Fiscal Year:	FY 2011	**Task Last Updated:**	FY 05/04/2011
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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		
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Zip Code:	02115-5804	**Congressional District:**	8
Comments:			
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Contact Monitor:		**Contact Phone:**	
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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 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 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 8h 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 simulation sleep-wake schedules will be advanced by 8h using 3 different protocol designs: 1) a "slam" shift in which the sleep episode is abruptly advanced by 8h and then maintained for 4 days, 2) a gradual shift in which the sleep episode is advanced by 1.6h each day for 5 days until an 8h advance is achieved, and 3) a "slam shift with naps in which the extended wake period prior to the 8h advance of the sleep period includes 2 short nap opportunities. Given the prolonged extended wake period on the second day of the slam shift schedule the new schedule involves the opportunity to obtain two short naps: one for 2h in the afternoon circadian dip, and the second for 4h at the circadian nadir during the night. A total of 44 subjects will be studied in the project. They will be randomized to 1 of 5 protocol conditions which differ by light and by shift. The 5 conditions are 1) white light slam shift, 2) green light slam shift, 3) combined white + green light slam shift with naps, 4) white light gradual shift, and 5) green light gradual shift.

Our specific aims are to test the hypotheses that:

1. exposure to ambient polychromatic green light from will be more effective than exposure to an equal illuminance of polychromatic white in shifting circadian rhythms, as measured by dim-light melatonin onset (DLMO), in response to both a gradual 8h advance and to an abrupt shift of their sleep-wake schedule.

2. 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. 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. 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 exposure to polychromatic green light throughout the day will rapidly entrain the circadian melatonin rhythm to the shifted sleep-wake schedule. We also predict that green light combined with brighter white to prevent the altered color-perception from the green light alone will enable implementation of this new technology to ensure circadian synchronization both during the pre-flight quarantine period and while aboard NASA flight vehicles. We predict that our new schedule with naps will reduce the excessive daytime sleepiness and other adverse effects often experienced with the slam shift due to prolonged wakefulness.

To date, 37 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 (90 lux) to be used for both the white and polychromatic green light. To date, 10 subjects have completed the gradual shift protocol, in either white (n=5) or green light (n=5), 21 subjects have completed the slam shift protocol, in either white (n=10) or green light (n=11), and 6 subjects have completed the combined slam shift with naps protocol. We have completed the third year ahead of schedule for enrollment (11 subjects/year), and anticipate completing the study well in advance of the end of the project period. Melatonin samples, alertness and performance testing data, and sleep recording data were collected in these studies and are currently being analyzed to address our specific aims. As per a supplemental grant (HPF00003), we implemented novel infra-red technologies into this protocol, and collected data on eye movements in n=30 subjects during periods of extended wake. New eye tracking technologies have also been implemented into the protocol, in order to examine causes of neurobehavioral deficits during periods of extended wake.

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 continued with our proposed study. We remained consistent with our target enrollment, studying 37 subjects in the laboratory in each of the five conditions: 10 subjects completed the gradual shift protocol, in either polychromatic white (n=5) or shorter-wavelength light (n=5), and 21 subjects completed the slam shift protocol, in either polychromatic white light (n=10) or shorter-wavelength light (n=11) and 6 subjects completed the combined slam shift with naps 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. As per a supplemental grant (HPF00003), we implemented novel infra-red technologies into this protocol, and collected data on eye movements in n=30 subjects during periods of extended wake.

Bibliography Type:	Description: (Last Updated: 02/11/2021)
Awards	Czeisler CA. "Charles A. Czeisler: Harriet Hardy Award, New England College of Occupational and Environmental Medicine (NECOEM), January 2010." Jan-2010
Awards	Czeisler CA. "Charles A. Czeisler: Mark O. Hatfield Public Policy Award, American Academy of Sleep Medicine, June 2010." Jun-2010
Awards	Czeisler CA. "Charles A. Czeisler: Mary A. Carskadon Outstanding Educator Award, Sleep Research Society, January 2010." Jan-2010