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Grounded Cognition

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Grounded cognition proposes that cognition emerges as classic cognitive processes (e.g., attention, memory, language, and thought) interact with the sensory-motor modalities and the body embedded in the environment (physical and social) during situated action. The grounded perspective further assumes that sensory-motor states in the modalities serve central representational functions in cognition, taking the form of multimodal simulations. Grounded cognition emerged as a reaction to classic cognitive theories, in which cognition is viewed as a modular process operating independently of sensory-motor modalities, using amodal symbols for representational purposes. Reviews of the empirical literature across the cognitive sciences and neurosciences noted increasingly that cognition, perception, and action were more closely related than the classic perspective assumed. Theories of grounded cognition began to emerge that motivated new empirical paradigms, yielding further evidence of the perspective's validity and utility. Considerable controversy has surrounded these developments, often related to whether amodal symbols do or do not play a role in cognition, whether multimodal simulation plays a central versus peripheral role, and how best to explain abstract concepts. The roles of language and symbolic processing also remain contested, together with the importance of biological contributions (the nativist–empiricist debate).

History

Antecedents of grounded cognition can be traced far back to many philosophers including Aristotle, Epicurus, Lock, Berkeley, Hume, and notably the nativist philosophers Kant and Reid ([Barsalou, 1999](#); [Prinz, 2002](#)). In modern times, [Searle \(1980\)](#) and [Hamad \(1990\)](#) posed the *grounding problem*, that is, the problem that the amodal symbols in classic cognitive theories are not linked to sensory-motor systems or the world but are simply linked to each other such, thereby remaining arbitrary and meaningless. This became a major focus of attention. [Varela et al. \(1992\)](#) were some of the first to develop and champion a grounded approach (also see [Thompson, 2010](#)). [Barsalou's \(1999\)](#) theory of perceptual symbol systems generated further interest, together with [Niedenthal and colleagues' \(2005\)](#) and [Barsalou's \(2008\)](#) reviews of supporting empirical literature. Groundbreaking empirical results from many researchers, including [Martin \(2007\)](#), [Zwaan \(2004\)](#), [Pulvermüller \(2005\)](#), and [Glenberg \(2010\)](#), suggested that cognition was indeed grounded in sensory-motor modalities, attracting much attention and stimulating further research that continues today.

Other significant developments occurred across the cognitive sciences, including the grounding of intelligence in developmental science ([Smith & Gasser, 2005](#)), situated action in robotics ([Brooks, 1991](#)), extended cognition in anthropology ([Hutchins, 1995](#)), and cognitive metaphor in linguistics ([Lakoff & Johnson, 1980](#); [Langacker, 2008](#); [Talmy, 1983](#)). [Barsalou \(2010\)](#) traced the many roots of grounded cognition and speculated about its future.

Pushback accompanied these developments, including [Mahon and Caramazza \(2008\)](#), [Machery, 2007](#), and [Dove \(2009\)](#). A special issue of *Psychonomic Bulletin & Review* (2016, volume 23) documents the evolution of these controversies.

Grounded cognition is often also referred to as *embodied cognition*, *situated cognition*, and *4E cognition*. The 4E theory of cognition has continued to develop the grounded perspective philosophically ([Newen et al., 2018](#)). Considerable work, basic and applied, continues to emerge across the cognitive sciences and allied disciplines.

Core concepts

Representation

The issue of *representation* lies at the heart of grounded cognition and its evolution [see [Mental Representation](#)]. Because representation is often equated with *amodal symbols* that are arbitrarily linked to their referents, it is often dismissed as a misguided construct ([Brooks, 1991](#)). Philosophical work, however, offers a much broader construct of representation that allows the states of sensory-motor systems to function as representations, even in nonlinguistic animals and plants ([Ramsey, 2007](#); [Rupert, 2011](#)). For example, when a person's visual memory of a dog becomes activated in their brain, it serves as a representation of the dog, carrying information about the dog's color, size, behavior, and many other features.

In general, most researchers assume that organisms possess powerful representational capabilities that provide information about what is currently present in the environment, future states likely to occur, and future actions that could ensure survival. Whereas classic theories propose that arbitrary amodal symbols constitute these representations ([Fodor, 1975](#); [Pylyshyn, 1984](#)), grounded theories propose instead that *multimodal states* across sensory-motor systems in the brain constitute them, at least significantly ([Barsalou, 1999](#); [Lakoff & Johnson, 1980](#); [Langacker, 2008](#)), with language playing important roles as well ([Barsalou et al., 2008](#)) [see [Concepts](#); [Language](#)].

One proposal for how grounded representations develop in the brain is as follows ([Barsalou, 1999](#)): Imagine that an individual experiences a specific dog perceptually and interacts with it motorically and emotionally. According to the grounded perspective, states of the perceptual, motor, and affective systems active in the brain while experiencing the dog become stored in memory. Later, if this memory is reactivated and replayed in some form, it offers a *simulation* of what the dog was like, even if it is no longer present. If one further assumes that such memories of dogs become aggregated together in long-term memory, perhaps associated with a linguistic label, a multimodal concept of a dog develops that can be used to represent dogs in general, not just one dog. If one needs to think about a dog for some reason, or to plan an interaction with one, the multimodal concept of dogs can be used to simulate it in its absence for these purposes (the fundamental role of representation). Starting with this basic notion of a multimodal concept, it becomes possible to develop a grounded theory of cognition that implements all the basic symbolic functions in classic theories without having to propose the problematic construct of amodal symbols (e.g., type-token relations, propositions, recursion, productivity, and conceptual composition) [see [Compositionality](#)]. The process of simulating past experiences also offers new ways of understanding perceptual inference, memory retrieval, language comprehension, reasoning, social cognition, and many other cognitive, affective, and behavioral phenomena [see [Memory](#); [Psycholinguistics](#); [Foundations of Rationality](#); [Social Learning](#); [Social Cognitive Neuroscience](#)].

Extended cognition

Moving beyond representation in the cognitive system, grounded cognition further brings in the body, action in the world, physical situations, and social situations, along with artifacts such as pencils and smartphones, that extend an organism's cognitive and behavioral capabilities ([Clark, 1998](#); [Hutchins, 1995](#); [Newen et al., 2018](#)). From this perspective, examining cognition in isolation as a modular entity not only limits our understanding of it but is likely to produce distorted accounts. Because cognition is intrinsically and profusely interconnected with sensory-motor modalities, the body, and the

environment, cognition depends critically on all of them, forming a complex interacting system that produces an individual's cognition, affect, and behavior in the world. As a result, constructs such as *embodiment*, *situated action*, and *extended cognition* have emerged as fundamental perspectives on how these complex systems develop and operate.

What emerges is the idea that cognition is not a standalone module in the brain that cognizes independently of sensory-motor systems, the body, and the world ([Fodor, 1975](#); [Pylyshyn, 1984](#)). Instead, the fundamental role of the cognitive system is to organize effective situated action for individuals embedded in their physical and social environments ([Barsalou, 2020](#); [Clark, 1998](#); [Newen et al., 2018](#)). In turn, action and the environment continually condition an individual's cognitive system, adapting it to support situations typically encountered and the actions effective in them ([Barsalou, 2016](#)).

Questions, controversies, and new developments

Amodal versus multimodal representations

One central question of considerable debate is whether the human brain contains amodal symbols at all, with many arguments both for ([Mahon, 2015](#)) and against ([Barsalou, 1999, 2016](#)). An important and closely related issue is whether abstractions of grounded representations exist in the brain's higher-order association areas ([Fernandino et al., 2022](#)).

Considerable empirical evidence has developed for multimodal representations in research domains such as cognitive psychology ([Barsalou, 2008](#)), social psychology ([Barsalou et al., 2003](#); [Niedenthal et al., 2005](#)), developmental psychology ([Smith & Gasser, 2005](#)), and multiple areas of neuroscience ([Fernandino et al., 2022](#); [Martin, 2016](#)). Again, however, not everyone is convinced by the evidence that has accrued, with debate continuing (for multiple perspectives, see the special issue of [Psychonomic Bulletin & Review, 2016](#)).

One common compromise is to assume that cognition utilizes both amodal and multimodal representations, with amodal symbols serving core representational functions, and multimodal simulations serving peripheral functions ([Mahon, 2015](#)). Some researchers, however, note that there is little, if any, compelling empirical evidence for amodal symbols in the human brain, much less in nonhuman brains ([Barsalou, 1999, 2016](#)). Nevertheless, amodal symbols remain central to many researchers' thinking [see [The Language of Thought Hypothesis](#)].

Questions of implementation

Another set of central questions concerns the details of how the multimodal simulation process works ([Ostarek & Huettig, 2019](#)) and also what the role of the language is in coordinating the simulation process ([Andrews et al., 2014](#); [Barsalou et al., 2008](#); [Louwerse & Jeuniaux, 2010](#); [van Hoef et al., 2023](#)). A related question in neuroscience is how the brain's association areas and modality-specific areas work together to implement multimodal simulation at multiple levels of granularity ([Barsalou, 2016](#); [Fernandino et al., 2022](#)). Still another important neuroscience question is how different levels of sensory-motor representation are implemented across cortical layers ([Persichetti et al., 2020](#)).

The challenge of abstract concepts

An especially challenging issue is explaining the representation and use of abstract concepts. Critics often argue that grounded cognition cannot explain abstract concepts, even though classic amodal theories have actually experienced surprisingly little

success in explaining them even minimally ([Barsalou, 1999](#)). Arguably, grounded accounts of abstract concepts are more developed than classic amodal ones ([Barsalou et al., 2018](#); [Borghi & Binkofski, 2014](#)). Regardless, it is remarkable how little is understood about abstract concepts from either perspective. Increasing evidence, however, indicates that sensory-motor information plays central roles in their representation and processing ([Banks & Connell, 2022](#); [Wilson-Mendenhall et al., 2013](#))

Empiricism versus nativism

Another challenge concerns the extent of the biological contributions to grounded cognition. Although critics sometimes refer to grounded cognition with the moniker of *neo-empiricism*, this actually demonstrates considerable naivete given how easy it is to be a nativist from a grounded perspective ([Barsalou, 1999, 2016](#)). For example, biological constraints on the modalities and association areas no doubt shape how grounded cognitive systems develop over the lifespan in powerful ways. Much remains to be learned about how grounded cognition emerges from the constant interplay of biology and experience.

Finally, a related issue concerns grounding across species. One problem for classic theories is how to explain the emergence of amodal symbols in humans when presumably they do not exist in other organisms ([Barsalou, 1999](#)). A strength of grounded views is that all animals, including humans, have cognitive systems that are grounded in the sensory-motor modalities, such that all these systems work in roughly the same basic ways for many core cognitive functions. What perhaps transpired in the evolution of humans was the emergence of language, greater cognitive control, and great potential for novel adaptive behavior ([Barsalou, 1999](#); [Buckner & Krienen, 2013](#)).

Broader connections

Grounded cognition is a truly interdisciplinary area, extending throughout all the cognitive sciences and beyond into neuroscience. Grounded cognition has also had considerable influence in many applied areas, including education ([Goldstone et al., 2010](#); [Macrine & Fugate, 2022](#)) and health ([Chen et al., 2016](#); [Dutriaux et al., 2023](#)).

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