

(LLM)

Agents

(with Reinforcement Learning)

Session 1, February 17th 2025, Polina Tsvilodub

Slides inspired by this [course](#) and this [tutorial](#)

# Logistics: Schedule

**Day 1 (Feb 17th):** Introduction, concept of agents

**Day 2 (Feb 19th):** Cognitive architectures

**Day 3 (Feb 18th):** Reinforcement learning

**Day 4 (Feb 20th):** LLM agents & neuro-symbolic systems

- ▶ session 4.3: **14:45–16:15** + QA time

**Day 5 (Feb 21st):** Exam

**Days 1–4:**

1. 09:00 – 10:30: intro / lecture for topic of the day
2. 11:00 – 12:30: paper discussion session
3. 14:00 – 15:30: discussions, exercises and / or lecture

**Day 5:**

Exam 09:00 – (12:30)

# Logistics: Grading

	3 CP	6 CP
In-person paper expert	10%	5%
Submission of a question for at least two other papers	10%	5%
In-person exam (Feb 21st)	80%	40%
Final group project	✗	50%

# Logistics: Grading

## Exam:

- ▶ one hand written cheat sheet allowed
- ▶ based on lectures, papers, exercises — applying discussed concepts

## Projects:

- ▶ groups of 3–5
- ▶ submission of a conference-paper style report + recorded presentation by March 31st on Moodle (one per group)
  - details & guidelines tba
- ▶ project topics will be available in a document on Moodle, tba (“final projects” section)

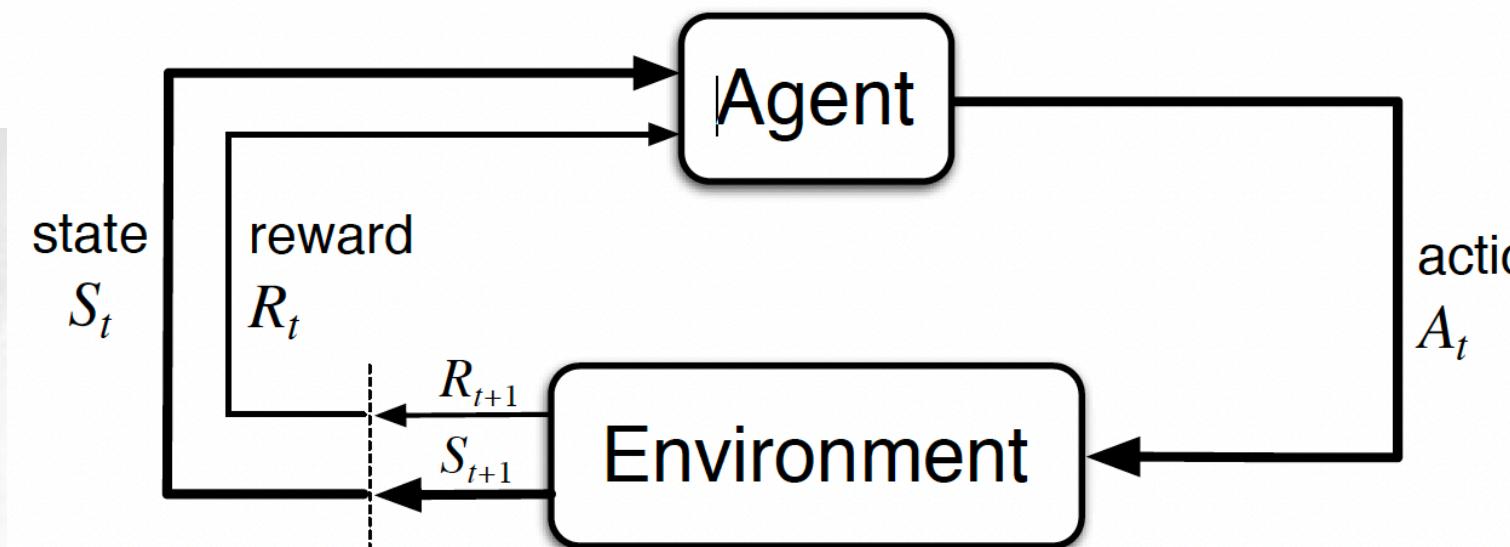


# Introduction: What are agents?





# Course on agents: Why now?



January 23, 2025 Product

 **LangChain**  
Announcing our \$10M seed  
round led by Benchmark

4 MIN READ APR 4, 2023

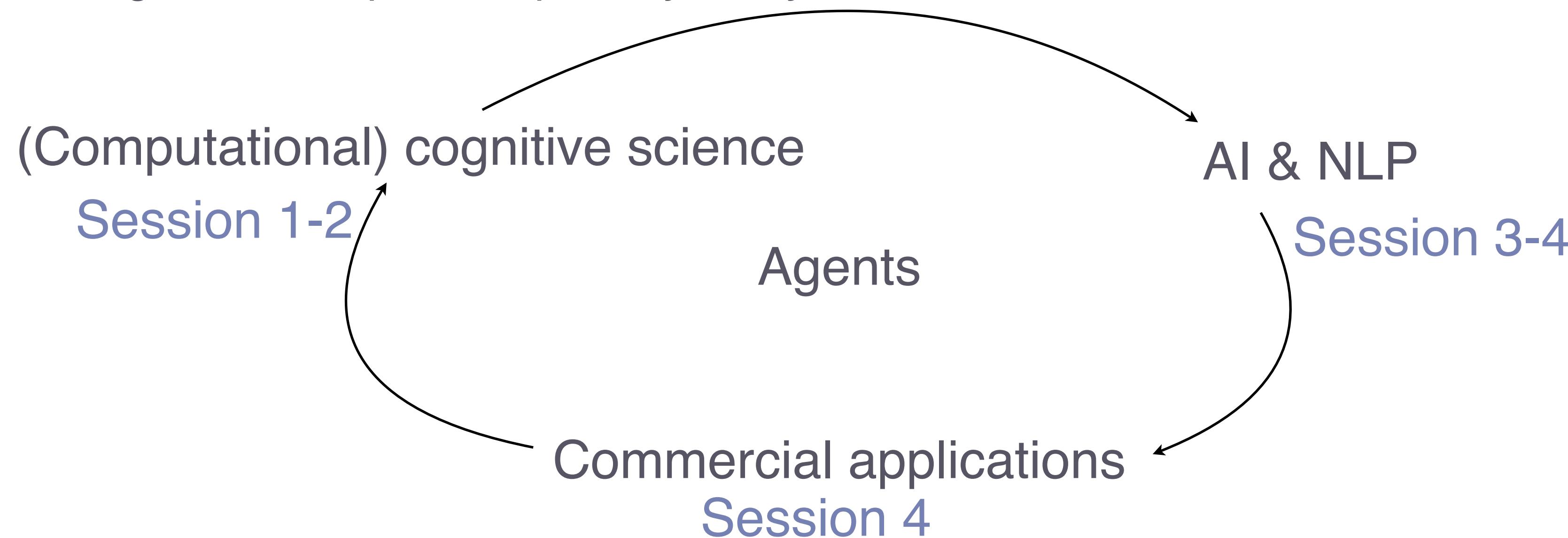
## Introducing Operator

A research preview of an agent that can use its own browser  
to perform tasks for you. Available to Pro users in the U.S.

Go to Operator ↗

# Course on agents: What I'd like you to take from this course

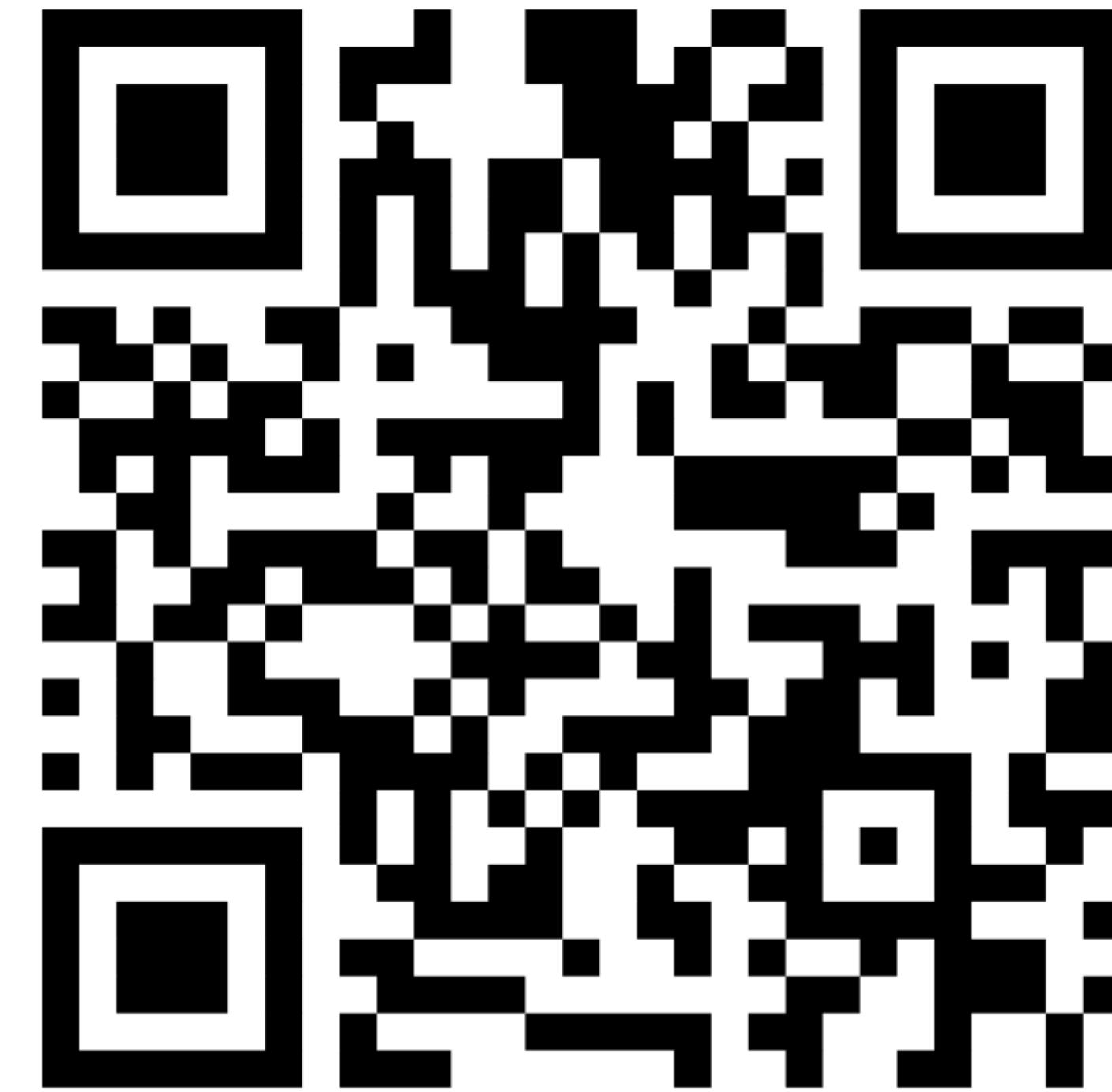
- ▶ work towards **understanding of the current AI developments & LLM agents** by **learning about different perspectives on agents**
- ▶ develop **system-level, task-decomposition thinking**
  - think: understanding which unit-tests to create for agents
  - MoE models; trend towards specialised, smaller models
- ▶ **think critically** and develop your own understanding, critical opinion of current technology
- ▶ course structure: mini-deep-dives every day
  - one overarching research question per day that you are invited to think about it



# What are agents?

Brainstorming

Mentimeter code:  
8274 2641



# What are agents?

## Definitions

- ▶ **AI & Computational modeling:**

- Russell & Norvig: any entity that perceives its environment through sensors and acts upon it through actuators
- Wooldridge & Jennings: “entities that exhibit (aspects of) intelligent behavior [with the properties of autonomy, social ability, reactivity, pro-activeness, rationality, representational capacity for knowledge, beliefs, intentions, obligations]”
- Cybernetics: a system that regulates itself through feedback loops from inputs to adjusting outputs
- Game theory: rational decision-makers who interact strategically with other agents

- ▶ **Reinforcement learning:** decision-making learner that interacts with (an uncertain) environment to learn behavior that optimizes goal achievement (i.e., maximizes a reward)

- ▶ **Cognitive science & philosophy:** “intentional stance”: an entity that acts intentionally, and can be attributed beliefs, desires, goals

- ▶ **Related:**

- social entities that understand other agents, e.g., via Bayesian reasoning
- embodied entities that interact with environment

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# What are properties of agents?

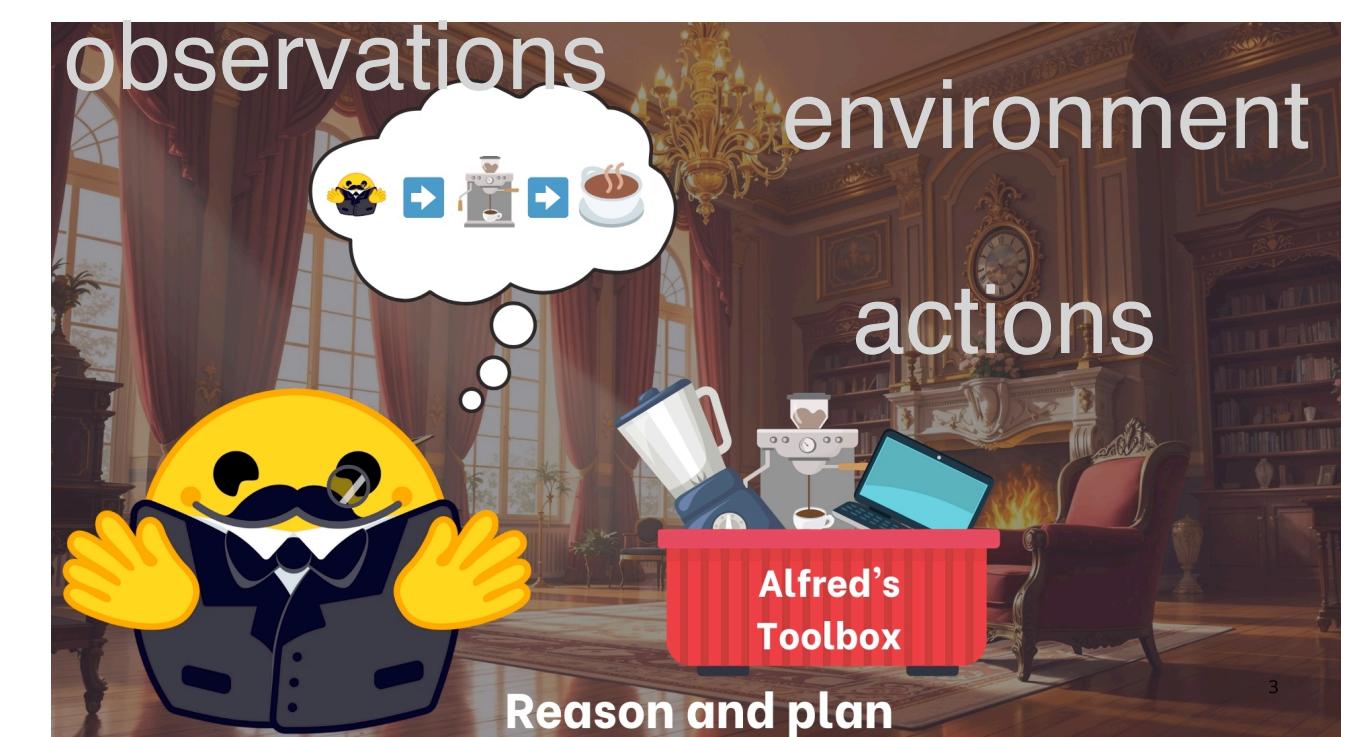
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# What are properties of agents?

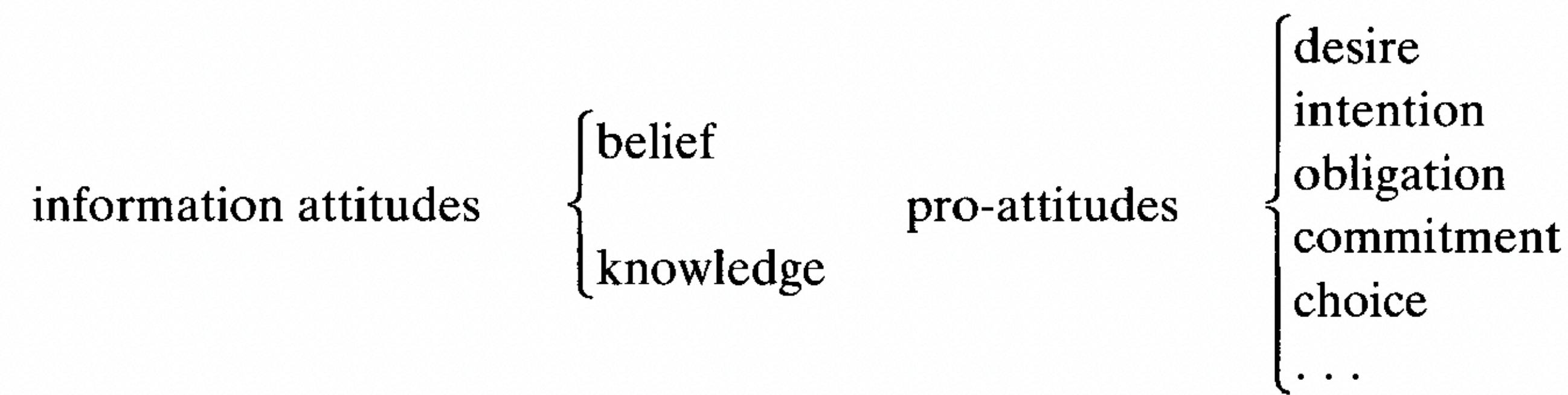
## Definitions

- ▶ “entities that exhibit (aspects of) **goal-directed intelligent behavior** with the properties of **autonomy, social ability, reactivity, pro-activeness, rationality**”
  - ↓ come up actions on its own based on relevant knowledge
  - ↓ interact with other agents
  - ↓ perception of / effect on environment
  - ↓ goal & task representation
  - ↓ anticipation of certain subtasks
  - ↓ execute actions
- ▶ **Cognitive science & philosophy:** “intentional stance”: an entity that **acts intentionally, and can be attributed beliefs & desires**
  - ↓ representation of state of the world
  - ↓ ideal target state of the world



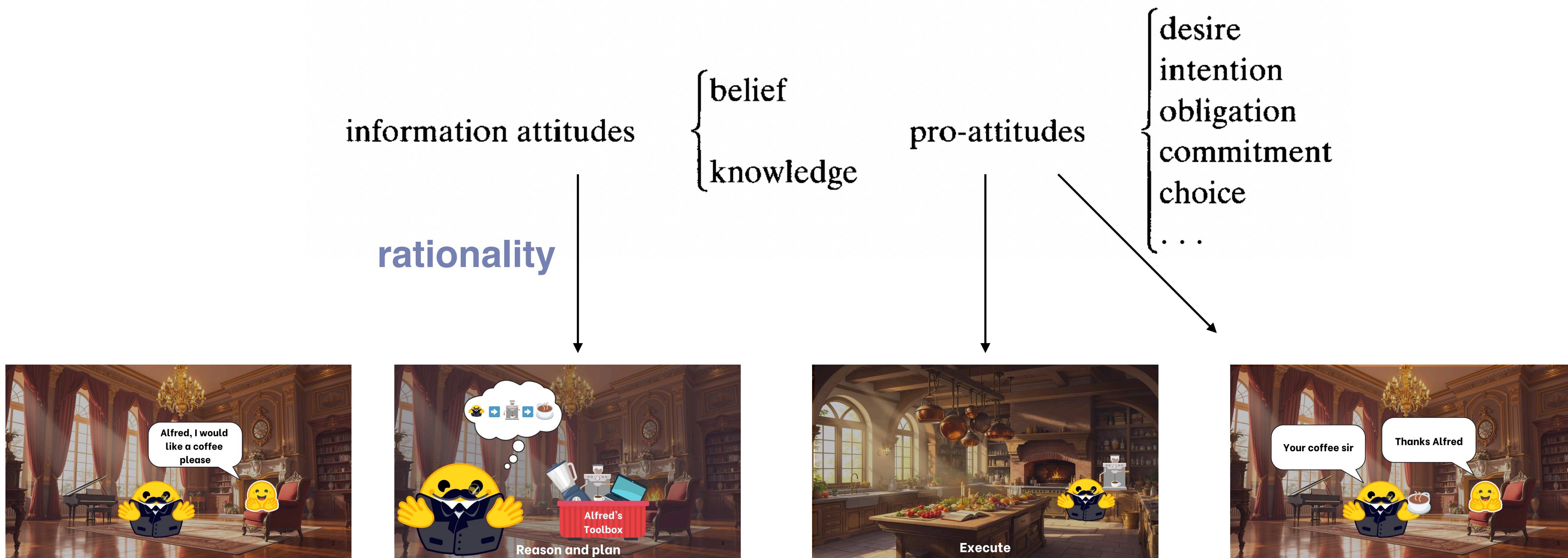
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# Belief-desire-intention model

Folk psychology based agent model for problem solving

Components:

- ▶ **Beliefs**: the beliefs about / model of the world ← how to update?
- ▶ **Desires**: desired end state of the world, the objective to accomplish
- ▶ **Intention**: the course of actions currently under execution to achieve the desire of the agent; consistent with beliefs ← how to select actions?

which ones to  
achieve first?

1. Intentions pose problems for agents, who need to determine ways of achieving them.
2. Intentions provide a “filter” for adopting other intentions, which must not conflict.
3. Agents track the success of their intentions, and are inclined to try again if their attempts fail.
4. Agents believe their intentions are possible.
5. Agents do not believe they will not bring about their intentions.
6. Under certain circumstances, agents believe they will bring about their intentions.
7. Agents need not intend all the expected side effects of their intentions.

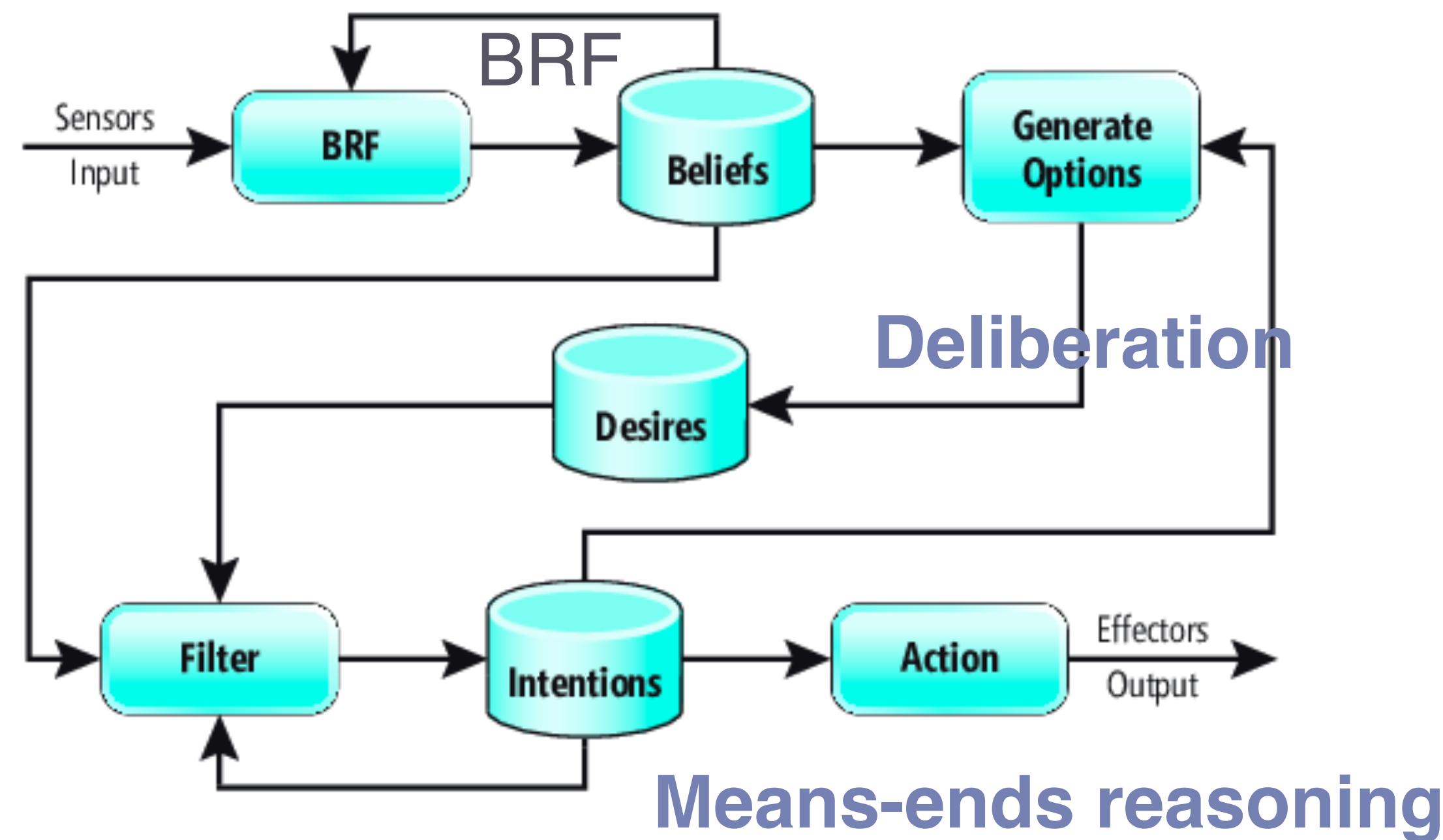
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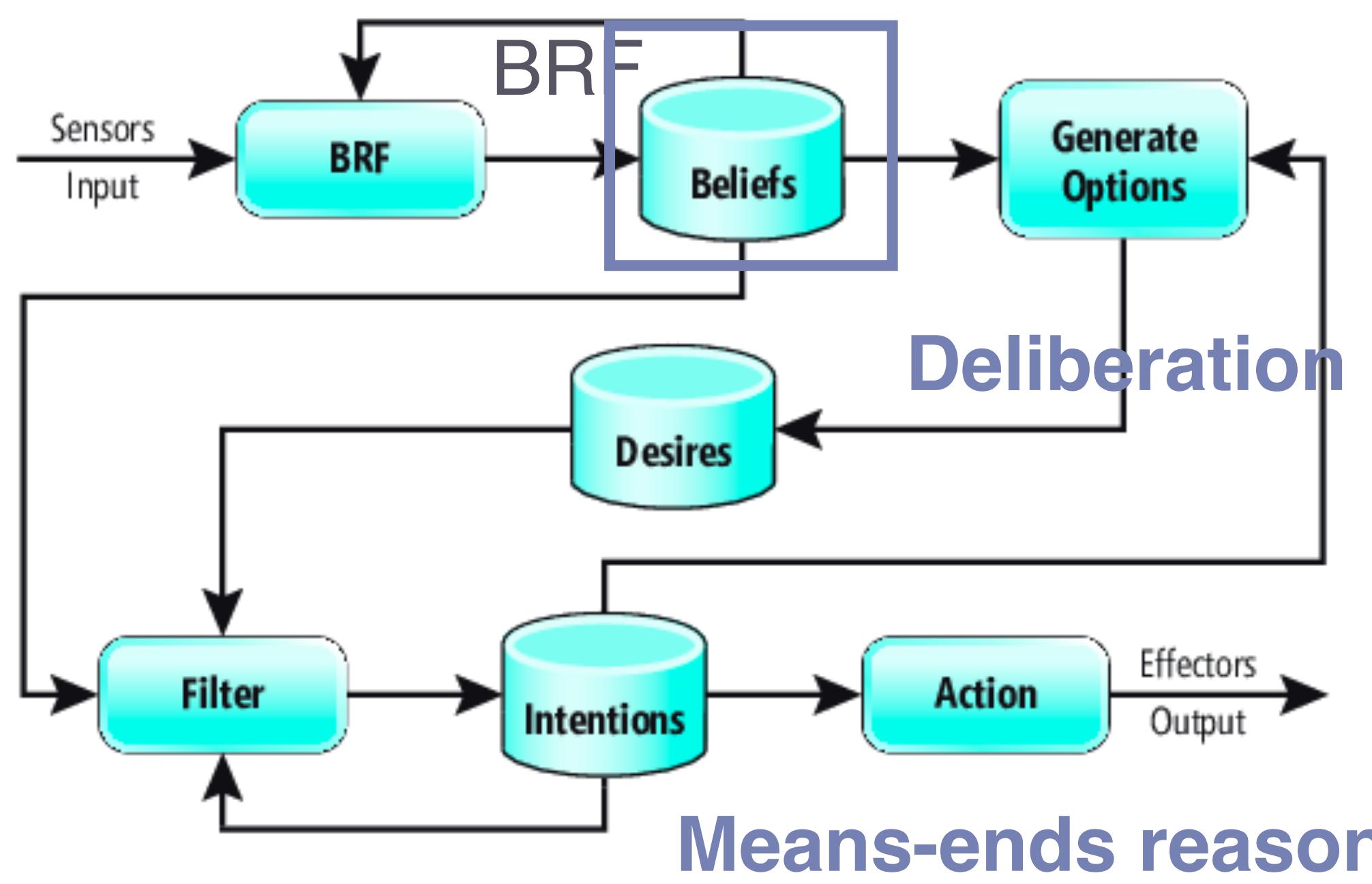
How are beliefs represented?

Components:

- ▶ **Beliefs:** the beliefs about / model of the world



First-order  
beliefs



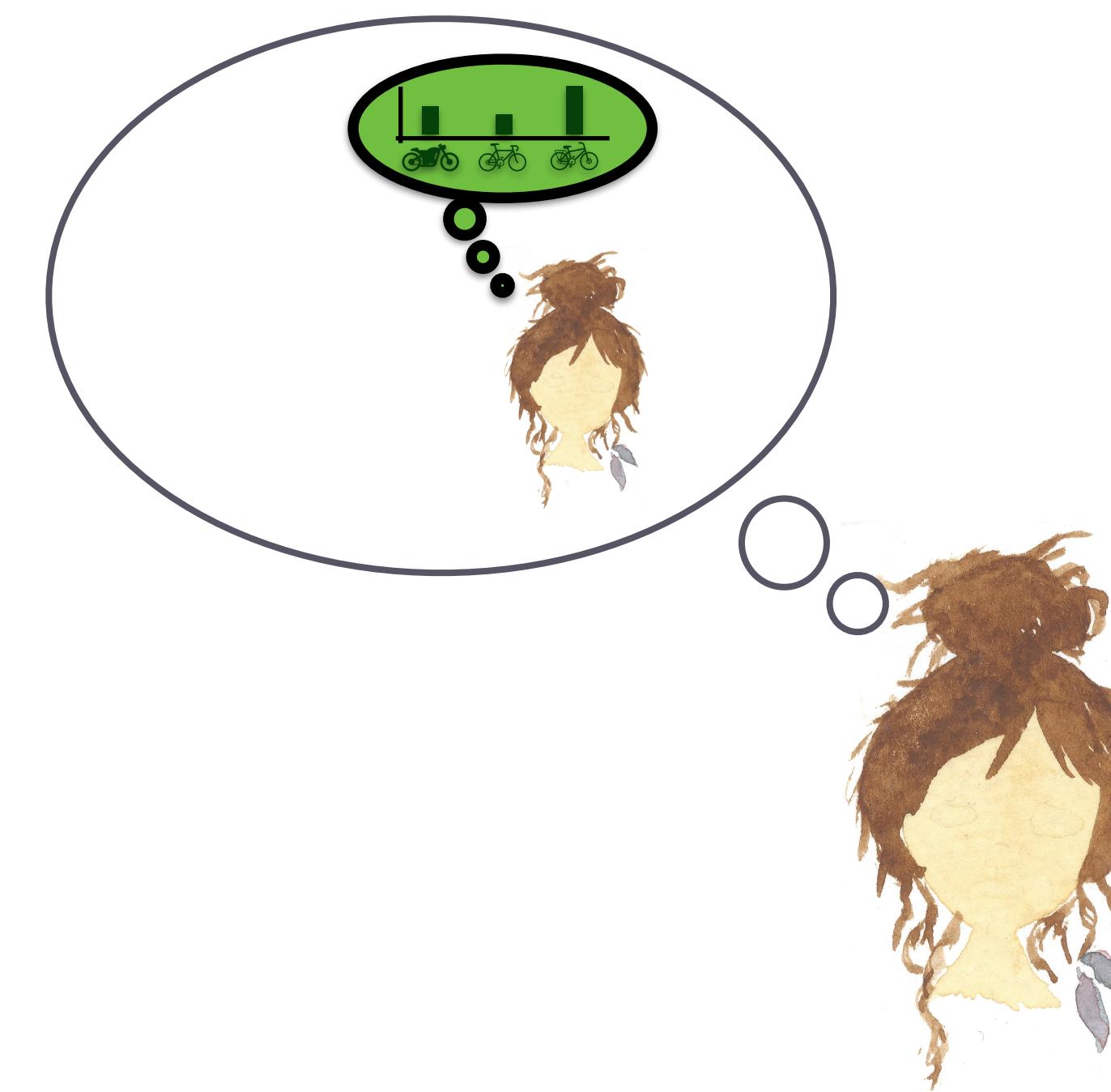
Bratman (1987), Georgeff et al (1999), Wooldridge & Jennings (1995)

# Belief-desire-intention model

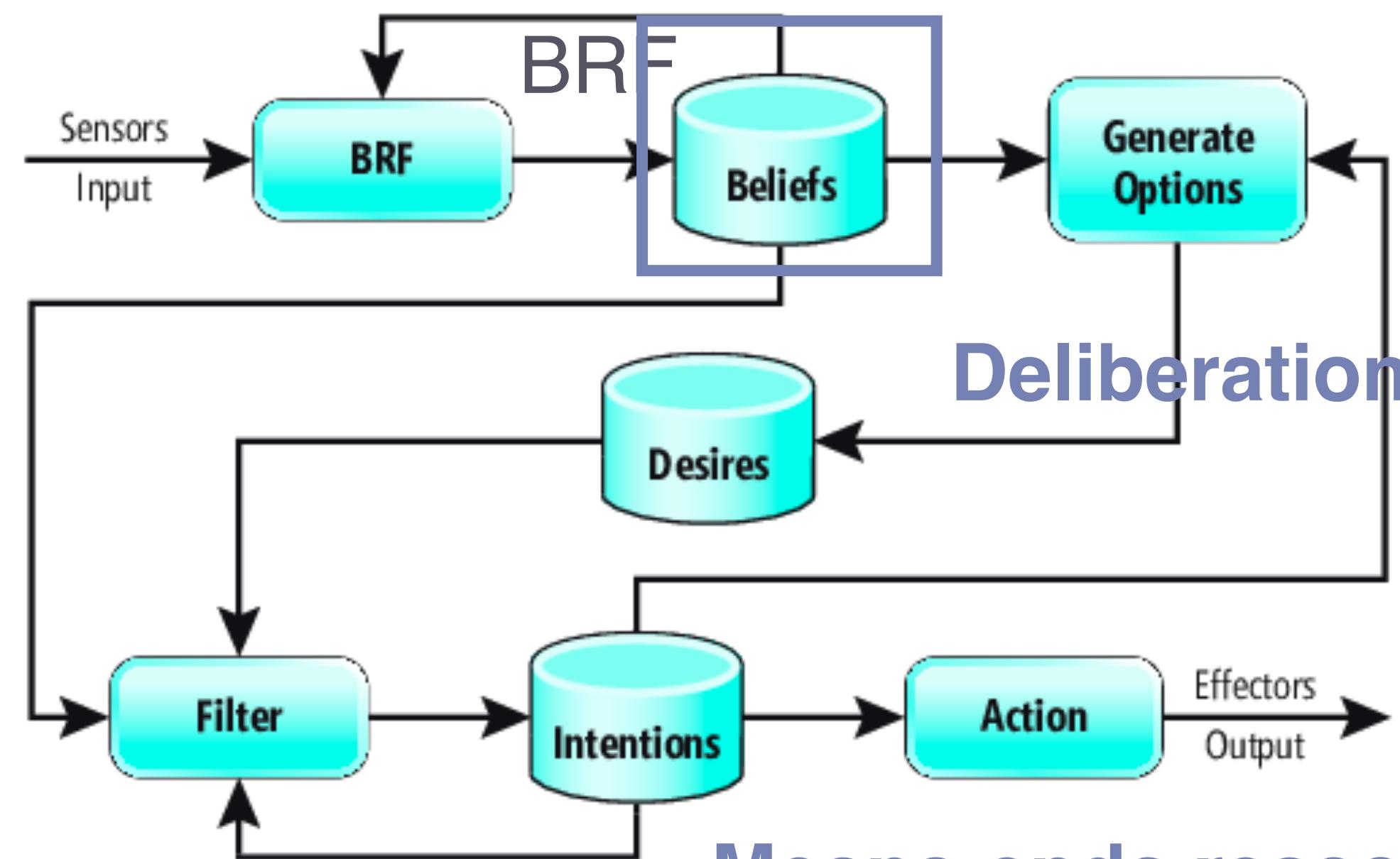
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Second-order  
beliefs



Means-ends reasoning

Bratman (1987), Georgeff et al (1999), Wooldridge & Jennings (1995)

# Belief-desire-intention model

How are beliefs represented?

Components:

- ▶ **Beliefs:** the beliefs about / model of the world
  - fact representation that facilitates *valid automatic reasoning*:
    - e.g., propositions & logic
    - (semantic) networks, hierarchies, scripts
- ▶ Common challenges:
  - distinction between knowledge and beliefs (i.e., **uncertainty**)
  - updates based on information from environment
    - conversion between sensory and symbolic representations
    - **frame problem** / relevance
  - granularity
  - flexibility
  - common sense
  - reasoning efficiency
    - **closed world assumption**

# From beliefs to actions

How does reasoning work?

Components:

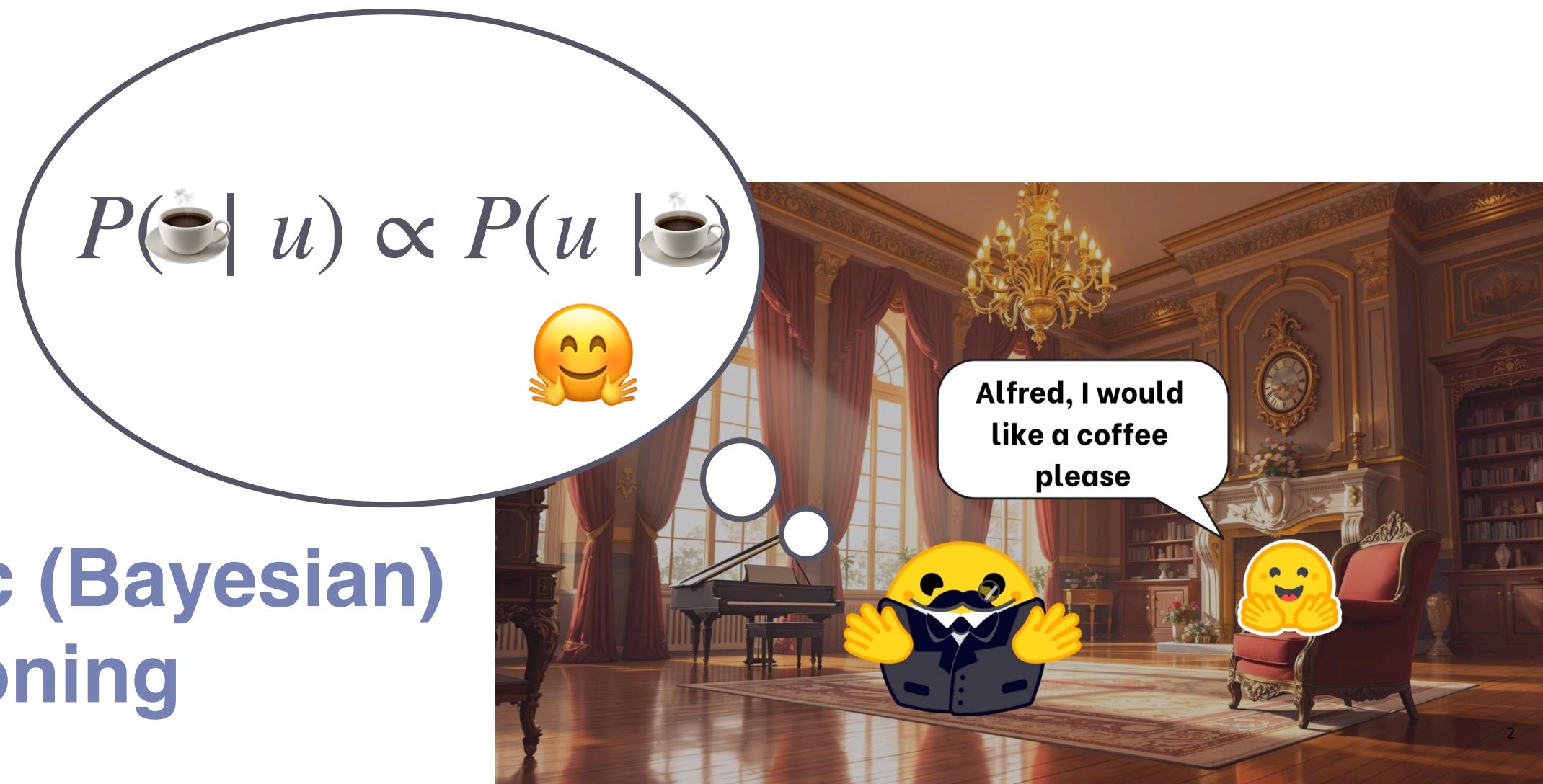
- ▶ Intention: the course of actions currently under execution to achieve the desire of the agent; derived via **deliberation / reasoning**
  - Wooldridge & Jennings: modal, intention logic based reasoning
    - side effect problem
  - Newell & Simon: reasoning as search through problem / action space (-> tomorrow!)
- ▶ Cognitive perspective:
  - reasoning: drawing conclusions to solve problems and make decisions
    - does not (always) follow classical logic! (e.g., sensitivity to language)
  - many aspects of reasoning are uncertain, i.e., **probabilistic**
    - special role of **social reasoning: theory of mind (ToM)**

# From beliefs to actions

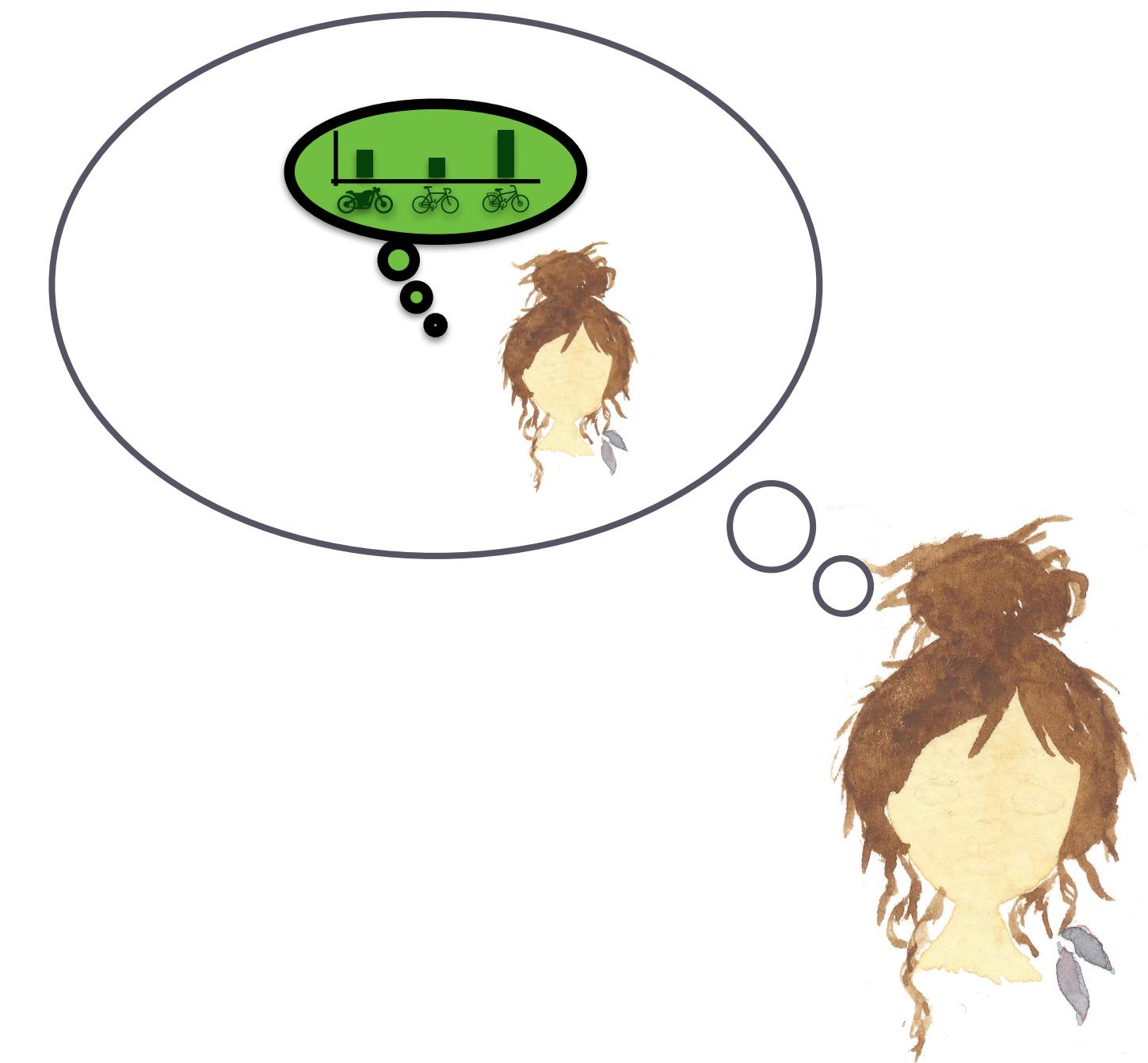
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Probabilistic (Bayesian)  
reasoning



Second-order  
beliefs

# From beliefs to actions

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    - special role of **social reasoning: theory of mind (ToM)**
  - Evans, Kahneman & Tversky: decision makers are **boundedly rational** and **have different reasoning processes: dual process theory**

# Dual process theory

How does reasoning work?

System 1 (Intuition)	System 2 (Reasoning)
Fast	Slow
Parallel	Sequential
Automatic / default	Controlled
Effortless	Effortful
Associative	Rule-governed
Slow-learning	Flexible
Contextualised (subject to priors, context effects)	Abstract
can be evoked by language	
operates on conceptual representations	



- ▶ although the overall distinction is widely supported, there are debates around:
  - is the distinction at the level of modes of thinking, or cognitive mechanisms?
  - mechanisms involved in S1 are also involved in S2
  - degree of modularity of the mind (Sperber, Fodor)

# Intermediate summary

What are agents?

- ▶ agents combine many complex properties like the ability to achieve goals, autonomously solve novel problems, interact with an environment based on available information, interact with other agents
- ▶ goal-directed behavior can be decomposed into different sub-components
- ▶ engineering approaches have strived to develop agents for different tasks, but flexible general systems have remained elusive
- ▶ cognitive science has provided insights into how humans navigate the complexities of real world

Outstanding questions:

- ▶ How can we combine insights about the human mind with engineering demands to build flexible and efficient artificial systems?
- ▶ How are intentions and goals formed in open-ended agents?
- ▶ Do these systems need to be *fully agentic*?

Disclaimer: we are leaving emotions, affect, consciousness and other aspects out of the picture

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# Paper discussion logistics

**Chu, Tenenbaum & Schulz (2024). In praise of folly: human flexible goals and human cognition**

1. split in two groups, half of the experts in each group
2. discuss the paper (e.g., start with questions of non-expert participants)
3. experts: responsible for adding key points, insights, new questions of the group to shared Google slides: [https://docs.google.com/presentation/d/1BH53A2ipfzrix9C0gR39Cd1uUIHZalZ2\\_CseZmhe81U/edit?usp=sharing](https://docs.google.com/presentation/d/1BH53A2ipfzrix9C0gR39Cd1uUIHZalZ2_CseZmhe81U/edit?usp=sharing)
  - a. maximally 3 slides!
  - b. make slides such that they will be helpful for exam!
4. joint discussion

# LLMs: Rudimentary models of agents / beliefs / actions?

AI agents in the age of LLMs

Language can be used as a vehicle for knowledge representation, reasoning, communication

*Pat watches a demonstration of a bowling ball and a leaf being dropped at the same time in a vacuum chamber. Pat, who is a physicist, predicts that the bowling ball and the leaf will fall at the same rate.*

Changing the last sentence of the prompt, we get:

*... Pat, who has never seen this demonstration before, predicts that the bowling ball will fall to the ground first. This is incorrect. In a vacuum chamber, there is no air*

Language Models as Agent Models [[Andreas, 2022](#)]