National Aeronautics and Space Administration

VALIDATION AND NORMS OF COGNITION AND SPACEFLIGHT ASSESSMENTS WITH SENIOR MILITARY LEADERS

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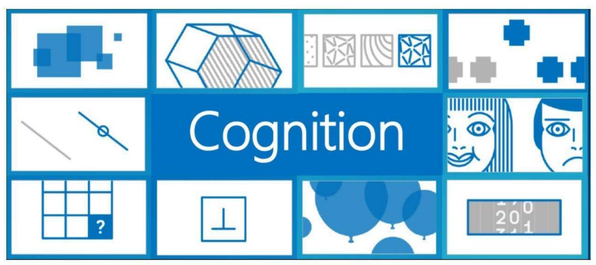
Abstract

Spaceflight hazards include risks to cognitive performance. NASA requires sensitive neuropsychological screening tools to determine changes to cognitive risks to crew health and performance. Currently, NASA uses WinSCAT for neurocognitive screening and to monitor the status of astronauts during spaceflight. The Cognition Test Battery was recently developed by NASA-funded researchers at UPenn as part of the Behavioral Health and Performance component of NASA Standard Measures. This research provides independently validated norms and psychometric properties to compare WinSCAT to Cognition using a military population who operates in high demand, extreme environments similar to those experienced by astronauts (deployments, isolation, extreme environments).



Introduction

While in space and on Earth, crewmembers and ground-support staff are exposed to elevated cognitive demands related to the high workload of mission operations. The ability of an astronaut to meet operational cognitive demands may differ based on experience (i.e., competency to perform the task), their appraisal of their competency to successfully meet the challenge of the task, and/or their ability to self-regulate in the presence of a novel, demanding task. The extreme conditions of spaceflight and associated human performance risk:

- Require a clinical tool to monitor the neurocognitive status of astronauts in space.
- Necessitate that any measures of neurobehavioral functioning offer sensitive, specific, and valid methods to assess the individual variability in cognitive performance, in the differential sensitivity to sources of that variation (e.g., sex, age, environmental factors) within both the basic and more complex functions.

An initial study [1] demonstrated the new cognitive test battery for spaceflight and compared it, similar to our study, to WinSCAT. Results show Cognition is a feasible, sensitive, valid research tool for assessing the high performance of the 8 astronauts and 11 flight controllers within this initial study. However, their small sample size (N=8) limits the generalizability of these findings.

Study Aim: Independently validate the Cognition Test Battery against WinSCAT to establish norms and identify intra-individual differences in mental effort during testing.

Method

Sample:

51 (48 males/3 females) Senior Service College (SSC) attendees/graduates, age range from 41-55, average age 47.07 years , SD = 3.4 years, 92% with > 17 years education.

Sample selection rationale:

Military officers attending SSC are among the most elite of military officers. Approximately 70% of astronauts are either current or former military officers (e.g., 6 of 8 astronauts in the 2015 class were military officers; 219 of 330 astronauts have military experience). Military officers attending an SSC may serve as a valid surrogate for astronauts since they are trained to maintain cognitive performance in complex operational environments (high risk, time-sensitive tasks, deployments, small teams) that are analogous to spaceflight operations (isolation, confinement, extreme environments).

Measures:

- Self-reporting: demographics, sleep information, medications
- Zephyr Physio Status Monitoring (PSM) System
- WinSCAT and Cognition Test Battery software loaded on calibrated laptops

***Table 1.* Subtests included in WinSCAT and Cognition.**

WinSCAT	1. Code Substitution Learning (CDS): Learning 2. Mathematical Processing (MTH) 3. Running Memory Continuous Performance Test (CPT): Attention and concentration 4. Delayed Matching-to-Sample (MTS): Visual memory 5. Code Memory Delayed (CDD): Short-term memory
Cognition	1. Motor Praxis (MPT): Sensory-motor ability 2. Visual Object Learning (VOLT): Visual object learning and memory 3. Fractal 2-Back (NBACK): Attention and working memory 4. Abstract Matching Task (AMT): Abstraction 5. Line Orientation (LOT): Spatial orientation 6. Emotion Recognition (ERT): Emotion recognition 7. Matrix Reasoning (MRT): Abstract reasoning 8. Digit Symbol Substitution (DSST): Complex scanning, visual tracking, and attention 9. Balloon Analog Risk (BART): Risk decision making 10. Psychomotor Vigilance (PVT): Vigilant attention and psychomotor speed

[1] Basner, M., Savitt, A., Moore, T. M., Port, A. M., McGuire, S., Ecker, A. J., et al. (2015). Development and Validation of the Cognition Test Battery for Spaceflight. Aerospace Medicine and Human Performance, 86(11), 942–952.

Procedure:

SSC students/graduates were presented an overview of the NASA IRB approved research. Once enrolled in the study, SSC participants completed the following in the SSC facility designated for this purpose, to ensure quiet, undisturbed testing conditions:

- Informed consent briefing and documentation
- Don a Zephyr PSM System
- Pre-screening (medications) and pre-tests (NASA-TLX, sleep, demographics, mood)
- Cognitive batteries (with counterbalancing):
  - ✓ Time 1 (day 1): Initial testing of both WinSCAT and Cognition batteries
  - ✓ Time 2 (day 90): Repeat testing of both WinSCAT and Cognition Test batteries
- Doff the Zephyr Physio Status Monitoring (PSM) System
- Debrief

Results (Reported for WinSCAT & Cognition Testing only):

WinSCAT Test	Time 1 (T1)	Time 2 (T2)	T2-T1	% Change	Cohen's d	R	Magnitude of r
CDS	45.51 (7.94)	48.38 (8.68)	2.88**	6.3%	.57	0.82	High
CPT	84.39 (20.26)	91.71 (22.00)	7.33**	8.6%	.49	0.76	Adequate
Math	17.80 (3.53)	18.14 (3.09)	0.34	<1%	.15	0.78	Adequate
M2S	31.28 (8.35)	31.52 (8.54)	0.24	<1%	.04	0.71	Adequate
CDD	42.28 (15.91)	46.58 (16.16)	4.30**	10.2%	.40	0.79	Adequate

* $p \leq .05$ ** $p \leq .001$ (Bonferroni corrected)

Cognition "Efficiency" Tests: 90-Day Pre-Post Testing, % Change, Cohen's D

Cognition Test	Time 1(SD)	Time 2(SD)	T2-T1	% Change	Cohen's d	R	Magnitude of r
MPT	720.76 (97.02)	737.04 (88.38)	16.28	2.3%	.21	0.65	Adequate
VOLT	605.12 (94.37)	611.20 (100.96)	6.08	1%	.07	0.62	Adequate
NBACK	523.14 (221.71)	566.52 (191.51)	43.38	8.3%	.21	0.54	Adequate
AMT	543.07 (100.63)	576.25 (97.84)	29.76	5.4%	.26	0.34	Adequate
LOT	666.20 (114.52)	684.12 (108.29)	17.92	2.7%	.19	0.66	Adequate
ERT	530.82 (94.82)	558.24 (80.34)	27.42	5.2%	.38**	0.68	Adequate
MRT	534.96 (121.36)	598.98 (138.56)	64.02	12.0%	.42**	0.33	Adequate
DSST	454.76 (157.43)	424.62 (145.17)	-30.14	-6.6%	.35**	0.85	High
BART	844.88 (167.68)	844.66 (143.74)	-0.22	<1%	0	0.03	Low
PVT	877.80 (81.53)	876.26 (95.06)	0.87	0.10%	.02	0.72	Adequate

Discussion & Deliverables

- This study provided a comprehensive understanding of the capabilities and limitations of the Cognition Test Battery compared to the currently used WinSCAT
- Significant changes in 90 day pre-post testing with Cognition related to improvements in efficiency scores (accuracy & speed of reaction/responding) in the areas of emotion recognition, abstract reasoning, and complex scanning.
- Significant WinSCAT improvements on tests measuring throughput (accuracy and speed of responding) related to the areas of learning, memory, and sustained attention.
- These results help validate the Cognition Test Battery, accelerating its use and acceptance as a component of HRP Standard Measures.