From behaviour reading to (minimal) theory of mind

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1. Abilities vs. cognition

Theory of mind *ability* = an ability that exists in part because exercising it brings benefits obtaining which depends on exploiting or influencing facts about others' mental states.

Theory of mind *cognition* = cognition of mental states.

2. Theory of mind abilities are widespread

- Humans in the second year use pointing to inform others[1] and predict actions based on false beliefs about the locations of objects[2, 3]

- Scrub-jays selectively re-cache their food in ways that deprive competitors of knowledge of its location[4]

- Chimpanzees select routes to approach food which conceal them from a competitor's view[5] and retrieve food using strategies that optimise their return given what a dominant competitor has seen[6].

What kind of cognition underpins these theory of mind abilities?

3. Reasoning about beliefs is expensive

- Acquisition takes several years[7, 8]

- Tied to the development of executive function[9, 10] and language[11]

- Development facilitated by explicit training[12] and siblings[13, 14]

- Requires attention and working memory in fully competent adults[15, 16]

Why does reasoning about beliefs and other propositional attitudes require conceptual sophistication and demand cognitive resources?

Because it is abductive reasoning about complex causal structures of states individuated by propositional contents and their normative implications.[17, 18]

4. Minimal theory of mind

Aim: construct an alternative to both belief reasoning (less costly) and behaviour reading (more flexible).

Why? Potentially explanatory of infants', scrub-jays' and chimpanzees' theory of mind abilities; and possible stepping-stone between behaviour reading and full-blown theory of mind cognition.

Prior art includes intentional relations to objects established by gaze,[19] 'engagement',[20, 21] and intervening variables.[22, 23]

5. What is behaviour reading?

Behaviour reading = segmenting a stream of bodily movement into chunks and discerning relations among chunks on the basis of statistical patterns and other cues.

Object-directed Behaviour reading involves motor actions that are object-directed such as grasping an object or placing an object. They are object-directed in the sense that their specification involves an object whose properties control how the action is executed

6. From behaviour reading to minimal ToM

An agent's *field* = the region of space an object has to be in if she is to act on it

What determines the extent of the field? Potentially any enabling conditions for perception. What determines whether an object is in an agent's field? Potentially any of the conditions controlling whether we can perceptually track objects.

An agent is *encountering* an object at a location = it is in her field in such a way that she can act on it.

Step 1 The ability to track and manipulate who encounters what where.

Application: level 1 perspective taking[29] in two-year old humans[30] and scrub-jay's choices of caching locations[31].

Step 2 Awareness of goal-directed action.

(I.e. awareness that (1) word-like units of actions as a whole have outcomes; and (2) that the occurrence of a whole word-like unit occurs in order to bring about an outcome.)

Application: learning by imitation without knowledge of goals.[32, 33]

Step 3 Past or present encountering is a condition on goal-directed action.

I.e. Where the goal of an action specifies a particular object, the action can only occur if the agent has encountered that object.

Application: the "uninformed" condition of Hare et. al's 2001 experiment with food hiding.[6]

Step 4 Awareness of correct registration as condition of success.

An individual *registers* an object at a location = she most recently encountered the object at that location.

In order to successfully perform a goal-directed action with a goal that specifies a particular object, the agent must correctly register that object.

Application: the "misinformed" condition of Hare et. al's 2001[6].

Application: scrub-jays, after being observed caching food by a competitor, will re-cache that food when in private.[4, 34]

Step 5 Predicting *unsuccessful* actions.

I.e. awareness that when an agent performs a goal-directed action with a goal that specifies a particular object, the agent will act as if the object were in the location she registers it as being in.

Application: Onishi and Baillargeon's false belief tasks.[2] Wimmer and Perner's false belief task(!).[7]

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