# Contextualizing Cognitive State & Event Detection for Human-Autonomy Integration

dcs corp

## Using Physiological & Behavioral Information

# Background

- Cognitive State and Event Detection (CSED) has potential to greatly enhance human-autonomy integration

- Investigated by previous and ongoing programs:
  - Augmented Cognition (AugCog)
  - High-Def. Cognition (HD Cog)
  - Cognition and Neuroergonomics Collaborative Technology Alliance (CaN CTA)
  - Autonomous Research Pilot Initiative (ARPI)

*Improving system design process*

*Continuously monitoring user states*

Alert! Overloaded Fatigued Distracted

*Spurring new technological development*

# Barriers to CSED

- Numerous challenges including
  - Complexity of the signals involved
  - Hardware limitations (e.g. resolution & reliability)
  - Software limitations (e.g. offline vs. online processing)

- Many CSED research paradigms lack critical contextual information needed to facilitate proper function in complex environments

- Brain function is situated

# Critical Need (1): Hardware

- How to measure variables for both CSED & context?
  - Brain measures
    - Electroencephalogram (EEG) & functional Near-Infrared spectroscopy (fNIR)
  - Physiology & behavior
    - Pupillometry, eye tracking, electrodermal activity
    - Heart rate, respiration, motion capture
  - Environmental sensors
    - Ambient light, temp., background noise, scene capture

*Low*     Technology Readiness     *High*

*High*     Proximity to Cognitive Function     *Low*

# Integrating Context (1): Hardware

- Lightweight & portable hardware solutions are needed
- Sensor integration & timing is a critical issue

*Current state-of-the-art*

*Research prototype*



MINDO Dry Electrode System

Android-based Mobile Device

Affectiva Q Sensor

Zephyr Bioharness

Adapted from McDowell et al., *IEEE Access*, 2013.
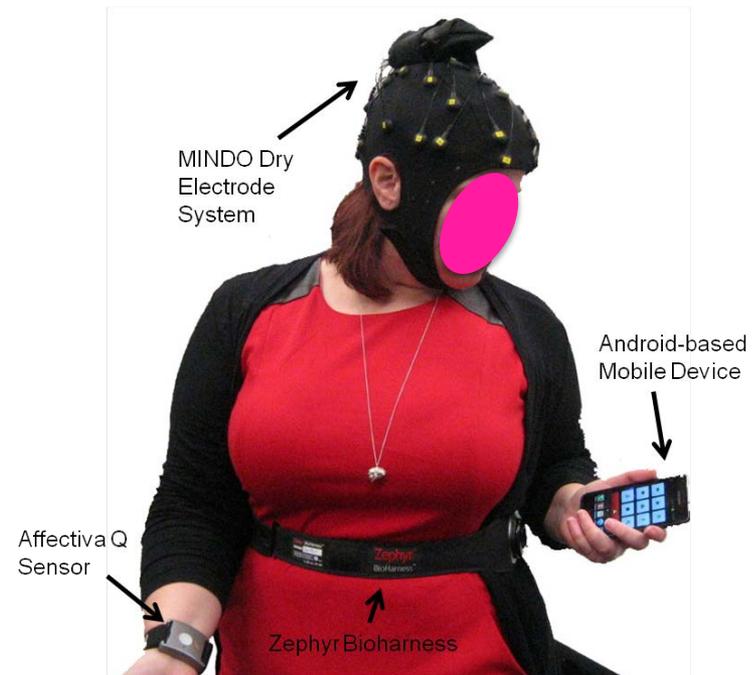
# Critical Need (2): Software

- Most current work on classifying brain activity is in the area of brain-computer interfaces (BCI)
  - Limited settings
  - Primarily to restore impaired function
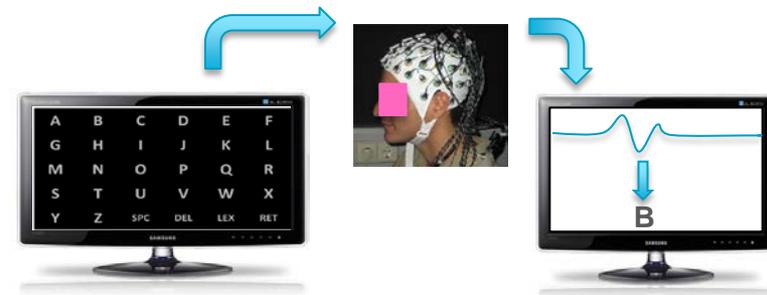


- Ambiguity of complex scenarios places high burden on CSED systems
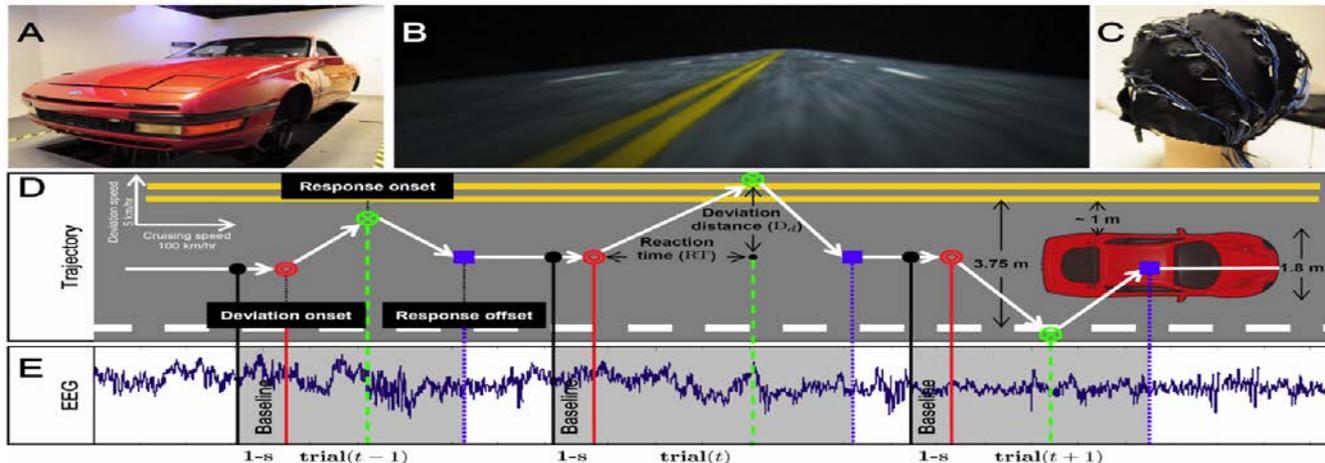
# Integrating Context (2): Software

- Integrating behavioral context not only helps model signal quality but can also provide information about the timing and trajectory of cognitive states & events

Target Appears
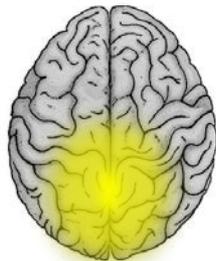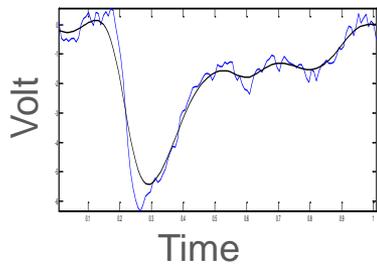
Shift Attention

Report

# Current Work: Software
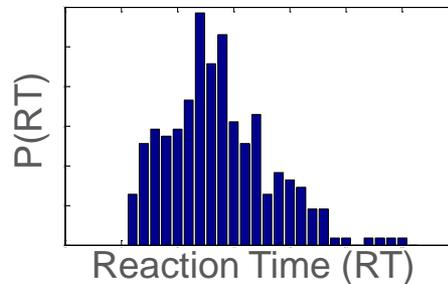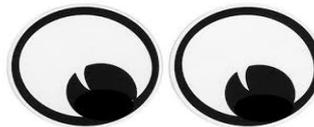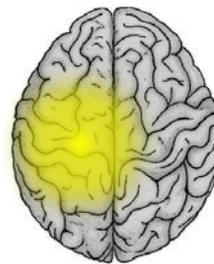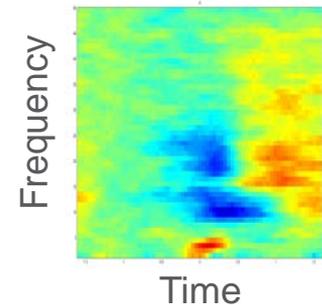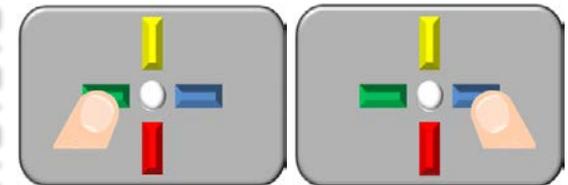
- Integration through advanced computational methods
  - Statistical approaches
    - Hierarchical discriminative components analysis, regularized generalized linear models, power-based methods
  - Fuzzy evidence theory & Bayesian approaches
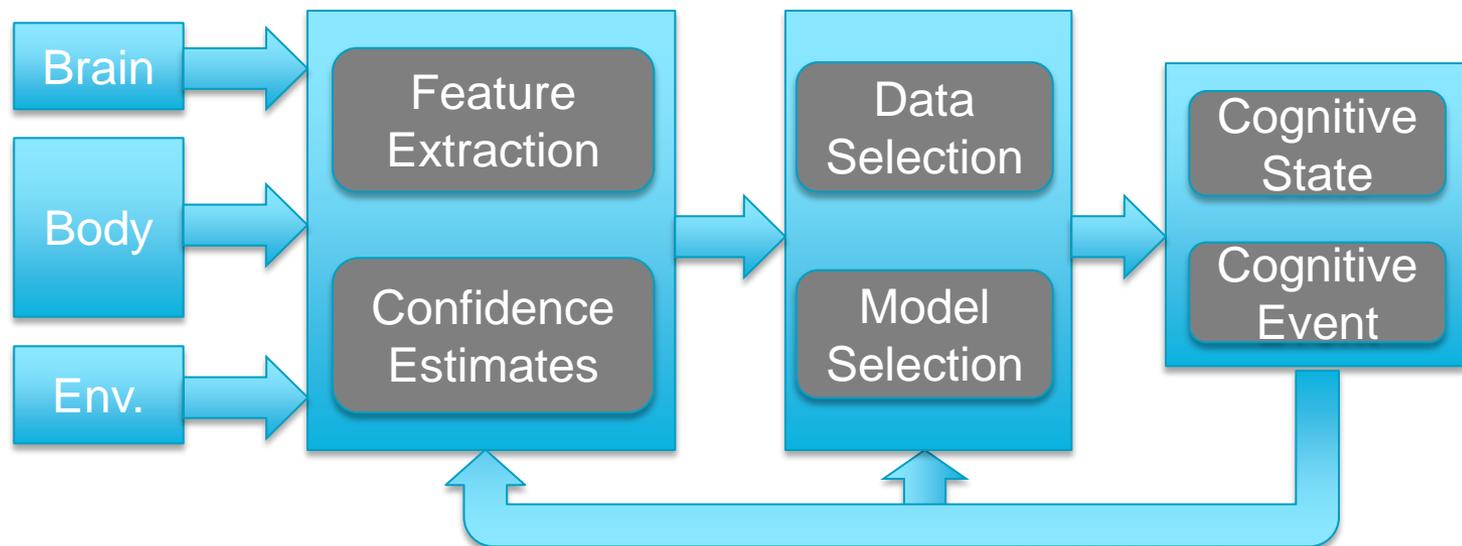
# Current Work: Data Collection

- In conjunction with researchers at Army Research Laboratory, UC San Diego, University of Michigan
    - High density 64 → 256 EEG
    - Eye movement data
    - Heart rate / respiration
    - Electrodermal activity
    - Motion capture / accelerometry
    - Audio / video
    - Scene capture
    - Seated & mobile tasks
    - Individual & team tasks
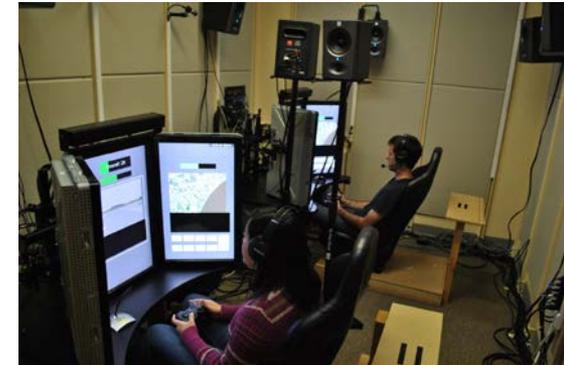
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