U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMY RESEARCH LABORATORY

Cognition and Neuroergonomics (CaN) Collaborative Technology Alliance (CTA)

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PROGRAM SUMMARY

Objectives:
Develop and demonstrate governing principles for the application of neuroscience-based research and theory to complex operational settings. Integrate neuroscience, engineering, psychology, and human factors approaches to revolutionize Soldier-system performance.

Program Provides:
- Advanced computational approaches and tools to investigate mind-body relationships in real-world scenarios
- Research on capabilities that augment existing, intact, physical and mental capabilities in healthy populations
- Research on fundamental neuroscience principles in naturalistic settings

Warfighter Payoff:
- Human system interfaces optimized to an individual’s characteristics
- Information systems designed to enable faster, more efficient decision making
- Soldier-systems designed for safer, more efficient and sustainable operations

Lin et al. (2016) Scientific Reports

Cognition and Neuroergonomics (CaN) Collaborative Technology Alliance (CTA)
http://www.cancta.net
OBJECTIVE

The development and demonstration of fundamental translational principles governing the application of neuroscience-based research and theory to complex operational settings.

Enable revolutionary advances in Soldier-System performance by integrating modern neuroscience with human factors, psychology and engineering to enhance our understanding of Soldier function and behavior in complex operational settings.

Technical Areas*

Advanced Computational Approaches (ACA):

Real World Neuroimaging (RWN):

Brain Computer Interaction (BCI):

* Reorganized in PY4
SCIENTIFIC ORGANIZATION

Advanced Computational Approaches (ACA):
What is the optimal way to decode, track, and fuse neural and non-neural sources of information to infer state?

Real World Neuroimaging (RWN):
How does the brain function in the real-world, outside the constraints of the lab?

Brain Computer Interaction (BCI):
How do we use neural signals to improve human interactions with computers, autonomous agents, their environment, and even other humans?

Key Crosscutting Goal: Continuous and robust estimate of cognitive state in complex tasks and real-world environments
RESEARCH TOPICS

ACA
- Cognitive State Identification
- Neural Sources
- Structural Connectivity
- Functional Connectivity
- Non-stationarity
- Uncertainty Estimation
- Decision Making
- Individual Differences

BCI
- Human-Agent Systems
- Temporal Variability
- Mutually Adaptive Systems
- Closed-loop / Feedback
- Robust Classification
- Machine Learning
- Calibration-free Methods

RWN
- Complex Tasks
- Ambulatory Environments
- Stress / Fatigue
- Social Influences
- Signal Quality / Artifact Mitigation
- Real-time Processing
- Validation Methods
- Big-data Analytics
STRATEGIC ALIGNMENT

Essential Research Programs

Human-Agent Teaming

Accelerated Learning for a Ready Force

Artificial Intelligence & Machine Learning

INFORMS*

* Information for Mixed Squads
SCIENTIFIC IMPACT

A Mind-Wandering Tends to Occur under Low Perceptual Demands during Driving


Driving under low demand conditions participants exhibited greater network outflow from the posterior cingulate cortex vs. driving under high demand conditions, during which participants exhibited greater network outflow from the midcingulate cortex.

Induction and separation of motion artifacts in EEG data using a mobile phantom head device


Novel methods for inducing quantifiable, realistic motion artifacts in EEG and providing the first empirical evidence for ability to separate simulated brain activity from these artifacts.
Brain connectivity dynamics during social interaction reflect social network structure


Identified increased cohesiveness in mentalizing brain networks during social exclusion revealed individual differences in brain dynamics associated with the density of participants’ friendship networks from social media.

Applications of Community Detection Techniques to Brain Graphs: Algorithmic Considerations and Implications for Neural Function


A review on how network science tools provide interpretive power and a framework to understand how neural units cluster into densely interconnected groups that are responsible for perception, action, and adaptive behaviors.
Subjects, Systems, Sessions: to what extent do these factors influence EEG data?


Utilizing a variety of standard laboratory tasks, this study revealed that EEG acquisition hardware system contributes to the overall signal variance as much as inter-subject differences and within-subject fluctuations over time.

Cortically Coupled Computing: A New Paradigm for Synergistic Human-Machine Interaction


Defines a new paradigm for human-computer interaction, cortically-coupled computing, and describes several proof-of-concept technologies that demonstrate this paradigm.
The Consumer Electronics Association (CEA), an ANSI-accredited standards developer, has formed a Working Group to standardize consumer EEG event description, metadata encapsulation, data transmission and storage.

Lab Streaming Layer (LSL), a system for the unified collection of measurement time series with millisecond-level synchronization, is being adopted by a growing number of commercial developers and vendors of human sensing technologies.
Technology: novel machine learning algorithms and real-time architecture that exploit neurophysiological data to understand human situational awareness.

Key Technical Demonstration: Identifying human interest in dynamic environments

- 1st Place in international EEG data challenge to detect brain signals related to human interest (NAILS Task)
- Proof-of-Concept demonstration of AI that detects human interest in unstructured environments (HID)

Enhancing situational awareness through improved insight into Soldier’s cognition

Key Publications:
Solon, et al (Submitted). Deep Learning Approaches for P300 Classification in Image Triage: Applications to the NAILS Task
Gordon et al. (2017). Human Interest Detector (HID), video demonstration

Potential:
- Algorithms that provide insights and prediction of human actions, intentions, goals, and general reasoning
- Novel technologies that improve human-AI integration by exploiting individual characteristics
- Detecting high level and potential sub-conscious cognitive constructs (e.g., danger) and social intuition w/o burdening Soldier
TECHNOLOGY TRANSITION

Technology: Novel methods & materials for testing and validating new biosensing devices and algorithms

Key Technical Demonstration:
Developed new methods and devices for providing missing “ground truth” necessary for T&E of previously unproven neuro-sensing hardware and cleaning algorithms

Potential:
• Provide key verification of sensor and system efficacy early in developmental pathway
• Enable additional applied research for real-world Soldier biosensing
• Enable game-changing research on cognitive fluctuations in real-world scenarios

Enabling (missing) validation of EEG equipment efficacy

Example Press:
MedGadget
https://www.army.mil/article/158604/phantom_head_may_one_day_take_guesswork_out_of_eeg_monitoring

IdeaConnection