The Embodied Language of Thought

Towards Understanding How the Mind Represents and Combines Meaning for Thinking and Language Understanding

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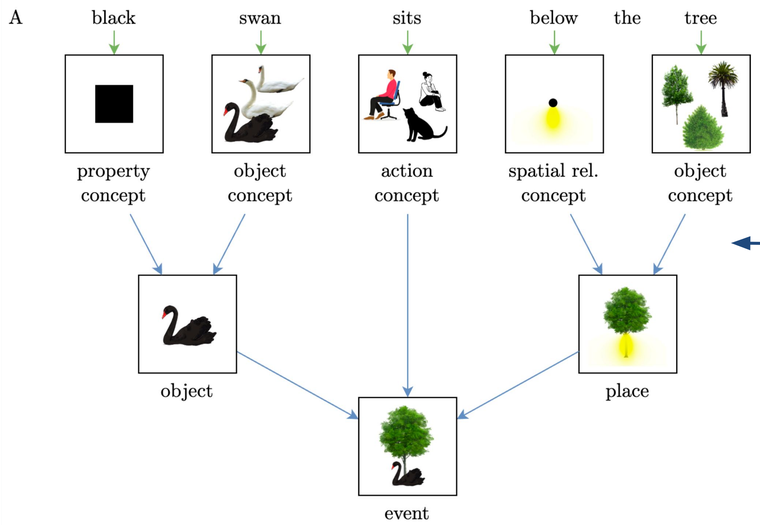
Abstract

We propose an empirically founded framework within which the question of how the brain enables thinking and language understanding can be explored. According to this framework, the brain enables the understanding of a sentence by activating neural representations of the meanings of its constituent words - called concepts - and combining these concepts in specific ways that are in accordance with how the words are arranged syntactically. This is achieved by representing the meaning of an expression as a composition of semantic constituents in the so-called "conceptual structure". That structure informs the processes that combine concepts to enable the understanding of the whole sentence.

Our framework is informed by and builds upon insights from Barsalou (1999), Jackendoff (2002), Fodor & Pylyshyn (1988), Doumas & Hummel (2012), Stewart & Eliasmith (2012), Eliasmith (2013).

The Framework

First tenet: The brain enables the understanding of a sentence by activating neural representations of the meanings of its constituent words - called concepts - and combining these concepts in specific ways such as to yield perceptual-motor representations of described entities, which are in turn further combined with each other in specific ways.



Second tenet: Concepts consist of prototypical perceptual or motor representations of categories of entities and derived abstract knowledge.

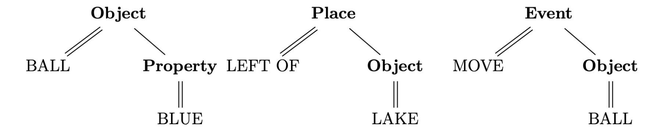
Third tenet: Derived entities comprise perceptual-motor representations of objects, places, events, properties, states, paths, and potentially more.

Fourth tenet: The way concepts and entities are combined is in accord with the *conceptual structure* of the language expression, a linguistic analysis tool that describes how the meaning of the expression may be characterized as a combination of semantic constituents.

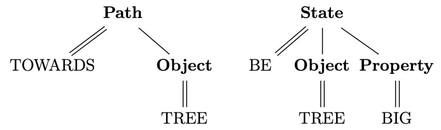
Fifth tenet: Conceptual structure and its perceptual-motor grounding are incrementally built as the stream of words is processed.

Conceptual structure

Linguistic analysis tool that describes how the meaning of a sentence may be characterized as a combination of semantic constituents (Jackendoff, 2002).



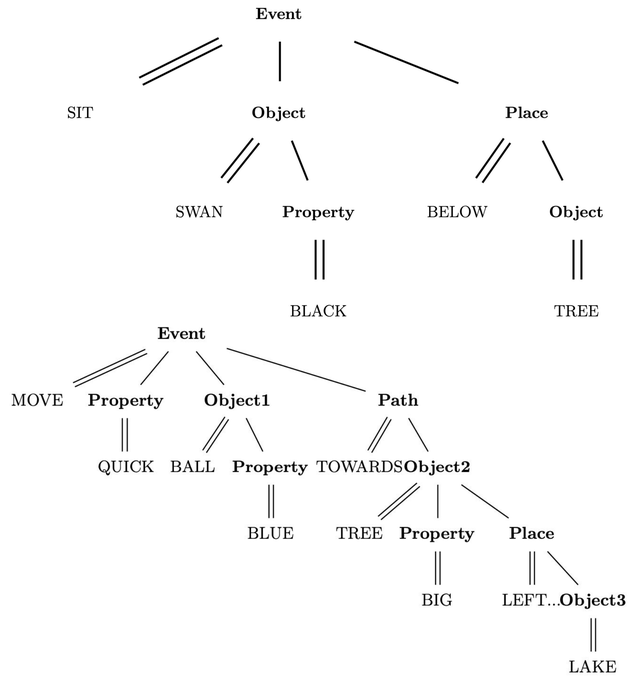
(a) "blue ball" **(b)** "to the left of the lake" **(c)** "the ball moves"



(d) "towards the tree" **(e)** "the tree is big"

Double-stroked lines link a semantic constituent to its head (a concept), and single-stroked lines link a semantic constituent to its arguments (which are themselves semantic constituents).

Semantic constituents can be recursively nested:



Arguments

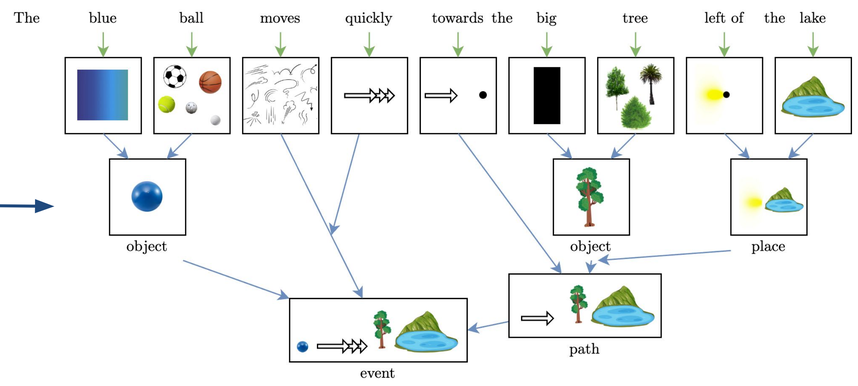
- Long history of experimental literature that links the meanings of words to perceptual-motor representations of prototypical category members, and that perceptual-motor imagery is involved during language processing tasks (e.g., Barsalou, 1999; Machery, 2009; Kemmerer, 2014)
- Expressions with the same syntactic structure are usually interpreted in a highly similar way whenever they occur (Fodor & Pylyshyn, 1988)
  - e.g., "tree", "big tree", "left of", "lake", "big tree left of the lake"
  - This requires that the interpretation of an expression is carried out by the same mechanism, regardless of where that expression occurs in a sentence or discourse
  - … which in turn requires that every occurrence of an expression must be passed on to the same mechanism
  - … which in turn requires that a larger expression is analyzed for its semantic constituents, each of which is semantically interpreted using its corresponding mechanism, and that semantic interpretation is then employed in the semantic interpretation of the larger expression

Towards understanding thought

If the framework is correct, then we can make progress towards understanding the nature of thought by understanding the nature of

- concepts
- grounded representations of semantic units
- the mechanisms by which concepts are combined to yield grounded representations of semantic units
- the mechanisms by which grounded representations of semantic units are combined to yield grounded representations of larger semantic units

All these constrain each other. Lexical semantics, compositional semantics, syntactic studies, cognitive psychology, and cognitive neuroscience can all provide insights into each.



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