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Introducing Embodied Grounding

Gün R. Semin and Eliot R. Smith

In just the last two decades, the embodiment perspective has inspired research and new theoretical ideas across a wide swath of the behavioral and cognitive sciences. Much of the appeal underlying this impact arises from the simple insight upon which the core ideas of embodiment rest: that nervous systems evolved for the adaptive control of action – not for abstract cogitation (chess-playing, in Brooks's memorable 1991 statement of this insight). This idea immediately has several significant implications.

First, minds co-evolved with bodies, especially sensory-motor systems. There are now many examples illustrating the importance of this fact. One is the way organisms use the physical properties of bodies to reduce the need for costly central computation (Thelen & Smith, 1994; Pfeifer & Scheier, 1999). Another is the "active vision" idea that when agents move, far from introducing problematic variation into sensory inputs, they actually create the conditions for discovering cross-modal associations, facilitating understanding of the environment and the adaptive shaping of action (Edelman, 1987; Pfeifer & Scheier, 1999).

Second, the embodiment approach suggests a renewed focus on the whole behaving organism in its natural context as the object of study. Seen from this perspective, either the isolation of specific "slices" such as central information-processing systems, or the study of organisms in environments vastly different from those in which they evolved, seem less than optimal research approaches.

Third, the context in which organisms behave is very often a social context. In the case of humans, the very capabilities that make us human – to elaborate philosophical ideas, build cities, sing, and dance – are usually collective acts or, even if performed by an individual, depend absolutely on a multitude of social products (not the least of which is language). The embodiment

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approach should shed light not only on the functioning of individual humans but also on the ways they cooperate, compete, and otherwise relate to each other, in groups and as individuals.

Fourth, a focus on the whole behaving organism in its context breaks down traditional disciplinary boundaries as well as distinctions between topics like cognition and motivation. The recognition of this basic fact has driven psychological theory and research to focus increasingly on the interdependences among cognition, motivation, affect, and action as they are all influenced by the body. An embodied approach is taking root not only in psychology but across a variety of disciplines ranging from the neurosciences to developmental processes to cognitive sciences and robotics with an increasingly powerful synergy between these different approaches. In this situation, fresh discoveries in one "field" lead to reformulations of the very same issues in a different "field."

The impetus to cross boundaries is also the inspiration for this volume, the foundations of which were laid during a four-day conference including the majority of the contributors in May 2006. This meeting gave rise to a unique synergy because the participants came from quite different specialties ranging from neuroscience to cognitive psychology, social psychology, affective sciences, and psycholinguistics. The discussions and exchanges resulted in the current volume, which follows a tripartite organization. The contributions that make the first part of this volume address the *embodied grounding of concepts and language*. Whereas the disciplinary breadth of the material in these contributions is considerable, ranging from neuroscience to experimental cognitive psychology, the authors of the different chapters are not only informed about each other's work but also influenced by it. These contributions examine the central issues in this field from complementary perspectives because interaction at the conference helped them build bridges across traditional boundaries. The driving theme for these four chapters is that our representations of the social world are fundamentally connected with the actions that our bodies perform, so that these actions inform our concepts, language, and thinking.

- The opening chapter by Barsalou presents an embodied account of symbolic operations, proceeding from the neural simulation of concrete concepts to how these relate to abstract concepts and symbols. He reviews the most recent research in this area, which come from a variety of different methods ranging from experimental behavioral work to neuroscientific findings. In concluding his contribution, Barsalou examines the link between language and perceptual symbols systems, arguing for links

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between, for instance, syntax and the role it may play in psychological processes such as retrieval, how simulations are assembled, and the nature of recursively embedded structures.

- The next contribution by Glenberg is based on his Indexical Hypothesis, a model that is designed to interface bodily states with language and action. His chapter outlines this hypothesis and the processes underlying how meaning is understood.
- Indeed, there is considerable intellectual cross-fertilization not only between Glenberg's Indexical Hypothesis and Barsalou's perceptual symbol systems model but also with the third chapter of this section, namely, Pulvermüller's examination of the cortical mechanisms responsible for semantic grounding and embodiment concepts.
- The final chapter in this part by Boroditsky and Prinz examines the sources contributing to human knowledge and thinking. They argue for two input streams to the complex human knowledge system and thinking. The first stream they refer to is the use of stored records of sensory and motor states, inspired by Barsalou's (Chapter 1) perceptual symbols systems model. The second source that they elaborate upon is the contribution of language – treated not as an abstract inner mental "code" but as a rich store of sensorimotor regularities in the real world, whose statistical properties offer important evidence for the construction and constitution of thought.

The second part of the volume focuses on the *embodiment of social cognition and relationships*.

- Semin and Cacioppo outline a model of social cognition that breaks away from a traditional individual-centered analysis of social cognition and treats social cognition as grounded by neurophysiological processes that are distributed across brains and bodies and is manifested in the co-regulation of behaviors. The theoretical framework they introduce is an attempt to model the processes involved from joint perception to co-regulation in social interaction.
- Smith describes how social relationships that link people to other individuals or social groups are both expressed and regulated by bodily processes. Drawing on Alan Fiske's Relational Models Theory, research described in this chapter tests hypotheses that both synchronized movements and interpersonal touch operate as embodied cues to close relationships (communal sharing relationships, in Fiske's terminology).
- A related chapter by Schubert, Waldzus, and Seibt also draws upon Fiske's model, relating it to Barsalou's fundamental point that abstract concepts (such as interpersonal closeness or differences in power or authority) are

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understood in terms of bodily metaphors. For example, research finds that authority differences are expressed in differences in size, height, or vertical position; the powerful literally do "lord it over" the rest of us.

- Briñol and Petty deal with a different aspect of social cognition: the effects of embodiment on processes involved in social influence, especially those leading to changes in attitudes or evaluations of particular objects. Their discussion is based on the Elaboration Likelihood Model, one of the best-supported and most far-reaching theoretical accounts of attitude change, showing how it organizes findings about the effects of bodily movements on attitudes, as well as generating new and intriguing predictions.

The third part has as its topic the *embodiment of affective processes*.

- Clore and Schnall take the viewpoint that affective reactions provide embodied evidence that people can use to validate or invalidate their evaluative beliefs about objects. In particular, affective reactions are sometimes found to have limited effects unless preexisting beliefs exist that are congruent with the affective reactions. The authors describe provocative research suggesting that holding incongruent beliefs and affective reactions has cognitive costs for the individual.
- Barrett and Lindquist address the embodiment of emotional responses. Noting that traditional theories hold that body and mind make separate and independent contributions to an emotional episode, they apply the embodiment perspective to generate the novel suggestion that the body helps constitute the mind in shaping an emotional response. That is, the conceptual knowledge that we use to categorize and understand our own (and other people's) emotions is itself represented in sensorimotor terms.
- Winkielman, Niedenthal, and Oberman similarly take an embodied approach to emotional processes in which such processes are grounded in modality-specific systems. They describe studies directly testing the hypothesis that manipulating bodily resources will influence the perception and understanding of emotional events. The chapter ranges widely, covering the role of embodiment in the formation of attitudes as well as in the representation of abstract emotion concepts.
- The chapter by Förster and Friedman presents a new conceptual model of the effects of bodily movements, facial expressions, and other embodied cues on attitudes as well as on cognitive processing styles (such as creativity and flexibility). Guided by Higgins's Regulatory Focus Theory, they show how effects of embodied cues can be accommodated and also how paradoxes in existing evidence may be resolved.

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Taken together, these chapters illustrate the extraordinarily broad range of topics upon which research has been influenced by the embodiment perspective. As we observed at the beginning of this introduction, embodiment calls for a focus on the entire organism rather than on isolated slices of information-processing or behavioral systems. As a group, these chapters reflect this breadth of focus, as researchers and theorists grapple with the implications of embodiment for levels and topics ranging from neuroscience to language comprehension, social relationships to attitude change, and affect to cognition. We hope that this volume will inspire and excite still more boundary-crossing research and theory, faithful to the true underlying message of the embodiment perspective.

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PART ONE

EMBODIED LANGUAGE AND CONCEPTS

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1 Grounding Symbolic Operations in the Brain's Modal Systems

Lawrence W. Barsalou

A central theme of modern cognitive science is that symbolic interpretation underlies human intelligence. The human brain does not simply register images, as do cameras or other recording devices. A collection of images or recordings does not make a system intelligent. Instead, symbolic interpretation of image content is essential for intelligent activity.

What cognitive operations underlie symbolic interpretation? Across decades of analysis, a consistent set of symbolic operations has arisen repeatedly in logic and knowledge engineering: binding types to tokens; binding arguments to values; drawing inductive inferences from category knowledge; predicating properties and relations of individuals; combining symbols to form complex symbolic expressions; representing abstract concepts that interpret metacognitive states. It is difficult to imagine performing intelligent computation without these operations. For this reason, many theorists have argued that symbolic operations are central, not only to artificial intelligence but to human intelligence (e.g., Fodor, 1975; Pylyshyn, 1973).

Symbolic operations provide an intelligent system with considerable power for interpreting its experience. Using type-token binding, an intelligent system can place individual components of an image into familiar categories (e.g., categorizing components of an image as people and cars). Operations on these categories then provide rich inferential knowledge that allows the perceiver to predict how categorized individuals will behave, and to select effective actions that can be taken (e.g., a perceived person may talk, cars can be driven). Symbolic knowledge further allows a perceiver to analyze individuals in an image, predicating properties and relations that apply to them (e.g., identifying a person as an adult male, or two people as having a family resemblance). Such predications further support high-level cognitive operations, such as decision making (e.g., purchasing a gas, hybrid, or electric car), planning (e.g., finding electricity to charge an electric car while

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driving around town), and problem solving (e.g., how to get in if the keys are locked in the car). Symbolic operations also include a variety of operations for combining symbols, such that an intelligent system can construct complex symbolic expressions (e.g., combining word meanings during language comprehension). Finally, by establishing abstract concepts about mental states and mental operations, an intelligent system can categorize its mental life in a metacognitive manner and reason about it (e.g., evaluating one's planning and decision making strategies).

What mechanisms implement symbolic operations? Since the cognitive revolution, language-like symbols and operations have been widely assumed to be responsible. Numerous theoretical approaches have been derived from predicate calculus and propositional logic. Not only have these approaches been central in artificial intelligence (e.g., Charniak & McDermott, 1985), they have also been central throughout accounts of human cognition (e.g., Barsalou, 1992; Barsalou & Hale, 1993; Anderson, 1983; Newell, 1990).

Although classic symbolic approaches are still widely accepted as accounts of human intelligence, and also as the engine for artificial intelligence, they have come increasingly under attack for two reasons. First, classic symbolic approaches have been widely criticized for not being sufficiently statistical. As a result, neural net approaches have developed to remedy this deficiency (e.g., Rumelhart & McClelland, 1986; O'Reilly & Munakata, 2000). Second, classic symbolic approaches have been criticized for not being grounded in perception, action, and introspection. As a result, researchers have argued that higher-order cognition is grounded in the brain's modal systems.

As statistical and embodied approaches are increasingly embraced, the tendency to "throw the baby out with the bath water" has often been embraced as well. Some researchers have suggested that classic symbolic operations are irrelevant to higher cognition, especially researchers associated with neural nets and dynamical systems (e.g., van Gelder, 1990; but see Prinz & Barsalou, 2000). Notably, some neural net researchers have realized that symbolic operations are essential for implementing higher cognitive phenomena in knowledge, language, and thought. The problem in classic theories is not their inclusion of symbolic operations but *how* they implement them. For this reason, neural net researchers have developed neural net accounts of symbolic operations (e.g., Pollack, 1990; Smolensky, 1990). Interestingly, these approaches have not caught on widely, either with psychologists or with knowledge engineers. For psychologists, neural net accounts of symbolic processes have little psychological plausibility; for knowledge engineers, they are difficult and inefficient to implement. As a result, both groups continue

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to typically use classic approaches when symbolic operations must be implemented.

An alternative account of symbolic operations has arisen in grounded theories of cognition (e.g., Barsalou, 1999, 2003a, 2005a). Not only does this account have psychological and neural plausibility, it suggests a new approach to image analysis. Essentially, this approach develops symbols whose content is extracted from images. As a result, symbols can be bound to regions of images, thereby establishing type-token mappings. Inferences drawn from category knowledge also take the form of images, such that they can be mapped back into perception. Analysis of an individual in an image proceeds by processing its perceived regions and assessing whether perceptually grounded properties and relations can be predicated of them. Symbol combination involves the manipulation and integration of image components to construct structured images that, in effect, implement complex symbolic propositions. Abstract concepts result from situated introspection, namely, the process of perceiving internal mental and bodily states in the context of external situations and developing image-based representations of them for later use in reasoning.

The remaining sections present this framework in greater detail. The next section illustrates how symbolic operations could arise from simulation. The following section presents current empirical evidence for this account. The final section addresses the role of language in symbolic operations.

GROUNDING COGNITION IN THE BRAIN'S MODAL SYSTEMS

Standard architectures assume that amodal symbols are transduced from experience to represent knowledge. Figure 1.1 illustrates this general approach. On experiencing a member of a category (e.g., *dogs*), modal states arise in the visual system, auditory system, motor system, somatosensory system, and so on (i.e., the solid arrows in Figure 1.1a). These states represent sensory-motor information about the perceived category member, with some (but not all) of this information producing conscious experience. Although modal states are shown only for sensory-motor systems, we assume that modal states also arise in motivational systems, affective systems, and cognitive systems. The perception of these internal systems will be referred to as *introspection* from here forward. Once modal states arise in all relevant modal systems for a category, amodal symbols that stand for conceptual content in these states are then transduced elsewhere in the brain to represent knowledge about the category (e.g., *legs, tail, barks, pat, soft* in Panel B for

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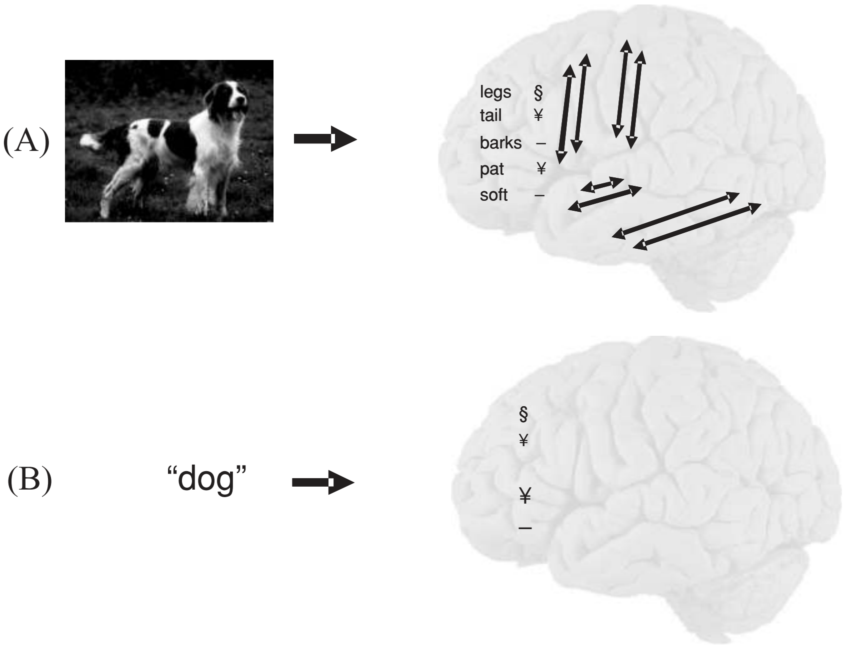

Figure 1.1. The transduction of amodal symbols from modal states in standard cognitive architectures (Panel A). Use of transduced symbols to represent the meaning of a word (Panel B). See the text for further description.

the experience of a dog). Although words often stand for transduced amodal symbols (e.g., *leg*), most theories assume that sub-linguistic symbols, often corresponding closely to words, are actually the symbols transduced (e.g., in Figure 1.1).

Once established in the brain, amodal symbols later represent knowledge about the category across a wide range of cognitive tasks (Figure 1.1, Panel B). During language comprehension, hearing the word for a category (e.g., "dog") activates amodal symbols transduced from modal states on previous occasions. Subsequent cognitive operations on category knowledge, such as inference, are assumed to operate on these symbols. Note that none of the modal states originally active when amodal symbols were transduced (Figure 1.1, Panel A) are active during knowledge representation (Figure 1.1, Panel B). Instead, amodal symbols are assumed to be sufficient, with modal states being irrelevant.

The architecture in Figure 1.1 underlies a wide variety of standard approaches to representing knowledge, such as feature lists, semantic

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