The Behavioral Health Risk
One Astronaut's Perspective

TRISH / Red Risk School
Michael Barratt / NASA Astronaut Office

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Disclaimers and Caveats

Views and opinions expressed here do not necessarily represent those of NASA

I am not a psychologist or cognitive scientist

More an onsite naturalist and consumer of BHP products

Space flyers have varying BHP expectations and outcomes, so interpret with care

The human factor is three quarters of any expedition.

- Roald Amundsen


C003
TMA


Discovery
United States

Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders

Risk Statement

Given the extended duration of future missions and the isolated, confined and extreme environments, there is a possibility that (a) adverse cognitive or behavioral conditions will occur affecting crew health and performance; and (b) mental disorders could develop should adverse behavioral conditions be undetected and unmitigated.

What the Full BHP Risk Represents

A methodology designed to identify problem areas / threats to a mission and guide research deliverables.

A very necessary and very strategic tool.

The result of years of evolution

Understanding a few factoids from crews' perspective may help in interpretation

ACUTE RESPONSE

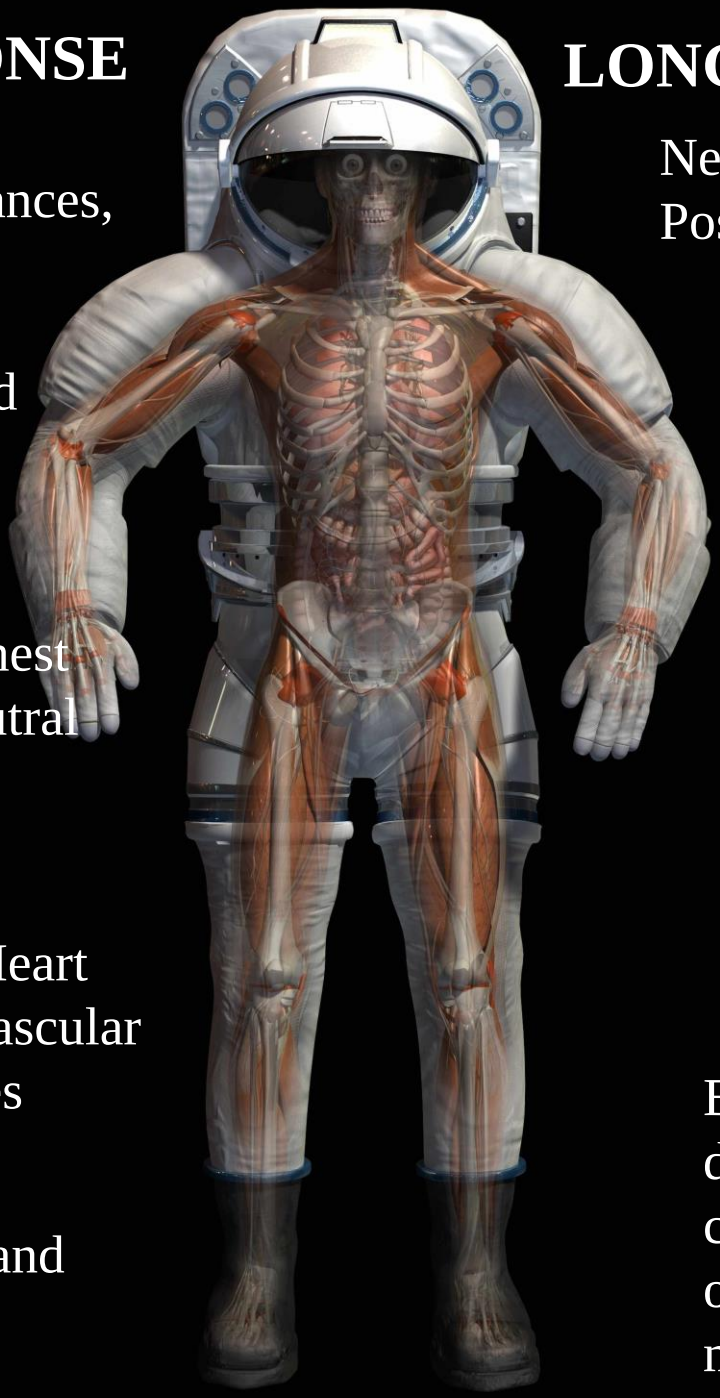
Neurosensory disturbances, space motion sickness

Fluid shift to chest and head; facial puffiness, head discomfort

Abd girth decrease, chest diameter increase, neutral body posture

CVP and thoracic pressure decrease, Heart volumes increase, vascular compliance increases

Onset of atrophy of postural musculature and skeletal mass



LONGTERM ADAPTATION

Neurosensory adaptation, 3 D Position sense and locomotion

Down regulation of plasma volume and rbc mass; discomfort improves. Cerebral vascular dynamics drive neuroanatomic and ocular changes, possible ICP increase

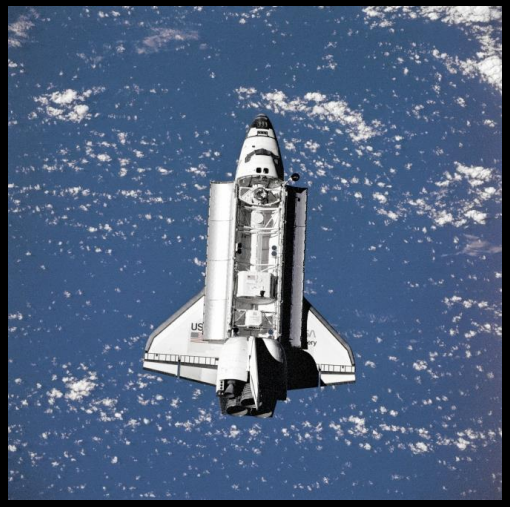
CO ↑41%, SV ↑35%, MAP ↓, SVR ↓39%, but symp tone increased

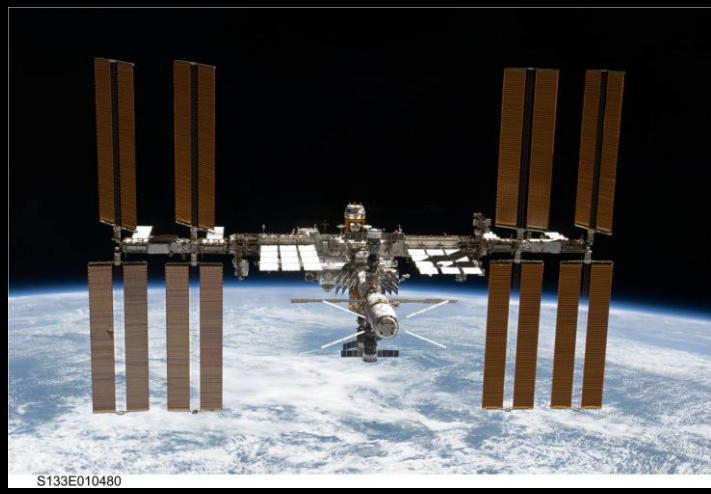
Bone, muscle, aerobic fitness determined by sum of physical countermeasures, nutrition, other factors (individual, metabolic, etc.)

Factoid #1

Short Duration vs. Long Duration Flight (LDF)

Most think of this only on the basis of elapsed time, largely driven by vehicle constraints of the Space Shuttle (1-2 weeks) and stations such as Mir and the ISS serviced by the Russian Soyuz (210 day service time)





Short Duration vs. Long Duration Flight (LDF)

Just as important as duration, maybe more so, is the distribution of responsibility, aka division of labor.

Space Shuttle Crew

International Space Station Crew

Short Duration vs. Long Duration Flight (LDF)

Compared with Shuttle, ISS crewmembers are each ‘uber-trained’, required to be proficient in launch vehicle ops, EVA, robotics, berthing systems, all ISS systems, payloads, and more.

And bi-lingual. ISS functions in English and Russian.

Consider this when making / interpreting comparisons between the two groups.

Factoid #2: The “Psychological Surround” of an LDF mission – wider than most think

Preflight: 2 ½ - 4 year intensive training period, frequent travel including international, learning in secondary language

Disproportionate training for dynamic flight events (launch, landing, rendezvous, docking)

Inflight: isolation / family separation, effects of microgravity, intensive work schedule, non-familiar food and hygiene, continual noise, constant scrutiny, pressure to succeed

Postflight: physiologic readaptation, intensive science and debrief schedule, public affairs activity, re-integration into family


km/h

Factoid #3: The ISS Flight Population

Late 30-something to mid 50-something highly technical, type A, disciplined, adventurous, well mannered professionals

Undergo career of continual scrutiny by peers, management, and press

Not Head Down Tilt Bed Rest subjects, Antarctic research station personnel, fighter pilot squadron, or the cast of “Lost”

Our main goal is executing the mission successfully

*** More is required of astronauts now than ever ***

EVA, robotics, systems, complex payloads, Russian language, etc.

Breaking Myth and Stigma

The public over-glamorizes us

The investigative community over-analyzes us

We have an internal Code of Conduct we take very seriously

We screw up sometimes

We are very much a family

We respect people that can tell us we’re full of crap when we are

By and large we work very hard

Factoid #4: The Shuttle Mir Program

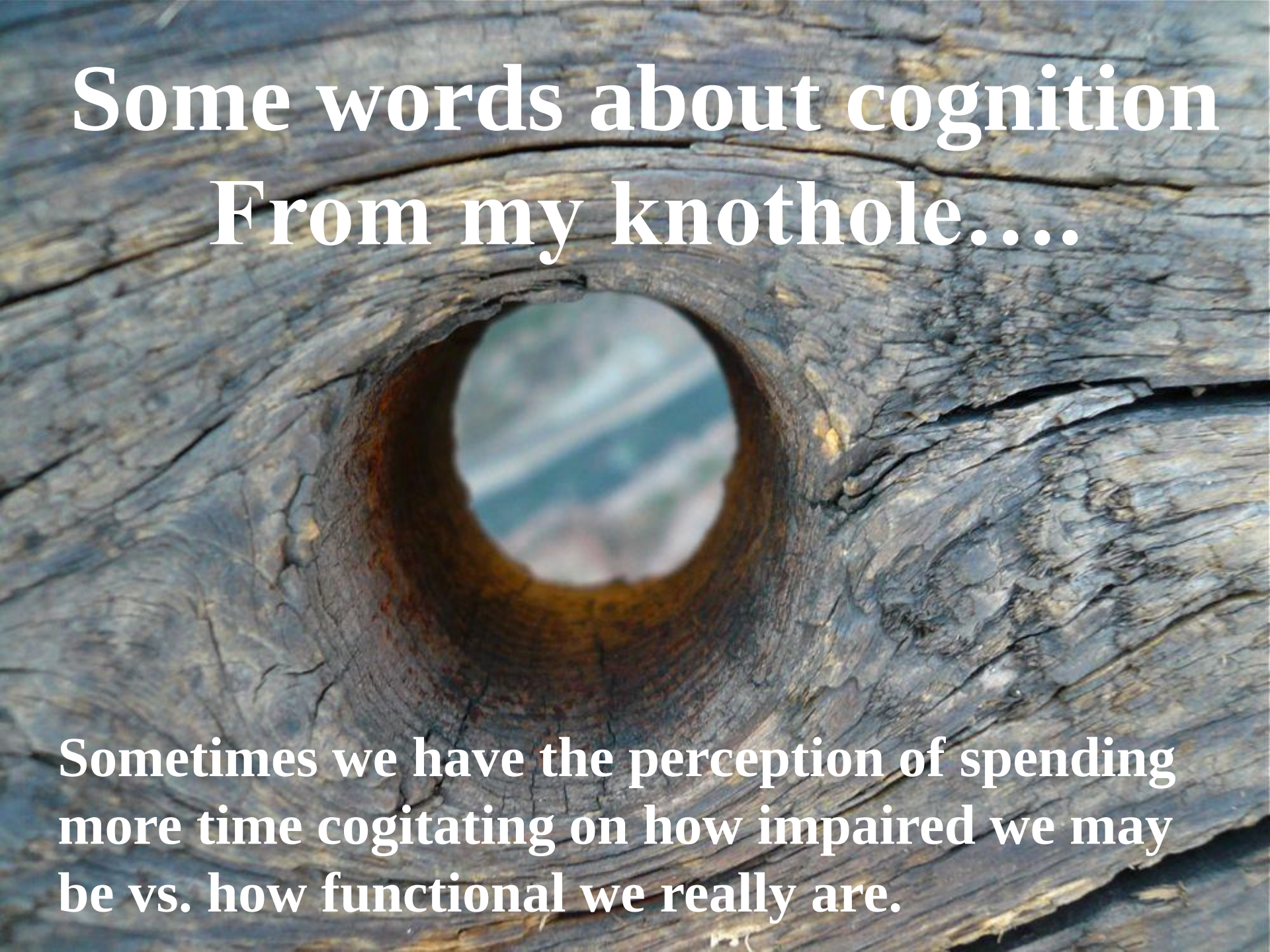
A unexpected but critical step in the transition from SDF (Shuttle) to LDF (ISS)

A collision of expectations and mission reality with predictable results (in retrospect)

Depression, crew disintegration, anxiety, boredom, anger with ground, punctuated by harrowing events.

(Fire, collision, political issues, ECLSS failures)

[Dragonfly: Brian Burrough, Harper Collins 1998]


Some words about cognition
From my knothole….
Sometimes we have the perception of spending more time cogitating on how impaired we may be vs. how functional we really are.

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Factoid #5: LDF does not equal monotony. Cognitive Challenges of ISS


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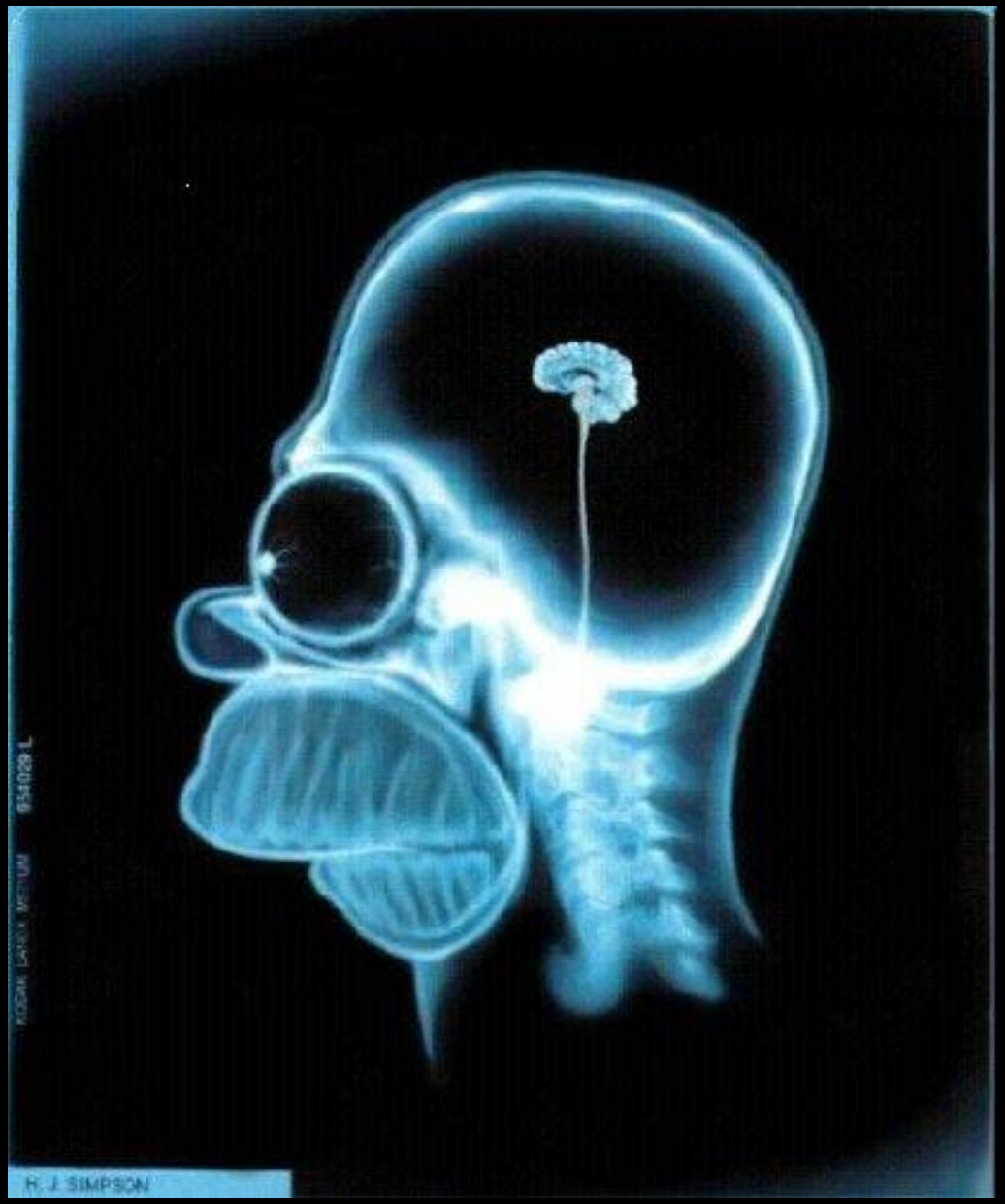
Space Fog

AKA “Space Stupids” or “Space Brain”



Space Fog, Space Stupids, or Space Brain

Factoid #6: Term coined by U.S. astronauts in anecdotal reports

Describes diminished ability to perform tasks for which they have trained and prepared, or other simple tasks

Crew reports increased errors, altered time awareness, checklists must be followed more meticulously, crew redundancy for critical steps needed

Tends to be reported by short duration crew

“Space Fog” or “Space Brain”

Literature on Cognitive Performance in Space

- Casler JG, Cook JR. Cognitive Performance in Space and Analogous Environments. International Journal of Cognitive Ergonomics, 1999, 3(4), 351-372. Lawrence Erlbaum Associates, Inc.

Surveyed 29 studies, cataloged by 6 cognitive measures.

- Response time
- Memory
- Reasoning
- Pattern recognition
- Fine motor skills

- Human Performance. In: Kanas, N; Manzey, D. Space Psychology and Psychiatry. Published jointly by Microcosm Press, El Segundo, CA, and Springer, The Netherlands 2008 pp. 49-88

Considered most of these and a few subsequent studies

“Space Fog” or “Space Brain”

Cognitive Performance in Space Flight

Casler and Cook: Showed minimal cognitive impairments. Minor deficits in pattern recognition, fine motor skills, and dual task performance, resolves within 3 weeks.

“Whether this cognitive adaptation period correlates to the physiological adaptation process time line cannot be stated at this point.”

Kanas and Manzey: Basic cognitive processes such as grammatical reasoning and memory search do not seem to be impaired or “can be fully compensated by the increased efforts of the astronaut.”

Higher cognitive demand functions, such as tracking performance and dual-task interference, show minor decrements that correlate with findings of visuo-motor and attentional disturbances of adaptation. These seem to resolve within a few weeks.

“Space Fog” or “Space Brain”

Astronauts’ Perception of Space Fog is based on the delta of task execution between two venues:

TRAINING: well rested, prepared and task-focused, low pressure, implications of mistakes minimal, quiet, Starbucks in hand

FLIGHT: acute phase adaptation, +/- SMS, +/- circadian desynchrony, learning curve for stowage and retrieval, comm with ground, other crew activity in small confines, working in 2nd language, implications of mistake accentuated, etc.

“..Shuttle and ISS crewmembers have typically performed their tasks with distinction, despite any experiences with space for they may have had, an un-doubted testament to their abilities and high degree of training. Further, the reports of serious cognitive disruption from space fog conflict with the relatively minor (or no) deficits observed when crew-members are measured on well-established cognitive tests.”

“Nevertheless, …. the fact that performance decrements on highly perfected tasks have rarely been observed (or at least reported) does not mean that cognitive deficits do not occur, posing a potentially serious threat to both mission and astronaut.”

Welch RB, Hoover M, Southward EF. Cognitive performance during prismatic displacement as a partial analogue of "space fog". Aviat Space Environ Med. 2009 Sep;80(9):771-80

Space Fog in Summary

Self-perceived decrement in performance of tasks reported in short duration flight.

Correlates temporally with acute physiologic and behavioral adaptation to spaceflight, as well as minor decrements in cognitive performance, both of which largely resolve within 3 – 4 weeks.

“Sensory saturation”, task distraction at work

Seems to be more associated with Shuttle flight than with Soyuz, perhaps due to increased complexity and workload as well as increased internal volume

Recommendation on Cognition Terminology in Space Flight

Classic Space Fog occurs amidst the integrated totality of spaceflight that you could not train before launch that affects primarily the first several days in weightlessness

Should be uncoupled from other more organic threats to cognition during long term flight, e.g. fatigue, hypercarbia, other toxicities, radiation, and other long term psychological issues

Functionally and practically, cognitive impairment is not a hallmark of long duration spaceflight for ISS type missions

But there are risks

Vigilance is required for ultra-long duration exploration class missions, such as three years to / from Mars

Factoid #7: Behavioral Adaptation Occurs

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JAXA

Behavioral Adaptation to Space Flight

Pretty much every physiologic system undergoes adaptation to microgravity and the spacecraft environment

Behavior and performance is not excepted, though poorly described

May be defined as behavioral and cognitive patterns and strategies that develop over time to cope with the physical condition of microgravity to enable efficient and effective performance.

There are identifiable neurosensory metrics that map to enhanced performance

Spatial orientation, locomotion & navigation, body restraint, mass handling, mass discrimination, managing items in micro-G, etc.

?? Other psychological and psychometric indices ??


Behavioral Maladaptation

Factoid #8: Meaningful Work is Huge

Britt et al; Enhancing the Meaningfulness of Work for Astronauts on Long Duration Space Exploration Missions. AMPH 2017 Aug1;88(8):779-83

Comparison of Two Journals Studies

French Journals study, 9 journalers over 13 months, ‘93-’94, Antarctic and remote South Indian Ocean field stations

In order of frequency of journal entries:

Group Interaction	~ 610
Outside Communications	~ 375
Workload	~ 350
Recreation and Leisure	~ 325

ISS Crewmembers, 10 journalers, 6 mo missions between 2003 and 2010

In order of frequency of journal entries:

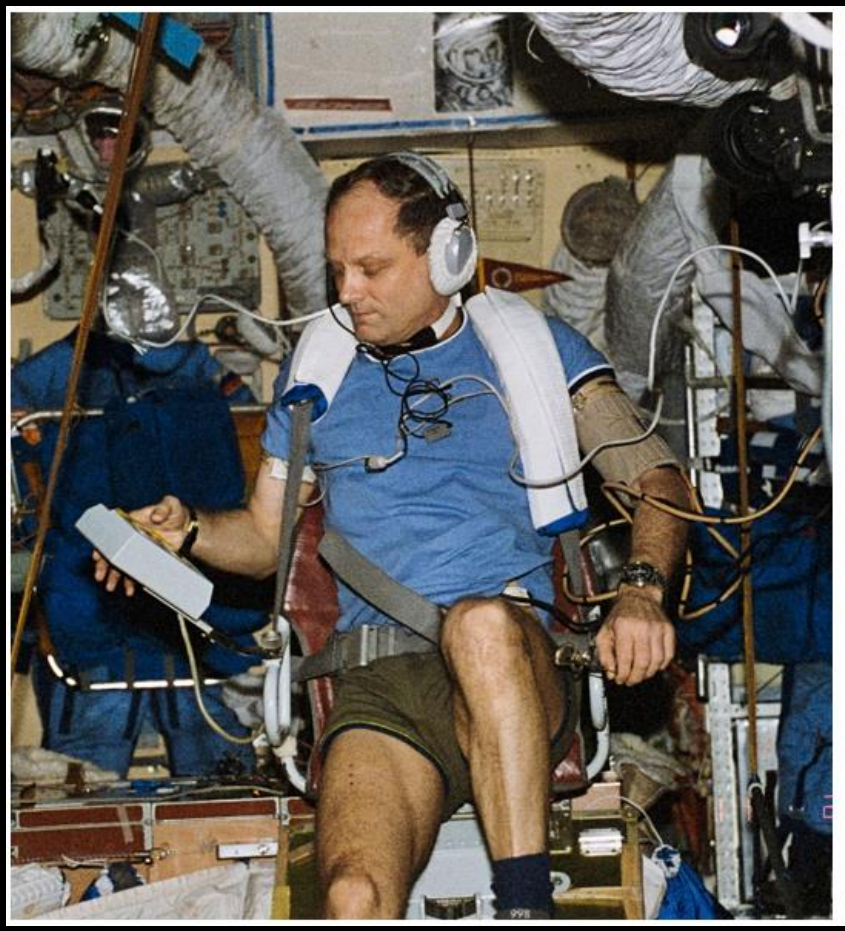
Work	1523
Outside communications	1456
Adjustment	1082
Group Interaction	777

From Stuster J. Behavioral Issues Associated With Long Duration Space Expeditions: Review and Analysis of Astronaut Journals 2010

The Role of Meaningful Work

1995, Russian Mir Station

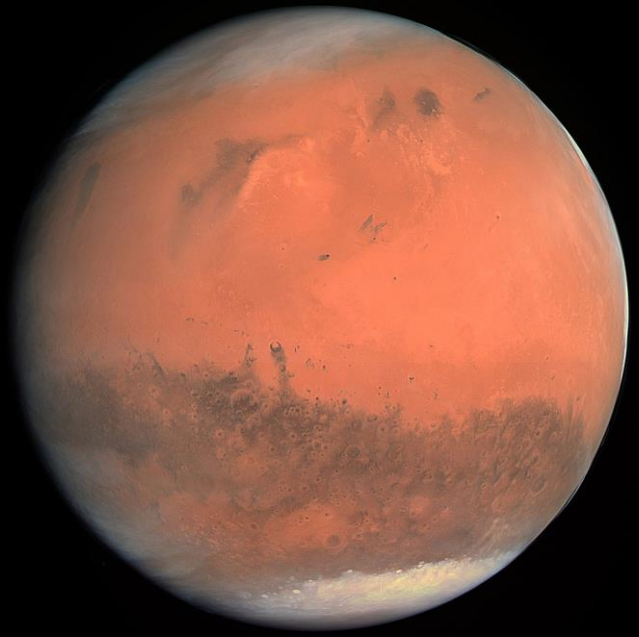
Russian ‘Spektr’ Science Module



US Astronaut Norm Thagard

ISS in its current state arguably represents the first "Golden Age of Space Habitability"

The Mars Design Reference Missions will be very different



Again, caution with comparisons.

The Simplistic Legs of the BHP Stool

Initial selection into the astronaut corps

Training, building expeditionary behaviors

Inflight BHP support by ground specialists

Inflight BHP support by onboard specialists

- This takes on greater prominence as missions lengthen and become more remote

Selection: The NASA Class of 2017

One Perspective:

Crewmembers view spaceflight risk fairly holistically…..

A Remembrance:

https://www.youtube.com/watch?v=6rwi_0DEd_0

Oct 31st, 2014; Virgin Galactic White Knight 2 and Spaceship 2

October 31st; Virgin Galactic Spaceship 2

Oct 28th, 2014; Orbital Science Antares Booster / Cygnus

October 28th Orbital Sciences 3

Progress 59P 28 April 2015

Progress 59P 28 April 2015

SpaceX 7 28 June 2015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HD


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1 Sept 2016 Space X Falcon 9 During Fueling

Soyuz 1st Stage Abort, Oct 11, 2018

Space X Demo 1 Capsule
Test stand mishap, 20 April, 2019


NASA


SPACE FACTS


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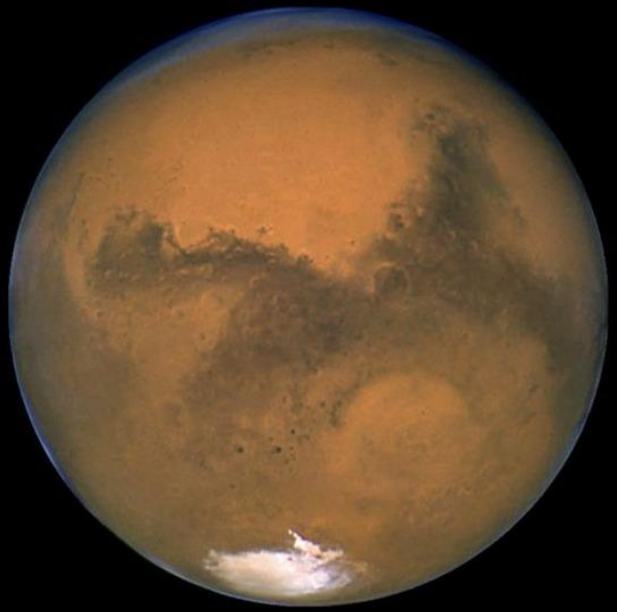
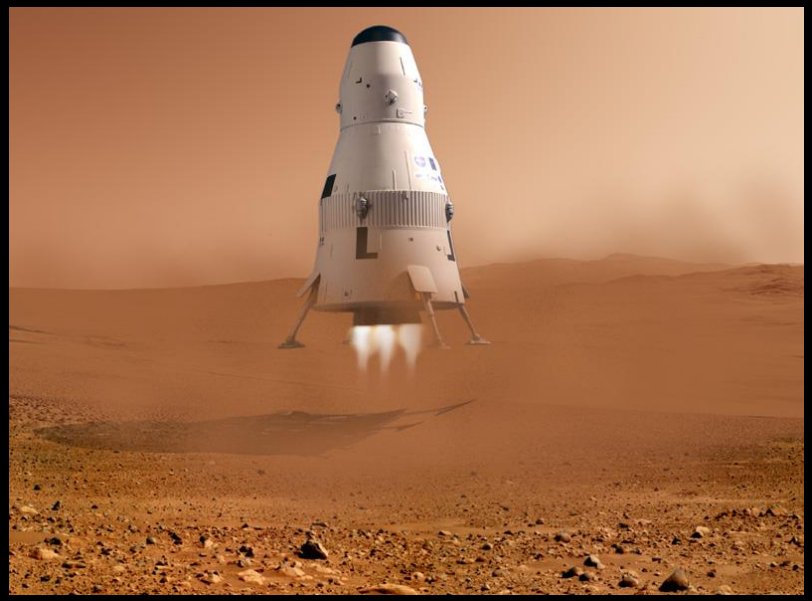
COLUMBIA

Historically, the mortality and morbidity of space flight is in dynamic flight events (launch / ascent, entry/descent/landing)

This is a backdrop against which crewmember see all risks associated with flight

For exploration class missions, these events will double in number





A Mars Ready Crew

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QUESTIONS?