Affective Agent Architectures

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Overview

- What are "affective agent architectures" and why should we care about them?
- The role of affect in "complex agents"
- Challenges for "affective AI"
- Some results from experiments with simple affective agents
- Concluding thoughts
- References

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Affective Agent Architectures

- *Affective agent architecure* := a control architecture of an agent that has *components*, which in connection with other *internal* and *external* (i.e., *environmental*) *states* can instantiate *affective states*
- *Affective state* :=$_{\text{appr.}}$ a *positively* or *negatively valenced*, *teleological* state that the agent does or does not desire to a varying degree
- NOTE: most (if not all) "affect concepts" are *cluster concepts* (and may thus, as a cluster, not have any feature in common; no necessary and sufficient cond.)

Affect-why should we care?

- Because it may not be possible to design complex agents without affect
- Because it may be beneficial to integrate affect (e.g., "computationally cheaper" for certain tasks)
- Because complex agents may not be able to interact effectively with human otherwise
- Because there are no agents without affect in nature
- Because we want to know if we can do it
- Because the game industry wants them

The Foundational Character of Affect

- Simple organisms have no deliberative capabilities, but they are "affective" (e.g., they have simple control states that give rise to attractive-aversive behavior, "fight-or-flight" behavior)
- Complex organisms have affective states at their base and on top a complex deliberative system (which often is used to control the affective system!)
- Affect seems to be used for internal and external control!

Different Roles of Affect I

- Control function for *immediate actions* (e.g., fear triggers a run-away or freeze behavior)
- Control function for *change in short-term and long-term behavioral disposition* (e.g., anxiety leads to increased alertness, but possibly to depression and loss of interest long-term)
- Control function for change in *problem solving* (moods or "negative affect" can change between global and local processing, e.g., top-down vs. bottom up, Bless et al. 1996, Gasper & Clore 2002)

Different Roles of Affect II

- Control function in *decision making*:
  - use *affective memory* (i.e., past affective appraisal of an object, agent or event) instead of longer, more complex cognitive re-evaluation (e.g., Kahneman 1997)
  - use *affective evaluation* as an implicit measure of the likelihood of the occurrence of a positive or negative future event (e.g., implicit knowledge about events may be represented as such and thus not be directly accessible to cognitive processes; see also, affective disorders, Damasio 1994)

Different Roles of Affect III

- Control function for *social behavior*:
  - signalling behavioral dispositions is a beneficial mechansim to coordinate groups as it allows for the prediction of individual behavior (e.g., by indicating “pain”, “pleasure”, “fear”, “anger”, etc.)
  - affective approval or disapproval of own or other agents' actions (relative to norms) can trigger corrective response (e.g., “shame”, “guilt”, “pride”, “awe”, “contempt”, etc.)
  - cultural changes of innately aversive stimuli (e.g., “liking the burn of red chili peppers”, Rozin 1990)

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Possible Roles of Affect in Agent Architectures

- *Action selection and behavior arbitration* (e.g., pick the "affectively preferred" behavior)
- *Decision making* (e.g., for choices under time pressure, "tie breaker", substitute for lack of knowledge)
- *Learning* (e.g., affective evaluations as Q values)
- *Integration* (e.g., control flow, resource management)
- *Goal processing* (e.g., arrangement and prioritization)
- *Coordinated behavior* (e.g., acting efficiently in unpredictable multi-agent enviornments)

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Callenges for "affective AI"

- *What kinds of affective states are useful and how can they be defined?* (don't wait for psychologists!)
- *How can they be integrated into agents architectures?* (e.g., what are the architectural requirements)
- *For what kinds of tasks are they beneficial, and are there tasks for which they are necessary?*
- *Do we need "embodied agents" for affect?*
- *Do we want "affective agents"?* (e.g., McCarthy 1995)
- *How do/can we know when we have them?*

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Experiments comparing Affective and Deliberative Agents

- *Idea of experimental comparison:* start simulation with different distributions of different kinds of agents in different environments
- The average number of surviving agents after a predetermined period is a *fitness measure* that can be used to assess *the relative advantage* of various architectural features of agents and their trade-offs
- *Caveat:* these kinds of experiments do not entail statements about architectural features *in general*
- (see Scheutz 2001, Scheutz and Schermerhorn 2002)

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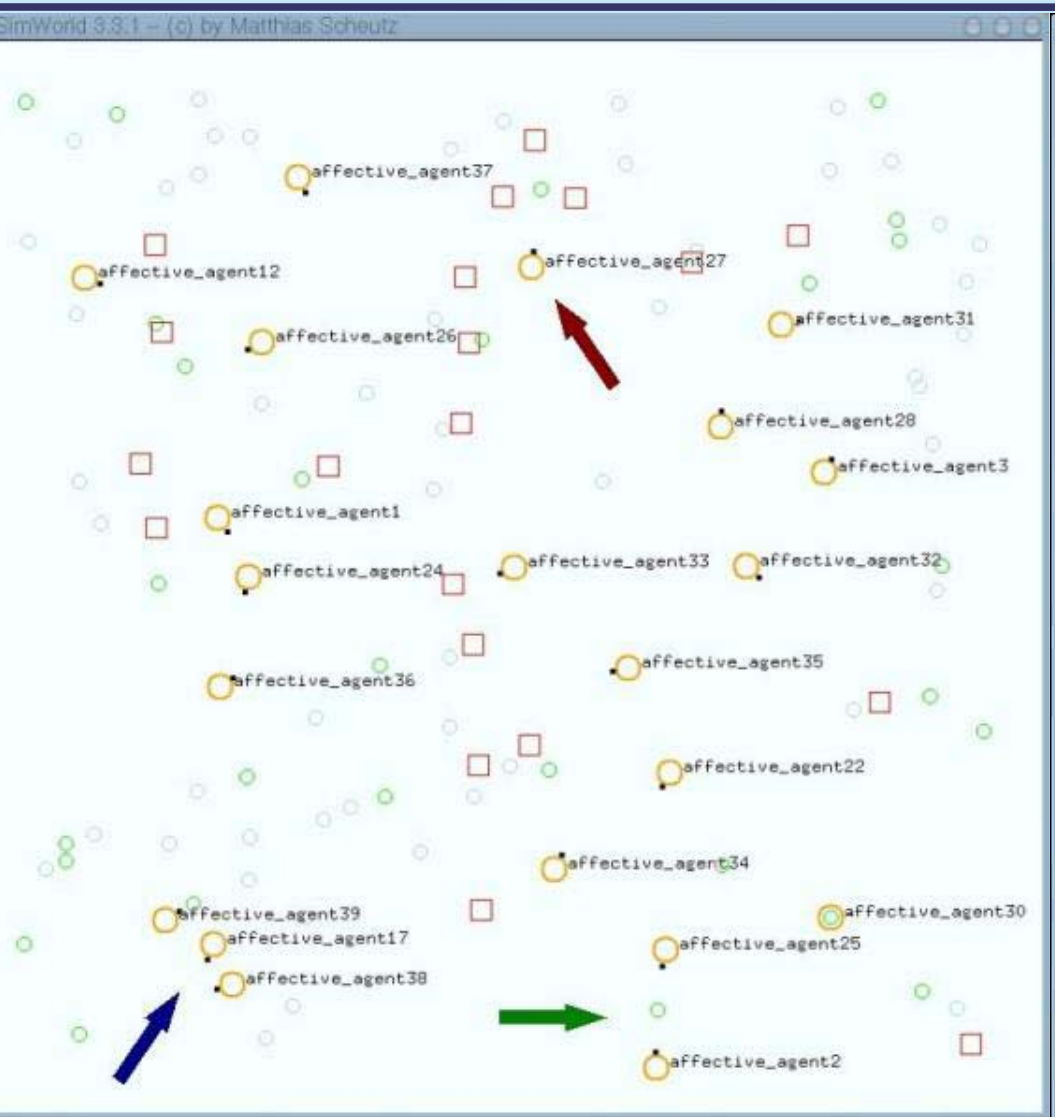
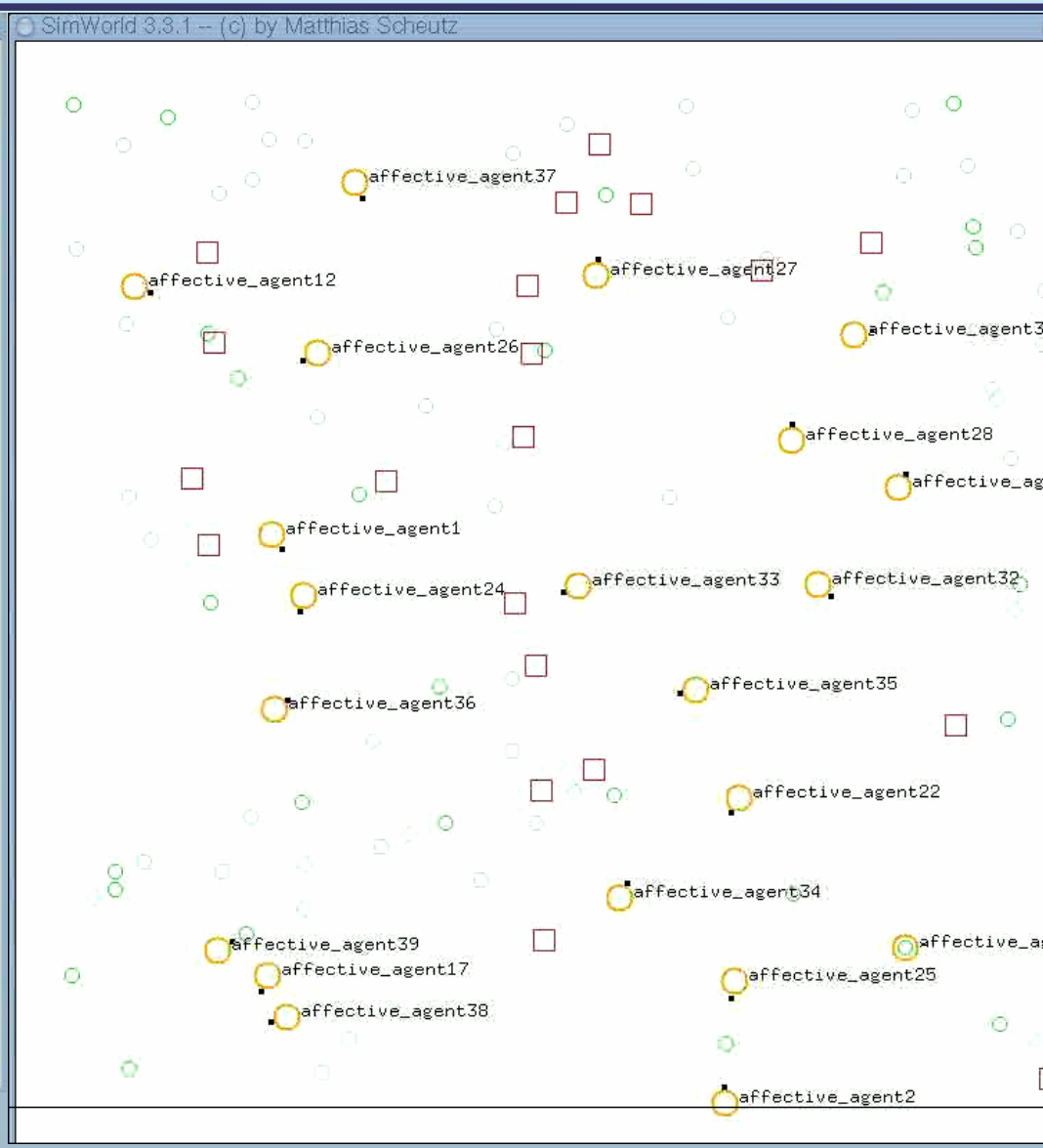
Experimental Setup: a 2-Resource Foraging Task

- Experiments conducted in SIMWORLD environment
- Each experiment consists of 20 runs of the simulation (for 10000 update cycles each)
- Obstacles are placed at random locations in the environment
- "Food and water rates" are fixed
- "Procreation age" is set to 250 update cycles
- Other parameters (e.g., food energy, ingestion time, movement energy, etc.) are also fixed in advance

The SIMWOLRD Environment





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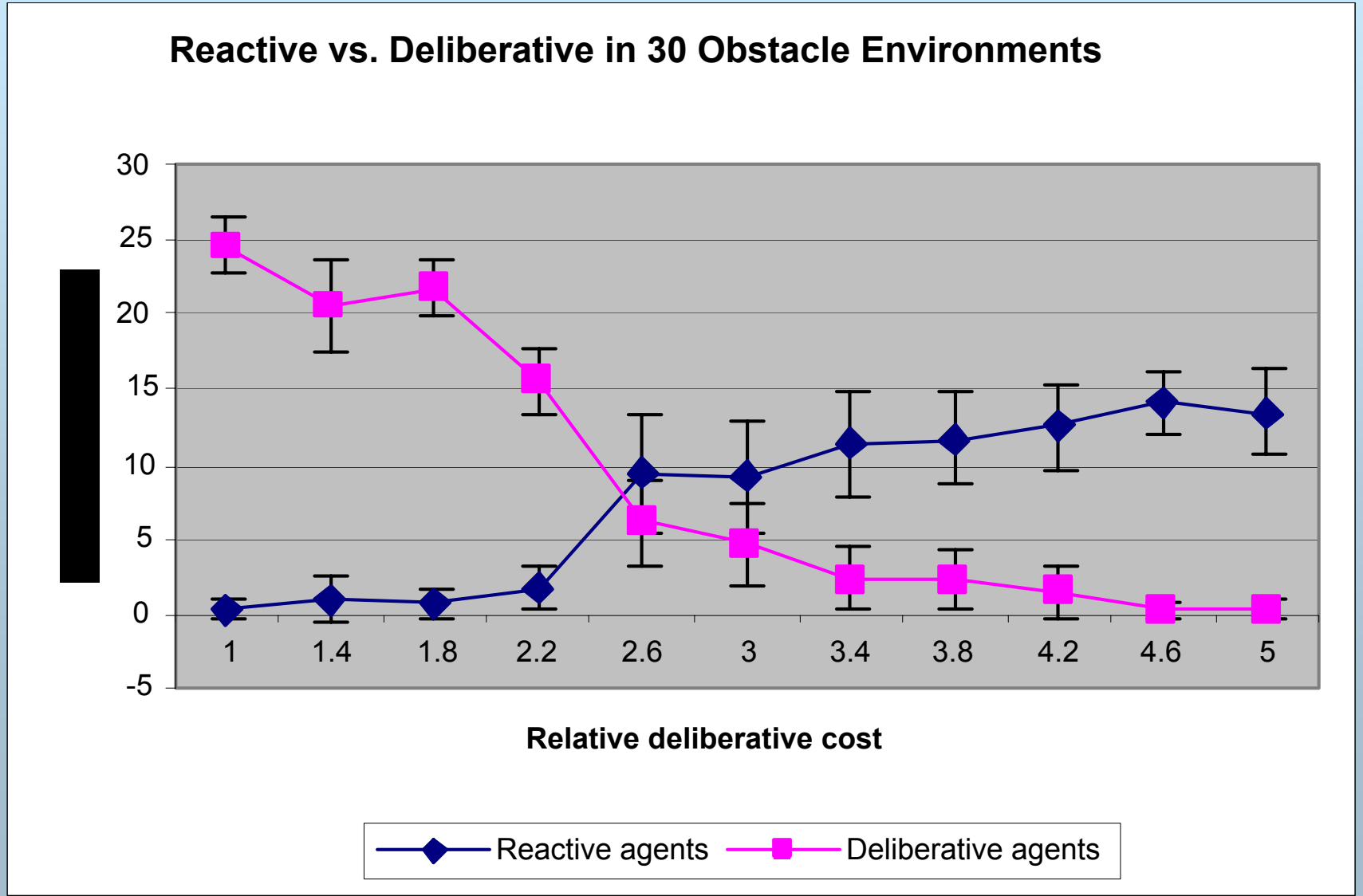
The Reactive and Affective Agents

- *Reactive* (as baseline): schema-based architecture ("greedy search")
- *Affective*: reactive + "affective extension" (i.e., control components to implement emotional control, Scheutz 2001, Scheutz under review)
- Simple fear mechanism ("fear of obstacles" and "fear of other agents" which will temporarily change the behavioral dispositions of an affective agent)
- "Need-based" foraging (through "hunger" and "thirst" states)

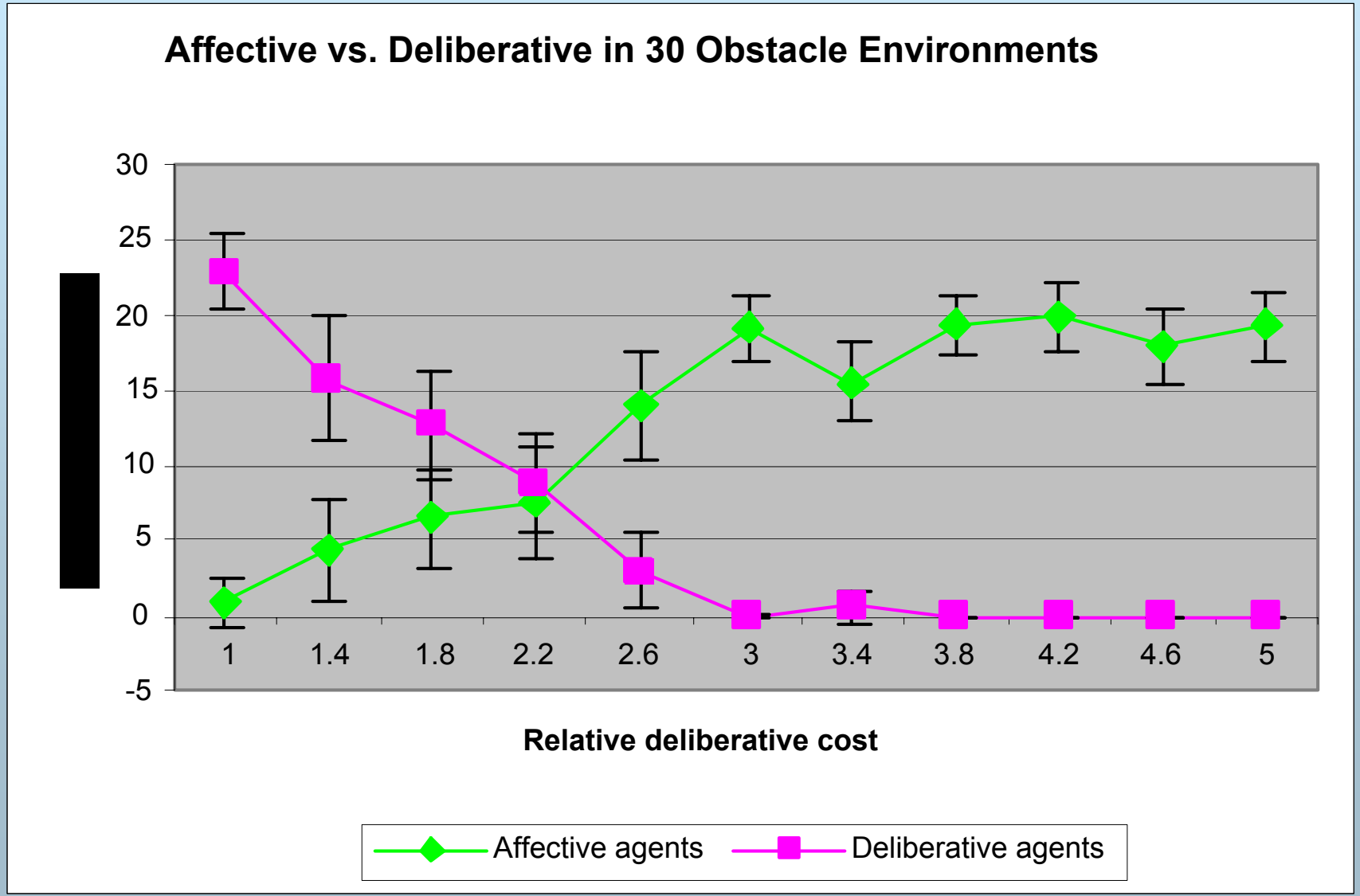
The Deliberative Agents

- (Unlimited) memory component to store location of objects in the environment
- Update mechanism for relative positions of stored entities to adjust for movements
- A* planner to compute optimal paths to resources
- Coherence mechanism to check whether locations of objects agree with perceived locations or whether goal item disappeared (which triggers re-planning)
- Replanning also triggered by closer goal item

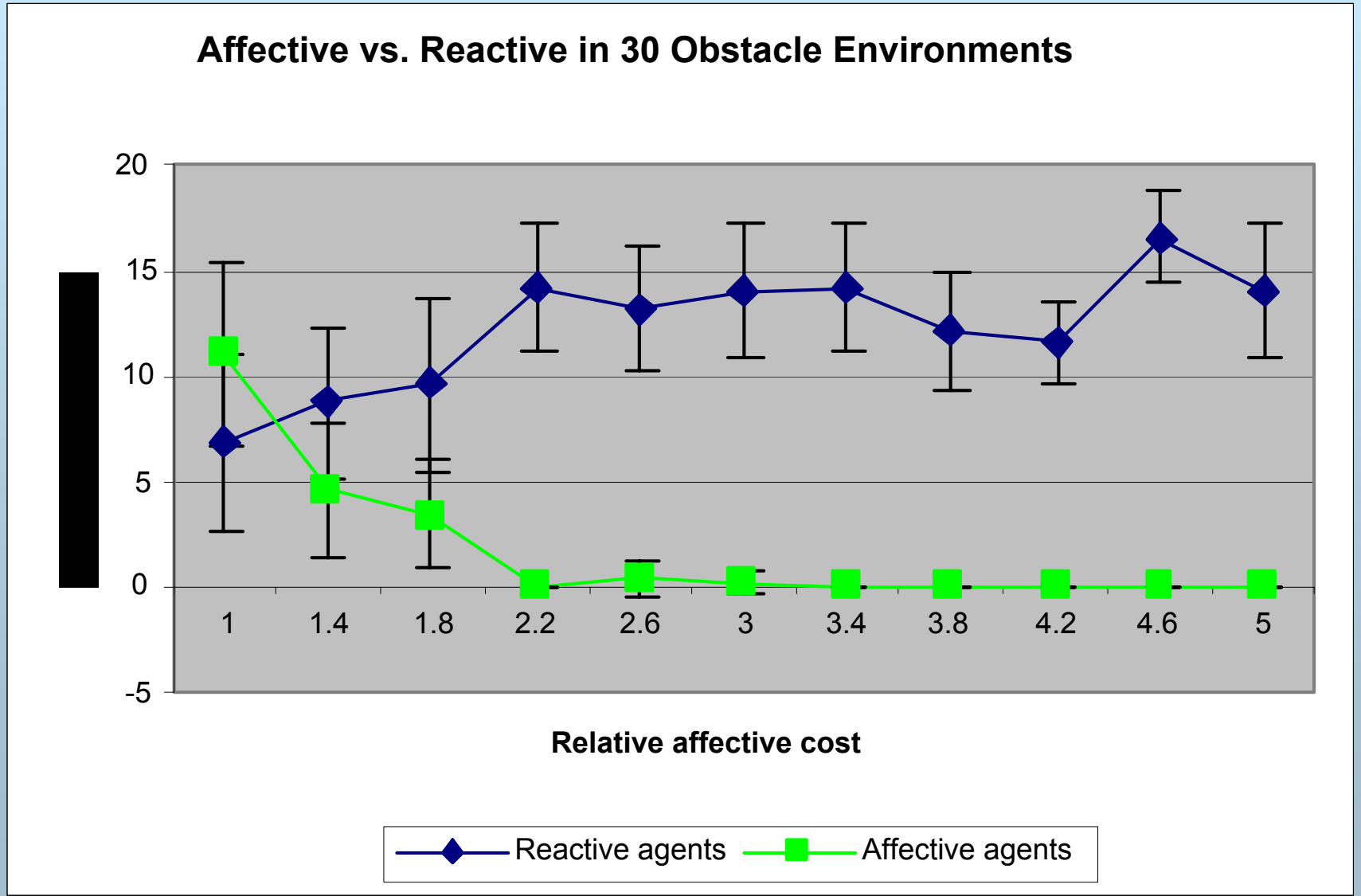
Results Experiment 1



Results Experiment 2



Results Experiment 3



Analysis of the Results

- Fitness ordering: deliberative > affective > reactive
- *Break-even points* in terms of relative cost:
  - deliberative = 3.4 * reactive cost
  - deliberative = 2.5 * affective cost
  - affective = 1.2 * reactive cost
- *But*: reactive and affective computational cost is much lower than deliberative cost (at least by a factor of 100)
- *And*: additional affective cost <20% of reactive

Concluding thoughts

- Affective control seems to be efficient for simple agents-what about complex ones?
- How can affect be utilized to improve cognition?
- How can we categorize “affect” in a way that allows for integration into (existing) agent architectures (e.g., SOAR, ACT-R, and others)?
- How can we implement and test affective mechanisms in complex agents? (e.g., what sorts of tasks would be appriopriate and challenging)

Some References to our Work on Affective Agents

- Scheutz, Matthias (2002) "Agents With or Without Emotions?". In *Proceedings of FLAIRS'02*, AAAI Press.
- Scheutz, M. and Schermerhorn, P. (2002) "Steps Towards a Systematic Investigation of Possible Evolutionary Trajectories from Reactive to Deliberativ Control Systems". In *Proceedings of Alife 8*, MIT Press.
- Scheutz, M. and Sloman, A. (2001) "Affect and Agent Control: Experiments with Simple Affective States". In *Proceedings of IAT-01*, World Sci. Publisher.
- Scheutz, Matthias (2001) "The Evolution of Simple Affective States in Multi-Agent Environments". In *Proceedings of AAAI Fall Symposium'01*, AAAI Press
- See also `http://www.nd.edu/~mscheutz/publications/`