
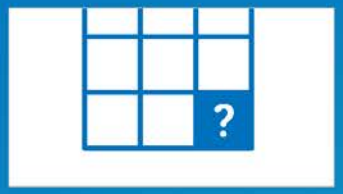
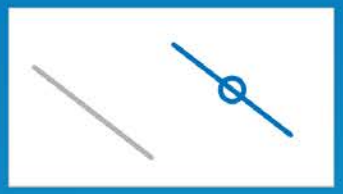
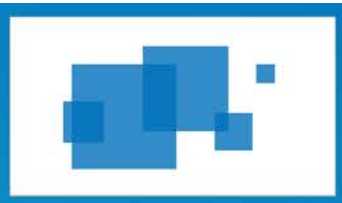
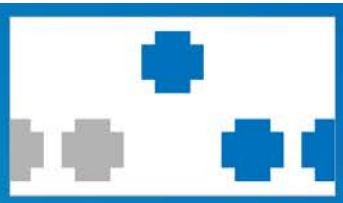

# COGNITIVE PERFORMANCE IN MILITARY SENIOR LEADERS: ANALYSIS & IMPLICATIONS

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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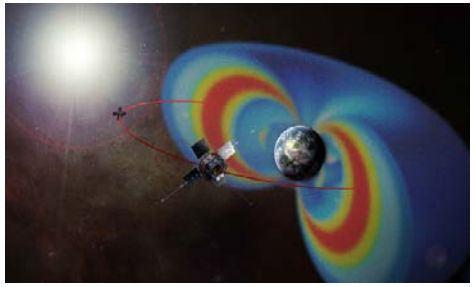
# *Potential Threats to Cognitive Functioning in Space Flight*

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



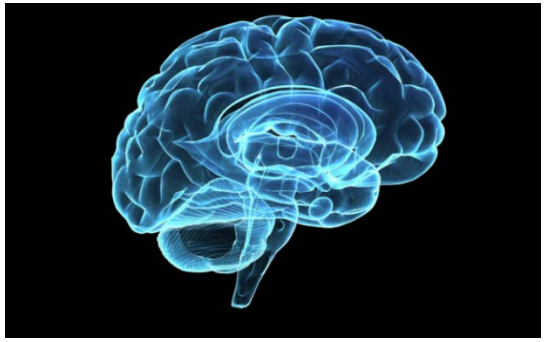
Radiation

Chronic Stress

Head Injury

Fluid Shifts

Mike Hopkins eating his Thanksgiving meal



Hypoxia

Decompression

Atmospheric Toxins

Circadian Disruption/Fatigue

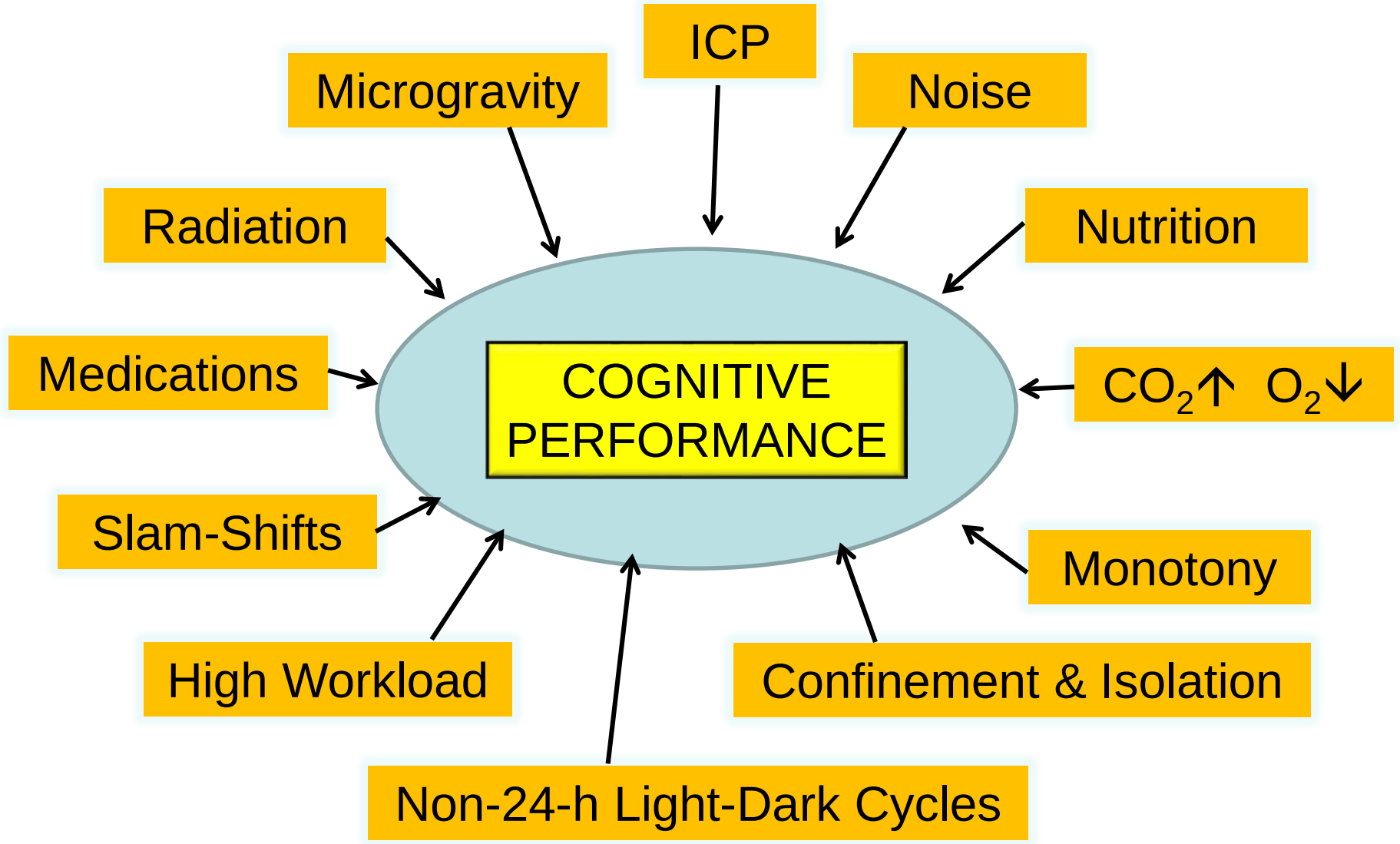
Isolation/Confinement

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

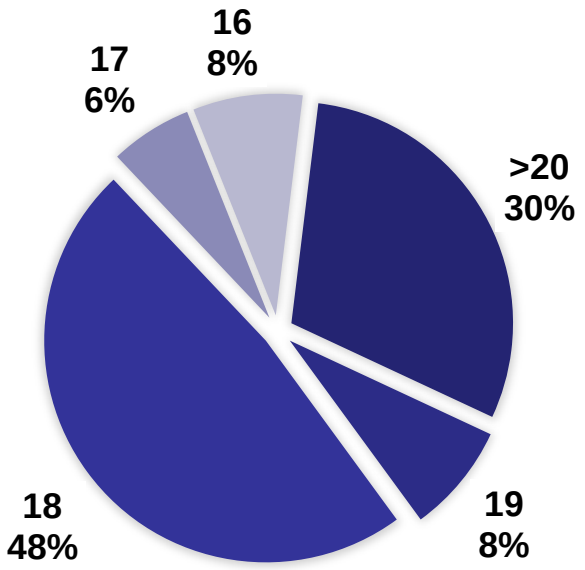
- Maintain our competitive learning advantage through:
  - Mastery of fundamentals of the art and science of war;
  - Intellectual curiosity, coupled with openness to new ideas;

# 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:



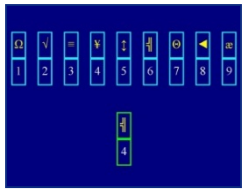
NASA astronaut Sunita Williams, Expedition 33 commander on ISS laptop. Japanese astronaut and flight engineer Aki Hoshide is behind her.
Credit: NASA

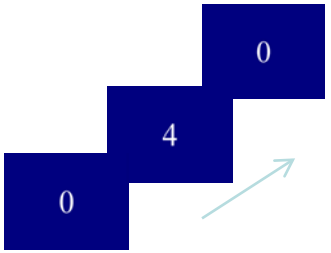
WinSCAT has been implemented with U.S. astronauts from one NASA/Mir mission and all 55 expeditions on the International Space Station

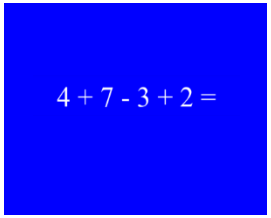
# *WinSCAT: Space flight Cognitive Assessment Tool for Windows*

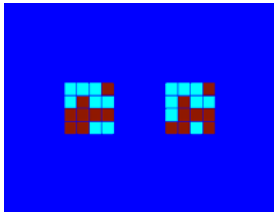
## WinSCAT Tests

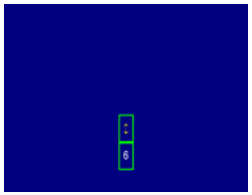
- CDS – Code Substitution
  - Learning
- CPT – Continuous Processing Task
  - Sustained attention and concentration
- MTH – Mathematics
  - Verbal working memory
- MTS – Matching To Sample
  - Visual short-term memory
- CDL – Code Substitution Delayed
  - Delayed recall





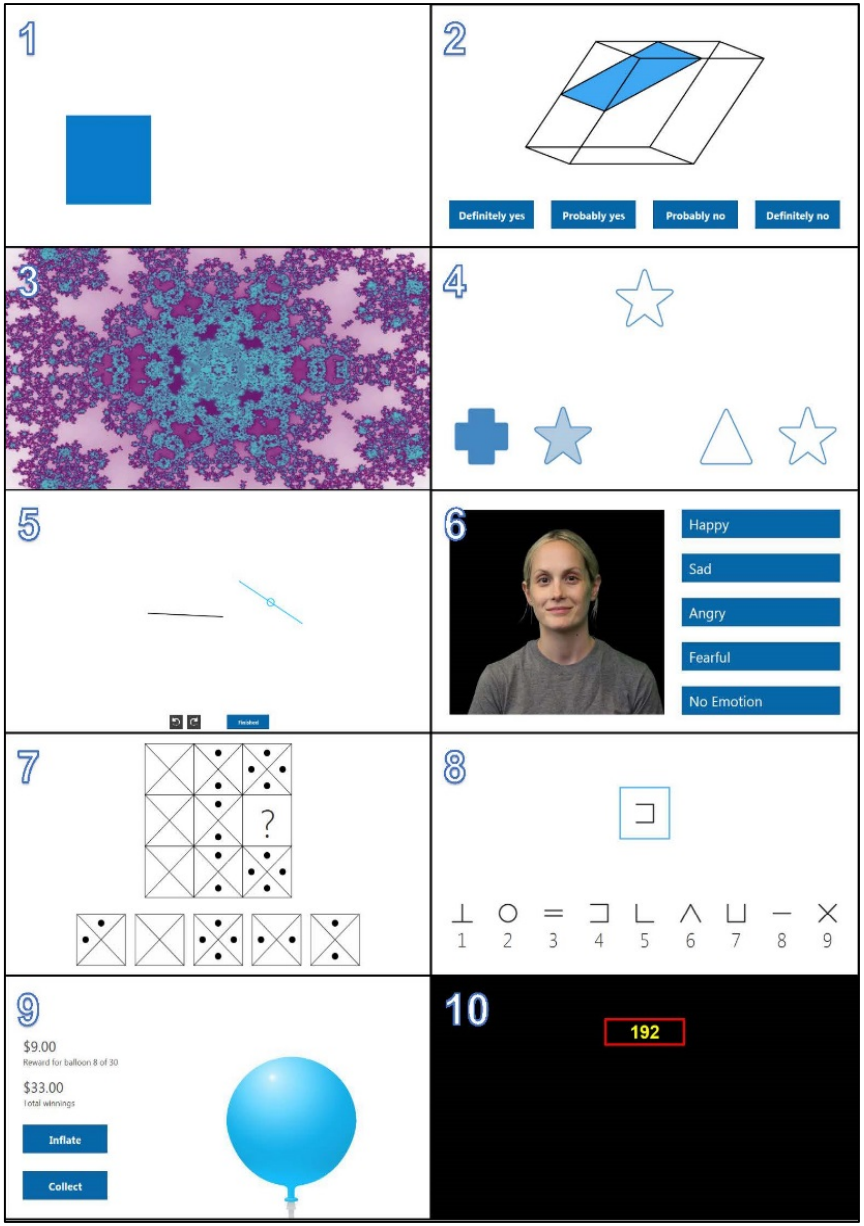





# Cognition Battery

| 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)

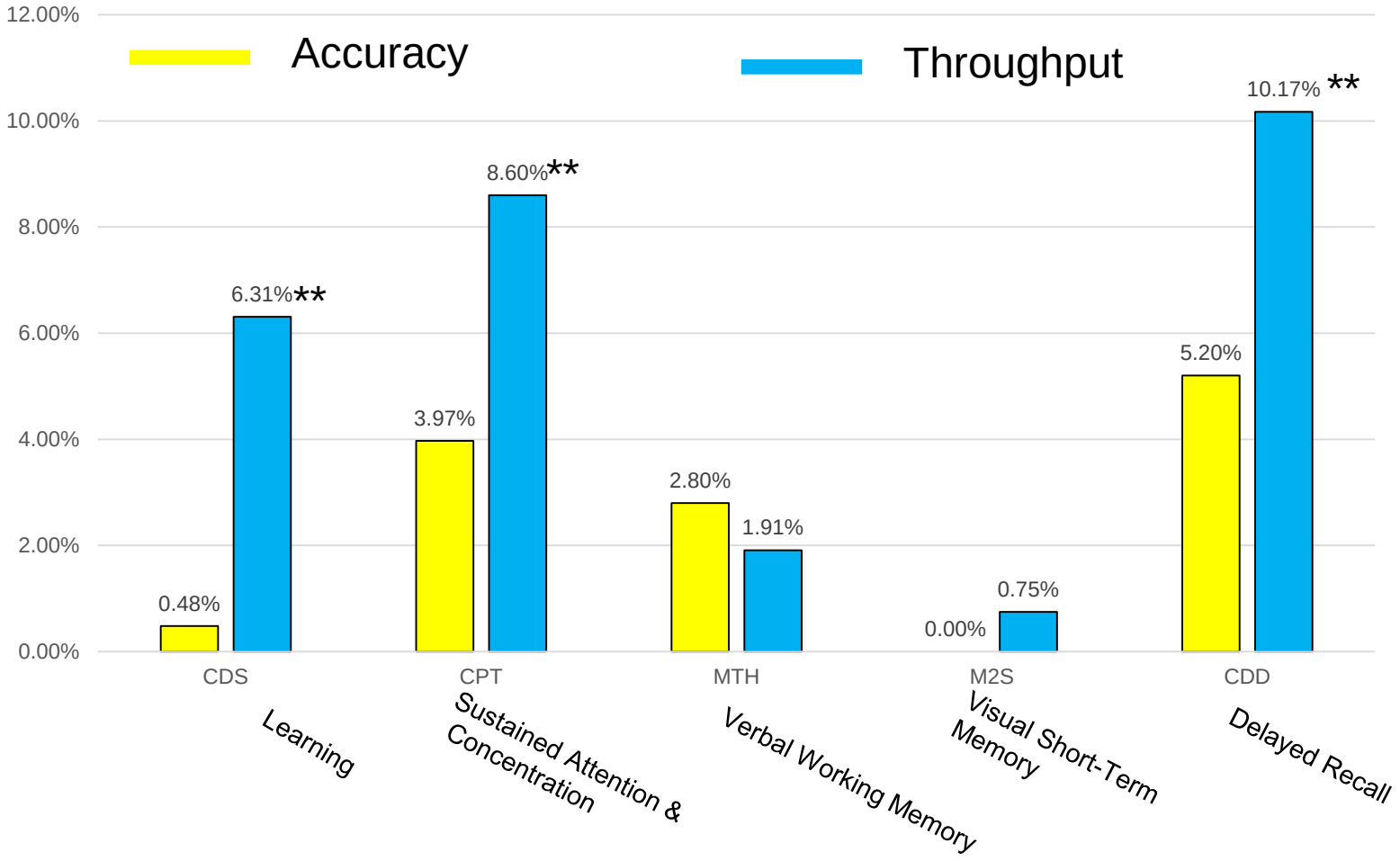
# Cognitive Performance:
## Accuracy & Throughput

- ***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

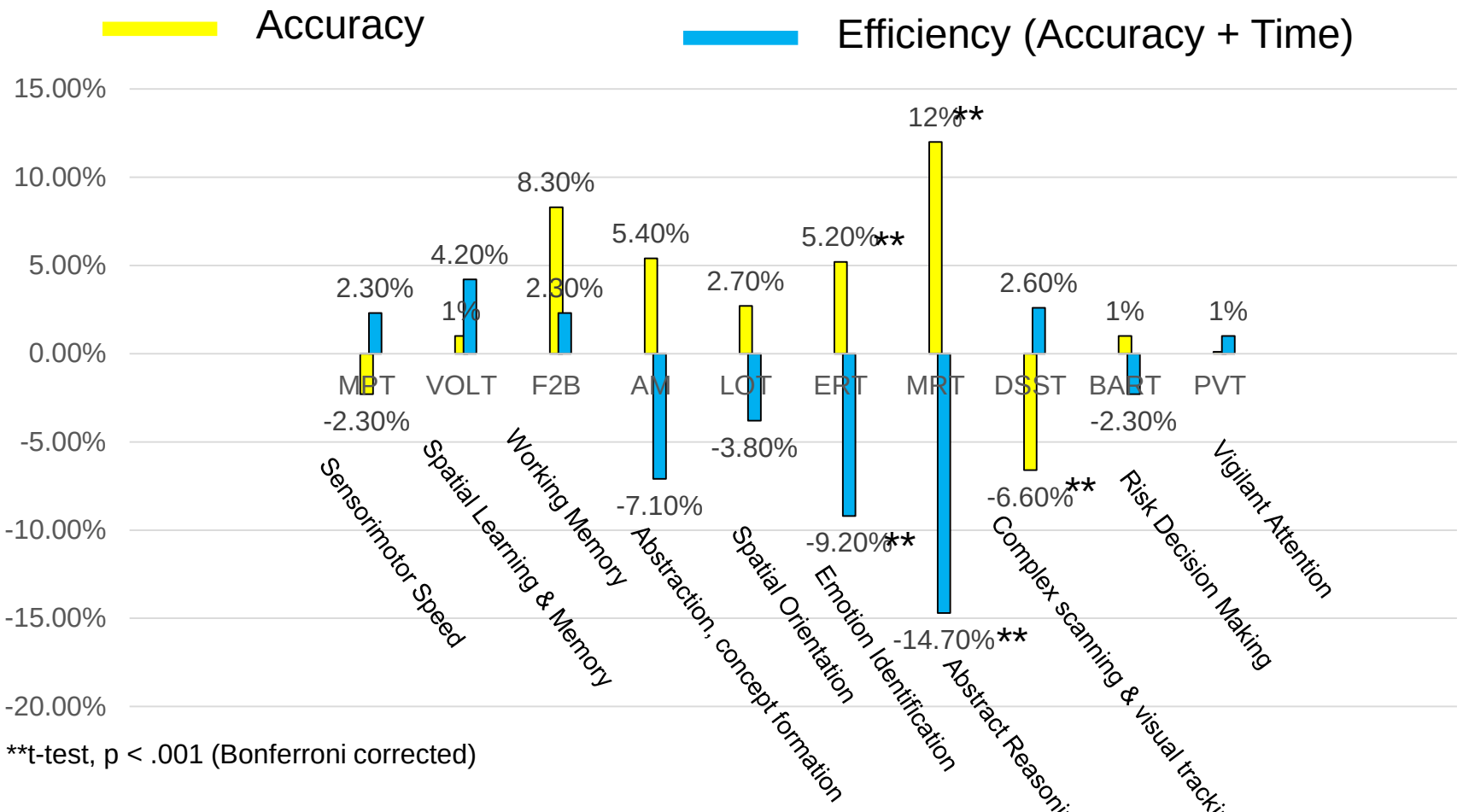
# WinSCAT: 90 Day Pre-Post % Change




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)

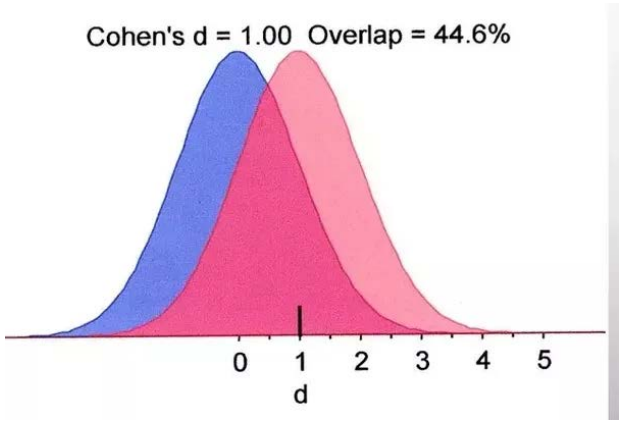
Motor Praxis (MP), Visual Object Learning (VOLT), Fractal 2-Back (F2B), Abstract Matching (AM), Line Orientation (LOT), Emotion Recognition (ERT), Matrix Reasoning (MRT), Digit Symbol Substitution (DSST), Balloon Analog Risk (BART), Psychomotor Vigilance (PVT)

# 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

# Acknowledgments

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