



Cassie Hilditch (Country)
Sleep and Performance in Space

FINANCIAL RELATIONSHIP DISCLOSURE



Ineligible companies are those whose primary business is producing, marketing, selling, re-selling, or distributing health care products used by, or on patients.

- ☐ **No**, I HAVE NOT had a financial relationship with an ineligible company in the past 24 months.
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Relationship type	Name of company

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What is it like to sleep in space?

- The spaceflight sleep environment
 - Past, present, and future
- Causes and consequences of sleep disruption during spaceflight
- Causes and countermeasures for circadian misalignment during spaceflight
- Countermeasures for sleep in space

The spaceflight sleep environment

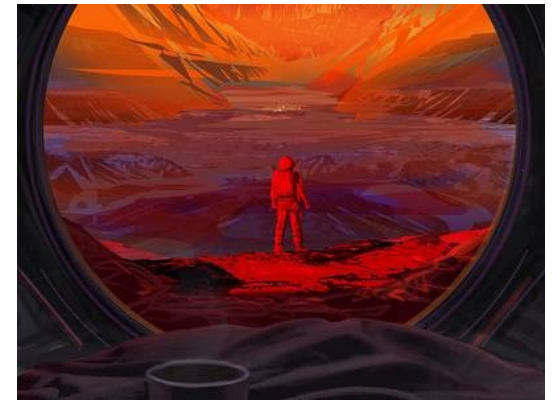
Past



Present



Future



The spaceflight sleep environment

Past



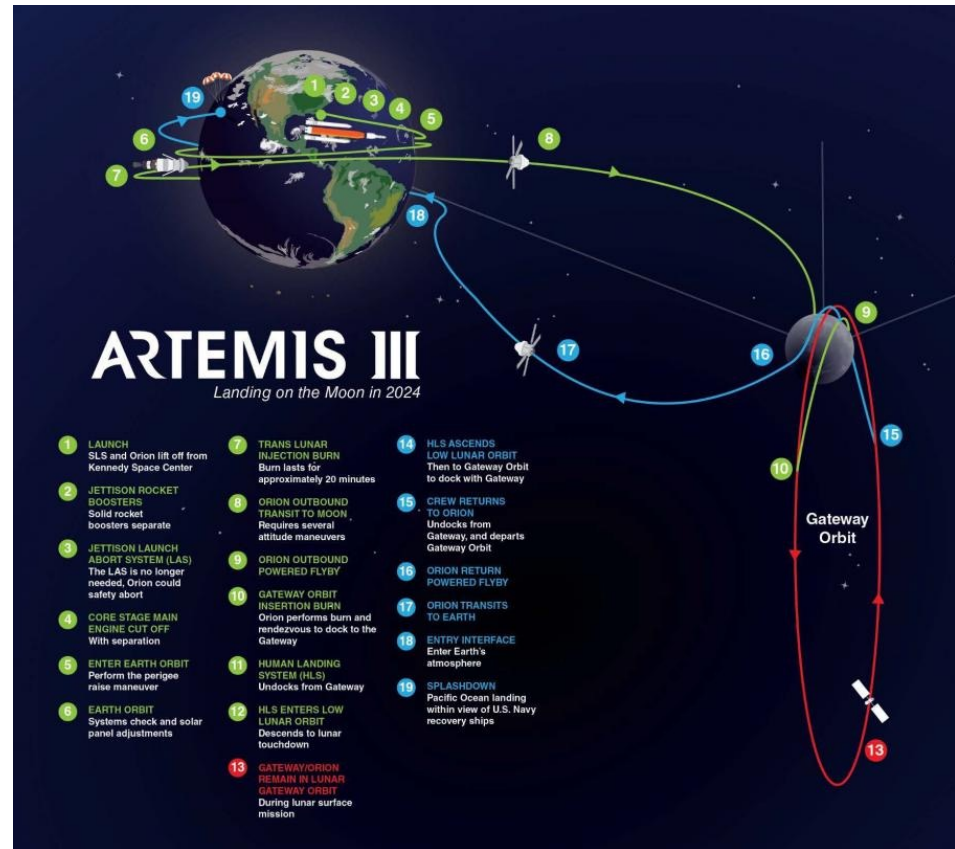
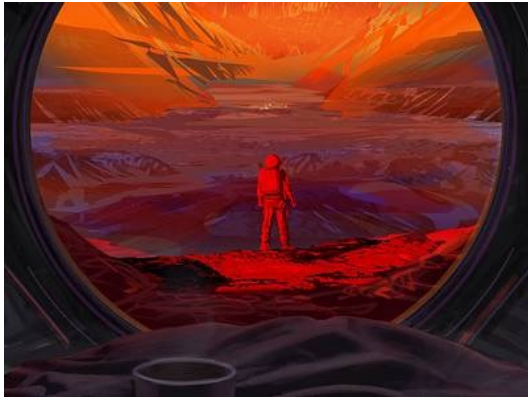
The spaceflight sleep environment

Present



The spaceflight sleep environment

Future



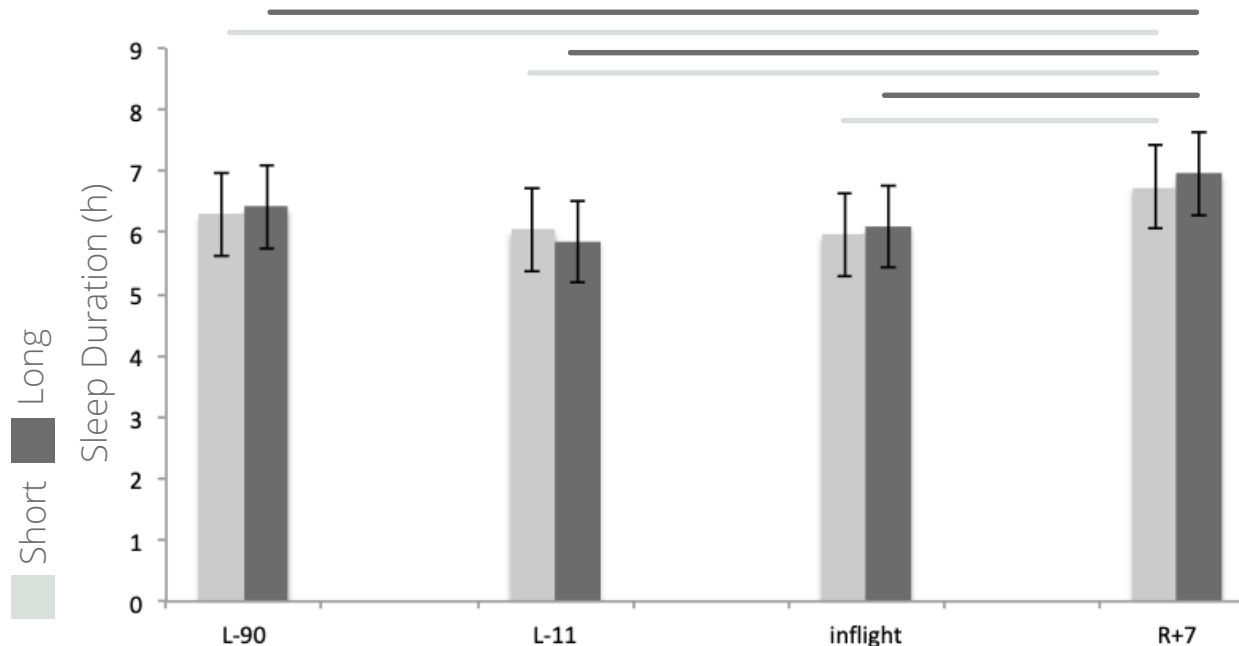
The spaceflight sleep environment

Common Features

- Isolation and confinement
 - Potential for psychosocial issues
- Altered gravity
- Irregular photoperiods
- Radiation exposure

Sleep is shorter in space

- Studies consistently find that astronauts sleep ~6 h (summarized in Kirkley *et al.*, 2023)



Barger *et al.* 2014 *Lancet Neurology*

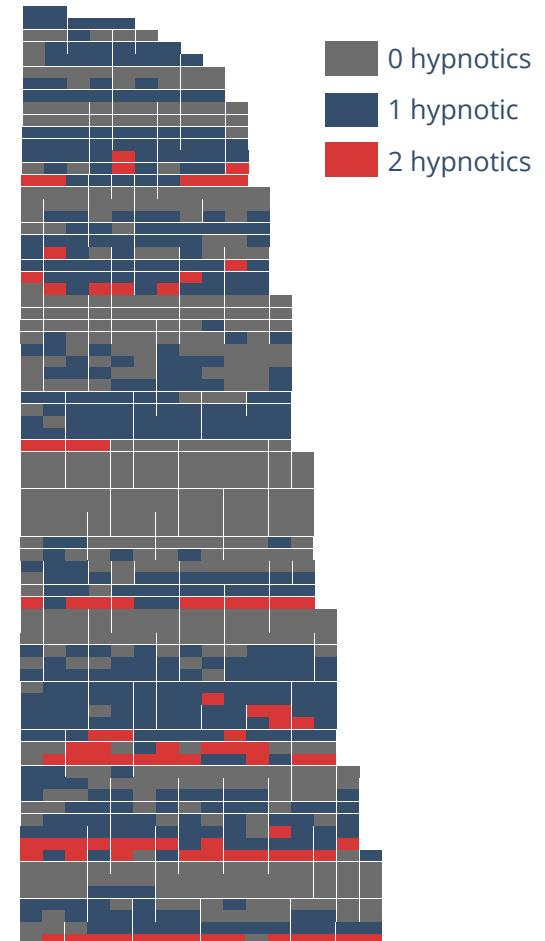
Causes of sleep disruption

- Environmental disruption
 - Noise, temperature, light pollution, lack of privacy
- Workload
 - Especially during short-duration missions
- Frequent schedule changes
 - Adjustments to accommodate mission events
- Microgravity? Radiation?

Consequences of sleep disruption

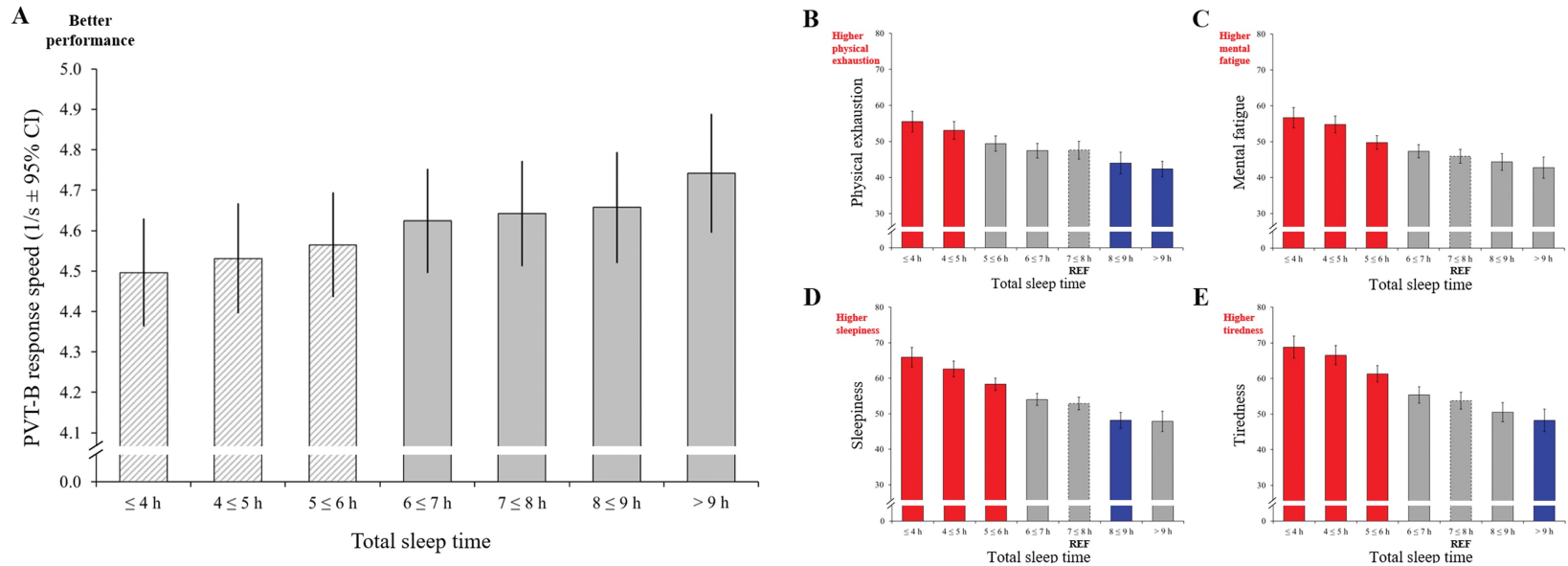
Increased hypnotic use

- 78% of crewmembers reportedly used hypnotic medication (Barger *et al.* 2014)
- Hypnotics used on >50% of nights in space (Barger *et al.* 2014)
- Two doses in one night reported by 18% of astronauts (Barger *et al.* 2014)



Consequences of sleep disruption

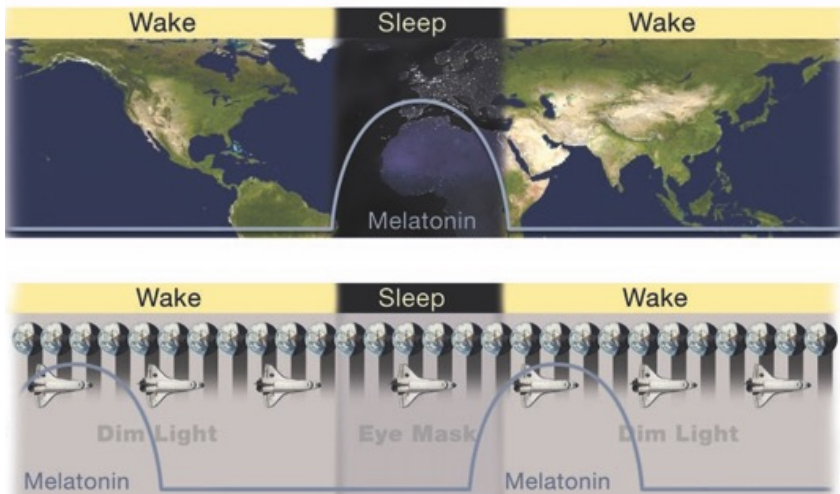
Reduced alertness and neurobehavioral performance



Jones et al., 2022 SLEEP

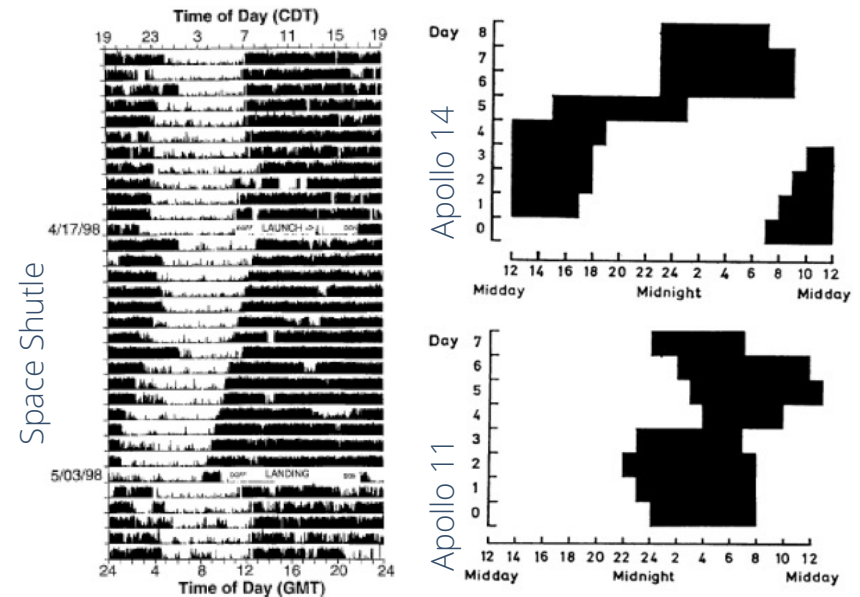
Causes of circadian disruption

Inappropriate/Insufficient Light Exposure



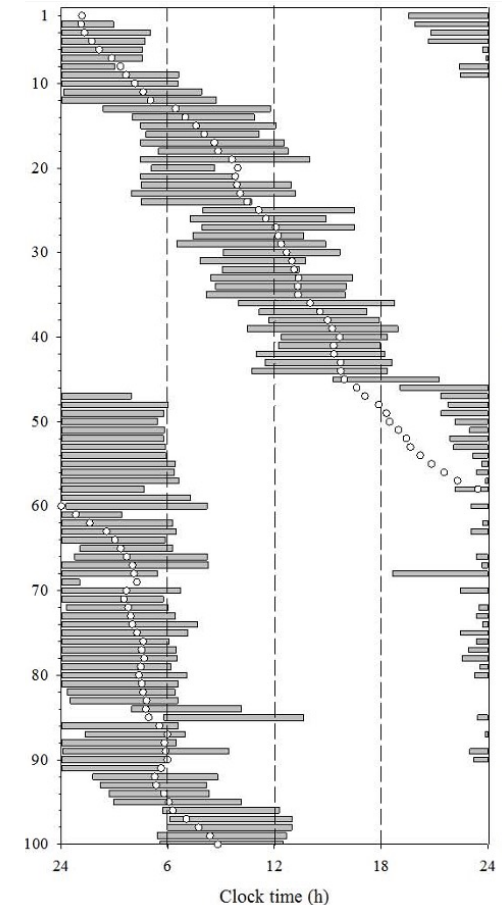
Dijk et al. 2001 *AJP RICP*, Nicholson 1972 *Proc Roy Soc Med*

Schedule-induced



Consequences of circadian disruption

	Aligned	Misaligned
Sleep duration (h)	6.4 (1.2)	5.5 (1.2)
Latency (m)	10 (15)	13 (25)
# wakings	1.7 (1.9)	1.8 (1.8)
Sleep efficiency (%)	89 (7)	90 (7)
Sleep quality	67 (18)	60 (21)



Flynn-Evans *et al.*, 2016 *Nature Microgravity*

Consequences of circadian disruption

Increased medication use

- Hypnotics reported on 24% of misaligned nights and 11% of aligned nights
- Any medication reported on 63% of misaligned nights and 49% of aligned nights

Countermeasures

Optimized sleep environment (Broyan *et al.*, 2008)

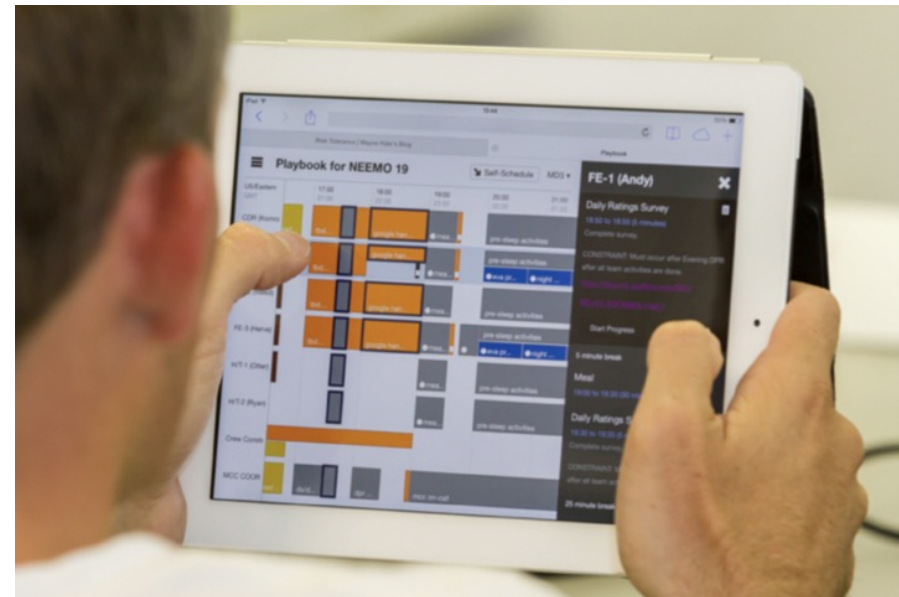
- Private
- Quiet
- Light blocking
- Appropriate temperature and airflow



Countermeasures

Optimized scheduling

- Reduced schedule shifts
- Biomathematical modeling (Shelat *et al.*, 2022)



Countermeasures

Personalized medicine

- Jet lag planning
- Countermeasure advice
- Hypnotic testing (Dinges *et al.*, 2019)



Countermeasures

Tunable lighting

- Mimics Earth photoperiod (Brainard *et al.* 2016)

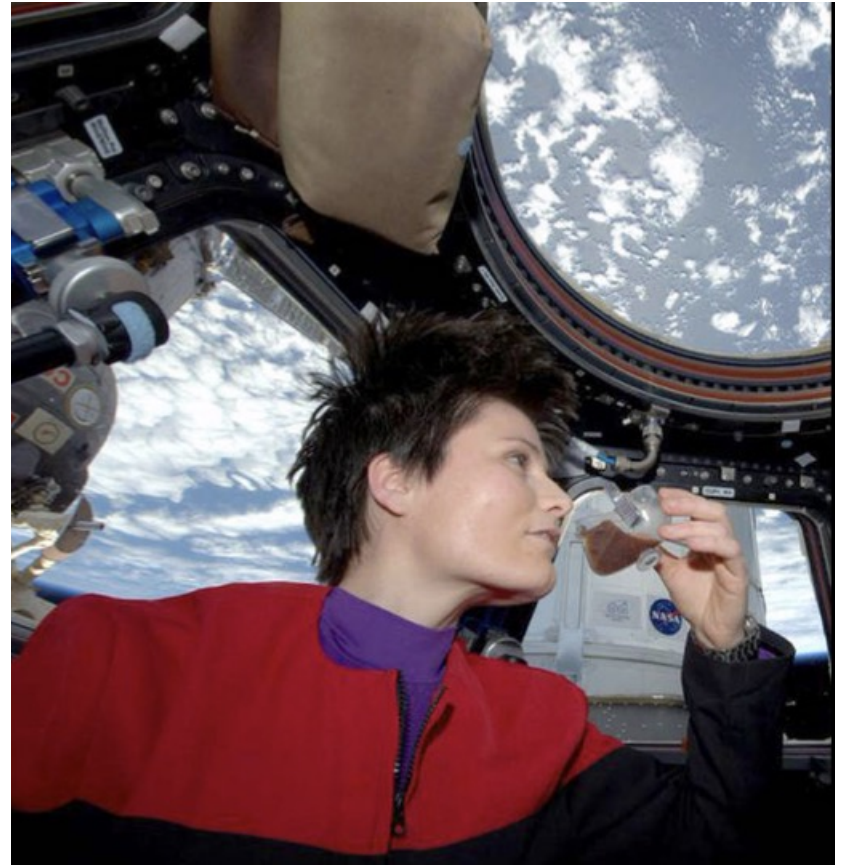


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Countermeasures

Caffeine

- Ongoing research



Future Directions

Assess impacts of altered gravity and radiation

- Potential interactions with glymphatic system?

Assess impacts of air quality

- Potential for CO₂ pockets
- Lunar dust

Develop countermeasures for Mars photoperiod

- Rotation of 24 h 39 m