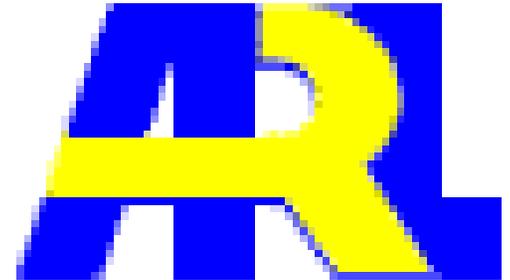
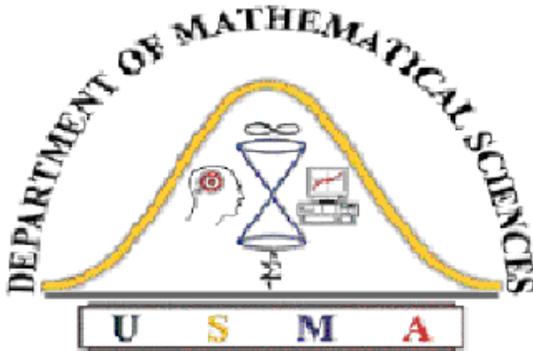


“The Effects of Fatigue on Position Determination and Cognitive Workload Using a Visual and 3-Dimensional Auditory Display ”



Eric L. Brown
Captain, US Army

Advisors: Dr. Nita Lewis Miller, LTC Eugene P. Paulo, USA



Take-Away (Army Future Forces)



- Both the primary task of land navigation and secondary task of enemy detections were negatively impacted by sleep deprivation.
- When both the primary and secondary task competed for the same sensory resources the secondary task degraded more significantly with increased sleep deprivation.
- It is critical that system designers do not overburden the soldiers by developing system that operate contrary to the human sensory system.
- It is essential that the HMD for OFW is designed and functions to counterbalance the effects of channel overload in order to achieve optimal performance.
- Military leadership must be educated on the possible negative ramifications of exposing their soldiers to HMDs in a sustained operational environment.



Outline



- Purpose of Analysis
- Background
- Types of Helmet Mounted Displays
- Methodology
- Analysis
- Recommendations





Purpose of This Analysis



Evaluate the following effects on the soldiers performance:

- HMD Modality (Visual vs. 3-D Auditory)
- Continuous Sleep Deprivation
- Stress
- Mood
- Workload

Primary Research Questions

- How does sleep deprivation affect primary soldier performance (land navigation) while operating in a HMD environment?
- How does sleep deprivation affect soldier secondary task performance (enemy detections) while operating in a HMD environment?
- Are there differences in soldier performance, mood and subjective workload when comparing visual versus 3-D auditory display of information over a 48 hour period of total sleep deprivation?



Background



Modernizing the Warrior through Army Transformation:

Land Warrior (LW) is the Army's flagship Science and Technology initiative to develop and demonstrate revolutionary capabilities for Future Force soldier systems. An integrated system of systems approach is being employed to support the Army transformation to a soldier-centric force. The Future Force Warrior is a major pillar of the Future Force strategy, complementing the Future Combat Systems (FCS) program.

*A Formidable Warrior
in an Invincible Team,
able to See First,
Understand First, Act
First, & Finish
Decisively.*





Why Land Warrior ?



- A Close Combat Fighting System Optimizing Squad, Platoon, Company Organizations

I know where I am
I know where my buddies are
I know where we need to be

SEE FIRST

I see the enemy situation
I understand what's developing

UNDERSTAND FIRST

We choose the fight
- Right place
- Right time
- Synchronized

ACT FIRST

My unit dominates the fight
We retain the initiative

STRIKE DECISIVELY

An Integrated Fighting System...



Issued to Combat Soldiers...
Designed For the Close Fight...



Lethal Small Units!

Land Warrior is About Increased Combat Power, Lethality, Survivability & Tactical Awareness

REQUIREMENTS STATUS

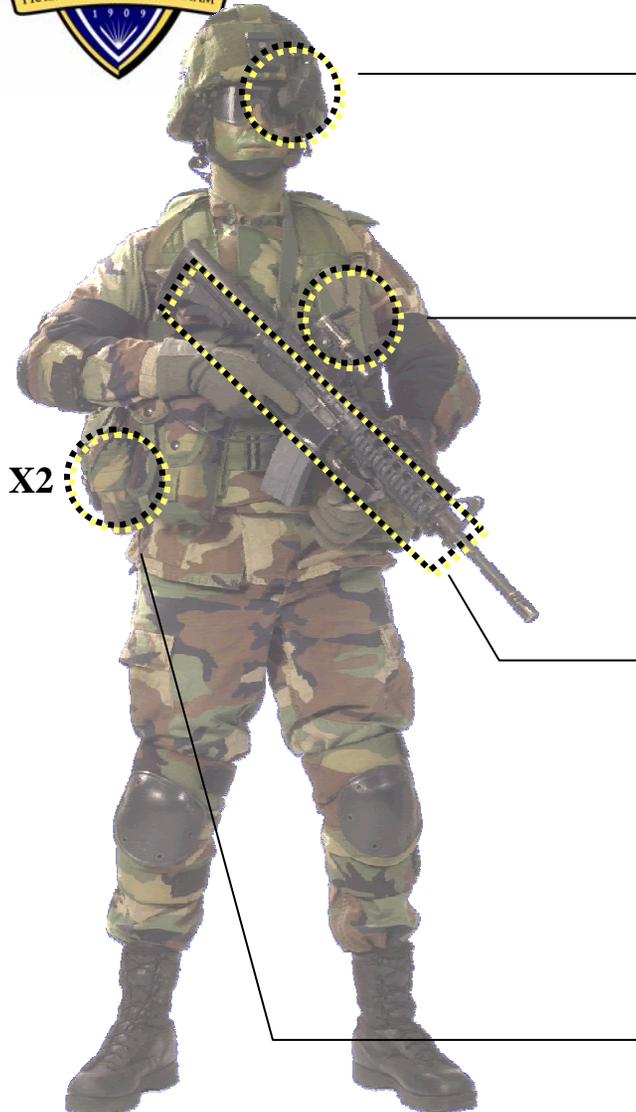
MNS	DCSOPS Sep 93
O&O	TRADOC Oct 01
ORD	HQDA May 02

CRITICS

- Weight (Soldier Load)
- Tactical Internet (Security)
- Sustainment (Power)



Land Warrior System



Helmet Subsystem

- Soldier Color Display / Audio Headset & Microphone
- Provides Soldier a common operational picture

Soldier Control Unit

- Soldier's device to control system & establish tactical identity
- Communications processor
- Single component to manage LW functions

Weapon Subsystem

- Tailored to integrate multiple systems
 - Thermal sights / Multi-functional Laser / Day Video Sight / Alternate user input device
- Soldier is focused on killing enemy

System Power

- One on each side of soldier
- Rechargeable or disposable batteries



Land Warrior System



Communications Subsystem

- Soldier “mesh” intercom antenna / Leader radio / Radio Antenna / power amplification /
- Embedded soldier communication with additional radio for leader longer range communications

Computer Subsystem

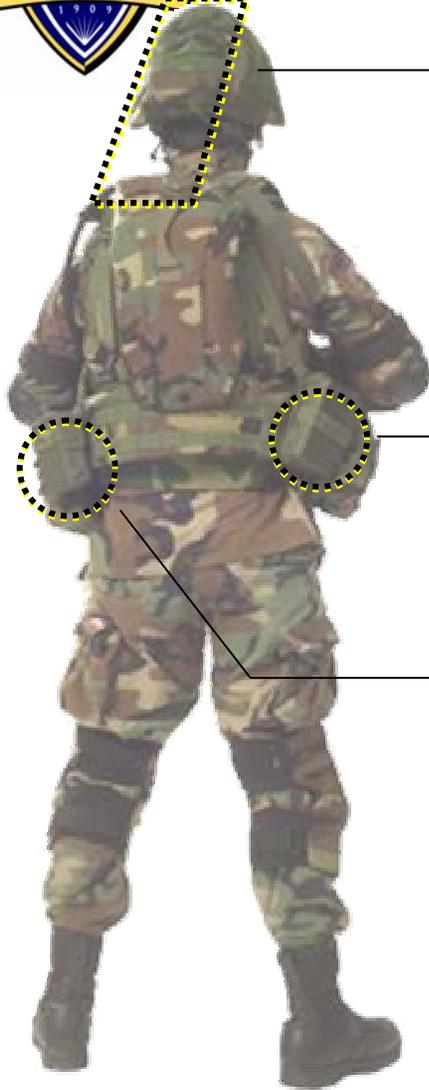
- Manages input, processing and output functions
- Stores manuals
- Stores standard map products

Navigation Subsystem

- Provides soldier position and heading on standard map products
- Utilizes dead reckoning module when GPS signal not present
- Soldier knows his location, know his teams location, maneuvers and shoots more effectively

Soldier Equipment

- Integrates soldier equipment improvements such as JSLIST / Interceptor Body Armor





Helmet Mounted Displays



- Advantages/Disadvantages
 - SA and ability to see and avoid obstacles at night are enhanced
 - HMD with enhanced imagery can improve TA/ TI, avoiding tactical threat and enhance safety
 - Limit Field of View (FOV)
 - Information overload and clutter
- Monocular HMDs
 - Displays single image source to one eye
 - Optical alignment relatively uncomplicated
 - Binocular Suppression
- Dual Ocular HMDs
 - Displays image source to both eyes
 - More closely resemble human visual system
 - System redundancy increases weight
- Auditory HMDs
 - Increase awareness of surrounding/ cue visual attention
 - Prevents overload of visual channel
 - Enhance the FOV of HMD

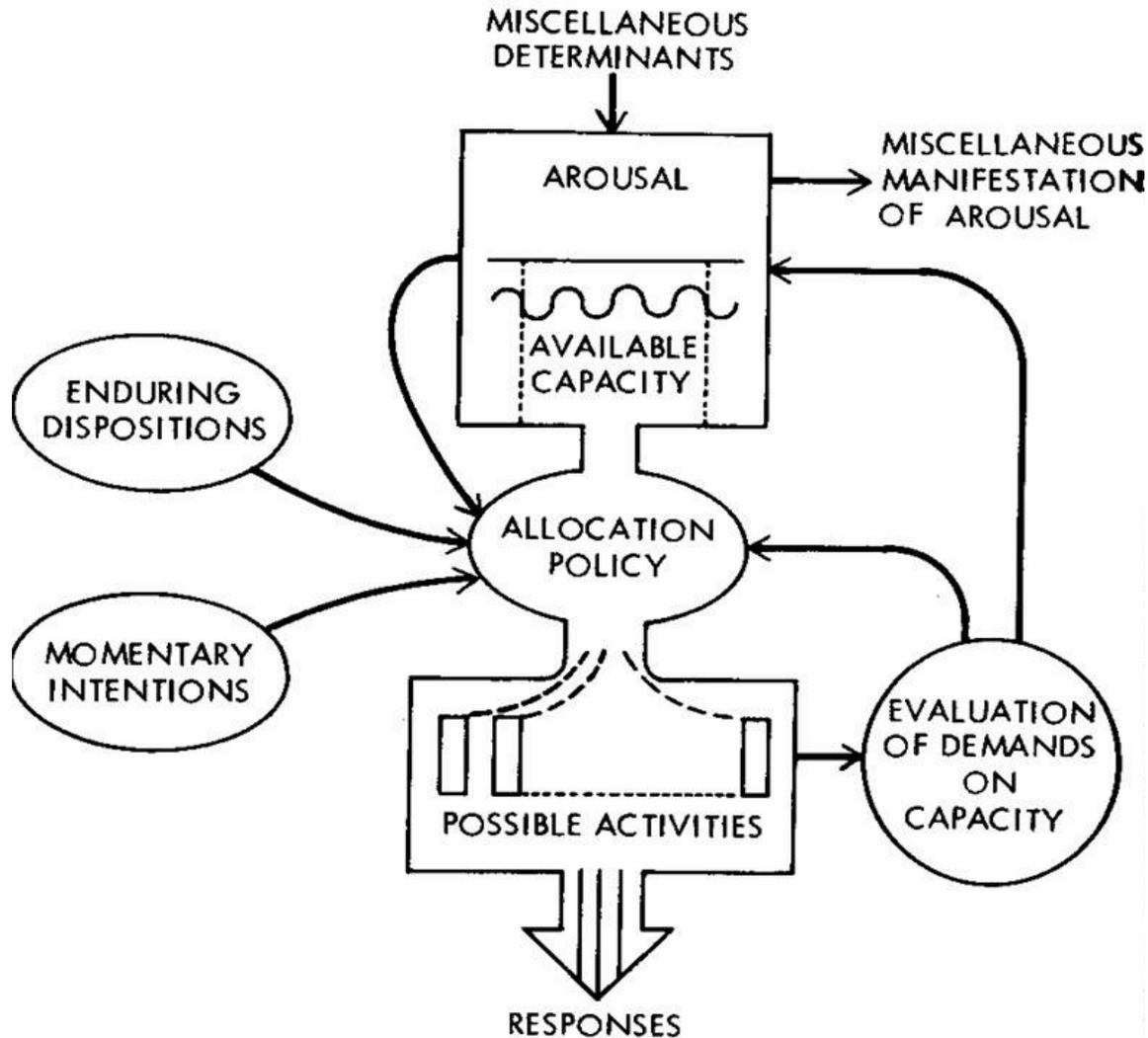


Cognitive Readiness



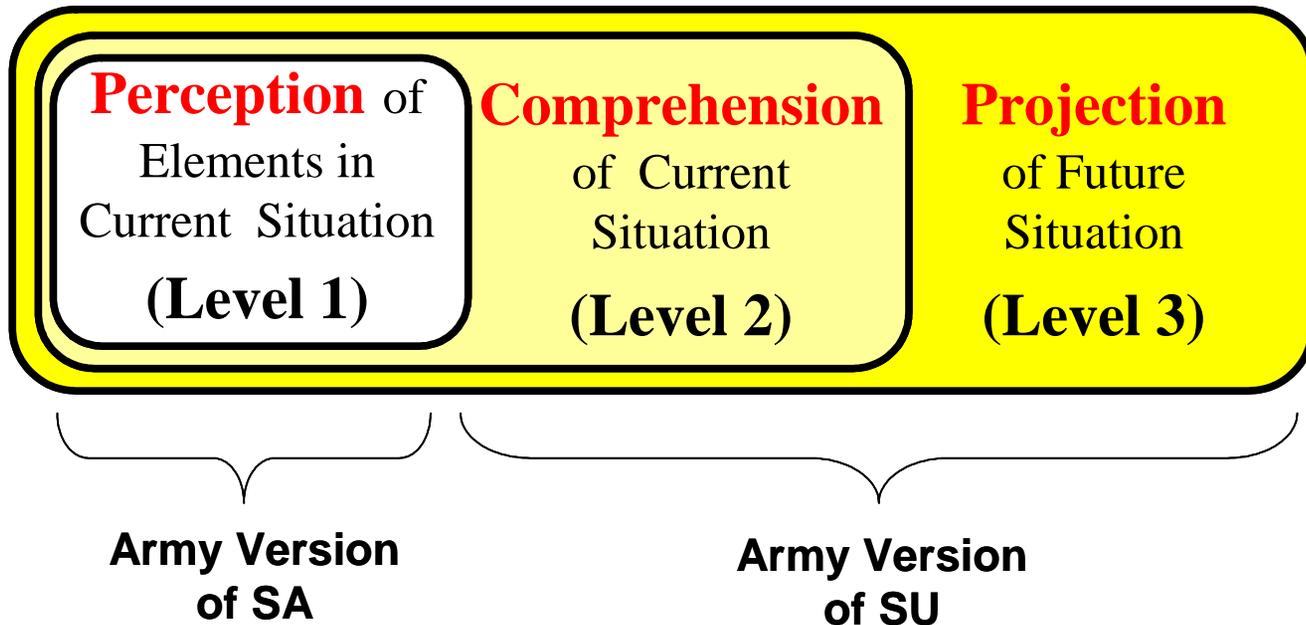
- A measure of a system's effects on the warfighter's capability to perform mental functions contributing to optimal performance.
 - Unitary Resource Model of Attention (Kahneman, 1973)
 - Multiple Resource Model (Wickens, 1984)
 - Situation Awareness Model (Endsley, 1988)

Unitary Resource Model of Attention

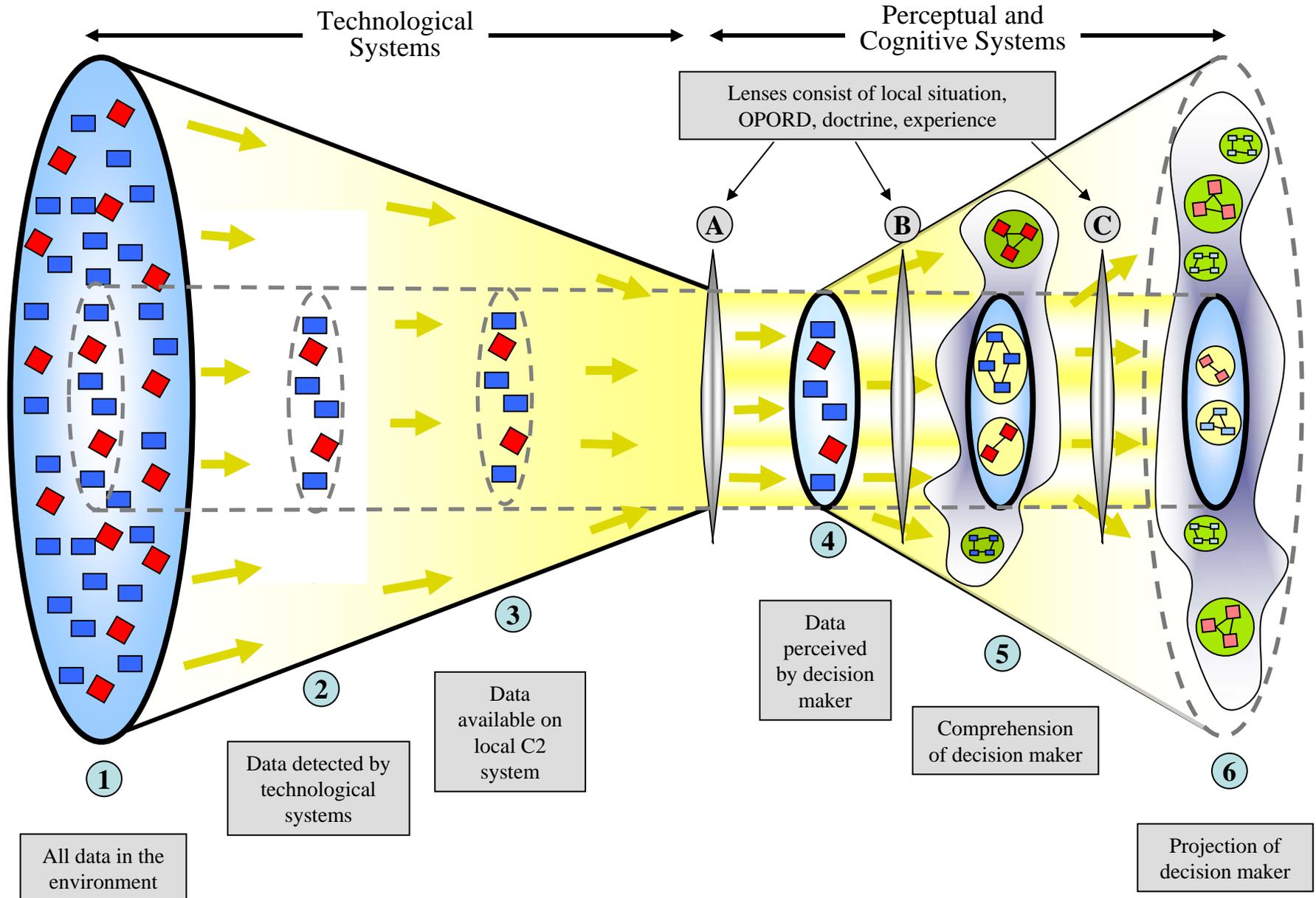


Situation Awareness

Scientific Definition: Situation Awareness is the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and their status in the near future (Endsley, 1988)



Dynamic Model of Situated Cognition





Methodology



- Subjects:
 - 12 Marines (average sample age 26.6)
 - MOS,0311 equivalent 11B Dismounted Infantry Soldier
- Equipment and Test for Collection Performance Data:
 - Trekker System (Monocular Display) developed by Rockwell Intl
 - Integrated Headgear Assemble Subsystem (IHAS) developed by Electro Voice
 - Data Display and Capture (DASHER II) by Sytronic, Inc.
 - Multiple Affect Adjective Check List-Revised (MAACL-R)
 - Stress: Subjective Stress Scale
 - Workload: NASA-TLX

Trekker- Monocular Display





Methodology



- Experimental Design:
 - 12 participants were divided into two groups of six individual and were trained and tested over a on week period.
 - Prescreening was performed and baseline measures obtained on the first day.
 - Duration of training was two days: one day of training in each of the two display modalities.
 - All participants executed required task during training days on practice course that would be demand during actual testing.
 - Instruction and familiarization of all psychological questionnaires.
 - Repeated measures design with display modality (visual and 3-D Auditory).
 - Two - 24 hour periods (total sleep loss) 12- 4 hour session within subject effects.
 - For each participant there is a two-hour separation from the presentation of one display condition to the next.
 - Dependent variables include navigation performance (Navigation Time) and performance on the secondary task (number of enemy correctly detected).
 - Dependent variables for psychological data includes stress response levels (anxiety, depression, hostility, and workload).

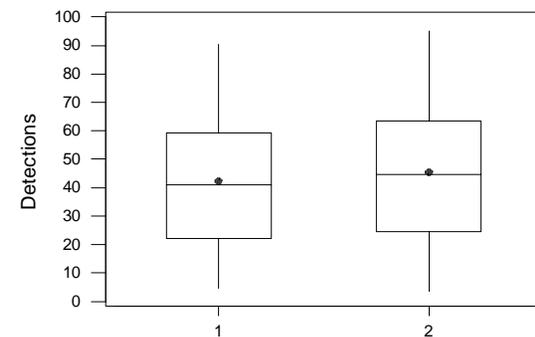


Analysis



- Focus: Warfighter's Performance, comparing two different helmet-mounted display modes (visual and 3-D auditory) over a 48-hour period in which participants are totally sleep deprived.
 - Analysis confirmed previous studies that there was significant difference in navigation time between the two modalities.
 - A two sample t-test ($p=.434$) revealed that there was no significant difference in the performance of the secondary task of enemy detection between the modalities

Box Plot HMD Modality vs. Detections



1- Visual
2- Auditory



Analysis



Primary Task

Navigation time with Increasing Levels of Sleep Deprivation

- One-way ANOVA test revealed significant difference in the average navigation time for at least one time period
- Primary task performance varied with increased sleep deprivation but declined over the course of the entire experiment.
- Performance in both the modalities are oscillates in the first 24 hours with less variance in later stages of the study.
- The modalities degraded performance oscillates opposite of one another indicating during different stages of the day one sensory system may seem compensate for the other to being over tasked.
- Increased sleep deprivation seems to have less effect of the performance of the primary task in the auditory mode in late stage of the experiment.

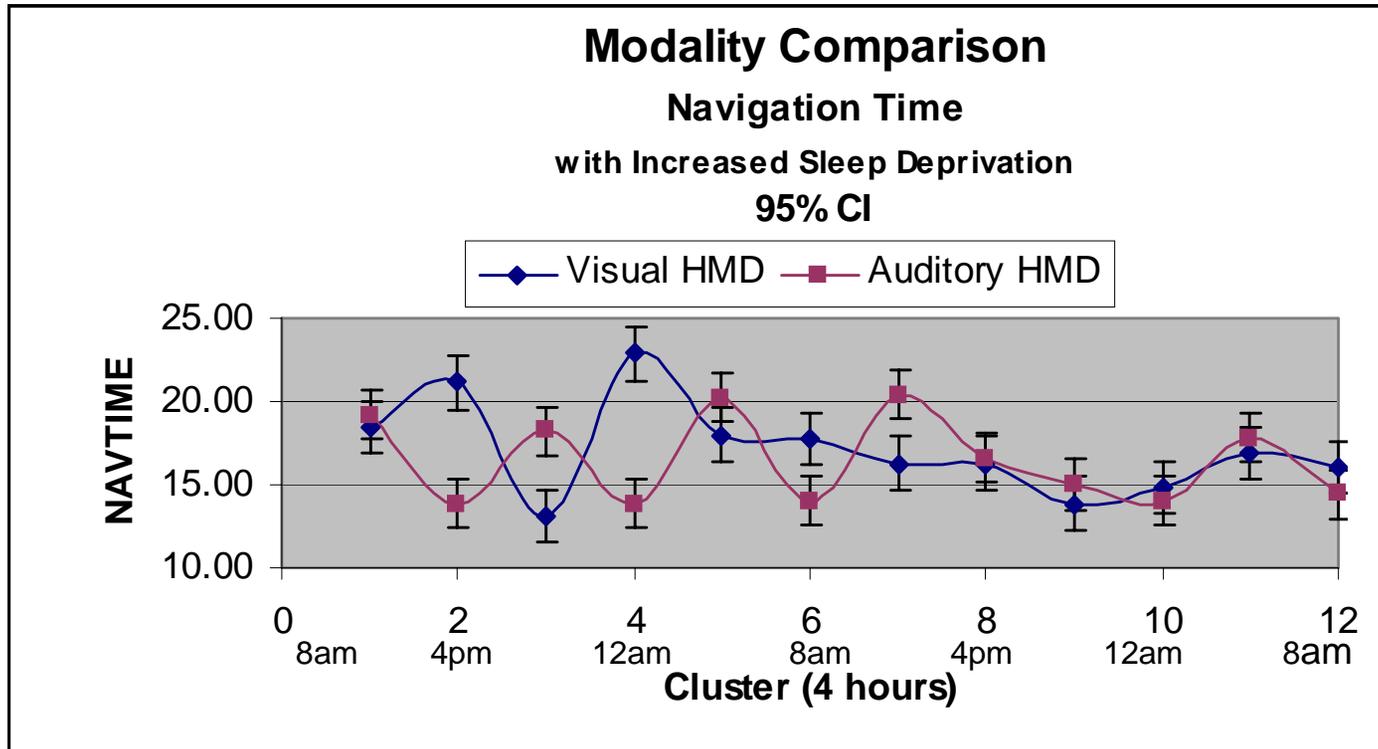


Analysis



Primary Task

Navigation time with Increasing Levels of Sleep Deprivation





Analysis



Secondary Task

Enemy Detections with Increasing Levels of Sleep Deprivation

- One-way ANOVA test revealed significant difference in the average enemy detections for at least one time period
- When subjects are sleep deprived for 40 hours, detections continuously decrease reaching a degraded performance level of 17 fewer detections from the peak detection rate on day 1.
- Detection rate was less impacted during later stages in the auditory mode than in visual which could be contributed to simultaneous tasking of the visual sensory system of navigation and enemy detection results in less detections.

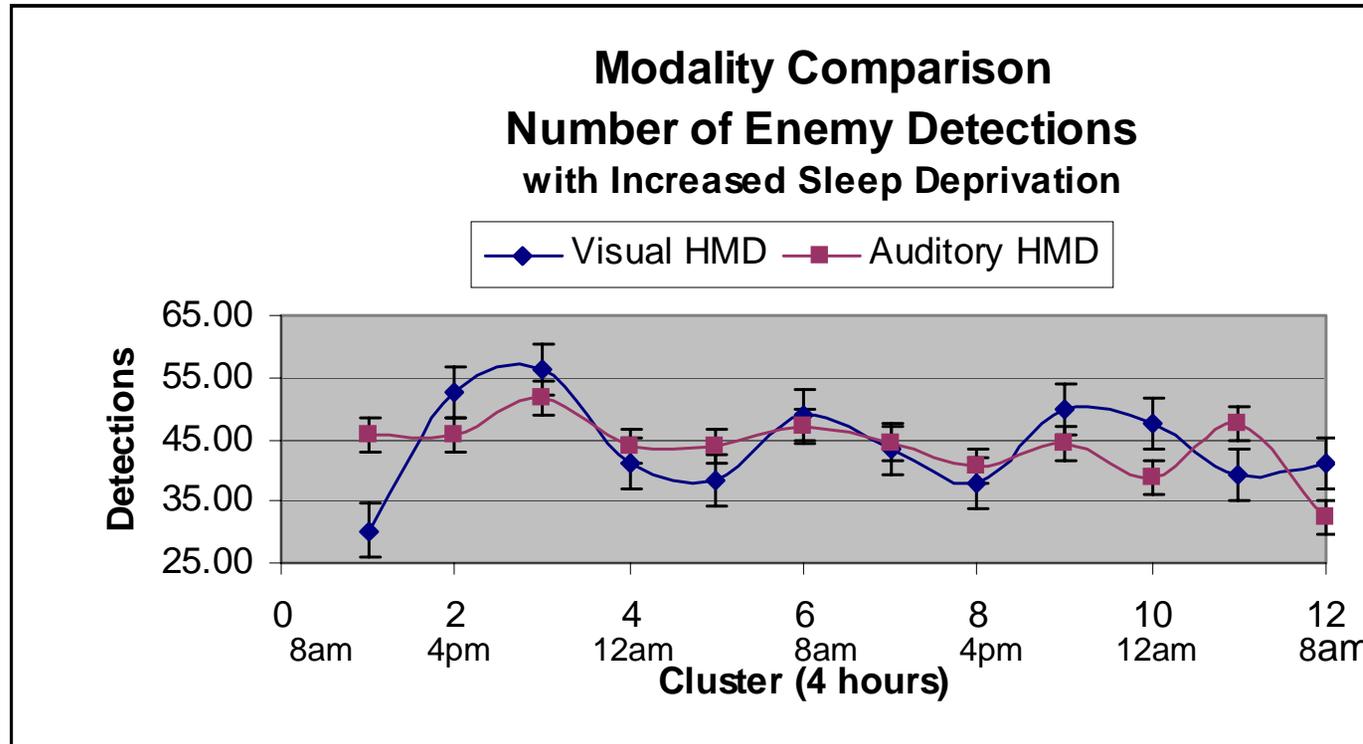


Analysis



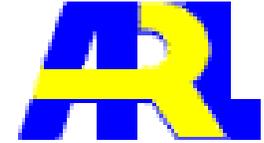
Secondary Task

Enemy Detections with Increasing Levels of Sleep Deprivation



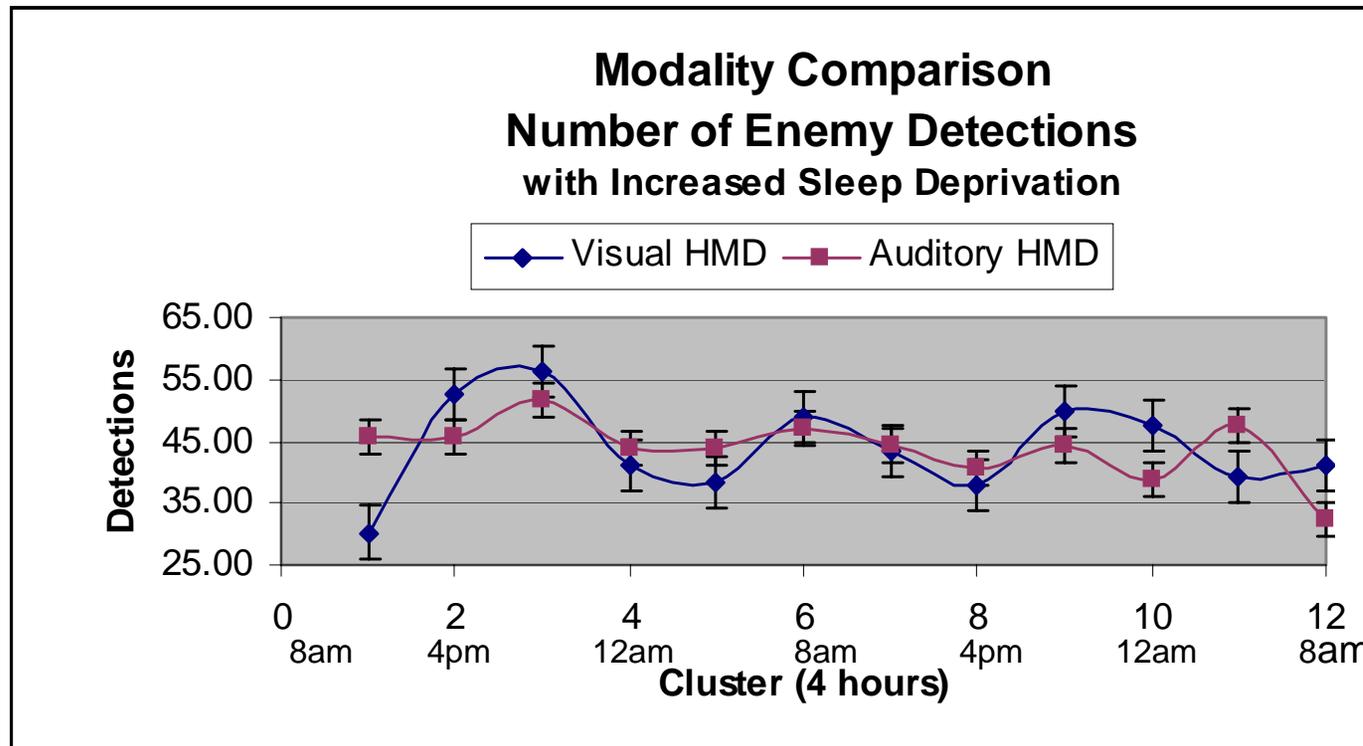


Analysis



Psychological Effects

Workload Effects with Increasing Levels of Sleep Deprivation





Recommendations



- Baseline performance for all participants in both visual and auditory modes is essential to any future study.
- The inclusion of a fully rested control group would significantly strengthen the design of study.
- More frequent measurements of performance, between group analysis to allow for time series analysis.
- Dedicated groups should be assigned to perform either auditory or visual modes (between group design to eliminate the confusion of modality with sleep deprivation and enable researchers to differentiate between these two potentially confounding factors).



Take-Away (Army Future Forces)



- Both the primary task of land navigation and secondary task of enemy detections were negatively impacted by sleep deprivation.
- When both the primary and secondary task competed for the same sensory resources the secondary task degraded more significantly with increased sleep deprivation.
- It is critical that system designers do not overburden the soldiers by developing system that operate contrary to the human sensory system.
- It is essential that the HMD for OFW is designed and functions to counterbalance the effects of channel overload in order to achieve optimal performance.
- Military leadership must be educated on the possible negative ramifications of exposing their soldiers to HMDs in a sustained operational environment.



Questions