Human Systems Integration at NASA Ames Research Center

Jeffrey McCandless, Ph.D.
Deputy Division Chief
Human Systems Integration Division
NASA Ames Research Center
Moffett Field, California

September 15, 2017

University of California, Berkeley
29th Annual Bay Area Vision Research Day (BAVRD)
SOVIET FIRES EARTH SATELLITE INTO SPACE;
IT IS CIRCLING THE GLOBE AT 18,000 M. P. H.;
SPHERE TRACKED IN 4 CROSSINGS OVER U. S.

HOFFA IS ELECTED TEAMSTERS' HEAD;
WARNOS OF BATTLE
Defeats Two Forks 2 to 1
— Says Union Will Fight 'With Every Ounce'

Course Recorded
Navy Picks Up Radio Signals—4 Report
Sighting Device

Source: columbia.edu
1958: National Aeronautics and Space Administration
1961: First man in space

Source: appel.nasa.gov
1961: First man in space

1963: First woman in space
1961: First man in space

1963: First woman in space

1965: First spacewalk

Source: appel.nasa.gov
Source: blogs.nasa.gov
Source: history.nasa.gov
1961: First man in space

1963: First woman in space

1965: First spacewalk

1969: First astronauts on moon
Today: International Space Station

Source: nasa.gov
Overview of NASA

Currently: 10 centers plus headquarters

Source: https://nasajobs.nasa.gov/images/map_notitle.gif
Overview of Ames Research Center

Photo credit: Jeffrey McCandless
Overview of Ames Research Center

Photo credit: Jeffrey McCandless
Overview of Ames Research Center

Photo credit: NASA

Hangar 1

Photo credit: Jeffrey McCandless
Overview of Ames Research Center

Photo credit: Jeffrey McCandless
Overview of Ames Research Center

80x120 foot wind tunnel

Photo credit: Jeffrey McCandless

Photo credit: NASA
Overview of Ames Research Center

Arc Jets

Photo credit: Jeffrey McCandless
Overview of Ames Research Center

Arc Jets

Photo credit: Jeffrey McCandless
Overview of Ames Research Center

Photo credit: Jeffrey McCandless
Overview of Ames Research Center

Human Systems Integration Division

Photo credit: NASA

Photo credit: Jeffrey McCandless
Overview of the Human Systems Integration Division

• Over 120 members
• 15 labs in areas such as:
  – Airspace Operations
  – Fatigue Countermeasures
  – Human Computer Interaction
  – Psychophysiological Research
  – Vision Research
Samples of Vision Research
Influence of Vibration and Acceleration on Visual Performance
(led by Dr. Bernard D. Adelstein)

Space Shuttle
• 3 G acceleration
• ±0.1 g vibration

Credit: NASA
Influence of Vibration and Acceleration on Visual Performance
(led by Dr. Bernard D. Adelstein)

Space Shuttle
• 3 G acceleration
• ±0.1 g vibration

Proposed Ares I rocket
• 3.8 G acceleration
• ±0.7 g vibration
  (12 Hz, 2.5 mm peak to peak)
Influence of Vibration and Acceleration on Visual Performance

Space Shuttle cockpit

Astronauts acquire information from the myriad of interfaces to make decisions.
Influence of Vibration and Acceleration on Visual Performance

29 foot radius centrifuge with 20 revolutions per minute
(to achieve 3.8 G acceleration)
Influence of Vibration and Acceleration on Visual Performance

29 foot radius centrifuge with 20 revolutions per minute (to achieve 3.8 G acceleration)
Influence of Vibration and Acceleration on Visual Performance
Influence of Vibration and Acceleration on Visual Performance

**Task**
1. Visually acquire the relevant information.
2. Make an eye movement to the cell.
3. Select a target string of three digits.
4. Read the digits in the target.
5. Make a two-alternative forced choice: “yes” if a monotonic sequence, “no” if not a monotonic sequence.
6. Press one of two response buttons.

**Independent variables**
1. Font size (10 and 14 point)
2. Vibration level

**Participants**
general population and crew
Influence of Vibration and Acceleration on Visual Performance
Influence of Vibration and Acceleration on Visual Performance
Influence of Vibration and Acceleration on Visual Performance

Strobing Countermeasure
Influence of Vibration and Acceleration on Visual Performance

Strobing Countermeasure
Influence of Vibration and Acceleration on Visual Performance

Strobing Countermeasure

Display was strobed in time with the vibrating chair.

Display strobing was an effective compensating technique for reducing reading errors in this study.

Patent 8,711,462 awarded in 2014.

Comprehensive Oculometric Behavioral Response Assessment (COBRA) (led by Dr. Lee Stone)

The goal is to assess neural impairment using a short (15 minute) oculometric assessment.

Impairment in visual processing and pursuit tracking can result from many causes (e.g., cortical lesions, brainstem damage).
Comprehensive Oculometric Behavioral Response Assessment (COBRA)

Scientists have investigated the association between oculometrics and nervous system disorders for decades.

The Dodge Photochronograph, 1908
Comprehensive Oculometric Behavioral Response Assessment (COBRA)

- Target speed: 16, 18, 20, 22 or 24 deg/sec.
- Target direction: 0° to 358° on the fronto-parallel plane in 2° increments.
- 180 trials
- Display: LCD high-definition monitor at 144Hz
- Eye Tracker: ISCAN video-based tracker at 240 Hz
Comprehensive Oculometric Behavioral Response Assessment (COBRA)

10 measures

**Pursuit Initiation**
1. Latency of pursuit initiation
2. Open-loop pursuit acceleration

**Steady state tracking**
3. Gain (ratio of eye velocity to target velocity along stimulus direction)
4. Catch-up saccade amplitude
5. Proportion of the response consisting of smooth movement
   (ratio of pursuit eye displacement to total eye displacement)

**Direction tuning**
6. Oblique effect amplitude
7. Horizontal-vertical asymmetry
8. Directional noise

**Speed tuning**
9. Speed responsiveness
10. Speed noise
Comprehensive Oculometric Behavioral Response Assessment (COBRA)

Results across 41 subjects

**Initiation**
- Median latency: 180 ms
- Median acceleration: $124 \text{ deg/s}^2$

**Steady-state tracking**
- Gain: 0.82
- Saccade amplitude: 2.31
- Proportion smooth: 67%

**Direction-tuning**
- Vertical-horizontal asymmetry: 0.10
- Cardinal-oblique anisotropy: 0.37
- Noise: 8.66°

**Speed-tuning**
- Slope: 0.55
- Noise: 3.43 deg/s
Example of Potential Benefit: Assessment of Traumatic Brain Injury

Compute a “TBI Impairment Index” based on z-scores for 34 TBI patients (red) and 41 control subjects (green).
Comprehensive Oculometric Behavioral Response Assessment (COBRA)

Summary

- It requires only about 15 minutes.
- This approach may be a useful quantitative screening test for pathological states.
- Specific deficits may show characteristic patterns across different metrics.
  - Example: Degenerative retinal disease may show prolonged pursuit latency but unimpaired steady-state tracking.
  - Example: Schizophrenia may show normal pursuit latency but low open-loop acceleration.
- Multidimensionality provides a relatively high overall sensitivity.


More Information

Ames Human Systems Integration Division: http://hsi.arc.nasa.gov

Ames Visitor Center: http://www.nasa.gov/ames/visitorcenter.html

Credit: NASA Ames