



## Grounded cognition

### Brief introduction to language

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## What are the research questions for this course?

- How is the knowledge (in our minds) grounded in our bodies?
- In anything else?
- What are concepts?
- What is the relation between cognition and language?
- What is the relationship between multimodal representations and symbols?
- How does language affect our cognition?
- ...

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## Language – some important concepts

- Purpose: communication
- Uniquely human ability
  - modality independent
- Variety of natural languages (evolution)
- Evolutionary aspects: which precursors?
  - Theory of mind
  - Semiotics – signs, meaning
- Relation to the brain: Language-specific area(s)?



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## Unique properties of natural languages

- Hierarchical structure
- Productivity (limited symbols, unlimited messages) - recursion
- Arbitrary symbolic reference
- Discreteness (elementary linguistic units are indivisible)
- Displacement
- Vocal channel that allows articulation (typical, not crucial)
- Additional properties:
  - vagueness
  - use of metaphors
  - context dependency



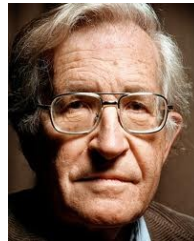
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## Key questions: Knowledge and language

- What is knowledge (semantic memory)?
- How do we represent the outside world in our mind?
- Does the world exist out there, independently of our minds?
- Is the world structured? If so, how?
- How do we process the representations in our minds?

### Language – “an interface” to our mind:

- What is the knowledge of language?
- How is it acquired?
- How is it put to use?
- Relation b/w language and cognition?

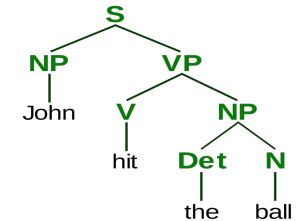


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## Language components

### Components:

- **Phonology:** cat → /kæt/  
– baby as a universal phonetician
- **Grammar:**  
– morphology: anti|abort|ion|ist|s  
– syntax: *John hit the ball* → N (V ((D) (N)))  
– rules vs statistics
- **Semantics:** agent - action - patient (semantic categories)
- **Pragmatics** (speaker's intention)



### Hierarchy of building blocks:

phonemes → syllables → words → phrases → sentences → pragmatics (discourse) ...

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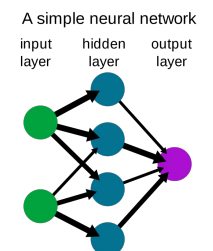
## Semantics

- Morpheme = basic unit that conveys meaning
- The most important and most difficult aspect of language
- What is meaning? How is it represented?
- Theories of semantics – referential, or non-referential:
  - **Realist semantics** – there exist objects (physical or mental) that are the meanings of linguistic expressions. Meanings are “in the world.”
    - Extensional ~ meanings are objects in the world (Frege, Tarski)
    - Intensional ~ meanings are mappings to possible worlds (Kripke)
  - **Cognitive semantics** – meanings are “in the head”, created during one’s experience with the world.
    - prototype theory (Rosch, 1983) → basic level categorization first
    - consistent with grounded theories of cognition

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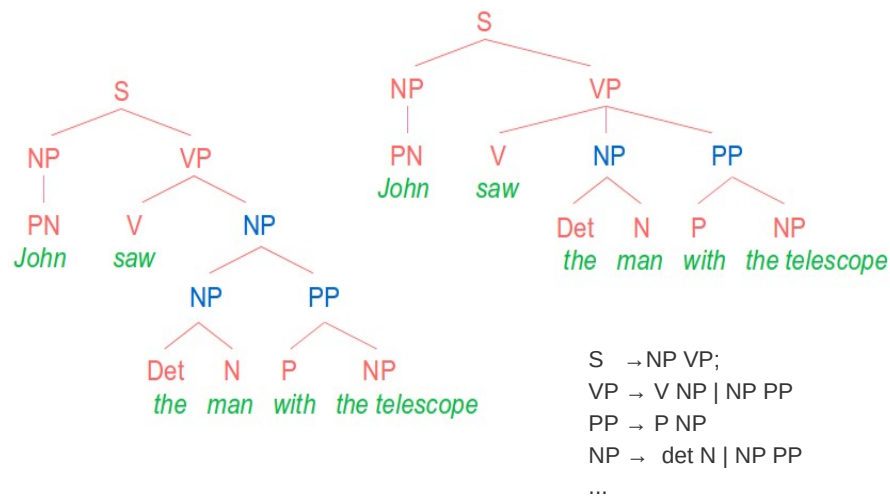
## Computational models of language processing

- **symbolic**
  - since 1950 (onset of computer era, **generative** linguistics)
  - based on **symbolic grammar** (e.g. context-free grammar, CFG)
  - emphasis on language **competence**
- **statistical**
  - **probabilistic grammars** (e.g. context-free grammar ~ Chomsky hierarchy)
  - training on annotated corpora
  - $P(w_t | w_{t-1}, w_{t-2})$ , e.g.  $P(\text{dog} | \text{walks man})$
- **connectionist (incl. deep learning)**
  - since 1985: „modern” PDP paradigm (in neural net)
  - **no grammar provided to the model**
  - statistical properties **exploited**
  - emphasis on **performance** (more human-like)



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## Syntactic parsing (of a sentence)



Who was holding the telescope in either case?

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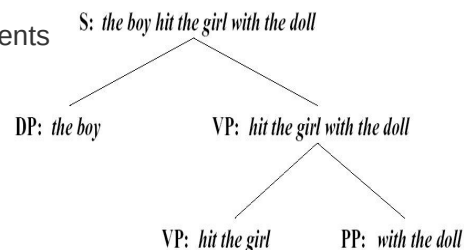
## Rules versus statistics

- **Rules** – abstract, symbolic level
  - in humans: may require conscious processes
  - e.g. in math (second language learning?)
- **Statistics** – frequency effects
  - symbolic level (as in statistical NLP)
  - subsymbolic level (as in ANN models)
  - in humans: likely to be unconscious (implicitly learned)
    - sequential learning (incl. non-adjacent dependencies)

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## Symbolic and connectionist approaches: comparison

- **symbolic**
  - explicit grammar
  - explicit manipulation with constituents
  - no memory problem
  - no problem with recurrence
  - no robustness
- **subsymbolic**
  - implicit grammar (emergence)
  - holistic processing
  - memory problem, recurrence problem (gradedness)
  - cognitive plausibility (robustness)



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## Major theories of language development

- universal trajectory across languages
- **Behaviorist** (Skinner)
  - learning (nurture) by associations, imitation and reinforcement
- **Nativist** (Chomsky)
  - Nature is crucial (universal grammar hypothesis)
  - Language parameters are triggered by environment
- **Cognitive developmental** (Piaget)
  - Nature is crucial but no specific inborn mechanism (as part of the developmental process) is specified
  - Language develops according to stages of cognitive development
- **Interactionist** (Vygotsky)
  - Nurture is crucial, but namely social interaction

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