Fiscal Year:	FY 2016	**Task Last Updated:**	FY 04/06/2016
PI Name:	Ryder, Valerie Ph.D.		
Project Title:	Effects of Acute Exposures to Carbon Dioxide upon Cognitive Function		
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 (2) **Sleep**:Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload (IRP Rev F)		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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PI Organization Type:	NASA CENTER	**Phone:**	281-483-4989
Organization Name:	NASA Johnson Space Center		
PI Address 1:	Toxicology MC: SK4		
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PI Web Page:			
City:	Houston	**State:**	TX
Zip Code:	77058-3607	**Congressional District:**	22
Comments:			
Project Type:	GROUND	**Solicitation:**	2014-15 HERO NNJ14ZSA001N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	07/01/2015	**End Date:**	06/30/2017
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:	Williams, Thomas	**Contact Phone:**	281-483-8773
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Flight Program:			
Flight Assignment:	NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		
Key Personnel Changes/Previous PI:	April 2016 report: Mathias Basner, Ph.D. and Usha Satish, Ph.D. are new CoInvestigators.		
COI Name (Institution):	Ploutz-Snyder, Robert Ph.D. (Universities Space Research Association, Columbia) Alexander, David M.D. (Co-PI: NASA Johnson Space Center) Lam, Chiu-Wing Ph.D. (Wyle Laboratories/NASA Johnson Space Center) Scully, Robert Ph.D. (Wyle Laboratories/NASA Johnson Space Center) Satish, Usha Ph.D. (State University of New York (SUNY)) Basner, Mathias Ph.D. (University of Pennsylvania)		
Grant/Contract No.:	Internal Project		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Evidence had been published that indicates that CO2 at concentrations below 2 mm Hg significantly impacted some cognitive functions that are associated with the ability to make complex decisions in conditions that are characterized by volatility, uncertainty, complexity, ambiguity, and delayed feedback – conditions that could be encountered by crews in off-nominal situations, or during the first missions beyond low Earth orbit. Our study will extend the original study by using measures of cognitive domains to determine if astronaut-like subjects are sensitive to concentrations of CO2 at or below limits currently controlled by flight rules. Human test subjects, selected based on similarities to the current astronaut cohort, will be exposed to 600, 1200, 2500, and 5000 ppm (0.5, 0.9, 1.9, and 3.8 mmHg) CO2 in a controlled facility. The concentration sequence will be randomized and unknown to study participants, and measures of cognitive function will be collected during exposures. Our use of cognitive measures in a well-controlled, ground-based study that is free of these potential confounding influences will establish a baseline terrestrial data set against which cognitive data collected in flight may be assessed. If confirmed, these findings would provide additional evidence that CO2 may need to be controlled at levels that are well below current spacecraft limits.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The need to assess safe limits of exposure to CO2 with respect to adverse effects upon cognitive functions are particularly urgent in a setting in which even small decrements in cognitive functions, such as those utilized in complex decision making, could pose significant risk to outcomes in which substantial resources and even lives are invested. One such setting is human space flight. Crew reports and other anecdotal evidence (Law, et al., 2010; Cronyn et al., 2012; Strangman et al., 2012) suggest that the space flight environment may depress mental faculties. However, it seems probable that the measures historically available to spaceflight crews (Spaceflight Cognitive Assessment Tool for Windows (WinSCAT) and MiniCog) lacked the sensitivity needed to detect deficits in cognitive functions experienced or observed as instances of “mental viscosity,” due to the ceiling effect, which occurs when subjects achieve perfect scores on subtests in these batteries and so there is no difference measurable among subjects at the ceiling level (Cowings et al., 2006). Thus for several reasons, including small sample size, learning effects, and lack of sensitivity, “our knowledge about cognitive effects of space flight is superficial” (De La Torre et al., 2012). Given that CO2-like symptoms, such as difficulty in concentrating and headache, are among the most common symptoms reported by crews (Strangman, 2010), are experienced at lower than expected levels of CO2 (4,000 to 8,000 PPM, or 3 to 6 mm Hg), and resolve when the spacecraft CO2 is reduced, the possibility exists that CO2 sensitivity may be enhanced in the space environment (Law et al., 2010, 2014), it is possible that the threshold for cognitive effects attributable to CO2 in space may be lower than that observed by Satish et al. (2012). If this holds true, it may result in the need to establish lower space flight limits for CO2 and in turn drive the development of new technologies for CO2 control onboard spacecraft. Although not impacted by physiological changes associated with microgravity, submariners experience similar isolated quarters with recycled resources and higher than average baseline CO2 levels. In addition, they are another population where minor effects on cognition and decision-making can have life threatening consequences. REFERENCES: Cowings PS, Toscano WB, DeRoshia CW, Taylor B, Hines S, Bright A, Dodds A. (2006). Converging Indicators for Assessing Individual Differences in Adaptation to Extreme Environments: Preliminary Report. NASA/TM–2006-213491. Cronyn PD, Wakins S, Alexander DJ. (2012). Chronic exposure to Moderately Elevated CO2 during Long-Duration Space Flight. NASA/TP-20120217358. De La Torre GG, van Baarsen B, Ferlazzo F, Kanas N, Weiss K, Schneider S, Whiteley I. (2012). Future perspectives on space psychology: Recommendations on psychosocial and neurobehavioural aspects of human spaceflight. Acta Astronautica 81(2): 587-599. Law J, Watkins S, Alexander D. (2010). In-flight carbon dioxide exposures and related symptoms: association, susceptibility, and Operational implications. NASA/TP–2010–216126. Law J, Van Baalen M, Foy M, Mason SS, Mendez C, Wear M L, Meyers VE, Alexander D. (2014). Relationship between Carbon Dioxide Levels and Reported Headaches on the International Space Station. Journal of Occupational and Environmental Medicine, 56(5), 477-483. Satish U, Mendell MJ, Shekhar K, Hotchi T, Sullivan D, Streufert S, Fisk WJ. (2012). Is CO2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO2 Concentrations on Human Decision-Making Performance. Environ Health Perspect 120:1671–1677. Strangman, G. (2010). Human Cognition and Long Duration Space flight. A literature review on the topic of: “Changes in Cognition and Psychological Well-being in Isolated, Confined and Extreme Environments”. Produced for NASA’s Behavioral Health and Performance (BHP) program element. In: Additional Evidence: Risk of Adverse Behavioral Conditions and Psychiatric Disorders. Strangman G, Beven G. (2012). Review of Human Cognitive Performance in Space flight. 84th Annual Scientific Meeting of the Aerospace Medical Association; 12-16 May 2013; Chicago, IL; United States
Task Progress:	To date, the study protocol has been developed/finalized, Institutional Review Board review and approval obtained, and contracts have been put in place with collaborators at SUNY (State University of New York) and the University of Pennsylvania to obtain the software planned for use in this study. This includes the strategic management simulations (SMS) described by Satish (2012) and the Cognition test battery described by Basner (2015). In addition, environmental chamber testing and safety reviews have been conducted to ensure that CO2 exposures at the target concentrations can occur. Crew-like test subjects have been recruited by the test subject facility at Johnson Space Center, and exposures are scheduled to begin in mid-April. Exposures will run through June 2016, and data will then be compiled and evaluated. REFERENCES: Basner M, Savitt A, Moore TM, Port AM, McGuire S, Ecker AJ, Nasrini, J, Mollicone DJ, Mott CM, McCann T, Dinges DF, Gur RC. (2015). Development and Validation of the Cognition Test Battery for Spaceflight. Aerosp Med Hum Perform 86(11):942-52. Satish U, Mendell MJ, Shekhar K, Hotchi T, Sullivan D, Streufert S, Fisk WJ. (2012). Is CO2 an Indoor Pollutant?

	Direct Effects of Low-to-Moderate CO2 Concentrations on Human Decision-Making Performance. Environ Health Perspect 120:1671–1677.
Bibliography Type:	Description: (Last Updated: 01/11/2021)