Cognitive semantics and cognitive theories of representation:

Session 4: Semantics of distinguishing criteria

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Goal

- Extend semantic theory to pre-verbal organisms (or detach it from language)
- Mutual coexistence of subjective and intersubjective meanings
- Dynamic nature of meanings
- Developmental and evolutionary pathways

Formalization – Roadmap

- Agent, Environment, Behaviour
- Subjective:
  - Perception, Similarity function, Schema
  - Signification, Situation schema
  - Memory (Knowledge Base)
  - Events, DC of change, Event schema
  - Autoreflexive attitudes, Beliefs, Desires, Intentions
  - Distinguishing criteria – transformers, detectors, constructors
  - Rules – Inference, Action
  - Goals, Plans, Routines
  - Me, It (Abductive view on another agent)
- Intersubjective

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Situated agent and its environment

- Time-dependent state of the environment – Env_t
- Observable actions of the agent – Beh_t
- Current **percepts** – $P(Env_t)$ is both projection and selection function
- $P(Env_t)$ are *iconic* representations (in Harnad's sense) – discrimination possible – similarity function sim_d

Schemata

- The similarity function enables the agent to recognize **common patterns** among recurring percepts and gradually extract (holistic) schematic views of their relations.
- Basic schemata arise directly from recurring sensorimotor experience early in development (Piaget & Inhelder, 1966).
- More complex ones are gradually built on top of these.
- They can be learned based on detecting statistical contingences among perceptual streams (e.g. inferring a concept of an *object* as time-locked correlations of percepts in different sensory streams).

Schemata

- Schemata allow the agent to make sense of its current perceptions by establishing their relation to previous experiences.
- More generally, integrate the new experience within the web of existing knowledge (expressed by schemata) – Piagetian *assimilation* (Piaget & Inhelder, 1966).
- Schemata can be formalized as layered labelled hypergraph; both vertices and edges can have multiple layers of labels. Some vertices are percepts, others are inferred constructs; the edges express relations. The labels are distinguishing criteria or autoreflexive attitudes (carrying type information).

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Signification

- A sense making act σ – *signification* (Peirce, 1931-58) of the agent is a process of constructing or evoking appropriate schemata, given the current percepts $P(Env_t)$.
- We will denote the result of signification $\sigma(P(Env_t))$ and call it ***situation schema***.
- Unlike percepts that are pure transductions of the external environment, a situation schema is a *representation* with the added value of interpretation of percepts (Gärdenfors, 1996).

Memory

- ***Knowledge base KB_t.*** The knowledge base is a set that includes the agent's remembered situation schemata - a subset of $\{ \sigma(P(Env_i)) \mid i < t \}$
- Some situation schemata may have been forgotten.

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Events

- In a dynamic world situations change to other situations.
- A change of one situation to another constitutes an ***event***.
- Similarity functions enable the agent to perceive temporal changes in situations.
- – formalized as ***distinguishing criterion of change*** – a function defined on pairs of the form $(\sigma(P(Env_{t-1})), \sigma(P(Env_t)))$; if the second one is a result of a change of the first, the assigned value is 1.

Event schemata

- The agent represents distinguished events by ***event schemata*** – two or more situation schemata linked by (hyper)edges labelled by distinguishing criteria of change.
- Event schemata can be constructed or evoked from memory (in case of recognition of a similarity to a past event).
- the act of event selection ε and its resulting event schema $\varepsilon(\sigma(P(Env_t)), KB_t)$.
- Extended def. of $KB_t := KB_t \cup \{ \varepsilon(\sigma(P(Env_i)), KB_i) \mid i < t \}$.

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Autoreflexive attitudes

- Special labels on (elements of) schemata, e.g. *current situation, goal, problem, question…*
- *beliefs* B_t – schemata of currently perceived situation/event
- *desires* D_t – schemata of the agent's needs and long-term goals
- *intentions* I_t – schemata of the agent's current goal, a plan to achieve this goal together with a state of its execution, and other agenda-related structures
- A **current state of "Me":** $Me_t = (KB_t, P(Env_t), B_t, D_t, I_t, Beh_t)$

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Operations on schemata

- *Refine, zoom in/out, abstract,…*
- ability to distinguish (and perform) these transformations formalized as ***transformers***.
  - a declarative aspect (as a description of relations among schemata)
  - a procedural aspect (as a device that transforms a schema into another schema).
- Transformers are a special type of **distinguishing criteria**

Grouping schemata by similarities

- *Types* of situations and events
- More sophisticated similarity functions.
- Special transformers called ***constructors*** operate on sets of schemata (exemplars) and construct a new distinguishing criterion representing their common characteristics, called ***detector***.

Detectors

- Internally, a detector consists of a schema specifying a template with features important for category membership (in some cases more or less abstract representation of a prototypical, salient or most frequent category member) and a similarity function specifying how important the particular features are and how they contribute to the overall similarity.
- Functionally, a detector can be formalized as a partial function that operates on (fragments of) schemata and returns their degree of membership in the implicitly represented category (either as 0=no, 1=yes, or by a fuzzy value from the closed interval [0,1]). Constructors can also modify an existing detector when new exemplars arrive.

What detectors detect

- *situation types* (e.g. a traffic jam)
- *event types* (e.g. a car crash)
- *objects/individuals* (such as Barack Obama)
- *classes* of objects (dog, stone, food)
- *properties* of objects (red, big, hairy)
- *relations* between/among objects (bigger than, ancestor)
- *changes* (grow, faint).

Types of distinguishing criteria

- **Detectors**
- **Transformers**
  - **Constructor** – a type of transformer that creates/modifies detectors (usually by inducing common properties of exemplars).
  - **Updater** – a special type of transformer that keeps track of changing schemas and DC.

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Rules

- keeping track of sequences of transformations typically occurring in certain situations – ***rules*** – schemata connecting:
  - *premises* (prerequisites – the rule's applicability conditions represented by distinguishing criteria of situation and event types) to
  - *consequences* (represented either directly by situation and event schemata or indirectly by transformers that can be applied to the current situation/event and construct the resulting one),
  - *justifications* (optional; situation and event types guarding the evidence that would prevent the application of the rule in case of *default rules*)

Rules

- ***inference rules*** – internal transformations
- ***action rules*** – effects of overt actions on the environment
- Rules can be chained together in the form of ***plans***. Remembered successful plans are called ***routines***.

Approximate truth

- "reality check" – compare the predicted outcome of an action with the real one.
- Helps to rank/order the representation in terms how well they match "the world".

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Toward intersubjectivity…

- Observable behaviour: $It_t = (Beh_t)$
- Abduced $(KB'_t, P'(Env_t), B'_t, D'_t, I'_t)$
- Complete view of another agent
  - $It'_t = (KB'_t, P'(Env_t), B'_t, D'_t, I'_t, Beh_t)$.

Instruments

- **Instrument** – a measure, which is generally accessible, interpretable in a unique way and *accepted by a group of agents*.
- Examples: religious dogmata, sacred texts
- History of science: measurement, proof, significance tests,…
- Cookbooks, lookup tables, mechanistic procedures, algorithms

Instruments

- A *distinguishing criterion with an instrument* is a function with a parameter that specifies how to compute its value for its arguments. The parameter is called *instrument* and it is a transformer.
- The transformer is either an algorithm or a conventional, more or less mechanical, procedure based on an expert knowledge. In the latter case, the expert knowledge is expressed by a set of schemata associated with the transformer (as its additional arguments).
- A schema generated by a transformer and a set of associated schemata will be called *schema with an instrument*.

Instruments in science

- Selection of an instrument generates a *paradigm*.
- Examples: Geometry, Psychology…
- "*The devices with knowledge built in their construction determine what in the world will we notice and how we will interpret it.*" (Kováč, 2000b)
- Or as an old proverb says: "When you have a hammer, you see nails everywhere".

Universal Truth?

- biological roots of meanings: a final reality-check of our meanings and conceptions is success and failure in achieving our goals.
- What is our ultimate goal then?
  - Autopoiesis - maintenance of our onticity?
  - Minimisation of suffering?
  - … ?