Real-Time Operator Physiological Monitoring to Drive Human-Robot Interaction (HRI) Design

Lisa Baraniecki

Biomedical Engineer

lbaraniecki@atinc.com

8737 Colesville Rd, Ste. L203

Silver Spring, MD 20910

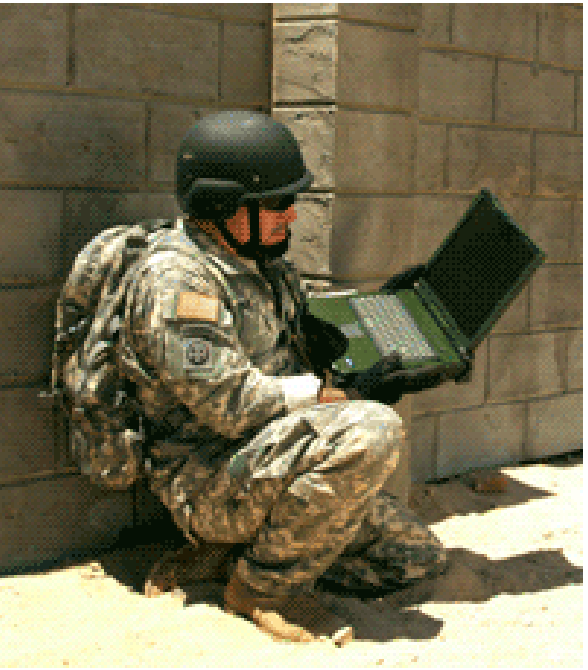
www.atinc.com

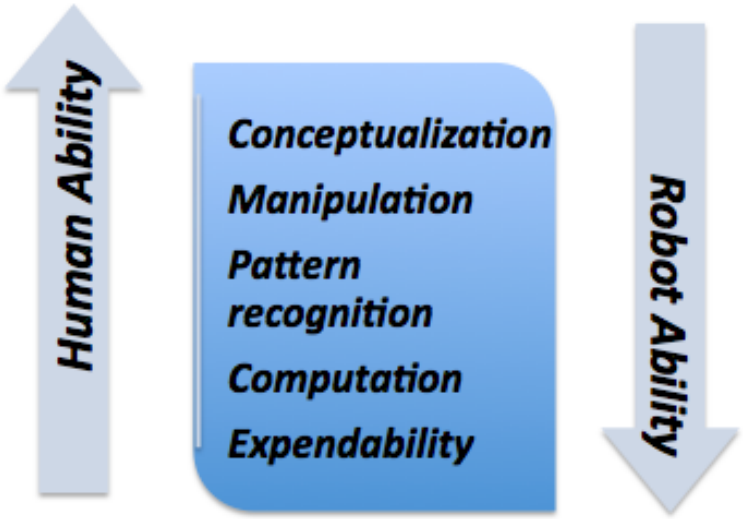
Background

Shared work spaces

Shared or dependent tasks

Shared “mental models”





Shared situation awareness

Affective awareness

Kinetic actions

Limitations

- **The capabilities of robots are constrained by interaction limitations**
  - Effectiveness of automation is dependent on human control capabilities
  - Robot performance is often dictated by operator skill
  - Interaction is largely dictated by interface design

Art vs. Science

- **Interface design is currently more of an art than a science**
  - Often based on engineering principles and robot functionality
  - Designers depend on user adaptability
  - Significant training time is currently required

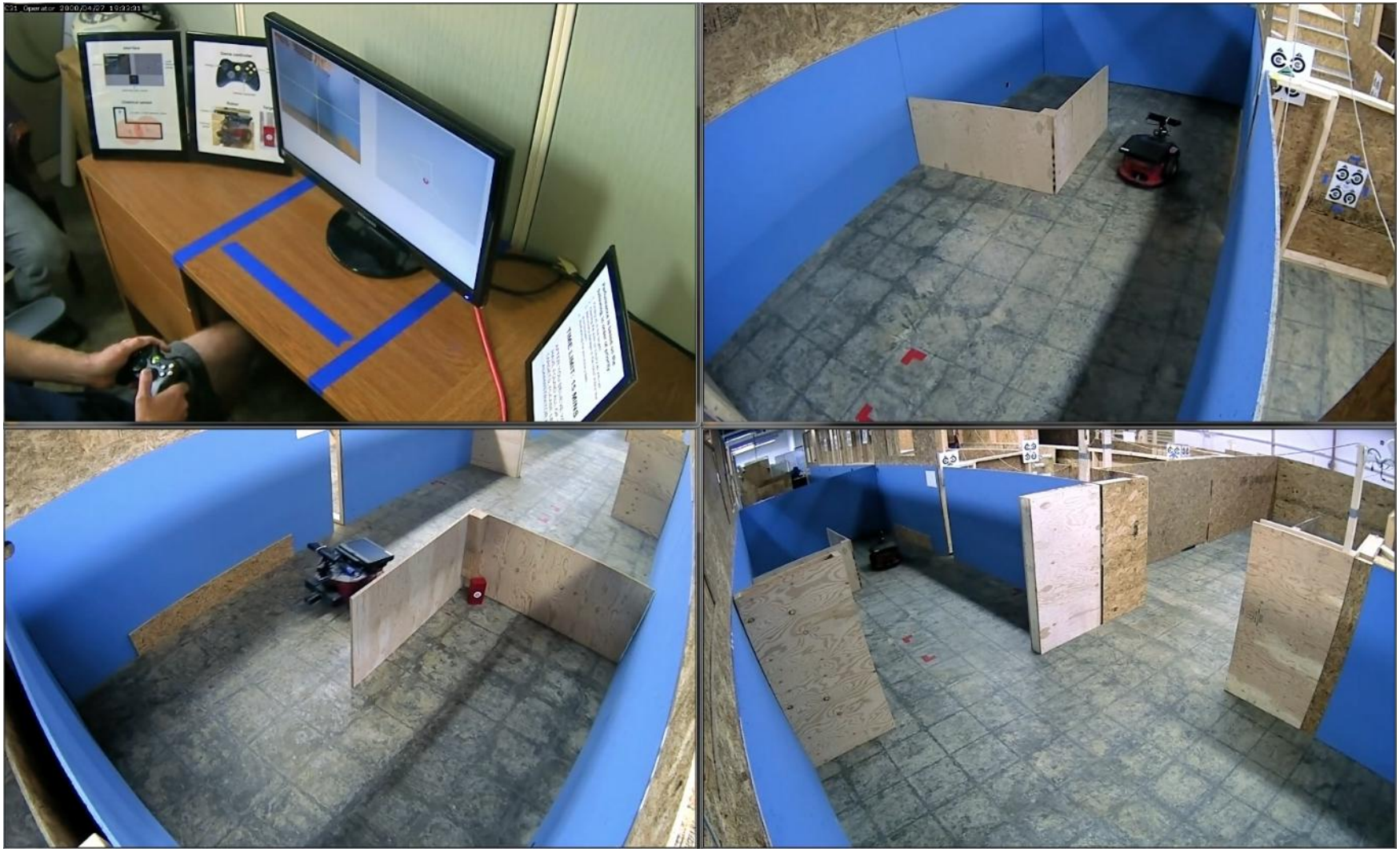
Solution

- **Interfaces must account for dynamic changes in interaction parameters**
  - Human/Robot/Mission parameters
  - Environment/Dispositions/SOPs/ROEs
- **Effective human-robot team interaction must optimize task allocation**
  - Exploit strengths and capabilities of humans and machines
  - Compensate for limitations of humans and machines

Efforts in HRI

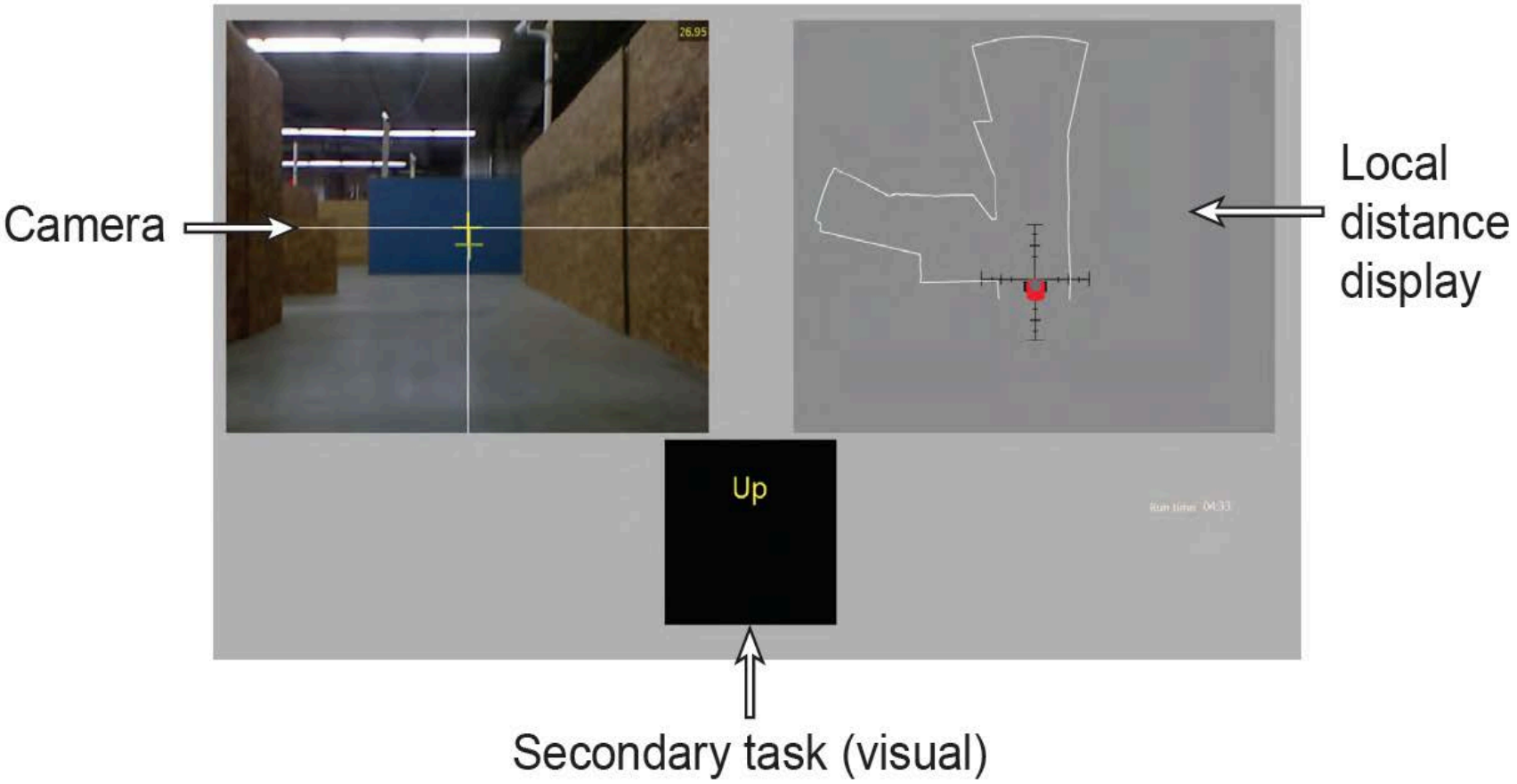
- **DRC Evaluation**
- **Dynamic Robot Operator Interface Design (DROID) Assessment, Guidance, and Engineering Tool (AGENT)**

Primary Task



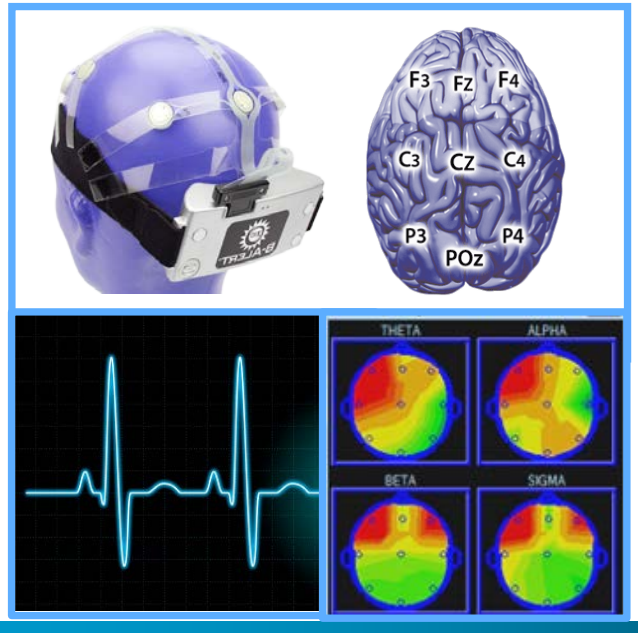
Secondary Task

Interface

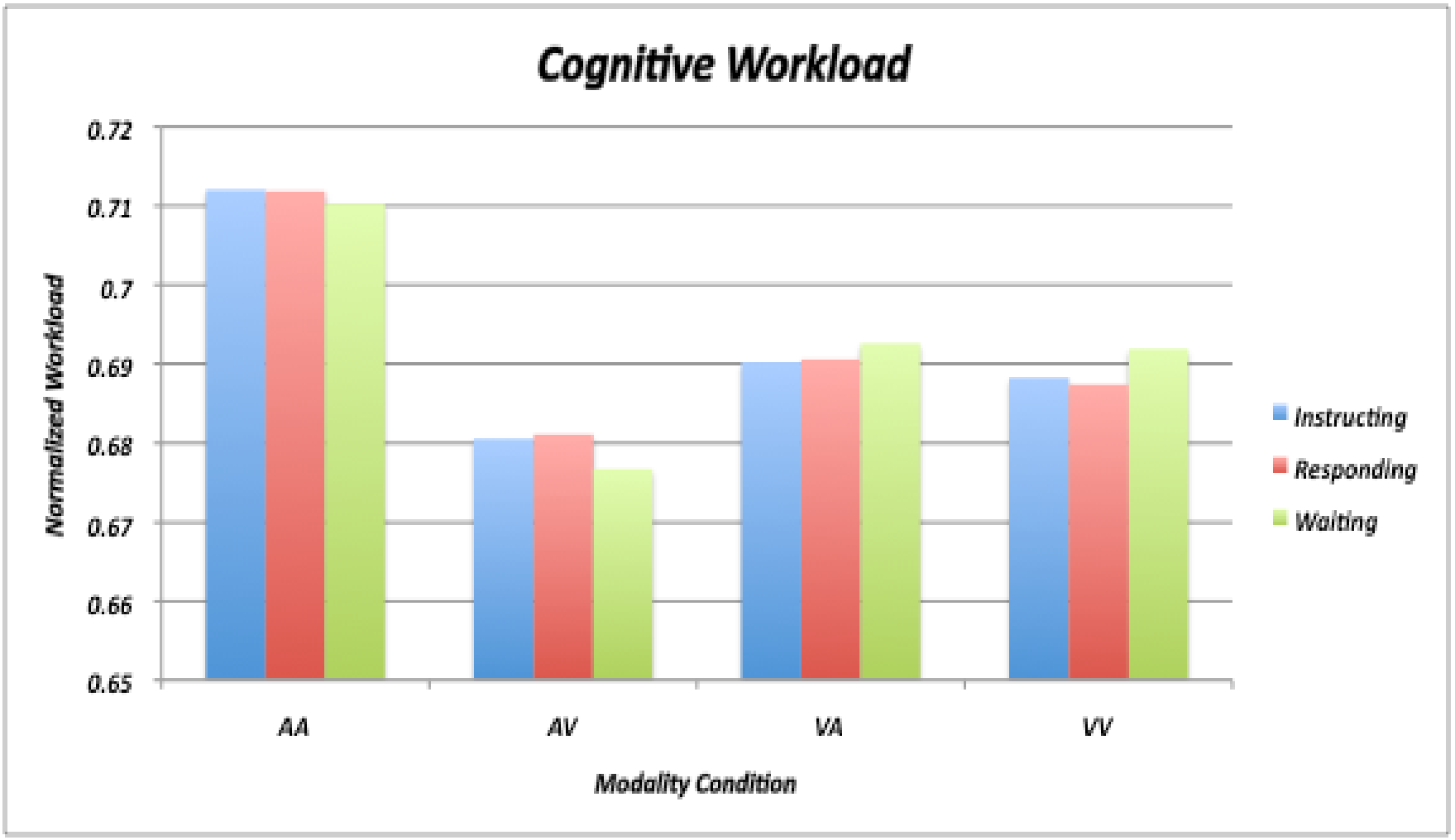


Physiological Metrics

- **Provide objective assessment of operator state**
  - Cognitive and affective state detection
  - Verbal vs Spatial working memory load
- **Can be empirically correlated to performance metrics**
  - Insight into underlying cognitive/ psychomotor/ affective processes



Findings


Cognitive Workload
Normalized Workload
0.72
0.71
0.7
0.69
0.68
0.67
0.66
0.65
AA
AV
VA
VV
Modality Condition
Instructing
Responding
Waiting

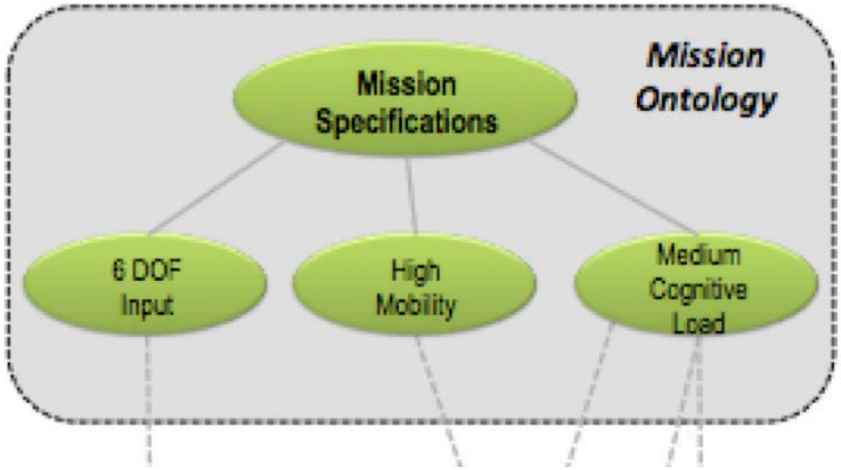
Adaptable Interfaces

- Support modularity and redundancy
- Customizable to specific mission, operator, and robot configurations
- Able to be reconfigured on the fly
- Automatically reconfigure in response to:
  - Operator state
  - Robot state
  - Environmental factors

HRI Design Ontology

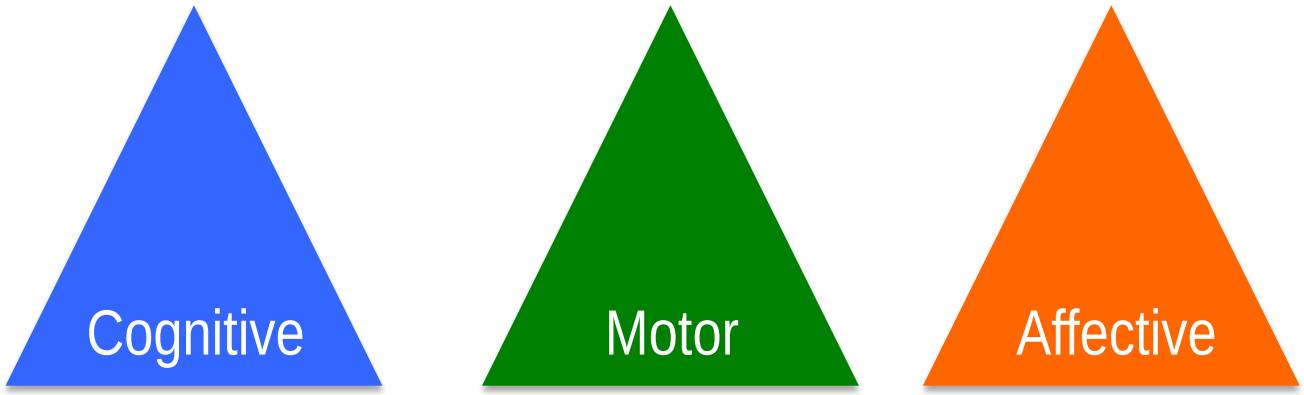
Design Ontology (Mission)

- **Ontology relates concepts within underlying taxonomy**
  - Smart agent software architecture, underlying database and ontology to support automated HRI design guidance
  - Formulate ontologies to allow analysis using an autonomous reasoning agent
  - Set of relationships are of particular importance for analysis
  - Based on scientifically-grounded design principles and validated assessment metrics



Goal

- **Based on Multi-disciplinary HRI design process**
  - Involve stakeholders early in design process
  - Leverage strengths/weaknesses of humans and robots
  - Act as a translator between humans and robots
  - Mission-centric approach
  - Multi-modal and adaptive interfaces



Taxonomy of Human and Robot Skills

Take Home

- **HRI should be considered from the beginning influencing robotic design**
- **Empirically-based methodology is needed**
- **Operator physiological monitoring can provide objective and quantifiable data to drive HRI design and assessment**
- **Real-time physiological measures can be used to drive adaptive interfaces**

Questions?