Fiscal Year:	FY 2009	**Task Last Updated:**	FY 05/08/2009
PI Name:	Czeisler, Charles A. M.D., Ph.D.		
Project Title:	Evaluation of Photic Countermeasures for Circadian Entrainment of Neurobehavioral Performance and Sleep-Wake Regulation Before and During Spaceflight		
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:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	02115-5804	**Congressional District:**	8
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2007 Crew Health NNJ07ZSA002N
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No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	3
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
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Key Personnel Changes/Previous PI:			
COI Name (Institution):	Barger, Laura (Brigham and Women's Hospital) Aeschbach, Daniel (Brigham and Women's Hospital)		
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Task Description:	To synchronize astronauts' circadian sleep-wake schedules to variable launch times, timed exposure to bright light and darkness in the crew quarters during the week-long pre-launch quarantine period has been used since 1990. Although successful at circadian entrainment, bright light protocols are complex to administer and astronauts' compliance is compromised because bright light glare compromises computer/television screen visibility, and increases frequency of headaches, irritability and nausea. Moreover, bright light remains unavailable as an in-flight countermeasure, requiring astronauts to rely upon hypnotics or wake-promoting therapeutics to provide symptomatic relief. Recent advances reveal that the human circadian pacemaker is most sensitive to shorter wavelength light for both phase shifting and direct enhancement of alertness and performance. We found that short-wavelength light (~460nm-512nm) in the blue/green range facilitates circadian phase shifting. We therefore propose to test the efficacy of exposure to short wavelength green light at a standard intensity for pre-launch and in-flight phase shifting. To this end, we propose to test the circadian phase-shifting efficacy of exposure to short wavelength light throughout scheduled wake times on a protocol designed to simulate the schedule of crew members during the pre-launch quarantine period on a mission that requires an 8-hour phase advance of the sleep-wake schedule. Our goal is to demonstrate that exposure to ambient short wavelength fluorescent light will synchronize human circadian rhythms to a shifted sleep/wake schedule within 4-5 days, enhancing alertness and performance during the biological night. During this proposed 8-day ground-based simulation, participants' sleep-wake schedules will be advanced by 8 hours. This advance shift will be done in 2 different protocol designs: 1) a "slam" shift in which the sleep episode is abruptly advanced by 8 hours and then maintained at this advanced time for 4 days, and 2) a gradual shift in which the sleep episode is advanced by 1.6 hours each day for 5 days until an 8 hour advance is achieved. A total of 44 subjects will be studied in the project. They will be randomized to 1 of 4 protocol conditions which differ by light (ordinary indoor white light (~90 lux) or 90 lux polychromatic green light) and by shift (slam or gradual) so that there will be 11 subjects/group. The 4 conditions are 1) white light slam shift, 2) green light slam shift, 3) white light gradual shift, and 4) green light gradual shift. Our specific aims are to: 1. Test the hypothesis that exposure to ambient polychromatic short wavelength light from fluorescent lamps will be more effective than exposure to an equal illuminance of ambient polychromatic white light from standard fluorescent lamps in shifting the circadian rhythms of test subjects, as measured by dim-light melatonin onset (DLMO), in response to both a gradual 8-hour advance and to an abrupt shift of their sleep-wake schedule. 2. Test the hypothesis that alertness and neurobehavioral performance in dim light on a constant routine during times at which crew members should be awake on the simulated mission will be significantly greater following 4-5 days of exposure to ambient polychromatic green light vs. ambient white light of equal illuminance, due to more effective circadian entrainment. 3. Test the hypothesis that alertness and neurobehavioral performance will be significantly better on the first night of exposure to ambient polychromatic short wavelength light vs. ambient white light of equal illuminance, prior to the induced circadian phase shifts, due to the immediate alerting effects of exposure to ambient polychromatic short wavelength light. 4. Test the hypothesis that sleep efficiency and total sleep time will be significantly increased and latency to persistent sleep and wake time after sleep onset will be significantly decreased during the sleep episode following 4-5 days of exposure to ambient polychromatic green light vs. ambient white light of equal illuminance, due to more effective circadian entrainment. We predict that, in contrast to white light, simple exposure to polychromatic green light throughout the day will rapidly (within five days) entrain the circadian melatonin rhythm to the shifted sleep-wake schedule, without the need for bright light exposure-rendering obsolete the crew quarters' bright light facility and enabling implementation of this new technology to ensure circadian synchronization both during the pre-flight quarantine period and while aboard NASA flight vehicles. To date, 5 subjects have completed the 8-day protocol. Four subjects completed the white light slam shift condition in order for us to determine the best level of illuminance to be used for both the white and polychromatic green light. Melatonin samples, alertness and performance testing data, and sleep recording data were collected in these studies and are being analyzed to address our specific aims. Based on the melatonin results from these first 4 subjects, we have decided to use a 90 lux level of illuminance, which is equivalent to that of ordinary indoor room light. The polychromatic fluorescent lamps have been installed in our laboratory and calibrated so as to achieve 90 lux. We began randomizing enrolled subjects after completing the initial 4 subjects and 1 additional subject has completed the white light gradual shift condition, with 3 additional subjects scheduled to complete the study in April 2009. We are continuing to enroll subjects and expect to be on target with enrollment (11 subjects/year) by the end of the first year of the project. In the coming year we anticipate being on or ahead of pace with at least 22 subjects completed by the end of year 2.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	We will be implementing and testing a new polychromatic fluorescent lamp with a peak spectral sensitivity of ~500nm. This is near the peak sensitivity of the human circadian system, and thus should be the most efficacious polychromatic lamp for shifting the timing of the human biological clock. In addition to benefits for NASA flight personnel, this technology will also have application to shiftworkers, to jet travelers, and to any personnel who need to shift the timing of their biological rhythms.

Task Progress:	In the last year, we implemented our proposed study. This included: designing a subject recruitment plan and implementing that plan to recruit and screen study participants; determining, based on results from our prior NSBRI-funded project as well as results from other ongoing projects in our laboratory that the peak sensitivity of the human circadian system is closer to 500nm than to 460nm; based on the new information about the peak sensitivity of the human circadian system, determining that the most efficacious specialized light source should have a peak near 500nm (as opposed to ~470nm as the lamps produced by Philips Lighting, Eindhoven, Netherlands, as originally proposed), and therefore identifying such a new specialized light source for our studies; retrofitting our laboratory with specialized lamps (manufactured by Sunnex Biotechnologies, Winnipeg, MB, Canada) with a peak sensitivity near 500nm; conducting calibrations of our laboratory to ensure the control lighting and the test lighting are applied similarly; and conducting preliminary tests to determine the level of lighting to be tested. To date, 5 subjects have completed the 8-day protocol. Melatonin samples, alertness and performance testing data, and sleep recording data were collected in these studies and are being analyzed to address our specific aims. We began randomizing enrolled subjects after completing the initial 4 subjects and 1 additional subject has completed the white light gradual shift condition.
Bibliography Type:	Description: (Last Updated: 02/11/2021)
Abstracts for Journals and Proceedings	Burke TM, Scheer FA JL, Ronda JM, Czeisler CA, Wright KP. "Contribution of homeostatic, circadian and sleep inertia processes on higher order cognitive functions using a forced desynchrony protocol." SLEEP 2009 23rd Annual Meeting of the Associated Professional Sleep Societies, LLC, Seattle, WA, June 6-11, 2009. SLEEP 2009 23rd Annual Meeting of the Associated Professional Sleep Societies, LLC, 2009. Abstract Book. , Jun-2009
Abstracts for Journals and Proceedings	Santhi N, Duffy JF, Czeisler CA. "Attentional failures are more pronounced in the latter half of a wake episode following an inversion of the sleep-wake schedule." SLEEP 2009 23rd Annual Meeting of the Associated Professional Sleep Societies, LLC, Seattle, WA, June 6-11, 2009. SLEEP 2009 23rd Annual Meeting of the Associated Professional Sleep Societies, LLC, 2009. Abstract Book. , Jun-2009
Awards	Czeisler CA. "Distinguished Scientist Award, Sleep Research Society, June 2008." Jun-2008
Awards	Czeisler CA. "Lifetime Achievement Award, National Sleep Foundation, March 2008." Mar-2008
Awards	Czeisler CA. "Lord Adrian Medal, Royal Society of Medicine, London, April 2008." Apr-2008