The following presentation materials are selected from a presentation for the “Transforming Healthcare and Well-Being through Lighting Workshop” supported by the IES and LESA.

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Light and Human Health: From Basic Science to Space Flight and Health Care Applications

George C. Brainard, Ph.D.
The Light Research Program
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RHT Retinohypothalamic Tract
SCN Suprachiasmatic Nucleus
PVN Paraventricular Nucleus
LGN Lateral Geniculate Nucleus

Intermediolateral Cell Column (T₁, T₂)

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MONOCHROMATIC LIGHT

BIOLOGICAL/BEHAVIORAL

Acute Effects
- Melatonin Secretion
- Body Temperature
- Cortisol Secretion
- Heartrate
- Alertness
- Brain Bloodflow
- EEG Responses
- Clock Gene Expression
- Cognitive Performance
- Psychomotor Performance

Longer Term Effects
- Circadian Phase-Shift
- Circadian Entrainment
- Sleep Physiology
- Light Therapy (e.g. SAD)

VISUAL EFFECTS
- VISUAL REFLEXES
Sleep duration, structure and quality are altered in space flight

- NASA recommends astronauts sleep 8 hr per day in space.
- Studies show that astronaut sleep averages 5.96 h (SST) and 6.09 h (ISS) per day in space.
- Chronic partial sleep loss leads to decrements in alertness and performance.
- Crew members report using sleep promoting drugs: 71% SST, 75% ISS (Barger et al, Lancet Neurology 2014).
Tunable Solid State Lighting Assembly for ISS

- LED arrays that are tunable for light intensity and spectrum
- Ground studies on human physiology at TJU, Harvard, MIT and JSC
- Installation on ISS began 10.5.16
  3 of 85 units now installed
- Three astronauts now consented for a JSC/Harvard/TJU flight study

Developed: Kennedy Space Center, Bionetics Corporation, Lighting Sciences Group

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Crew Sleeping Quarters

Building 15 JSC

Node 2: ISS
Precise replica of ISS Crew Sleeping Quarters

Numerical Verification Test (N=8)
4800 K  90 µW/cm² (300 lux)

Unpublished Data Removed

Light For Vision

Melatonin Suppression (N=8)
4800 K  0 - 405 µW/cm² (0 - 1268 lux)

Unpublished Data Removed

Light For Biology

Brainard et al. unpublished
General Vision
4800 K SSLM-R LED Light
238 lux

Alerting / Phase Shift
6500 K SSLM-R LED Light
1270 lux

Pre-Sleep
2700 K SSLM-R LED Light
90 lux
(20 lux)
Spacecraft Lighting to the Patient Bedside
TJU - NSF Engineering Research Center

Circadian, Sleep and Mood Disturbance in Brain Injury

Phase I Observational trial on brain injury symptoms
   - Concussion trial (M. Serruya, MD, Co-PI)
   - Stroke trial (C. Pineda, MD Co-I)

Phase II Light therapy trial for concussion symptoms

Phase III Hospital lighting for brain injured inpatients
1.6 to 3.8 million concussions occur annually

Mild traumatic brain injuries (mTBI) lead to 1.4 million ER visits

Healthcare cost of mTBIs: $60 billion each year

Concussion patients often report sleep and mood problems
Preliminary Sleep/Wake Actigraphy Data

Control subject with normal healthy sleep

Activity

Light

Rest

Sleep

Concussion subject with poor sleep

Sleep Onset Latency
(Unpublished Data)

Unpublished Data Removed
mTBI SLEEP DISTURBANCE PRELIMINARY RESULTS (unpublished)

Means and standard errors of Pittsburg Sleep Quality Index (PSQI)

Concussion patients (N=10) versus age and sex matched control subjects (N=10)

Unpublished Data Removed
mTBI MOOD DISTURBANCE PRELIMINARY RESULTS (unpublished)

Means and standard errors of Beck Depression Inventory (BDI)

Concussion patients (N=10) versus age and sex matched control subjects (N=10)

Unpublished Data Removed
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