The International Technology Alliance
in
Network and Information Sciences

Towards a Cognitively Realistic Computational Model of Team Problem Solving Using ACT-R Agents and the ELICIT Experimentation Framework

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Aims & Approach

- Aims:
  - advance our understanding of the interaction between cognitive, social, informational and technological factors in team-based problem-solving.
- Approach:
  - use cognitive architectures (ACT-R) to develop computational models of team-based problem-solving.
  - evaluate models using human performance data.
  - develop generic simulation capability to support cognitive social simulation experiments.

Cognitive Social Simulation

- Social Simulation:
  - use of multi-agent simulation techniques to study social processes and collective behaviour, e.g. social influence.
  - criticized for lack of cognitive fidelity.
- Cognitive Social Simulation:
  - relies on the use of cognitively-sophisticated agents that feature human-like cognitive capabilities.
  - individual agents implemented using cognitive architectures (e.g., ACT-R) – these support the development of cognitively-plausible computational models.
  - enables us to manipulate cognitive parameters.
  - enables us to gather cognitive data.

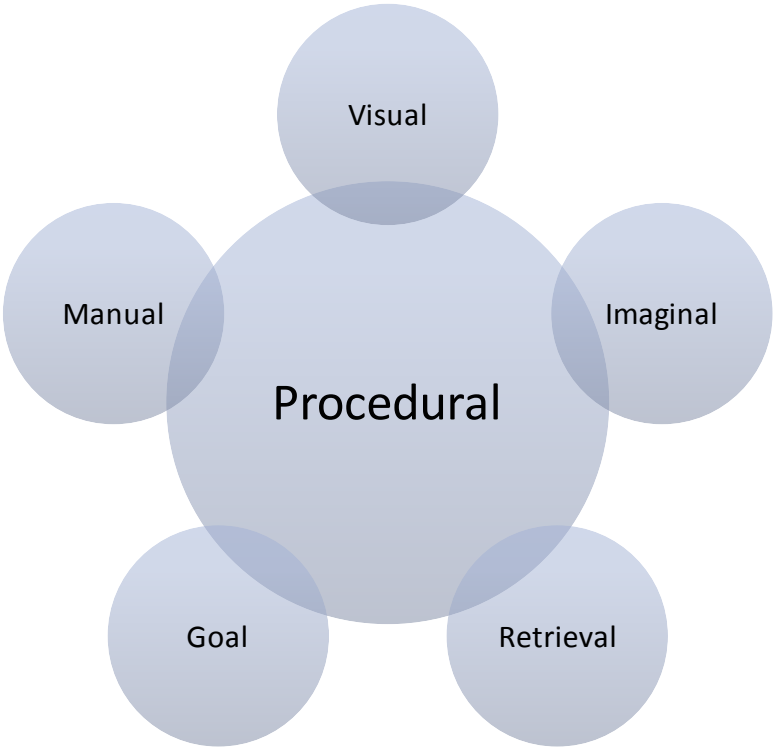
Why Cognitive Social Simulation?

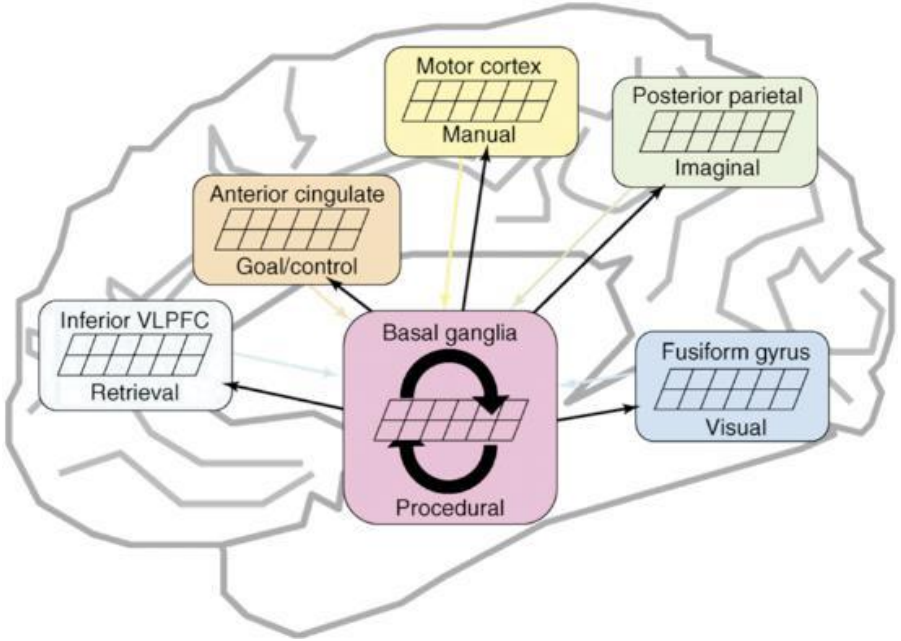
- Social / Cognitive
  - communication serves as the mechanism for socially-mediated elaborative rehearsal – influences what is encoded/recalled.
  - cognitive capabilities influence the character of social processes.
- Informational / Cognitive
  - memory limitations play a positive functional role in supporting the forgetting of outdated information.
  - information quantity influences the allocation of limited cognitive resources.
- Technological / Cognitive
  - technologies influence cognitive capabilities.
  - cognition determines how technological resources are manipulated and exploited.

ACT-R

Modules provide support for visuo-motor control, mnenomic retrieval, goal representation and working memory.

Modular Architecture





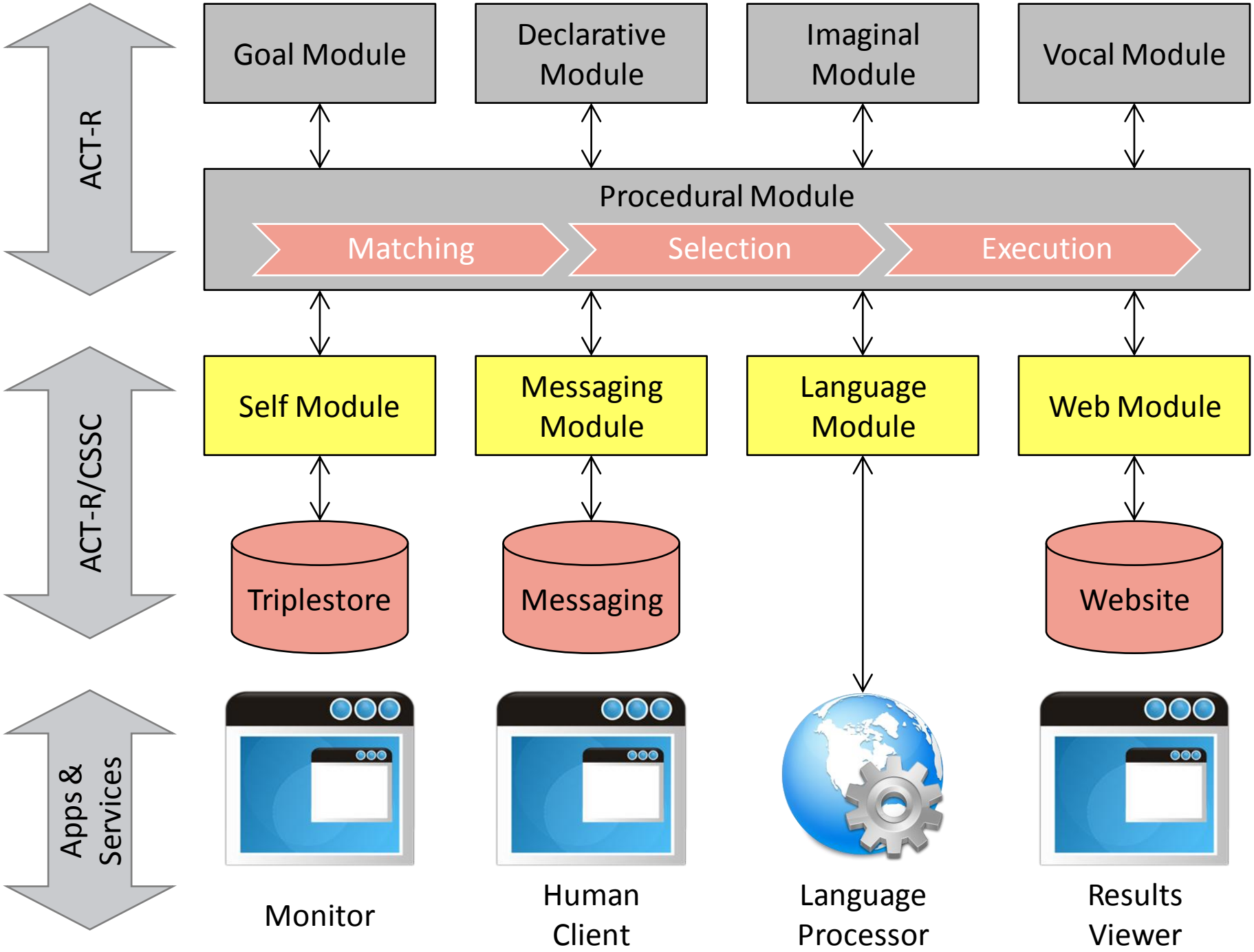
Neurocognitive Grounding

Simulations can predict what brain regions will be activated during a task.

ACT-R (Social) Applications

Synthetic opponents using the Unreal Tournament engine.

Human-robot interaction – social robots.


ACT-R
Goal Module
Declarative Module
Imaginal Module
Vocal Module
Procedural Module
Matching
Selection
Execution
ACT-R/CSSC
Self Module
Messaging Module
Language Module
Web Module
Triplestore
Messaging
Website
Apps & Services
Monitor
Human Client
Language Processor
Results Viewer

ELICIT Task (1)

- ELICIT - Experimental Laboratory for Investigating Collaboration, Information Sharing and Trust.
- Sponsored by the U.S. DoD Command and Control Research Program (CCRP).
- Sensemaking activity – aims to capture at least some of the features of intelligence analysis tasks.
- Previously used to study the effect of organizational environments on performance using human teams.

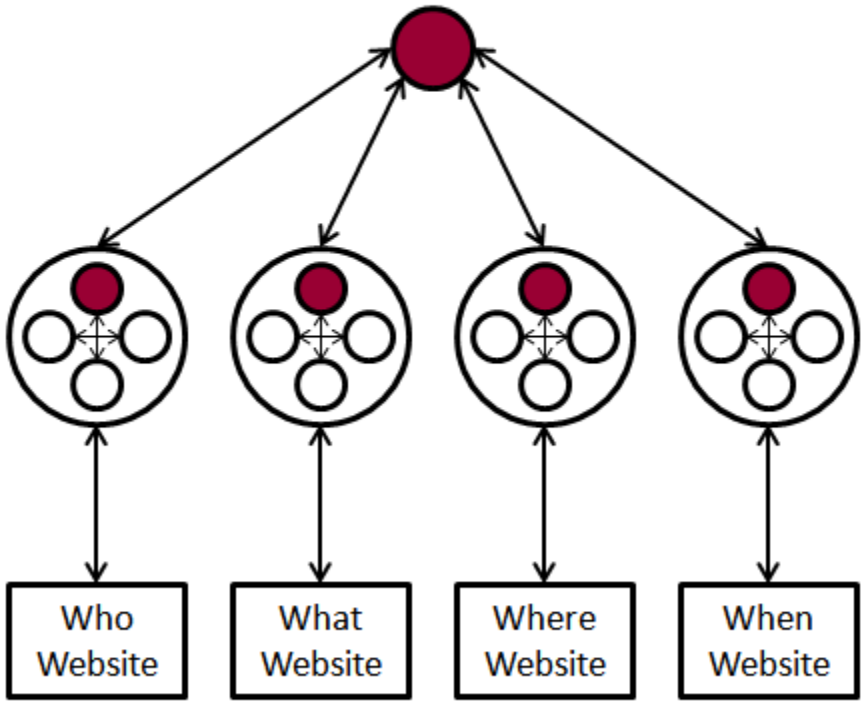
ELICIT Task (2)

Goal: Exchange task-relevant information (factoids) in order to collaboratively identify the who (group), what (target), when (time), where (country) of impending terrorist attack.

Example Factoids:

1. The Gray and Teal groups do not employ suicide bombers
2. There will be a suicide bomber attack at a school
3. The Silver group does not work in Pi
4. The Silver group only attacks during the day
5. The Rose group may be involved
6. The Sienna and Rose groups only target the military
7. Reports from the Teal group indicate standard levels of activity

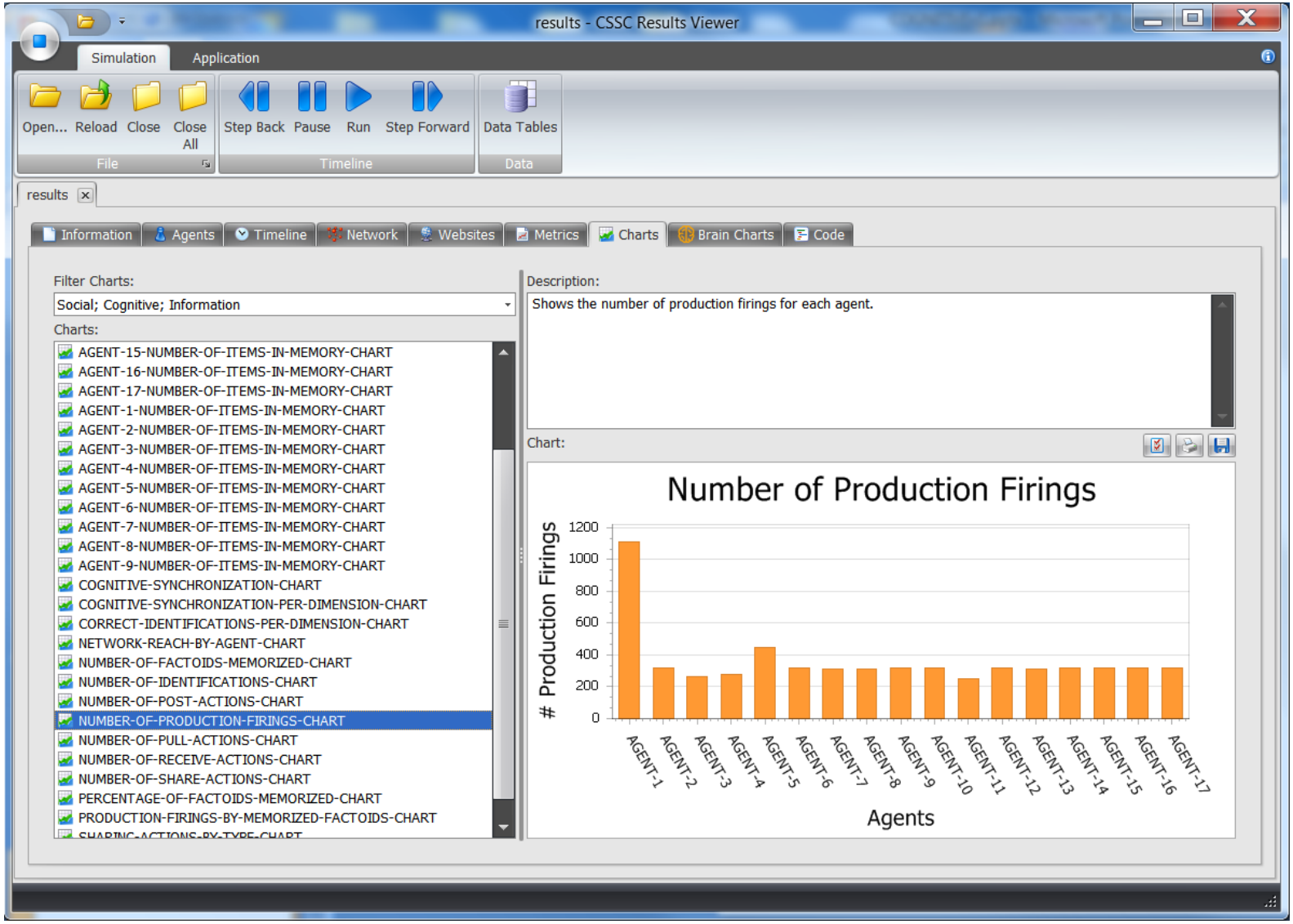
Example C2 Organization:



Why Not….

- …use the existing ELICIT experimentation platform?
  - integration challenge with ACT-R environment.
  - trying to develop generic capability that is not limited to ELICIT task.
- …use agent-based variant of ELICIT?
  - want to assess the effect of cognitive-level variables on individual and collective performance.
  - future work aims to compare performance with abELICIT and human subjects.

Demonstration



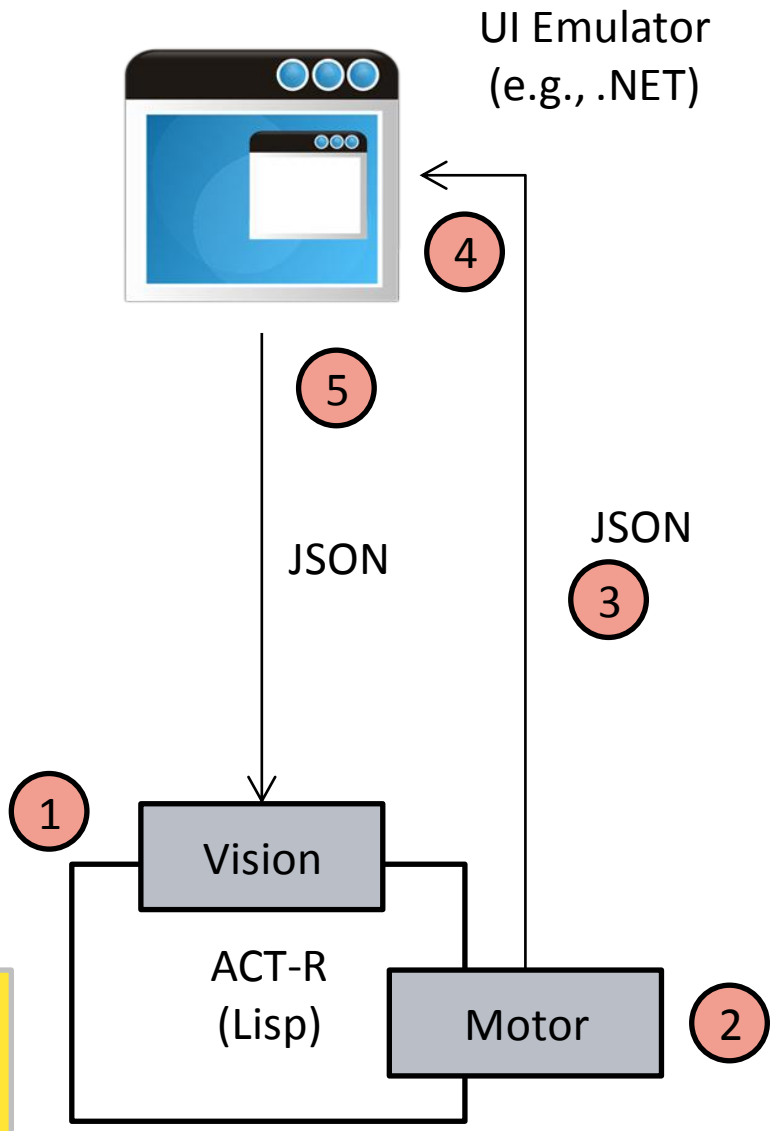
Some Challenges

- Modelling effort:
  - complex task environment
  - multiple agents working in a team setting
- Language processing:
  - how important is it to have a native natural language processing capability in ACT-R?
- Scalability:
  - lots of events being processed; lots of data being generated
- Embodiment/agent-world interaction:
  - how to enable ACT-R agents to structure and exploit the environment?

Embodied Agents

1. Interface elements represented as visual chunks in vision module.
2. ACT-R responds to visual chunks by generating motor actions, e.g. mouse movements.
3. Motor information sent to UI emulator using JSON and TCP/IP.
4. UI emulator receives and interprets motor information – updates user interface accordingly.
5. Updated UI elements are represented as visual chunks and posted back to ACT-R using JSON and TCP/IP.

Custom UI components could be implemented to support the conversion to ACT-R chunks. Could provide support for future usability studies.



Summary

- Aim is to develop generic capability to support cognitive social simulation experiments using the ACT-R cognitive architecture.
- Use of the CCRP ELICIT task to support the testing and evaluation of the simulation capability.
- Future experimental work aims to explore the interactions between cognitive, social, informational and technological factors in the context of team-based problem-solving activities.