Fiscal Year:	FY 2017	**Task Last Updated:**	FY 11/24/2017
PI Name:	Fiore, Stephen Ph.D.		
Project Title:	Macrocognition in Teams: Examining and Developing Team Cognitive Processes and Products in the Context of Long Duration Exploration Missions		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
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) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (3) **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		
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Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-Crew Health (FLAGSHIP, NSBRI, OMNIBUS). Appendix A-Crew Health, Appendix B-NSBRI, Appendix C-Omnibus
Start Date:	08/01/2016	**End Date:**	05/31/2018
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:	2	**No. of Bachelor's Degrees:**	3
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 5/31/2018 per NSSC information (Ed., 5/7/19) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Burke, Shawn Ph.D. (University of Central Florida) Salas, Eduardo Ph.D. (Rice University)		
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Task Description:

Teams conducting long-duration exploration missions (LDEM) face the pervasive risk of decrements due to inadequate collaboration within the spaceflight crew as well as between and across Mission Control teams. Given that team cognition has been shown to be a significant predictor of team performance across a number of domains and tasks (DeChurch et al., 2010; Salas & Fiore, 2004), it is critical to understand how team cognition occurs under LDEM conditions, how it shifts over time, and how to implement countermeasures to improve it. Fiore and colleagues developed the macrocognition in teams model (MITM) to integrate the more general literature on team cognition with a particular focus on complex real world collaborative cognition (Fiore et al., 2010a; Fiore et al., 2010b). Building off of this theory, the Principal Investigator (PI) recently examined this in the context of LDEM and detailed a set of team cognitive processes and team cognitive knowledge to explicate the form of team cognition that needed to be understood for LDEM (Fiore et al., 2015). In this proposal we describe a multidisciplinary approach designed to refine and validate the MITM in the context of LDEM and use this as the theoretical foundation to develop and validate training protocols that lead to resilient team cognitive processes. In doing so, we take a multi-pronged approach combining analysis of archival documents and qualitative coding of crew communication in analog environments with new ground-based and analog studies. Our goal is to: (1) provide a richer understanding of team cognition and its relation to team performance in space crews and the larger multi-team system and (2) use this understanding to refine and validate training to mitigate decrements in team cognition.

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Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

The proposed effort will impact numerous areas of research need for NASA. First, this research will address theoretical gaps associated with how individual and team cognitive processes affect each other and change over time. The relevant gaps identified by NASA are: (1) The need to understand the key threats, indicators, and life cycle of the team for autonomous, long duration and/or distance exploration missions (Team Gap 1), (2) The need to identify psychological measures that can be used to select individuals most likely to maintain team function for autonomous, long duration, and/or distance exploration in missions (Team Gap 4), and (3) The need to identify validated ground-based training methods that can be both preparatory and continuing to maintain team function in autonomous, long duration and/or exploration missions (Team Gap 5). The current literature does not provide much information regarding longitudinal shifts in cognition, especially in the context of teams working in LDEM settings. Because of these knowledge gaps, it is essential to determine the causes that impact cognitive processes across the lifespan of teams throughout LDEM settings. This knowledge supports this effort's second contribution in the development of effective countermeasures aimed to maintain adequate levels of cognition at both the individual and team level. Finally, the third contribution will be the identification of a suite of measures for assessing individual and team cognitive processes and how these change over time. The elements of isolation and confinement in future LDEM warrant investigation of innovative and less intrusive assessments of cognition. Thus, this effort will attempt to identify the types of individual and team cognitive measures that can be implemented effectively in such environments. Findings from this research will contribute, not just to gaps identified by NASA, but will also enrich the broader area of team cognition research. In particular, by studying the inter-relation of individual and team cognition, and providing potential alternatives to traditional assessment techniques, this research will inform the general study of teams in complex contexts. The resultant knowledge gained will assist in facilitating crew performance by identifying the manner in which cognitive processes change over time, how individual decrements in cognition cascade to the team level to impact the crew's performance, and potential countermeasures for such effects. Additionally, it will also impact those on Earth as this awareness can be used to facilitate the interaction between crew and ground control so as to maximize the synergy present in these expert teams.

The first year of effort put into this research project was spent in a "pre-work" phase appropriately termed the 'Definitional Phase.' The main objective for the Definitional Phase of this project was to update, refine, and/or expand upon various aspects of our research proposal aimed at understanding the cognitive processes (both individual and team) involved in long duration exploration missions (LDEM). Three gaps were initially identified by NASA, but through this process, five overarching tasks of work were elicited where refinements were made to the initial proposal, going into specific detail on how all relevant aspects were affected.

Task 1 involved the elaboration of plans made for performing archival analyses. Within this task, we specifically identified a comprehensive set of sources for examination and extraction of critical incidents. The purpose of the extraction of critical incidents from archival sources such as books, interviews, analog experiments, and documented spaceflight events is to further study cognition in real world settings. To this end, we aim to understand cognitive processes in complex settings, how these shift over time, what the conditions are that cause these shifts, and how we can improve team cognition. Also included in this task are how and why sources were chosen, and protocols for both conducting interviews and training in the effective extraction of incident data.

Task 2 pertained to the methods and measures we plan to implement within analog environment testbeds. We provide a detailed overview of our analog environment research plan as it relates to our macrocognition in teams theoretical approach. Particularly, we provide an explanation of how we have elaborated on our model and integrated it with specific measures that will be used to address our research questions. Facilitating this effort was previous work conducted by the principal investigator on the study of well-structured and ill-structured problems in constrained vs. unconstrained solution spaces. This work aided the identification of tasks and measures to be utilized within the Human

Task Progress:	Exploration Research Analog (HERA). From this, hypotheses were revised and measures identified that would tap the constructs of interest. The goal was to integrate our approach for studying individual and team cognition with research in the HERA context, building from what we identified in the archival analyses (Task 1). Task 3 comprised of all lab experiment specifications. The purpose of this task was to review measures of individual and team cognitive processes that can be implemented in our laboratory studies, and further details of the methodology and specific variables targeted in said studies. The individual-level facets of cognition of attention, working memory, and reasoning were examined and measures targeting those constructs identified. Similar work was conducted on team cognitive knowledge (i.e., shared mental models and transactive memory) and team cognitive processes (i.e., planning, decision making, and problem solving), along with identification of measures designed to tap those constructs. The work detailed in this section provided the necessary first steps toward developing validated measures aimed at assessing individual-level and team-level cognitive processes in LDEM. This also offered insight into the development and validation of training protocols that lead to resilient team cognitive processes. Additionally, this task is related to our theoretical foundation for understanding the linkages between individual and team cognition which may influence team performance in LDEM. Task 4 was conducted in order to determine the uniqueness of the training countermeasures proposed within the grant, but also to take initial steps to facilitate the transition of the countermeasure to operational use. In doing so, we were not only interested in mapping our approach, methodology, and content against current operational training efforts, but also garnering input regarding the utility and feasibility of the proposed training from operations. In performing these functions, we delineated a new task (not initially identified in the original proposal) to be conducted in later years of the project involving ensuring that: 1) the developed tool fits its unique niche, 2) the terminology used within the developed tool is in alignment with current training, and 3) investigate potential points where it might best fit into the timeline. This task involves working with NASA personnel involved in astronaut candidate (ASCAN) training to establish both face and content validity as well as operational utility. We aim to conduct focus groups (or one-on-one interviews, depending on circumstances at the time) with individuals involved in the development and implementation of training, as well as portions of the user community to include but not limited to astronauts and personnel within mission control. The two goals of this task are to gain information on potential barriers to implementation or additional considerations that we may need to take into account during the design process, in addition to gaining insight into how we can best incorporate our efforts into the models which are currently being utilized to train ASCAN. Task 5 further specified the data sharing agreements and transfer of data to the Life Sciences Data Archive common to analog research. As we have not engaged in any data sharing agreements with NASA before, we will draw on our past and current data sharing agreements, using their formats to guide the process within NASA. The data sharing agreement plans on covering what data will be shared, with whom the data will be shared, the manner in which the data is planned to be used, the length of time the data sharing agreement is in effect, and any other areas deemed necessary by traditional NASA data sharing agreements. Prior to sharing any data, we will ensure that all parties with which we are sharing data have appropriate Institutional Review Board (IRB) approval at both the host institution and NASA. Further additions and/or revisions will be made as the point of data collection approaches within the three years of the grant.
Bibliography Type:	Description: (Last Updated: 01/12/2021)
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