
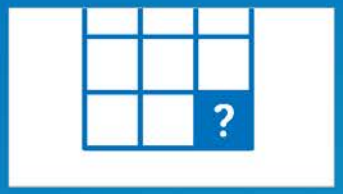
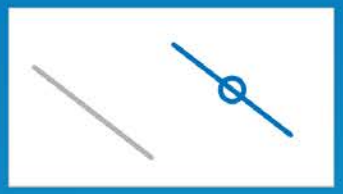
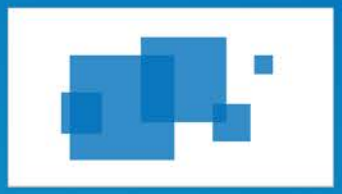
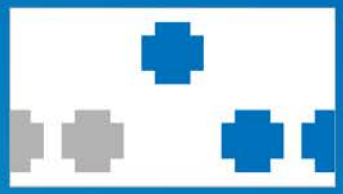

COGNITIVE PERFORMANCE IN MILITARY SENIOR LEADERS: ANALYSIS & IMPLICATIONS

T. J. Williams[1], L. B. Landon[2], J. S. Schneiderman[2], K. Seaton[2], W. B. Vessey[1], J. Tisson[3], R. Stanley[3], C. Kusmeisz[3], D. Arias[2] , S. Stranges[2], J. Dunn[2] , M. Basner[4], A. Ecker [4]

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[3]U.S. Army War College, Carlisle, PA
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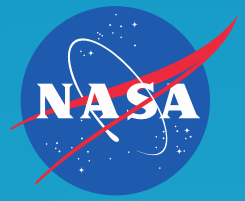
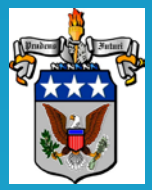
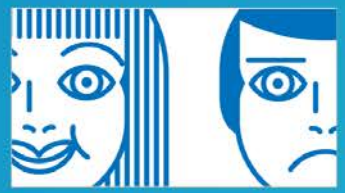




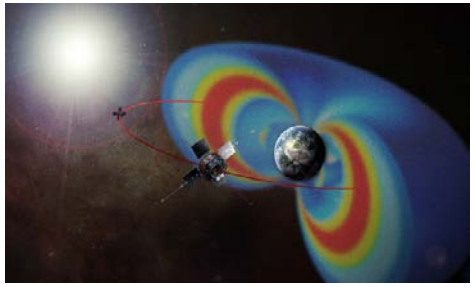






Potential Threats to Cognitive Functioning in Space Flight

- *The spaceflight environment is filled with risk factors that can have a negative impact on cognitive functioning.*



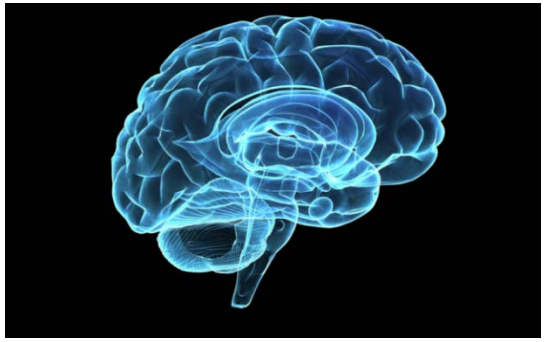
Radiation

Chronic Stress

Head Injury

Fluid Shifts

Mike Hopkins eating his Thanksgiving meal



Hypoxia

Decompression

Atmospheric Toxins

Circadian Disruption/Fatigue

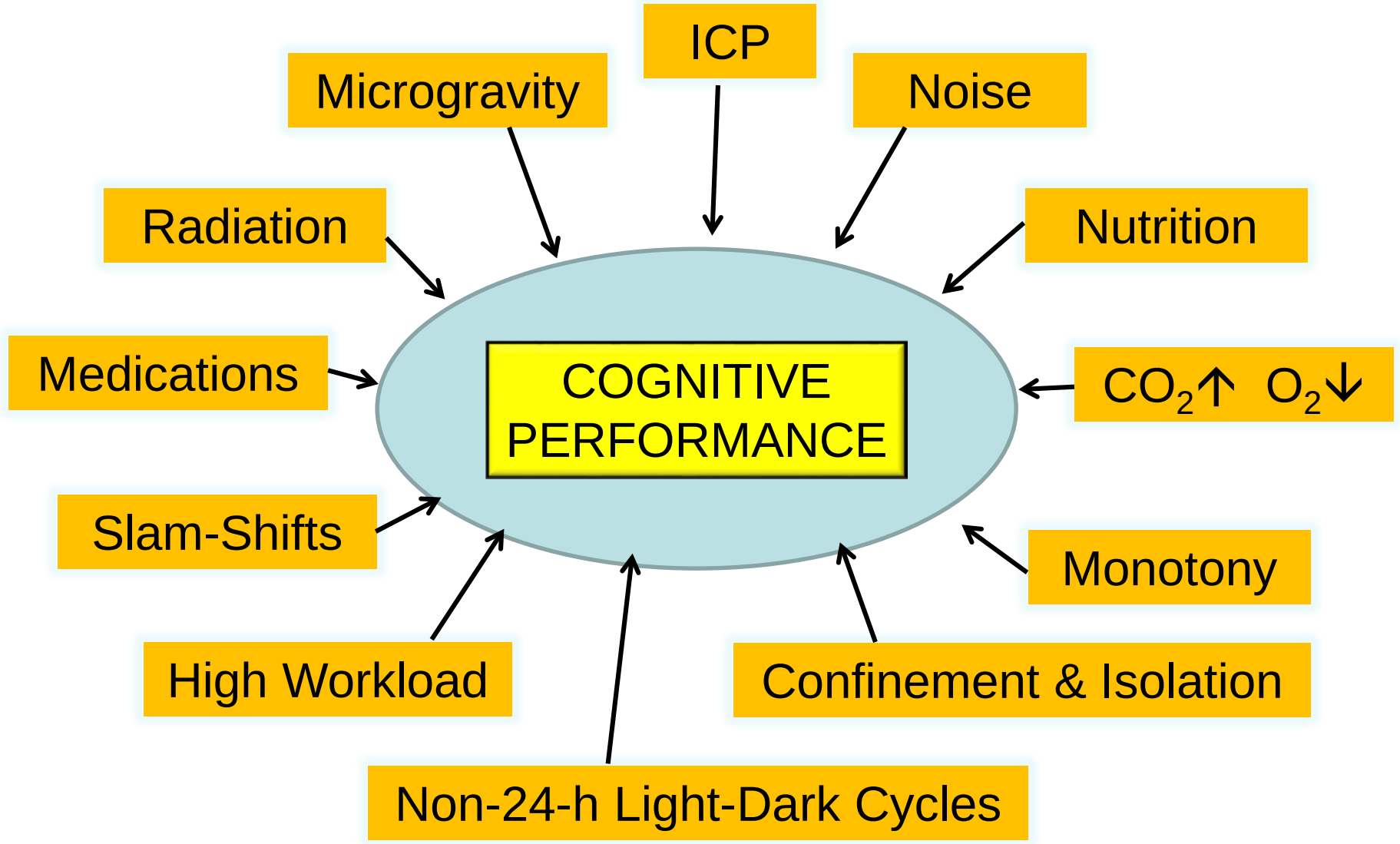
Isolation/Confinement

Elevated CO_2

Reid Wiseman on an EVA

- *Risks may increase in severity, and new threats may emerge for longer duration exploration missions.*

At least 25 risks and gaps of NASA's Human Research Roadmap mention human cognition.



Courtesy of M. Basner

Space Exploration: Extreme Demands in Extreme Environments

NASA is interested in completing Cognitive Assessments of Astronauts

- Spaceflight hazards pose risks to crew health and performance
- Brief screening assessment of cognitive functions is needed.
- Behavioral Medicine requirement for all long-duration U.S. astronauts and currently with JAXA, ESA, and CSA astronauts.

- In-flight tests: Scheduled monthly to establish baseline and maintain proficiency with the test.
- Provides immediate, objective clinical feedback to the astronaut and flight surgeons.

Creative, adaptive leaders….

Joint Education

White Paper

16 July 2012

The National Military Strategy
of the
United States of America
2015

FOSTERING INNOVATION

- Producing creative, adaptive leaders
- Adopting efficient, dynamic processes
- Developing flexible, interoperable capabilities

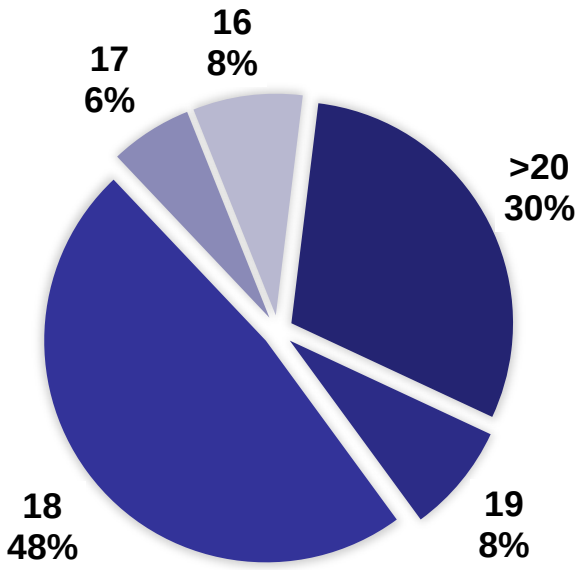
- Maintain our competitive learning advantage through:
  - Mastery of fundamentals of the art and science of war;
  - Intellectual curiosity, coupled with openness to new ideas;

Research Aims

- Compare and validate current (WinSCAT) vs. proposed (Cognition Battery) NASA operational performance tools
  - Independently test and evaluate the 90-day test-retest reliability properties of two measures
  - Develop norms
- Cognitive processing & performance

Demographics

- N=51
- 48 Male, 3 Female
- Ages 41-55, Mean 47.07, SD = 3.73
- All in top 10% of senior military officers
- Education Years:



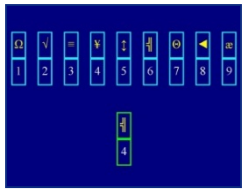
NASA astronaut Sunita Williams, Expedition 33 commander on ISS laptop. Japanese astronaut and flight engineer Aki Hoshide is behind her.
Credit: NASA

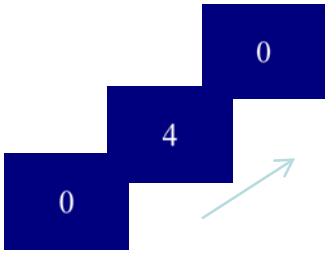
WinSCAT has been implemented with U.S. astronauts from one NASA/Mir mission and all 55 expeditions on the International Space Station

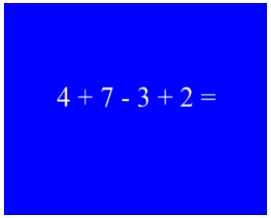
WinSCAT: Space flight Cognitive Assessment Tool for Windows

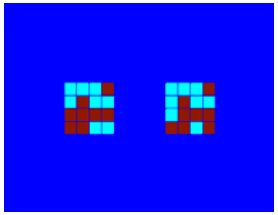
WinSCAT Tests

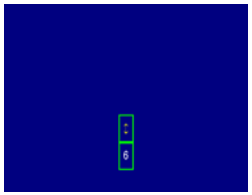
- CDS – Code Substitution
  - Learning
- CPT – Continuous Processing Task
  - Sustained attention and concentration
- MTH – Mathematics
  - Verbal working memory
- MTS – Matching To Sample
  - Visual short-term memory
- CDL – Code Substitution Delayed
  - Delayed recall





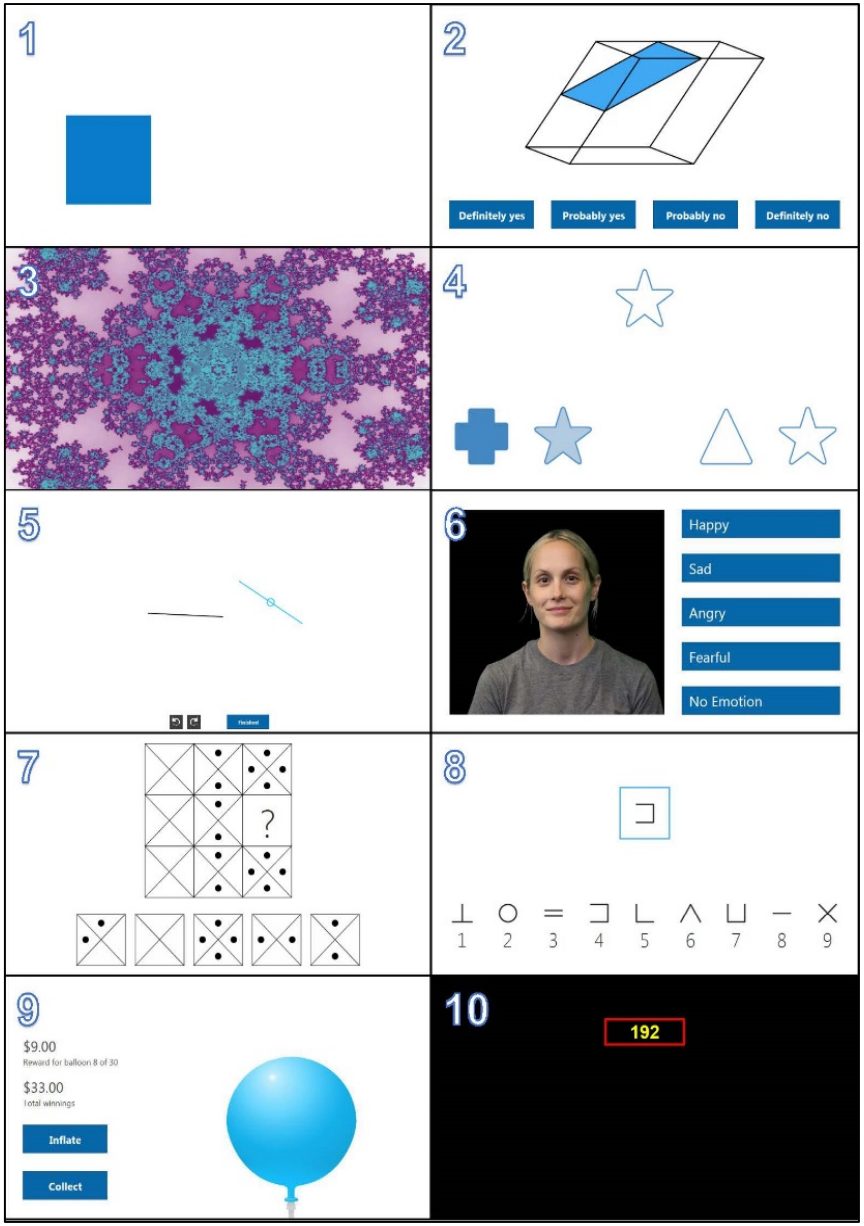






Cognition Battery

Test	Cognitive Domains Assessed	Administration Time [Minutes] Median (Range)
1. Motor Praxis (MP)	Sensory-motor speed	0.4 (0.3 – 2.3)
2. Visual Object Learning (VOLT)	Spatial learning and memory	1.7 (1.4 – 8.2)
3. Fractal 2-Back (F2B)	Working memory	2.0 (1.7 – 16.5)
4. Abstract Matching (AM)	Abstraction, concept formation	1.8 (1.3 - 7.9)
5. Line Orientation (LOT)	Spatial orientation	1.2 (0.8 – 2.4)
6. Emotion Recognition (ERT)	Emotion identification	1.7 (1.2 – 3.1)
7. Matrix Reasoning (MRT)	Abstract reasoning	2.1 (0.6 – 3.9)
8. Digit Symbol Substitution (DSST)	Complex scanning and visual tracking	1.6 (1.6 – 2.6)
9. Balloon Analog Risk (BART)	Risk decision making	2.1 (1.7 – 4.1)
10. Psychomotor Vigilance (PVT)	Vigilant attention	3.2 (3.1 – 4.5)



Cognitive Domains Assessed

WinSCAT

- Learning
- Sustained Attention & concentration
- Verbal Working Memory
- Visual Short-term memory
- Delayed Recall-Memory

Derived from: Automated Neuropsychological Assessment Metrics (ANAM)

Cognition

- Sensorimotor speed
- Spatial learning & memory
- Working memory
- Abstraction, concept formation
- Spatial orientation
- Emotion identification
- Abstract reasoning
- Complex scanning & visual tracking
- Risk decision making
- Vigilant attention

Derived from: PENN Computerized Neurocognitive Battery (CNB)(Basner et al., 2015)

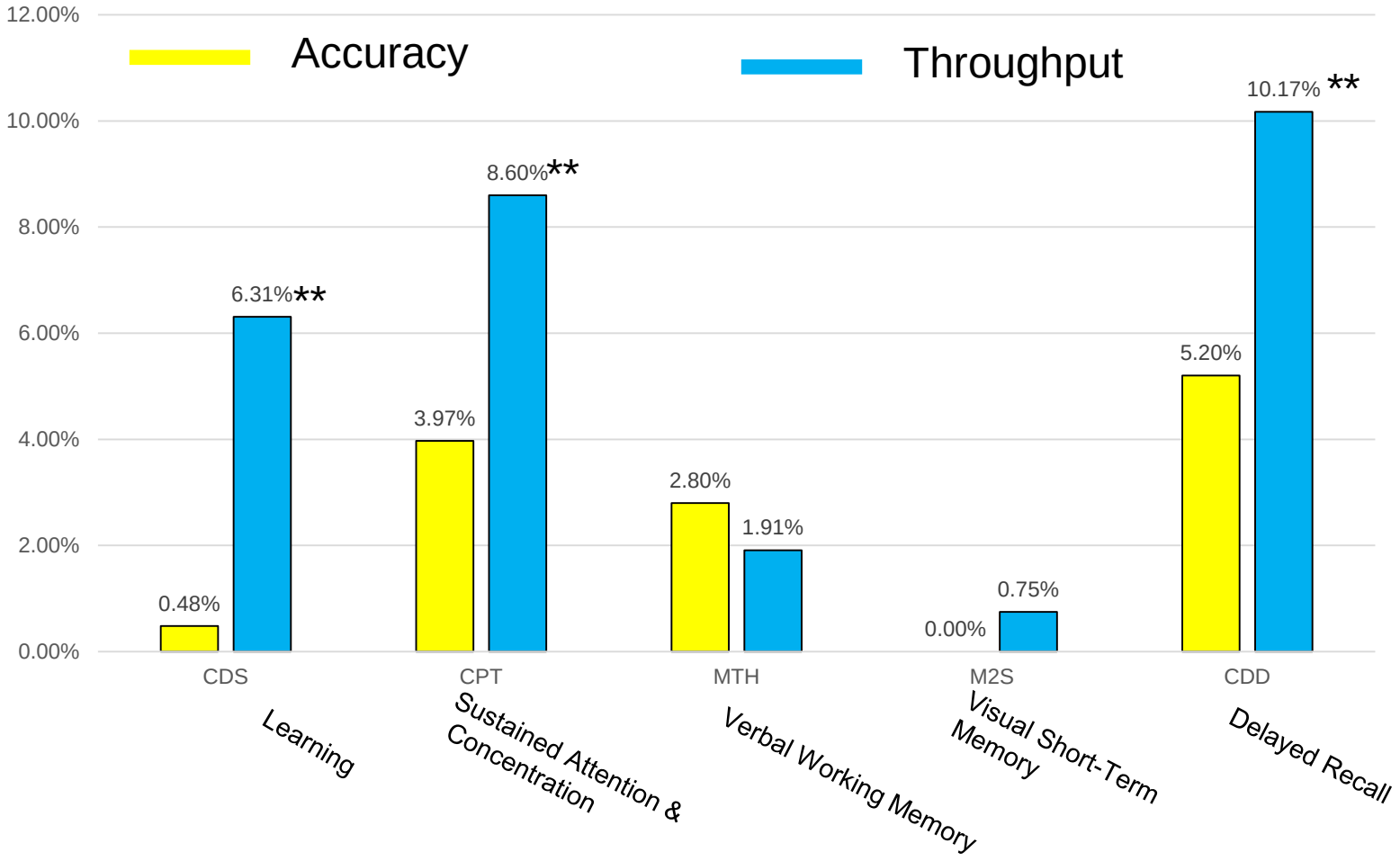
Cognitive Performance:
Accuracy & Throughput

- ***Throughput*** (speed of response or reaction/processing)
  - Measure of mental efficiency
  - Correct responses within specified time
- ***Accuracy*** (% or number correct)
- ***Speed-Accuracy Trade-off***
  - “Fast” or “Good”
  - Asymptotic accuracy at long response times
- ***Improved Cognitive Performance***
  - Increased accuracy
  - Decreased response or reaction time

Cognitive Efficiency

- Attentional resources
  - Limited
  - Ability to cope (competing demands)
- Flexibility
  - Ability to operate at different speeds
  - Less flexible *may appear* less able
- Higher throughput = greater cognitive efficiency

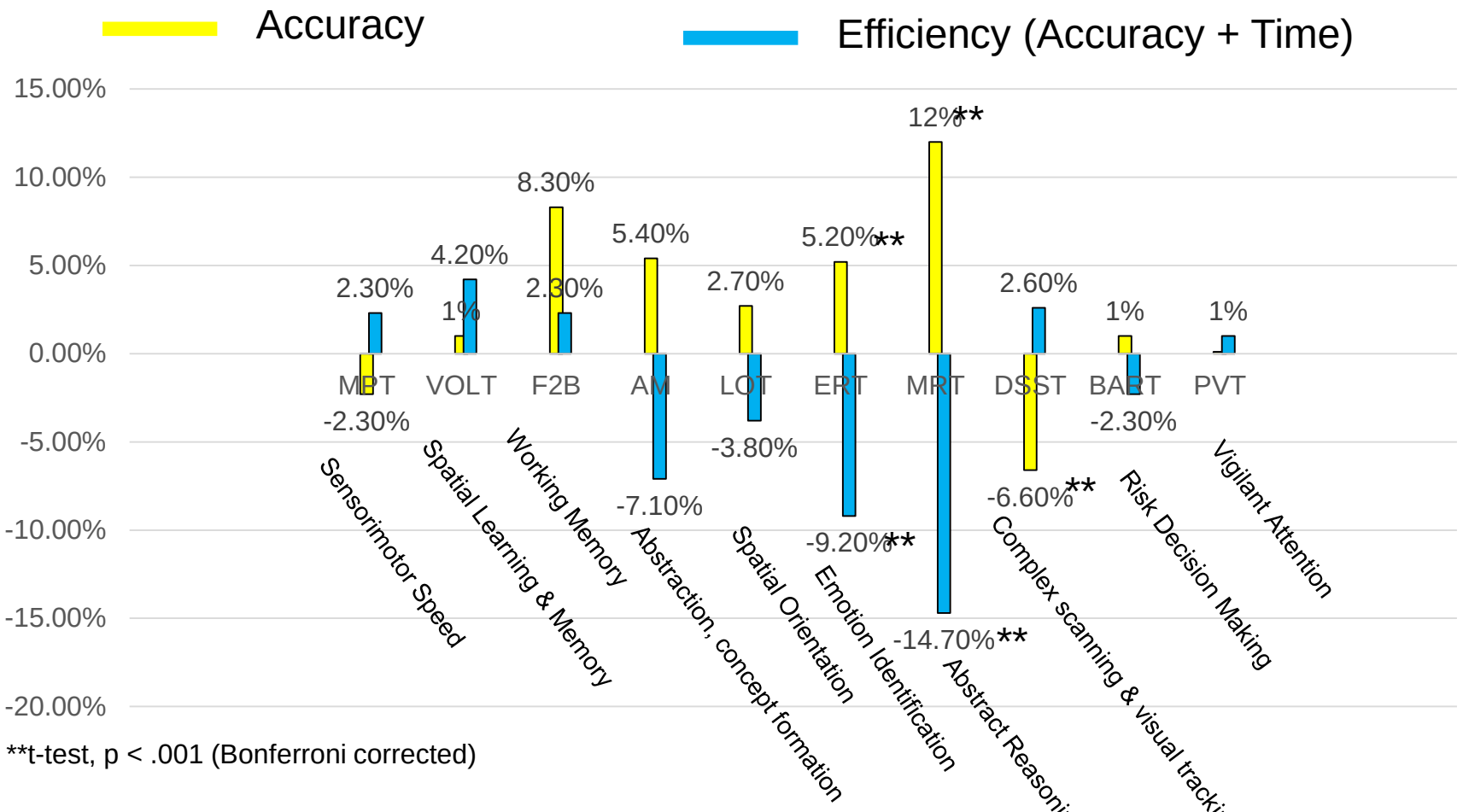
WinSCAT: 90 Day Pre-Post % Change



Code Substitution (CDS), Continuous Processing Task (CPT), Mathematics (MTH), Match to Sample (M2S), Code Substitution Delayed (CDD)

**t-test, $p < .001$ (Bonferroni corrected)

Cognition: 90 Day Pre-Post % Change



**t-test, p < .001 (Bonferroni corrected)

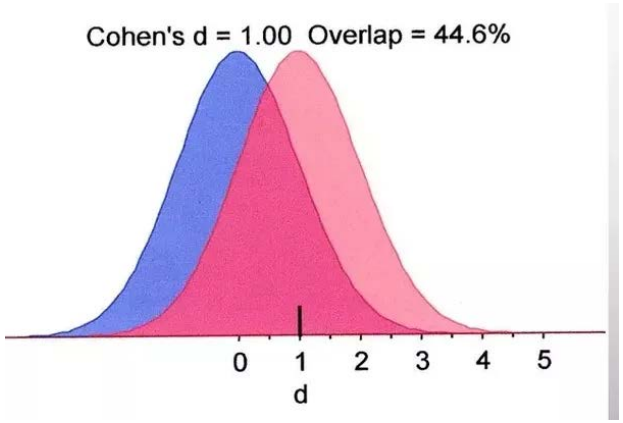
Motor Praxis (MP), Visual Object Learning (VOLT), Fractal 2-Back (F2B), Abstract Matching (AM), Line Orientation (LOT), Emotion Recognition (ERT), Matrix Reasoning (MRT), Digit Symbol Substitution (DSST), Balloon Analog Risk (BART), Psychomotor Vigilance (PVT)

Stability of Test: Effect Size (reciprocal) to Derive Estimate of Overlap of Pre-Post Scores

WinSCAT

(% Overlap; Pre-Post)

	Accuracy	Throughput
• CDS	~85%	~62%
• CPT	~85%	~67%
• MTH	~85%	~90%
• M2S	~99%	~99%
• CDD	~89%	~73%



Cognition

(% Overlap; Pre-Post)

	Accuracy	Throughput
• MPT	~99%	~99%
• VOLT	~99%	~85%
• F2B	~85%	~92%
• AMT	~82%	~85%
• LOT	~85%	~85%
• ERT	~75%	~71%
• MRT	~73%	~71%
• DSST	~79%	~82%
• BART	~99%	~95%
• PVT	~99%	~92%

= Statistically significant change, pre-post

Conclusions

- WinSCAT (W) & Cognition (C)
  - Generally stable: 90 Day Pre-Post testing
  - Highest Overlap Consistency (Throughput, Pre-Post)
    - Sensorimotor (C-MPT, 99%)
    - Visual, short-term memory (W-M2S, 99%)
    - Verbal working memory (W-MTH, 90%)
    - Risk Tasking (C-BART, 95%)
    - Working Memory (C-F2B, 92%)
    - Vigilant Attention (C-PVT, 92%)

Conclusions (cont'd)

- WinSCAT (W) & Cognition (C)
  - Lowest Overlap Consistency (Throughput, Pre-Post)
    - Delayed recall (W-CDD, 73%)
    - Emotion recognition (C-ERT, 71%)
    - Complex reasoning (C-MRT, 71%)
    - Sustained attention (W-CPT, 67%)
    - Learning (W-CDS, 62%)
  - 90 Day Pre-Post Significant Changes
    - WinSCAT: Learning, Memory, Sustained Attention
    - Cognition: Emotion recognition, abstract reasoning, complex scanning

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