Fiscal Year:	FY 2010	**Task Last Updated:**	FY 05/11/2011
PI Name:	Czeisler, Charles A. M.D., Ph.D.		
Project Title:	Operational Evaluation of a Photic Countermeasure to Improve Alertness, Performance, and Mood During Night-Shift Work on the 105-Day Study (105-Day Russian Chamber Study)		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Human Factors and Performance Team		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **BHP**:Behavioral Health & Performance (archival in 2017)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	caczeisler@rics.bwh.harvard.edu	**Fax:**	FY 617-732-4015
PI Organization Type:	UNIVERSITY	**Phone:**	617-732-4013
Organization Name:	Brigham and Women's Hospital/Harvard Medical Center		
PI Address 1:	Division of Sleep Medicine		
PI Address 2:	221 Longwood Ave., Ste. 438		
PI Web Page:			
City:	Boston	**State:**	MA
Zip Code:	02115-5804	**Congressional District:**	8
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	Directed Research
Start Date:	02/01/2009	**End Date:**	08/31/2010
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:	4	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	1	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Wright, Kenneth (University of Colorado at Boulder) Barger, Laura (Brigham and Women's Hospital/Harvard Medical Center)		
Grant/Contract No.:	NCC 9-58-HFP00002		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The success of long-duration missions depends on the ability of crewmembers and mission support specialists to be alert and maintain high levels of cognitive function while operating complex, technical equipment. Optimal human health, performance and safety during spaceflight requires sufficient sleep and synchrony between the circadian pacemaker - which regulates the timing of sleep, endocrine function, alertness, and performance - and the timing of the imposed sleep-wake schedule. Crewmembers of the 105-day experiment were required to work one night shift every sixth night. We hypothesized that this schedule would likely result in sleep loss and circadian misalignment, especially when lighting conditions are similar to those experienced during spaceflight. Mission controllers supporting the 105-day study were required to work 24-hour shifts. We hypothesized that this schedule, too, would result in both sleep loss and circadian misalignment. It has been well documented in laboratory and field studies that both working the night shift and working extended-duration shifts result in negative effects on alertness, performance, and mood. Light has been successfully used as a countermeasure for circadian misalignment and to acutely increase alertness. Recently, shorter wavelength light (480-500 nm) has been reported to be more effective for these purposes than longer wavelength light. The goals of the study were to test the operational feasibility of sleep and circadian assessments and test a lighting countermeasure to improve alertness and performance during night-shift work occurring during a long-duration analog space mission. Specific Aims 1) Evaluate the feasibility of monitoring sleep and circadian neuroendocrine rhythms in a high fidelity operational simulation 2) Test the hypothesis that sleep, alertness, performance, and mood will be impaired during night shift work operations, in both crewmembers and external mission controllers 3) Test the hypothesis that alertness, performance, and mood of crewmembers and external mission controllers exposed to shorter wavelength light (with a peak wavelength between 485 to 525 nm) during the night shift will be significantly better than the alertness, performance, and mood of those same crewmembers when they are exposed to intermediate wavelength light (with a peak wavelength of either 545 nm to 555 nm) or longer wavelength light (620 nm to 690 nm) during the night shift Throughout the 105-day experiment, measurements were obtained to assess sleep, performance, alignment of the circadian system, and nighttime melatonin levels. We collected 349 days of actigraphy from 6 crewmembers. Crewmembers slept significantly less during the 24 hour day that included a night shift and significantly more in the 24 hours following the night shift. Crewmembers reported using caffeine and naps to counter fatigue. Inspection of the night shift room after the completion of the mission revealed supplemental polychromatic lighting had been added to the room during the mission that further increased the intensity of light exposure on the night shift. Consequently, there was no difference in light intensity, as measured by wrist-worn actigraphy, or in melatonin suppression between the three lighting conditions. Crewmembers completed 48-hour urine collections approximately every two weeks for analysis of 6-sulphaxtoxymelatonin and free cortisol rhythms to estimate the phase of the circadian pacemaker. Some crewmembers maintained stable circadian phase and other had considerable phase misalignment. Eighteen mission controllers reported working 358 24-hour shifts. Mission controllers slept <4 hours on their 24-hour extended duration work shifts. As expected, learning was observed across the study. Nonetheless, performance, alertness, sleepiness, and mood of crewmembers and mission controllers deteriorated during night work across the study, indicating little adaptation to 24h work operations. No significant differences in performance were seen between light conditions. These data demonstrate that it is feasible to monitor sleep, circadian rhythms, and performance in an analog spaceflight environment. Cognitive learning across the 105-day mission in both crewmembers and mission controllers was consistent with subjects in ground based studies who have appropriate circadian alignment. Deterioration of performance, alertness, and mood were evident during 24-hour extended duration overnight work shifts despite countermeasure use. Some crewmembers had considerable circadian phase misalignment. Whether this misalignment was due to failure to entrain or a consequence of the recurrent night shifts is a subject for future research. There were no significant differences in alertness or performance across lighting conditions. Factors in the protocol over which the experimenter had no control (e.g., additional lighting used in the night shift room beyond that currently possible during spaceflight) may account for this latter finding and necessitate further exploration of this aspect of the study.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Extended duration work schedules and nighttime operations are associated with impaired performance, reduced alertness and mood, and increased sleepiness and risk of accidents. Appropriately scheduled light/dark exposure is a powerful means of resetting the human circadian pacemaker. Bright light has been used in various clinical settings to induce physiologic adaptation in individuals suffering from circadian rhythm disorders (e.g., night shift workers, people with Advanced and Delayed Sleep Phase Syndromes). Properly timed exposure to bright light can produce rapid physiologic adaptation of the circadian pacemaker to a single week of night work and facilitate rapid entrainment to a rotating work schedule, as well as enhance the alertness of night workers during their work shifts. Advanced and Delayed Sleep Phase Syndromes (ASPS and DSPS, respectively) are characterized by a marked difficulty in maintaining appropriate timing of sleep during the desired hours, and there is evidence suggesting that circadian misalignment may underlie the pathophysiology of this condition. We and others have reported data from clinical studies that suggest evening exposure to bright light or early morning exposure to bright light are successful in the treatment of ASPS or DSPS, respectively. The current study was designed to evaluate the effectiveness of shorter wavelength light exposure over intermediate and longer wavelength light as a countermeasure for circadian misalignment. The findings highlight the need for further development of effective and energy-efficient methods for treatment of circadian rhythm disorders. Optimizing the wavelength of light holds the potential for producing shorter, more efficient light treatment regimens. Shorter treatment

	regimens would not only increase compliance in clinical populations, but would make light treatment more practical in industrial/work settings. This lighting countermeasure could be beneficial for those on Earth who work extended duration overnight shifts or other unusual schedules and may negate the effects of fatigue on work performance.
Task Progress:	The 105-day isolation study was conducted at the Institute for Biomedical Problems (IBMP) from 31 Mar 09 to 14 Jul 09. Six crewmembers lived and worked in an isolation facility and participated in our study validating the efficacy and operational feasibility of a photic countermeasure to improve alertness and performance during night shift work occurring during a simulated expedition mission. Eighteen mission controllers who worked 24-hour extended duration shifts also participated in the study. Throughout the 105-day experiment, a variety of measurements were obtained to assess sleep, performance, alignment of the circadian system, and melatonin levels. All data were collected and analyzed and a manuscript is in preparation.
Bibliography Type:	Description: (Last Updated: 12/13/2023)
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