Frances McClelland Institute
Children, Youth, and Families

Theory of Mind-based Cognitive Architecture for Teams (ToMCAT): Protocol and Implications

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BACKGROUND

Artificial Intelligence (AI) & Teamwork:

- **AI** allows for computer systems to learn and make recommendations on complex knowledge bases unlike humans
  - facilitates improvement in workplace teams
- Benefits:
  - User-friendly
  - Appeal to younger generation
  - Targets specific areas that need improvement
  - Tailors specific interventions for teams
  - Creates teams with complementary skillsets (3)

Collaboration Literature

- Using EEG and fNIRS, (1) found that **c**ooperation conditions had significantly greater brain synchronization between partners when compared to competition
- Using eye-tracking, (2) found a significant correlation between percentage convergence of visual focus and achievement score (= **success** in game)
  - Significant correlation between **convergence of visual focus** and **quality of collaboration**

Goals of the ToMCAT Project

- Build **artificially intelligent agents** that understand **social** and **goal-oriented** aspects of teams in mission-like scenarios (e.g., search-and-rescue missions), and can reason about possible interventions to **steer** the team

Agent: ToMCAT

- Needs to model human players' **affect and beliefs** about the situation and about each other's affect and beliefs (theory of mind)

Extensive measurements of humans interacting in small teams

- Audio, video, eye tracking, electrocardiography (EKG), electroencephalography (EEG), functional near-infrared spectroscopy (fNIRS), and self report

Task:

- Participants execute **missions** within a Minecraft environment with three human players interacting with the ToMCAT agent

Physiological Measurements

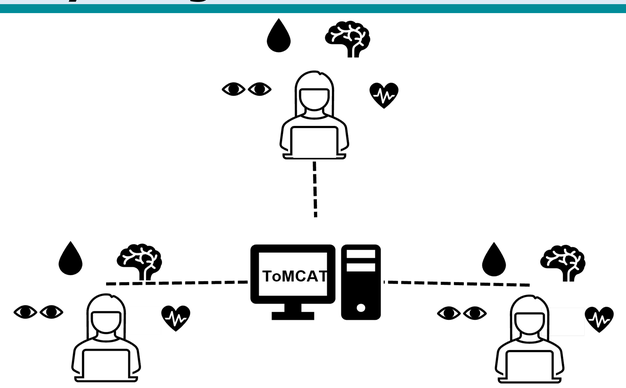


Figure 1. Schematic of the participant data collection environment.

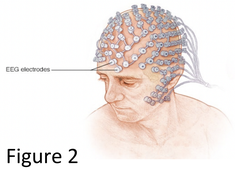


Figure 2

Electroencephalogram (EEG)
Records electrical activity of brain via **electrodes** that detect tiny changes in electrical charge resulting from neuronal activity (Fig 2).

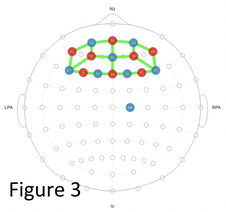


Figure 3

Functional Near-Infrared Spectroscopy (fNIRS)
Measures hemodynamic response, or blood oxygenation levels, via near-infrared light with **optodes**
(See Fig 3**;** Red= Sources, Blue= Detectors).

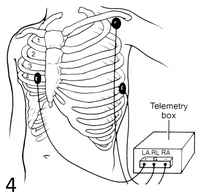


Figure 4

Electrocardiogram (ECG or EKG)

- Measures electrical heart activity (Fig. 4)

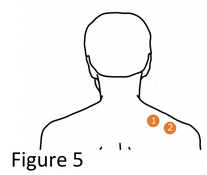


Figure 5

Galvanic Skin Response (GSR)

- Measures sweat gland activity (Fig. 5)

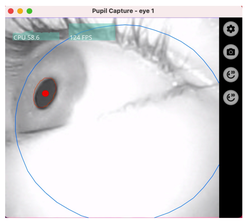


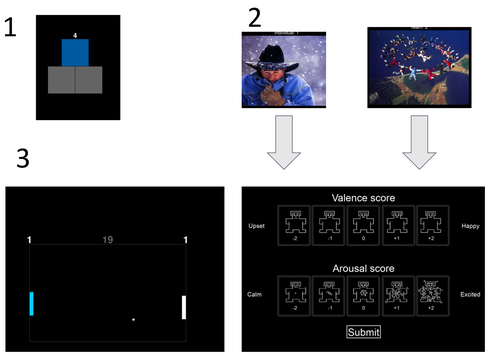
Figure 6

Eye-tracking

- "Eyes to the mind"
- tracks eye movements
- gaze location, duration
- pupil diameter (Fig. 6)

BASELINE TASKS

1. **Finger tapping**
   - individual
   - team
2. **Picture Rating Task**
   - individual
   - team
3. **Ping Ping**
   - player vs player
   - team vs AI



MINECRAFT MISSION (2x)

Search and rescue scenario:

- Goal: find victims and save them
  - different victim types
    - critical
    - regular (A & B)
- 3 different **player roles**:
  - Medic
  - Engineer
  - Transporter/ Stretcher
- time limit: 15 min
  - 2 min planning session

- **Cooperation** between participants
- Mirrors real life situations

Mission Info:

- Time
- Victims saved

Role tools

IMPLICATIONS

Improve communication between rescue teams and headquarters
- reduce **time** and **cost** spent on search and rescue missions
- reduce **number of casualties** both of rescue team and victims

With the construction of AI through ToMCAT we can expect a reduction in cost, time, and number of casualties in search and rescue missions

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