 questionnaires.

ISS survey data collection began in November of 2018 and has continued during ISS expedition 58/59 using the on-board Data Collection Tool (DCT) software.

Journals: At the end of our previous reporting period, journal entries from all four of the HERA simulated asteroid rendezvous missions (N=16 crewmembers) had been transcribed and analyzed. Only one crewmember of the Neumayer III Antarctic station completed a confidential journal, which allowed limited analysis to be performed. Data-collection on the ISS began in December 2018 with two astronauts participating in the BCM study. Each astronaut has completed eight journal entries and the mid-mission questionnaire at the time of this writing, with two months remaining in the expedition. No analyses have been conducted yet.

Category Analysis

The numbers of parsed journal statements assigned to the 25 major topical categories were tabulated for each subject’s journal and then combined to calculate the overall total for each category. The subjects’ rankings are remarkably similar to the category ranking derived from the journals of ISS astronauts during the 13-year Journals Flight Experiment.

Subcategory Analysis: Adjustment

Statements extracted from the HERA A/V journals were assembled according to their category assignments and the mission quarter during which they were recorded. Only the primary, secondary, and tertiary assignments for the Adjustment category were subjected to a subcategory analysis in this study. Statements were assigned to subcategories based on similar content. A total of 20 subcategories emerged from the data. Journal statements assigned to the Adjustment category range from references to the positive effects of exercise to the importance of remaining busy with meaningful work.

Net Positivity/Negativity

Each parsed journal statement was assigned a code to indicate whether the statement was positive, negative, or neutral in its tone or content. A metric called Net Positivity/Negativity (NPN) was derived by subtracting the proportion of negative entries from the proportion of positive entries. This metric was calculated for all category assignments by quarter for each expedition. NPN analyses were performed by journal with data from all categories combined and by journal focusing exclusively on statements assigned to the Adjustment category. NPN analyses were conducted to test hypotheses concerning a “third quarter phenomenon,” a decline in affect, general attitude, or “morale” during the third quarters of missions, regardless of duration. The third quarter phenomenon was suggested by anecdotal accounts and evidence from previous content analyses of expedition journals.

Conclusion

Results of the Journals Component of the BCM study that was conducted during four HERA simulations in 2016 and the Neumayer Antarctic expedition in 2017 confirm previous experiences with French polar explorers and NASA astronauts that analysis of confidential journals can be used to assess the behavioral health of personnel in remote-duty environments. However, certain conditions must be met for the method to be effective: 1) The personnel must make at least weekly journal entries; 2) Audio entries must be at least eight minutes in duration, or one page of typed text; 3) Participants must describe events, experiences, and observations candidly; 4) Journal entries must be transmitted to an analyst who is outside of the participants’ organization soon after they are made for immediate review and analysis; and, 5) A mechanism must be in place to enable the analyst to intervene when a serious behavioral issue is detected without jeopardizing the confidentiality of participants.

ROBoT: In the most recent year of the BCM project, we initiated (and are still conducting) a feasibility study of ROBoT-r testing aboard the ISS. Preparations included Institutional Review Board (IRB) approvals, revising the ROBoT-r scoring system to better align with astronaut expectations, modifying the user feedback screens to avoid conflicts with ROBoT trainer feedback, developing training materials, holding informed consent briefings, team member training for astronaut instruction, and developing baseline data collection plans suitable for both US-based and Russia-based crews.

Data acquisition and analysis for this feasibility-test phase of the project is still underway. Baseline data collection on the ground led to a requested change in ROBoT-r trial difficulty—including a software patch for uplink to ISS—to more closely match the range of trial difficulties that are normally included in the standard astronaut training program for ROBoT. Comments after follow-up tests suggested these modifications were successful. To date we have collected data from 2 complete baseline sessions plus 12 complete in-flight sessions on ROBoT-r. One feasibility concern arose in-flight, namely conducting a ROBoT-r session (which involves capture of HTV-II) within 2 weeks of a planned capture of a Dragon spacecraft as part of planned operations. This led to the delay of the ROBoT-r session until after Dragon capture was achieved.

Preliminary data analysis suggests that astronaut performance on ROBoT-r is significantly better—and exhibits less

variance—than HERA participants, Neumayer subjects, or relevant controls. This was particularly notable for angle error at the point of capture, where the worst mean performance by astronaut subjects was still better than the best mean performance by individuals in the other groups. Interestingly, there appears to be evidence of a modest learning effect across sessions in astronauts (simultaneous improvements in both speed and accuracy), although much less dramatic as compared to other groups. This was unexpected, given the 100s of hours of training on ROBoT that astronauts receive as part of their training flow. One possibility is that the runs used by ROBoT-r are not identical to those used in the standard ROBoT training and hence additional learning is occurring on these slightly different run types. This finding remains to be fully investigated.

In addition, in year 4 a supplementary effort with regard to ISS data collection was requested by NASA administration. The goal is to obtain ROBoT-r data on three occasions within 24 hr post-landing. The research question is whether or not astronauts can perform complex operational tasks like ROBoT-r effectively within this early post-landing period. The answer to this question will help lock-down the design of initial crewed Mars mission landing vehicles, as the current concept of operations is to have astronauts perform a complex electrical umbilical hook-up after landing to maintain their life support system. For this con-ops to work, the astronauts need to be capable of performing this maneuver within 24-hr of landing, or the life support system will fail. We have worked with Dr. Tom Williams, the ER/DST laboratory and ISSMP to determine the best way to achieve this goal. The plan is to conduct three tests: (1) in a tent in Kazakhstan within 3-6 hrs of landing, (2) in the Prestwick, Scotland airport during the refueling stop within 10-12 hrs of landing, and (3) in Building 21 on Johnson Space Center (JSC) campus after arrival in Houston and <24 hours post-landing. Preparations are still underway to achieve this supplementary data collection process.

Team Measure Questionnaires: Data from the Team Measures battery was successfully acquired from all four 30-day HERA C3 missions (N=16 individuals) with 100% compliance.

Preliminary analyses of the HERA data, thematic analysis of the initial Team Measures battery, and assessment of operational acceptability led to recommendations for a reduced and modified Team Measures battery and data collection schedule for long-duration missions in operational environments. This iteration of the Team Measures battery was deployed in a long-duration mission at Neumayer Station in Antarctica (N=7 individuals). The pre-mission demographics and IPIP-NEO-120 measures were completed by all participants (100% compliance). The in-mission measures included a combined Team Performance, Team Processes, and Team Climate session scheduled for completion every two weeks, as well as the BCM's newly developed Group Living assessment scheduled for completion every month. Compliance for the bi-weekly team measures was generally high, with 75% of sessions completed. Notably, non-compliance was not distributed evenly across the mission. Specifically, no data were recorded for January or February 2018, although it is unknown why this lapse occurred. Interestingly, and despite the less frequent administration schedule, compliance for the Group Living measure was low, with only 32% of sessions completed (2017 February, July, November, and 2018 March). Feedback from the crew indicated that some participants were uncomfortable with the 360 nature of the assessment where every crewmember rates him/herself and every other crewmember. In addition, since the number of participants directly affects the duration of the assessment, this introduces a risk of unacceptable time burden. Lessons learned from this assessment have been incorporated into the development of Standard Measures for spaceflight. Specifically, the Group Living measure is no longer a 360 assessment where every crewmember rates every other crewmember, instead opting for a format where each item refers to the entire team. Although this provides lower resolution data, it is more operationally acceptable and still provides insight on this critical competency for long-duration exploration missions.

The final stage of data collection is BCM on ISS. This effort is currently ongoing with N=2 astronauts, with the Team Measures battery administered once every four weeks. The battery includes 28 ratings and two open-text items covering the Team Performance, Team Processes, Team Climate, and Group Living constructs. Despite the concerns raised and mixed compliance with the Neumayer crew in-mission, operational acceptability on ISS has been notably high, with 100% compliance thus far. Not surprisingly, team functioning was rated highly, although not suspiciously or artificially high. Although the range of responses was limited and there were no clear temporal trajectories, there were intra-individual variations, and very clear and consistent individual differences in perceived team functioning. Taken together, these data support the sensitivity of the BCM Team Measures' design, specifically the adaptation of measures from ordinal Likert scales to continuous variables via visual analog scale formats, in order to enable detection of small but potentially operationally significant effects (cf. Wolfson & Mathieu, 2018).

Wolfson, M. A., & Mathieu, J. E. (2018). Sprinting to the finish: Toward a theory of Human Capital Resource Complementarity. Journal of Applied Psychology, 103(11), 1165-1180. https://

Discussion:

Data collected during the 14-month Neumayer mission have shown that the standardized suite of Behavioral Core Measures is feasible, acceptable, and reliable for tracking cognitive performance and behavioral health during a long-duration mission in extreme conditions (12-14 months). However the possible exception of Journals (for which only 23% of expected data were acquired) may reflect a cultural bias of the German crew.

BCM on ISS has been fully implemented and data collection is ongoing for N=2 astronauts.

Bibliography Type:	Description: (Last Updated: 05/08/2025)
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Abstracts for Journals and Proceedings	Dinges D, Basner M, Strangman G, Stuster J, Roma P, Mollicone D, Gur R, Stahn A, Dennis L, Ecker A, Nasrini J, Mott C. "Standardized behavioral measures for detecting behavioral health risks during exploration (Behavioral Core Measures)." Presentation at the 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. Abstracts. 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. , Jan-2019
Abstracts for Journals and Proceedings	Roma PG, Landon LB, Schneiderman JS. "Overview of NASA Behavioral Health & Performance Standard Measures." Presentation at the 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. Abstracts. 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. , Jan-2019
Abstracts for Journals and Proceedings	Roma PG, Landon LB, Schneiderman JS. "The NASA Behavioral Health & Performance Standard Measures Suite for Integrated Multidisciplinary Research in Isolated, Confined, and Extreme Environments." Presentation at the 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. Abstracts. 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. , Jan-2019
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