Biologically Inspired Cognitive Architectures

Brandon Minnery, PhD

703-983-1026 • bminnery@mitre.org

DARPA/IPTO

Project Data (internal use only)

- Project Number: 0706D070-NF
- Ceiling Source: DARPA
- Principal Investigator: Brandon Minnery
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- External Web URL:
  http://www.darpa.mil/ipto/Programs/bica/descriptions.htm

(Approved for Public Release, Distribution Unlimited)

Problem

- Current AI paradigms do not capture the functional complexity of the human brain.
- New types of cognitive computing architectures are required if the ambitions of the AI field are to be realized.

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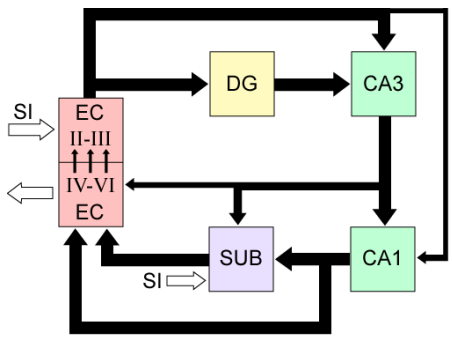
Background

- The traditional approach to machine intelligence pursued by the artificial intelligence (AI) community has fallen short of the grand vision of integrated, versatile, intelligent systems.
- Revolutionary advances may be possible by building upon new approaches inspired by cognitive psychology and neuroscience.
- Such approaches have the potential to help us understand and model significant aspects of intelligence thus far not attained by classic formal knowledge modeling technology.

Example: the hippocampus - a neurobiological circuit involved in declarative memory



After Brown and Zador (1990)

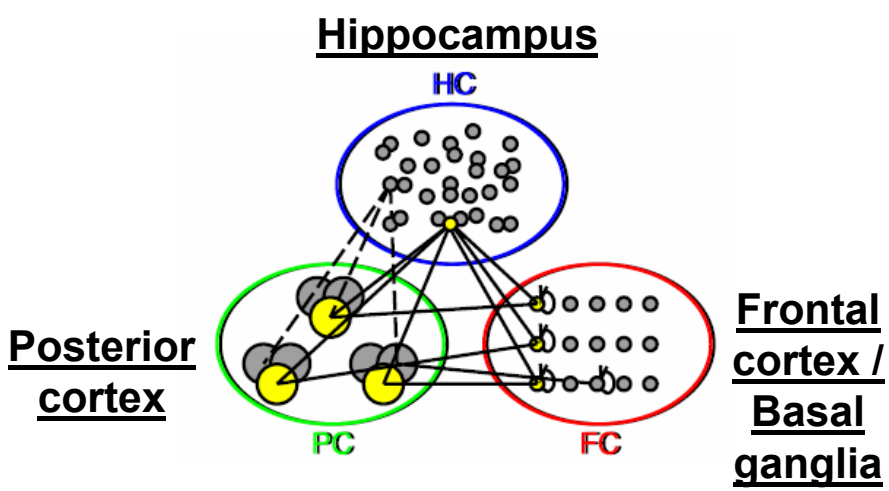
Objective

- BICA will develop *psychologically* based and *neurobiologically* based theories, design principles, and architectures of human cognition.
- BICA seeks the design (Phase 1) and implementation (Phase 2) of architectures that replicate the human capacity for:
  - -- Learning
  - -- Memory
  - -- Perception
  - -- Decision Making
  - -- Symbolic Communication

Activities

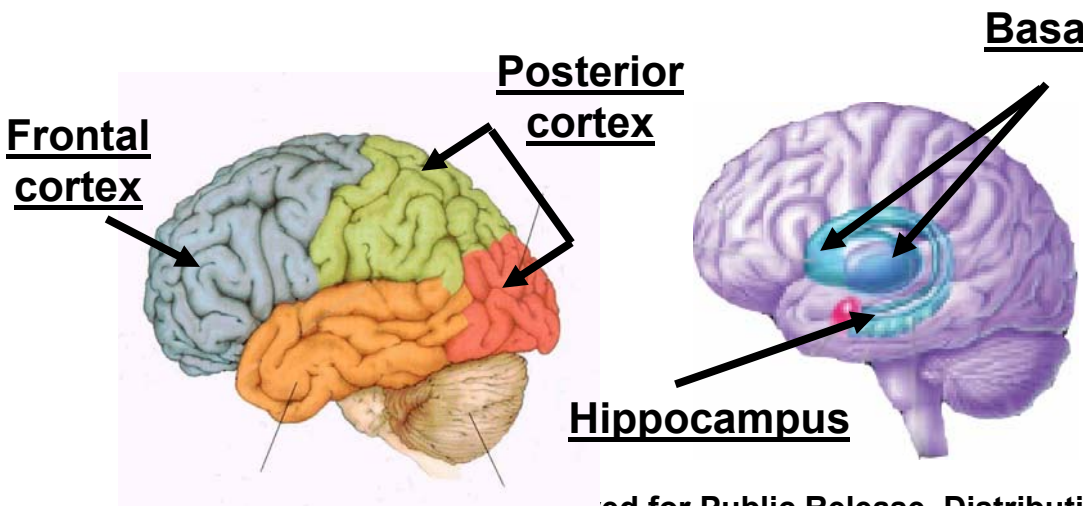
- Workshop: *Data Storage, Retrieval and Processing in Biological Systems* (March 25–26, 2004)
- BAA; Source Selection (April 2005)
- PI site visits (September-October 2005)
- BICA Kickoff Meeting (November 2005)
- BICA Community Website (MITRE-hosted)
- *MITRE continues to provide the DARPA sponsor with neuroscience-related technical expertise*

Highlight: A Brain-Based Architecture Proposed by U. Colorado Boulder Team



"Tripartite" Architecture emphasizing three complementary brain regions

Atallah et al. (2004) *Neurobio Learn & Mem*, 82/3: 253-67.

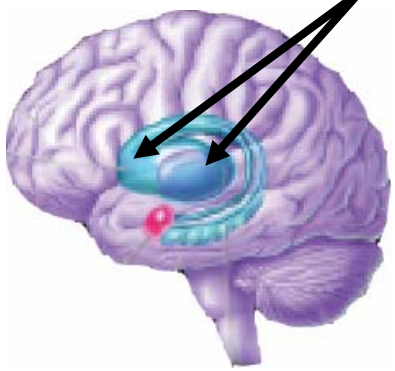


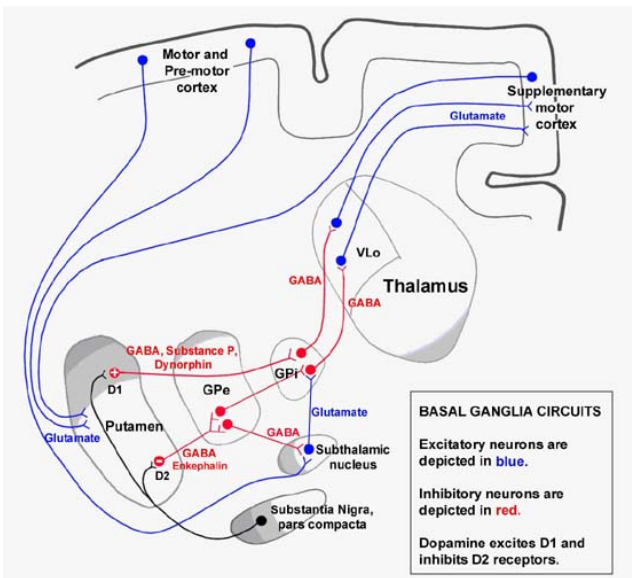
- Key concept: *computational tradeoffs* between major brain systems
- Biologically realistic learning mechanisms
- Integration of multiple component models into large-scale architecture

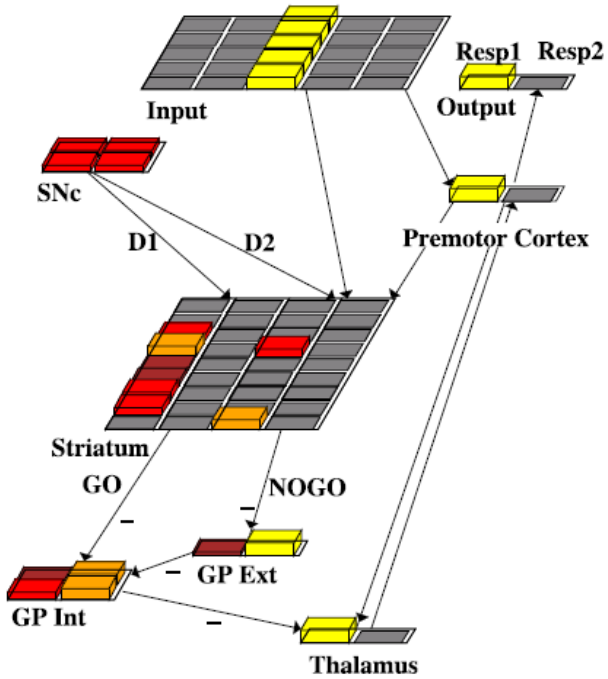
Highlight: A Brain-Based Architecture Proposed by U. Colorado Boulder Team

- Architectural components are based on known neuroanatomy and neurophysiology

Example:
Basal Ganglia







Atallah et al. (2004) *Neurobio Learn & Mem*, 82/3: 253-67.

- Component models implemented as multi-layered connectionist nets (biologically constrained NNs)

Impacts

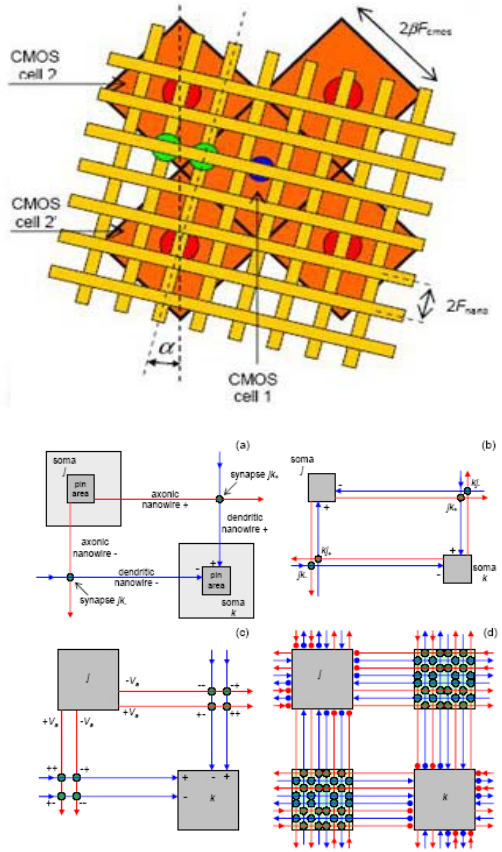
Revolutionary Advances in Artificial Intelligence, including:

- Adaptive high-performance computing
- Decision support systems
- Intelligent human–computer interfaces
- Autonomous robotics
- Virtual training environments
- Modeling and simulation

Future Plans

- Conduct technical exchange meetings to promote the exchange of ideas among BICA researchers (Task 2 of Phase 1).
- Synthesize integrated cognitive architectures that merge neuromorphic and psychologically based designs (Task 3 of Phase 1).
- Evaluate architecture performance in real and simulated environments (Phase 2).
- Investigate novel, hardware-based implementations of BICA-derived architectures.

Neural circuits constructed from CMOL (CMOS + nanowires + molecules)*



*Turel *et al.* (2004) *Int J Circ Theor Appl*, 32: 277-302.