

## George Mason University Krasnow Institute for Advanced Study

- Lead investigators and current team members:
  - Kenneth A. De Jong, Giorgio A. Ascoli, and Alexei V. Samsonovich (presenter)
- Research areas of interest, which are also areas of qualification and unique capabilities:
  - Cognitive and metacognitive architectures (Samsonovich, De Jong & Kitsantas, International Journal of Machine Consciousness, 1, 111-130, 2009)
  - Connectionist modeling of the hippocampal formation (Samsonovich & McNaughton, JN 1997; Samsonovich & Ascoli, Learn&Mem 12, 193-208, 2005)
  - Semantic cognitive mapping of natural language (Samsonovich & Ascoli,
     Frontiers in AI & Applications, 157, 111-124, 2007; PLoS One, under review)
- Specific capabilities our group is seeking are:
  - Robust learning in agents based on a cognitive-metacognitive architecture (CMA)
  - Spatial learning / navigation based on cognitive mapping in a spiking neural network
  - Automated semantic mapping of arbitrary data (text, images, internal representations of knowledge) based on given or detected relations of synonymy and antonymy



# Meta-Cognitive Architectures: From GMU BICA to CMA

#### **GMU BICA:** I-Goal I-Alt-Goal I-Meta-1 Working memory I-Imagined-2 Working I-Meta-2 I-Imagined-1 **Episodic** I-Imaained-3 I-Subgoal Scenario output I-Past: satisfaction Analysis •Past Intermediate I-Next experience goal situation **I-Previous** I-Now I-Next-Next Procedura Semantic Prospective I-Previous I-Now: /// memories I-False-Belief •Ideas I-Next: I-Past Visual input Intent Scheduled action I-Feel Expectation I-Detail-2 l-Detail-1 I-Past-Revised She-Past She-Past-Prev He-Now He-Now-I-Now User **CMA Working memory Episodic memory Iconic memory** (symbolic interface) (mental states) (mental state assemblies) I-Imag I-Meta -> I-Imag -> I-Goal He-Now < I-Now I-next Task Env. **Procedural memory** Value system Semantic memory (drives & values) (primitives) (schemas, maps)



## NeuroNavigator1: A microcircuit designed under SyNAPSE program

The NN1 microcircuit implements the core of the navigator.

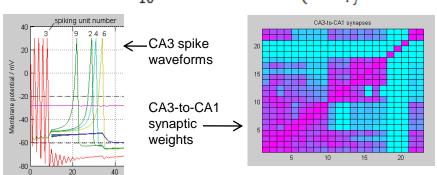
- The architecture of the NN1 network is a three-layer perceptron.
- Every layer is made of N=22 neurons, each representing a distinct location.
- NN1 interacts with the rest of the cortex to receive sensory information and send motor directions.

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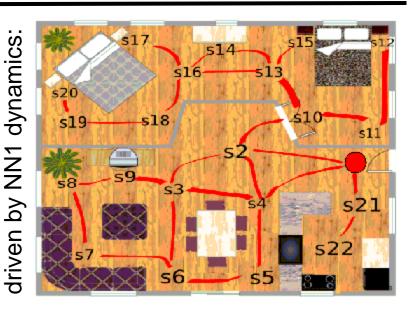
#### Salient features of NN1

Parameters: 3N = 66 neurons,  $2N^2 = 968$  synapses (N=22) The architecture is scalable to larger N (e.g.,  $10^6$ ). CA3-to-CA1 learning rules are (j is presynaptic neuron):

$$W_{ij}^{\text{new}} = \frac{\text{round}\left(10 * \max(W_{ij}^{\text{old}}, p_j)\right)}{10}, \quad p_j^{\text{new}} = \begin{cases} 1, & \text{if neuron } j \text{ spikes} \\ 0.905 p_j^{\text{old}} & \text{otherwise} \end{cases}$$



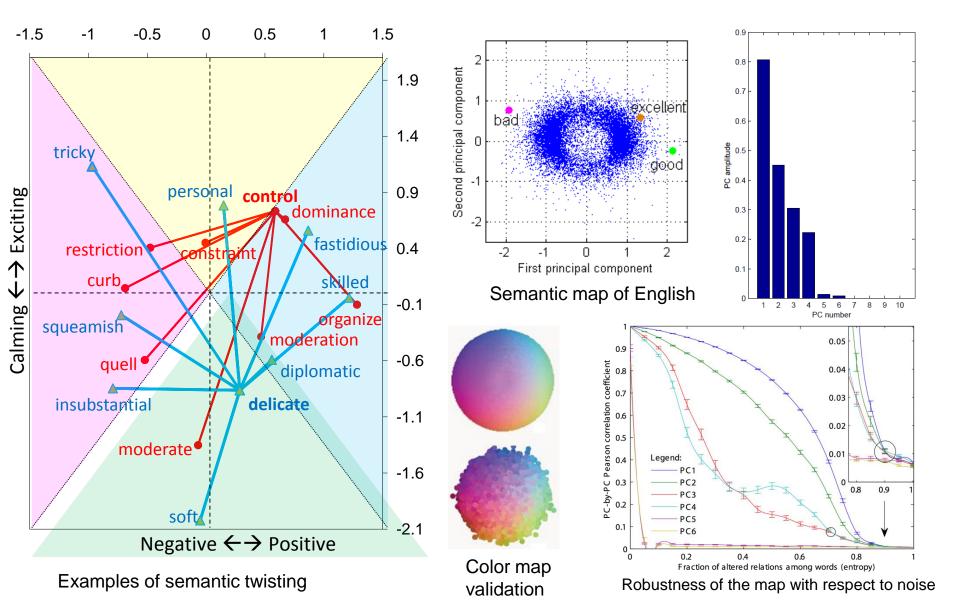
Simulated agent behavior



Our target is a network of 1,000,000 neurons with 10,000 synapses each



### Semantic cognitive mapping of language





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