

Grounded Cognition

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Definition of grounded cognition

- **the core representations in cognition are not:**

- amodal symbols and data structures

processed independently of the brain's modal systems for perception, action, and introspection

- **core sources of information and representation that ground cognition:**

- the environment

“situated cognition”

- the body

“embodied cognition”

- simulations

in the brain's modal systems for perception, action, and introspection

30 years ago

- **symbol grounding**

- the Chinese room problem

Searle (1980)

- **conceptual metaphor**

- grounding abstract concepts in bodily experience

Lakoff & Johnson (1980)

- **the environment supports perception and cognition**

- ecological optics

Gibson (1979)

- cognitive ecology

Hutchins' STEAMER project

30 years ago (continued)

- **mental imagery**

- perceptual representations in higher cognition

Shepard & Cooper (1982), Kosslyn (1980)

- **situated language**

- the importance of context in text comprehension

Bransford & Johnson (1973)

- common ground

Clark & Marshall (1981)

The past 20 years

- **cognitive linguistics**

- cognitive grammar and mental spaces

Talmy (1985), Langacker (1987), Fauconnier (1983), etc.

- **situated action in robotics**

- importance of bodies in the environment

Brooks (1991), Kirsch (1991), etc.

- **neural bases of mental imagery**

- imagery originates in neural systems for perception and action

Kosslyn (1994), Jeannerod (1995), etc.

- **category-specific brain lesions**

- sensory-motor lesions disrupt category knowledge

Warrington & Shallice (1984), etc.

The past 10 years

- **neuroscience evidence (PET, fMRI, ERP, TMS)**

- activation in the brain's modal systems during higher cognition

Martin (2001, 2007), Pulvermüller (1999), Thompson-Schill (2003), etc.

- perception produces motor inferences in higher cognition (mirror circuits)

Rizzolatti et al. (1996), Decety & Grèzes (2006), Goldman (2006), etc.

- **behavioral evidence in cognitive psychology**

- effects of sensory-motor variables on higher cognition

Glenberg (1997), Zwaan et al. (2002), Hegarty (2004), Barsalou (2008), etc.

- dependencies between vision, action, and cognition

Prinz (1997), Tucker & Ellis (1998), Wilson & Knoblich (2005), etc.

- **behavioral evidence in social psychology**

- effects of embodiment on social cognition

Niedenthal et al. (2005), Barsalou et al. (2003), etc.

- **behavioral evidence in developmental psychology**

- cognition originates in bodily interactions with the environment

Thelen & Smith (1994), etc.

Current status

- **continued demonstrations of grounding**
 - across diverse areas and phenomena
- **increasing awareness and acceptance**
 - 10 years ago, grounding seemed irrelevant for higher cognition
 - now widespread belief that grounding plays some role
- **the causal status of grounding mechanisms in cognition**
 - epiphenomenal?
 - perhaps traditional symbolic mechanisms determine cognition
 - mixed models
- **lack of computational and formal accounts**
 - the area largely consists of demonstration experiments
 - hardly any computational or formal models
 - but see Ullman, Plaut, O'Reilly*
 - relatively few empirical tests to distinguish models

Current status (continued)

• what's amodal in the brain?

- do classic symbolic mechanisms constitute the core of cognition?
with grounding mechanisms being epiphenomenal
- do non-grounded statistical representations constitute the core?
or do statistical and modal representations form integrated units
- do amodal representations underlie “special domains”?
number, space, etc.

• symbolic operations and abstract concepts

- do simulation mechanisms implement symbolic operations?
amodal symbols, perceptual symbol systems, Barsalou (1999)
- how does the brain represent abstract concepts?
amodal symbols, conceptual metaphor, grounding in events and introspection

• speculation that grounding will lead to new discoveries

- relations between perception, action, and higher cognition
- the nature of representation and knowledge
- the development of intelligence

The next 30 years

- **integration of perspectives, not competition**

- classic symbolic processing
- statistical and dynamical systems
- grounding in situations, bodies, perception, action, introspection

- **grounding will become a part of standard explanations**

- no longer a controversial issue
- the environment, the body, and simulations will be standard components in accounts of cognition across areas

perception, action, memory, knowledge, language, thought, knowledge, development, social cognition, cultural cognition

- grounding will play a causal role (not epiphenomenal)

- **computational and formal accounts of grounding will evolve**

- as research becomes less demonstrational and more theory-driven

The next 30 years (continued)

- **integrating grounding will be relatively painless**
 - basic empirical phenomena will acquire an additional level of explanation
similarity, structure mapping, Bayesian inference, etc.
 - representations in cognitive architectures will become increasingly grounded
production systems, neural nets, Bayesian systems, etc.
- **if new grounded architectures develop, they are likely to:**
 - reflect influences from neuroscience
 - incorporate mechanisms from existing computational accounts
 - incorporate constraints from behavioral research
 - be grounded in developmental research
 - be implemented in robotic systems