

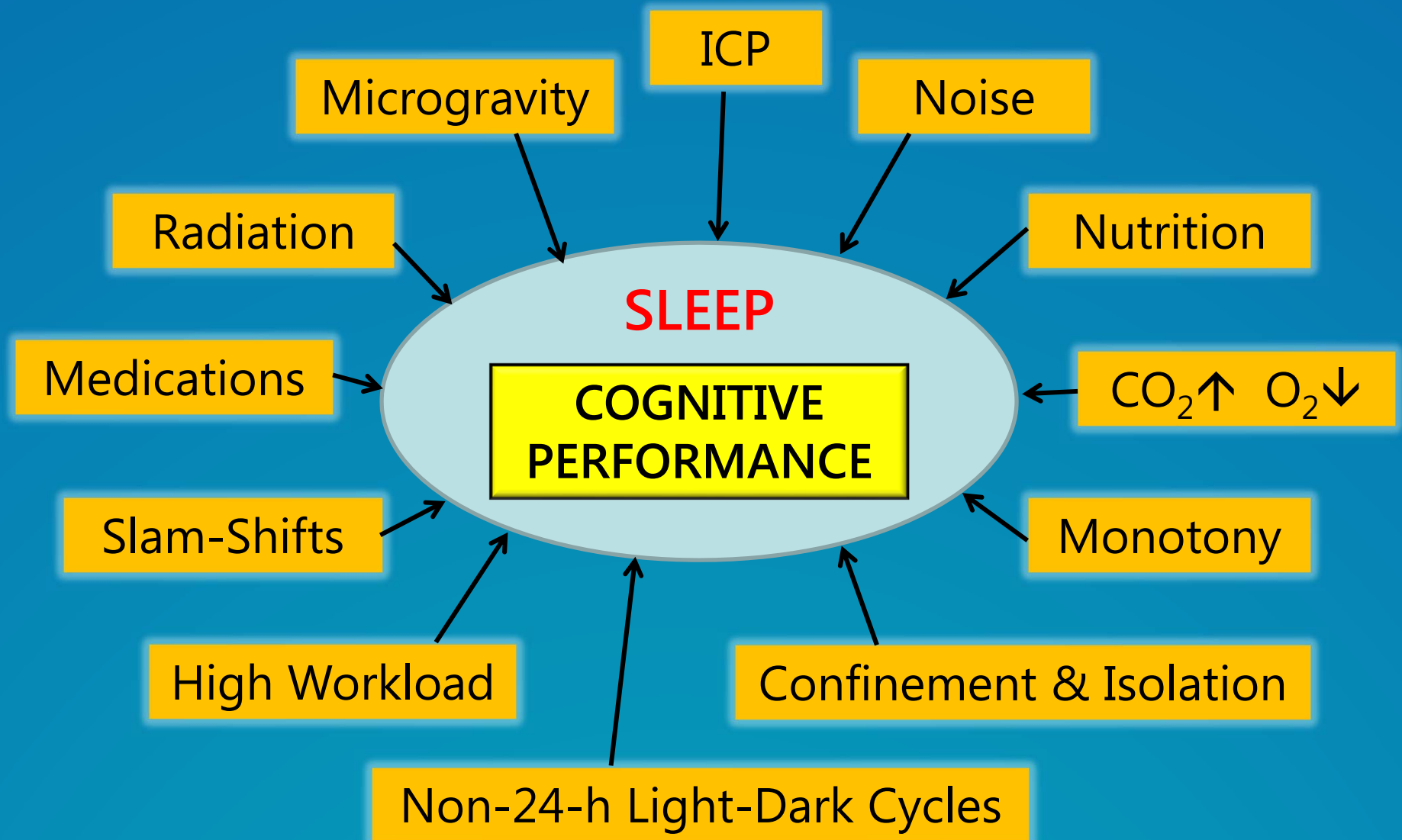
# Individualized Real-Time Neurocognitive Assessment Toolkit for Space Flight **Cognition**

Joint CSA/ESA/JAXA/NASA Increments 41 and 42  
Science Symposium

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# Space Flight Stressors Affecting Cognitive Performance





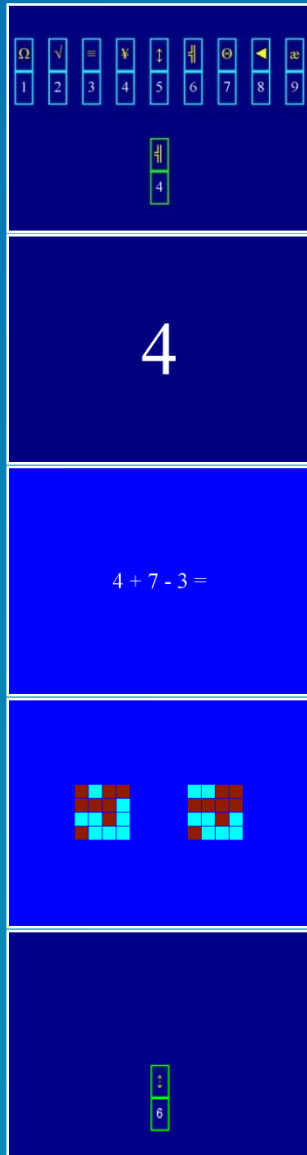
# NASA Human Research Roadmap



**Cognitive performance is mentioned directly or indirectly in a total of 37 gaps in the NASA Human Research Roadmap!**

- Sleep Gaps 1, 2, 4, 5, 6, 7, 8, 9, 10
- BMed Gaps 1, 2, 3, 4, 5, 6, 7, 8
- Team Gaps 1, 2, 3, 4, 5, 6, 7, 8
- SHFE-HCI Gaps 1, 2, 3
- SM Gaps 4, 6, 26
- EVA Gaps 6, 9
- SHFE-HAB Gap 3
- CNS Gap 5
- PH Gap 10
- Acute Gap 1

# WinSCAT



## Code Substitution - Learning

Complex scanning and visual tracking

## Running Memory Continuous Performance

**Working memory**

## Mathematical Processing

Basic computational skills and **working memory**

## Matching to Sample

Spatial processing and visuo-spatial **working memory**

## Code Substitution - Delayed

Learning and delayed visual recognition memory



# Cognition



- Consists of 10 brief cognitive tests (1-3 min).
- Total test administration time: 17.8 min (range 12.7-25.6 min).
- Test principles extensively validated in healthy and patient populations.
- Specifically designed for high performing astronauts.
- Tests cover a wide array of cognitive domains.
- Brain regions recruited by each test established via fMRI.
- Cognition administration is flexible.



# Cognition Development Team



- Unit for Experimental Psychiatry at U of Penn (PI M. Basner)
  - *Expertise on effects of sleep loss on cognitive performance*
  - *Numerous studies in space flight and analog environments*
  
- Brain and Behavior Laboratory at U of Penn (Co-PI R. C. Gur)
  - *Expertise in neuropsychological test development and validation*
  - *Expertise in adaptive testing*
  
- Pulsar Informatics Inc. (Co-PI D. J. Mollicone)
  - *Software development*
  - *Numerous studies in space flight and analog environments*

# Cognition Tests 1-5



Motor Praxis

**Sensory-motor ability** (0.5 min)



Visual Object Learning

**Visual object learning** and memory (1.7 min)



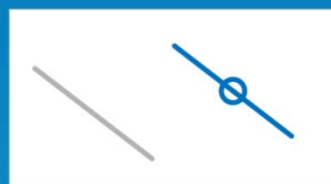
2-Back

Attention and working memory (1.9 min)



Abstract Matching

**Abstraction** (2.4 min)



Line Orientation

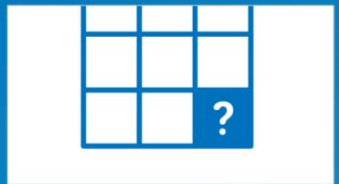
**Spatial orientation** (2.1 min)

# NeuroCog Tests 6-10



## Emotion Recognition

**Emotion recognition** (2.2 min)



## Matrix Reasoning

**Abstract reasoning** (2.0 min)



## Digit Symbol Substitution

Complex scanning and visual tracking (1.6 min)



## Balloon Analog Risk Task

**Risk decision making** (2.3 min)



## Psychomotor Vigilance Test

**Vigilant attention** (3.2 min)





# Validation Studies

- Laboratory studies on the effects of acute total and chronic partial sleep deprivation on cognition (ongoing).
- Study on the effects of different levels of hypercapnia on cognition (planned).
- Study on the effects of anesthesia and medications (promethazine, sleep meds) on cognition (ongoing/planned).
- Use of Cognition in space analog environments (HERA, HI-SEAS, Antarctica) (ongoing/planned).



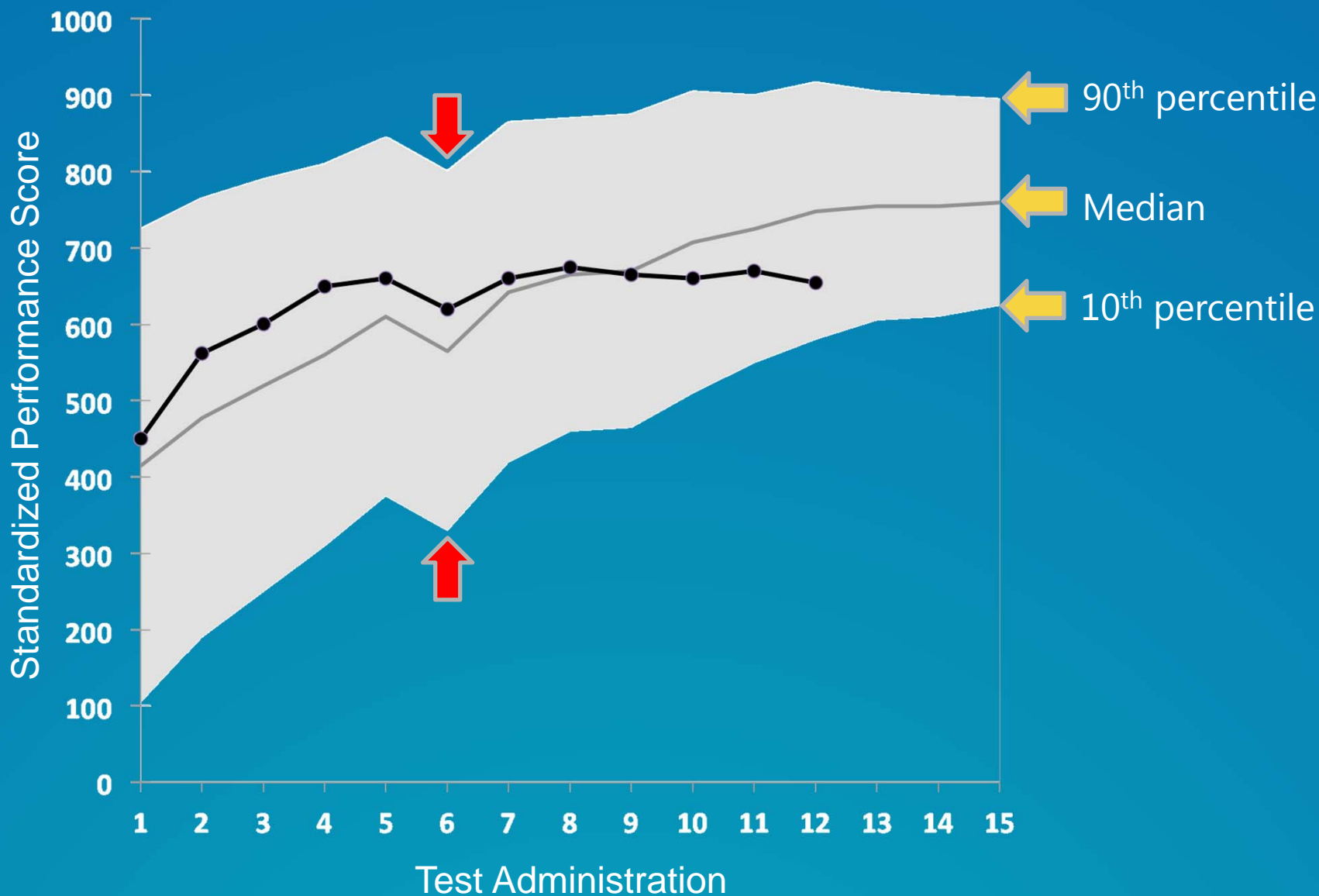
# Goals of this study

- Test feasibility of Cognition administration on the ISS.
  - Software will be installed on one HRF-PC (Columbus).
- Receive astronaut feedback on Cognition software for future improvements.
- Start looking at effects of:
  - Early exposure to microgravity
  - Environmental space flight stressors
  - Time in mission
  - Re-exposure to gravity
- Ultimate goal: Provide NASA and the international space research community with a brief, valid, comprehensive, and sensitive cognitive test battery



# Cognition Norms

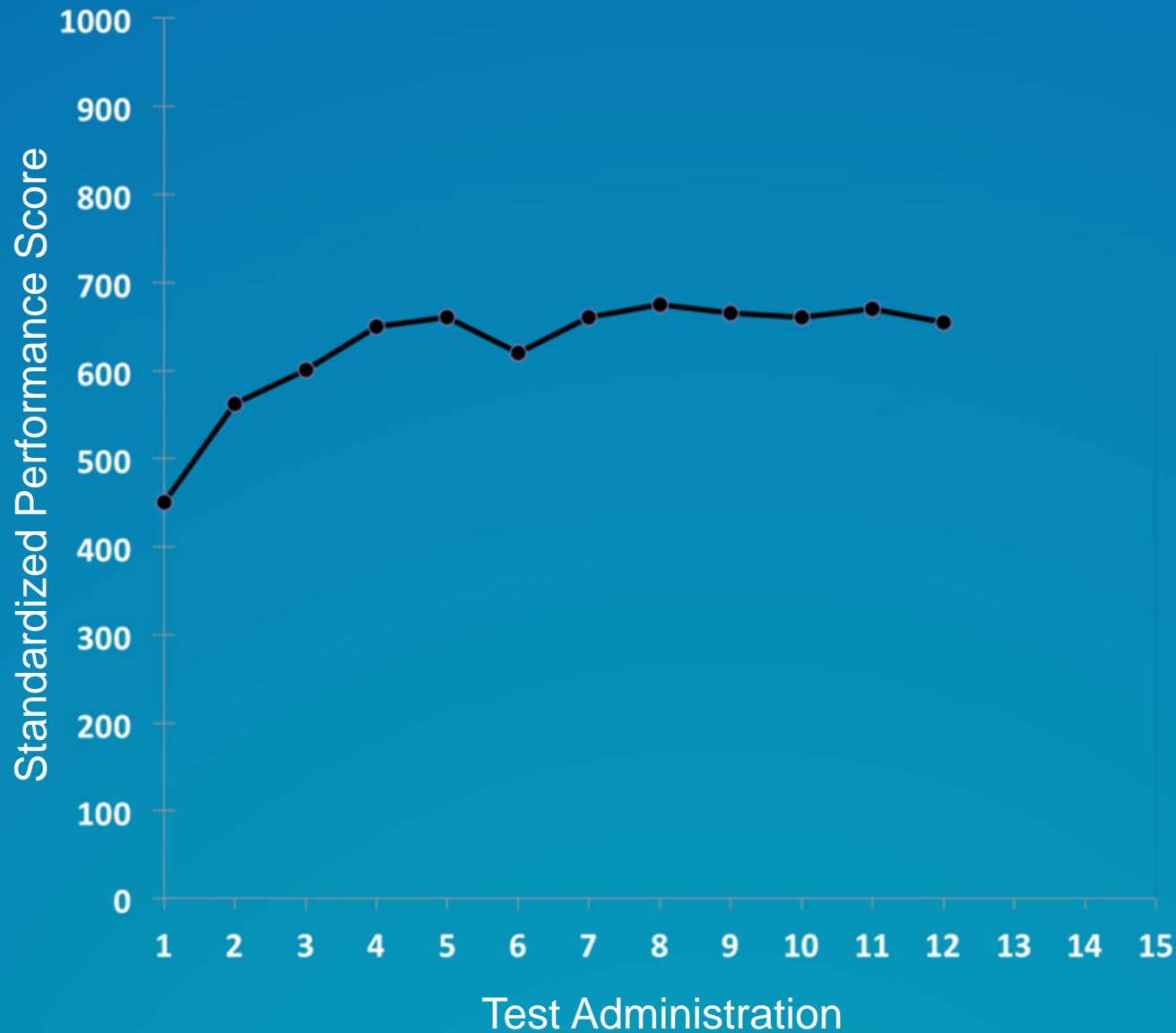
Gathered in ground-based study at JSC





# Cognition Norms

Gathered in ground-based study at JSC





# Measurement Approach



- Sample size: N=6 astronauts
- Measurement schedule:
  - 1 familiarization session
  - 3 baseline sessions (L-90, L-60, L-10)
  - 11 in flight sessions (at 2-4 week intervals)
  - 3 post flight sessions (L+10, L+60, L+90)
- Cognition is part of NASA's 12 month mission and the TWINS project.
  - One Year Mission Crewmembers count towards the N=6



# Earth Benefits/Spin-off Applications



- Cognition is of considerable interest to a wide range of contexts on Earth in which there is a need to determine the extent to which someone is cognitively compromised
  - Especially for high-performing populations
- One major goal is to make Cognition available to a broader research community within and outside of NASA.
  - An iPad version already exists and is used by a number of researchers around the world.



# Acknowledgments

Supported by the  
National Space Biomedical Research Institute (NSBRI)  
through NASA NCC 9-58

- NSBRI  
*Graham Scott, Dorit Donoviel*
- NASA PsychOps  
*Walt Sipes, Gary Bevin*
- NASA BHP  
*Jason Schneiderman, Lauren Leveton, Laura Bollweg, Sandra Whitmire, Diana Arias, Kristine Ohnesorge*
- NASA ISS-MP  
*Laura Sarmiento, Kelly Norwood, Geminessse Dorsey, Margaret Klee*
- NIH, ONR, McDonnell Foundation