An Introduction to the Theory of Embodied Cognition

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Arthur Glenberg, the preeminent cognitive psychologist who has extensively tested and written about the theory of embodied cognition, starts his course on the topic with questions such as these: "Do left-handers perceive the world differently than right-handers, such that, for example, right-handers like objects on the right more than objects on the left, but lefties like the opposite?"; "When you say about a potential date, 'He leaves me cold,' do you literally feel cold?"; "Does getting a Botox injection to remove frown lines make it difficult to understand a sentence about sadness?"; and, "When you are leaning backwards, are you more likely to think about your past than your future?" These questions clearly implicate the body in thought, and the surprising answer to all is "yes." The empirical evidence that provides this answer supports the theory of embodied cognition.

Philosophical Roots of the Theory

Before describing how a philosophical version of the theory of embodied cognition evolved into a testable theory for cognitive psychologists, let me tell you how I start my course on this topic. My approach is a bit different from the above hook of Glenberg because it emphasizes the theory's approach to how we represent all the knowledge we have in our brain. The way I do this

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How the Body Shapes Knowledge: Empirical Support for Embodied Cognition, by R. Fincher-Kiefer

is to have my students play a few rounds of "20 Q"—an electronic version of the game "Twenty Questions"—with me on the first day of my advanced laboratory course in cognition. My goal is to give them firsthand knowledge of "symbolic knowledge representations," or *nonembodied knowledge*, and they come to understand this when playing this handheld game. Here's why: The electronic version begins just as the verbal version of the game does—you come up with your animal, vegetable, mineral, or "other" thought, and then the handheld device begins the electronic questioning by posing questions such as, "Is it bigger than a microwave?" You respond with the "yes," "no," or "sometimes" button press on the device. This continues for 20 questions, or fewer if the device decides it has an early guess.

My students are always amused when they see that this toy can in fact "read their mind" and, more often than not, guess their thought correctly. So I ask them, "Does this game have a *mind*?" (They can't be tricked into responding that it has a physical brain, but to ask if it has a mind is a different issue.) Most tentatively say no—the "mind" seems to be quintessential to being human, so it is hard to claim that an inanimate object has one. But of course some students answer, "Well, sort of . . ." I ask those pondering this, "Why do you think it has a mind?" They respond, "Because it's thinking and processing information and guessing." The mind is the game's intellect, and it clearly has one because it is able to guess what someone is thinking. "So *how* does it have this intellect?" I ask my students, and that makes them start thinking about how the computer chip inside this game stores knowledge, how it is structured and organized, and then I use the word *represented.*

Once it is acknowledged that the device has to have knowledge represented to play the game, then we can discuss what the nature of that representation is and what the processes are that eventually lead to it being able to guess what they are thinking (i.e., "20 Q" cognition). After playing the game, students intuit that once the first answer is processed (e.g., "Yes" it is an animal), that narrows the possibilities for what the correct guess is going to be and influences what questions should be asked (e.g., "Does it swim?"). Each new answer continues to constrain what the guess could be; by the time 20 questions are asked, the pruning of possibilities in the game's knowledge base has left very few, if not one, best guess. And students understand that the literal representation of that network of knowledge in "20 Q" is binary code, as in all computers.

What my students have described as they work through how "20 Q" makes its guess is that the game has a hierarchical semantic network of knowledge that uses the process of spreading activation to get to its response. This is exactly what cognitive psychologists theorized for human knowledge representation in the early days of the subdiscipline. In fact, the representation of knowledge was perhaps the central problem for cognitive psychologists when the subdiscipline first became recognized as a branch of experimental psychology in the late 1950s and early 1960s. Cognitive psychologists were questioning what philosophers had been debating for centuries—what is knowledge? Where does it come from? How do we derive meaning from our world? Some very early philosophy-of-mind theorists, starting with Descartes, argued for mind–body dualism, such that mental phenomena were completely separate from any body effects. However, in response to Cartesian dualism, Kant argued that knowledge results from the interaction of the mind and the external world and, as an early precursor to the theory of embodied cognition, suggested that the body is essential or central to human cognition.

More recently, some philosophers responsible for initially defining and developing the theory of embodied cognition have viewed cognition as serving the needs of the body as it meets the demands of real-world situations (hence the name). From this perspective, internal mental representations of the world are not essential, and there is little need to discuss the actions of "the brain" (see dynamical systems theory of Thelen & Smith, 1994, and Beer, 2003, as well as Brooks's 1991a, 1991b, work in robotics). This stance arose from a general philosophical belief that the concept of internal mental representations had been overused in explaining cognition, as well as a disillusionment with cognitive science's lack of interest in how perception and cognition were linked to action. This brought about the antirepresentational view of "radical embodied cognitive science" (Chemero, 2009; Gallagher, 2005; Thelen & Smith, 1994).

However, other philosophers flipped the relationship to suggest that the body serves the mind (cognition), such that the external world leads our body to respond in a way that will inform and guide the mental representations that constitute thought. For example, Clark's (1998; 1999; 2008) view is more moderate in terms of considering the role of internal representations in cognition and yet still suggests that the interaction of the body and the external world can explain much of what has typically been considered the work of the brain. Clark, as well as Varela, Thompson, and Rosch (1991), argued that the body is essential in the production of cognition; in fact, the body plays a constitutive role in cognitive processing. The position of these philosophers and cognitive scientists has been referred to as "embodied cognitive science," and the central issue that distinguishes it from radical embodied cognitive science is the presence of internal representations (Alsmith & de Vignemont, 2012).

There has been extensive discussion of how these philosophical approaches to the theory of embodied cognition emerged and how they differ (e.g., Shapiro, 2011, 2014; and M. Wilson, 2002), but it is important to remember that in the philosophical tradition, empirical work is often cited to support a view, but it is not essential in developing and testing the theory. Cognitive psychologists became interested in the theory of embodied cognition because we, too, were interested in the body–mind interplay. However, within the experimental psychological tradition, the theory's tenets required examination and testing. Cognitive psychologists adopted only one perspective of the theory of embodied cognition, and from a philosophical and cognitive science standpoint, it is considered a "narrow view" of the theory. This is because the perspective is "brain centered"—it assumes internal representations and, as such, shifts from the view that the mind operates to serve the body to a view that the body serves the mind. As M. Wilson (2002) stated,

> This takeover by the mind, and the concomitant ability to mentally represent what is distant in time or space, may have been one of the driving forces behind the runaway train of human intelligence that separated us from other hominids. (p. 635)

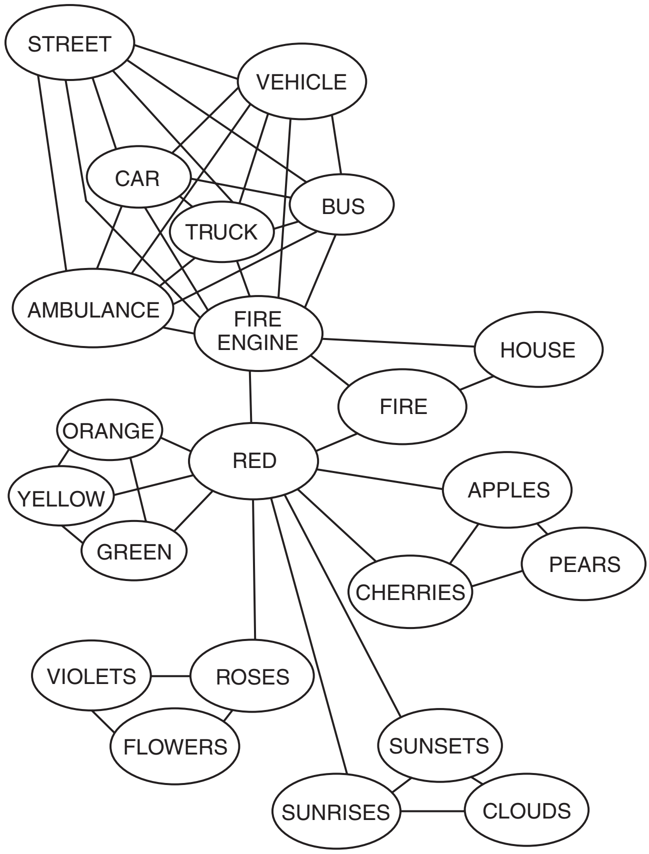
Psychological Roots of the Theory

Getting back to the historical roots of cognitive psychology, the issue of internal representations of knowledge was of central concern to the first cognitive psychologists. We were emerging from the ashes of behaviorism, and the interest in the mind was being driven by the emerging field of computer science. In 1956, John McCarthy, a professor of mathematics at Dartmouth College, organized a conference titled Summer Research Project on Artificial Intelligence, where the intent of the conference was to "proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it" (see McCarthy, Minsky, Rochester, & Shannon, 2006, p. 12). Mathematicians, computer scientists, linguists, and psychologists attended this conference, all united by this curiosity in understanding human thought and cognitive processes to the degree that a computer could mimic them.

Another important conference in the same year took place at the Massachusetts Institute of Technology, where the lingering interest in behavior was fading quickly and being replaced by an interest in the study of mental processes. At this conference, George Miller presented his idea that there are limits to human's ability to hold information in memory, that limit being somewhere around 7 "chunks" (G. A. Miller, 1956). Some psychologists were working on the "processing" aspect of cognition and were trying to understand perception, attention, memory, and reasoning. Others were working on the "structure" aspect of cognition—that is, how the knowledge we have is organized and coherent so that it can be retrieved and used by cognitive processes. Theories of knowledge were developed and tested, and they varied from feature comparison models (cf., Smith, Shoben, & Rips, 1974) to prototype models (cf., Rosch, 1973) to semantic network models (cf., Collins & Loftus, 1975; and J. R. Anderson, 1983). Figure 1.1 shows a semantic network from Collins and Loftus (1975), where the links between concept nodes are short or long depending on personal experiences with these thoughts: The shorter the link, the stronger the connection, and the faster the reaction time to respond to this connection in any object identification or categorization task (think "20 Q" responses and early guesses based on predictability in this network of knowledge). Semantic network theories were widely tested and modified to address results that could not be explained, but the newer versions became so general and flexible that they were criticized for being difficult to falsify, thus losing explanatory power.

In the 1980s, a new approach called *connectionism* gained favor, which was an approach to create computer models for representing knowledge that was based on what was known at that time about neural networks. These models were called parallel distributed processing (PDP) models of knowledge representation, and in some sense they were technological updates of more traditional semantic network models. These PDP models argued that neuron-like nodes are excited or inhibited by the action of other nodes, and thus knowledge was represented by patterns of excitation or inhibition rather than particular nodes. Spreading activation still flows through networks of linked concepts, but processes can occur in parallel, rather than the more

FIGURE 1.1



A schematic representation of concept relatedness in a stereotypical fragment of human memory (where a shorter line represents greater relatedness). From "A Spreading-Activation Theory of Semantic Processing," by A. M. Collins and E. F. Loftus, 1975, *Psychological Review*, *82*, p. 412. Copyright 1975 by the American Psychological Association.

hierarchical earlier models, and are distributed across brain sites (cf., McClelland & Rogers, 2003).

The zeitgeist of the subdiscipline of cognitive psychology for its first 40 or so years was to think about cognitive processes such as sensation, perception, attention, and memory as *modular*, that is, they existed in and of themselves with minimal interaction with each other (Fodor & Pylyshyn, 1988; Newell & Simon, 1972). The representation of knowledge was also functionally autonomous, and there was little discussion of how processes would affect or determine what was being represented. This could be likened to having a computer on one's shoulders with input and output modules that worked fairly independently from one another. This traditional view was that mental representations were symbolic in nature, quasilinguistic (propositional), and abstract. Any symbol (or word), for example, *chair*, was abstract in the sense that it referred to the general instance of the concept. Further, the symbol (word) was an arbitrary referent to the concept because the way in which it looked and sounded bore no relation to the physical or functional properties of the concept.

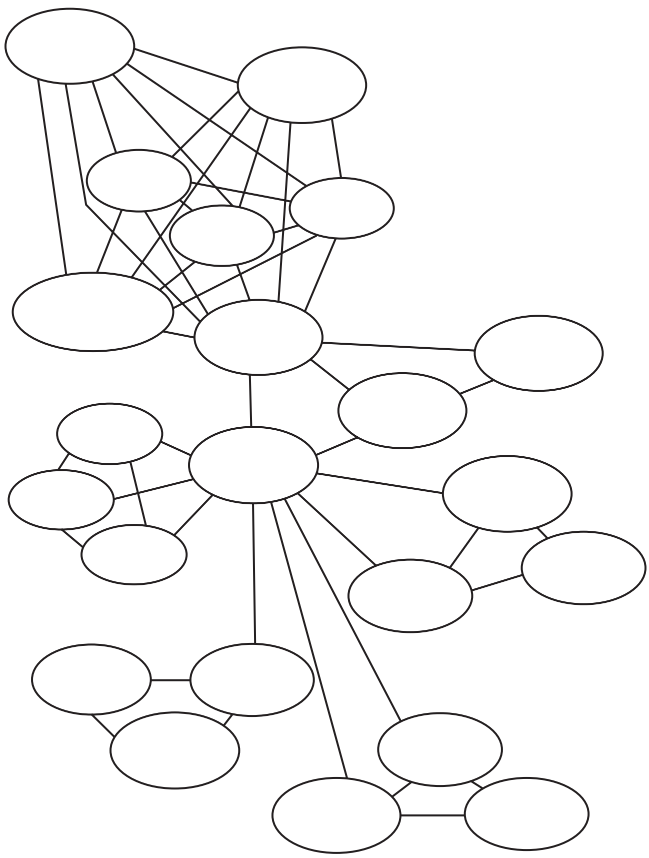
According to this view, these symbols that represented our knowledge of a concept were *amodal*; they were not tied to any specific modality or bodily action. Further, these symbols were organized propositionally, with their meaning emerging from relations to other symbols. Thus, this early theory holds that meaning is an internal process, and cognition is not shaped by perception or action. Newell and Simon's (1976) physical symbol system hypothesis (PSSH) was a theoretical instantiation of this view of knowledge: Abstract symbols can be found in both human thought (propositions) and computer representation (binary code), and thinking is the manipulation of these symbols, which does not involve perception or action.

As cognitive psychology grew as a discipline, there were many theoretical arguments and empirical results that undermined a PSSH system of knowledge representation. One of the most damning arguments against a wholly symbol system view of knowledge is the "symbol-grounding" problem (Harnad, 1990; Searle, 1980). This problem basically states that abstract symbols (words) that are arbitrary and have no connection to the external world can have no meaning. If thinking (or computation in a computer) is symbol manipulation that goes on internally, just within our heads or in the computer, and there are no external referents, then we have what Harnad (1990) referred to as the "symbol merry-go-round" problem. This is when symbols cannot be assigned meaning according to what they refer to (which would make them nonarbitrary); instead, their meaning is just in relation to other symbols. Glenberg (2015) likened this to trying to find the meaning of a word in a foreign language in a dictionary made up of only other foreign language words—the search would never be successful if none of the symbols have any meaning to the person searching. He described this problem in the following way:

> Imagine that you land at an airport, perhaps in China, where you don't speak the local language. You see what appears to be a sign consisting of logograms (or any other noniconic marks). Although you don't speak the language, you do have a dictionary written in that language. You look up the first logogram and find its definition, but of course the definition consists of more logograms whose meanings are obscure to you. Undaunted, you look up the definition of the first logogram in the definition, and you find that its definition consists of even more uninterpretable logograms. The point is that no matter how many of the logograms you look up, this closed system of abstract symbols will never produce any meaning for you. (p. 165)

What Glenberg (2015) pointed out about the standard cognitive models of knowledge representation is that in those models, understanding the meaning of a symbol could be likened to going round and round in an infinite circle. Looking for the meaning of one symbol involves trying to find the meaning of another arbitrary symbol, and the meaning of that symbol requires the same kind of internal search for another arbitrary symbol. If you look back at Figure 1.1, it seems as if the symbols (the ellipses that have the labels underneath) are meaningful—but that is because we are providing them with meaning. The shape is not related to the meaning, and the label (the word) is something we have provided. The words are there for the convenience of the reader; if we opened up someone's head and looked inside, we would not see labels on ellipses. Figure 1.2 more accurately represents the semantic network theory. Here the abstract symbols (ellipses) are not labeled, and thus they are authentically amodal, abstract symbols. This portrayal of the theory makes clear this symbol merry-go-round argument. One can start at any node and trace relations to any and all other nodes, but no matter how many relations are traced, no meaning will ever be available.

FIGURE 1.2



A schematic representation of the semantic network theory with amodal abstract symbols. Adapted from "A Spreading-Activation Theory of Semantic Processing," by A. M. Collins and E. F. Loftus, 1975, *Psychological Review*, *82*, p. 412. Copyright 1975 by the American Psychological Association.

Never leaving "the head" (or the computer) to determine what a symbol is referring to in the external world would mean an infinite regress of search for meaning. We can only break from this symbol-grounding problem if the symbols refer to something in our external world, that is, have referents that *ground* those symbols in perception, action, and/or emotion. This grounding represents the meaning of the symbol. The embodied approach to cognition argues that all knowledge is grounded in sensory, perceptual, and motoric processes and that these processes are a function of one's own morphology (shape and size) and physiology (internal processes).

Evidence from cognitive neuroscience supports embodiment in revealing that thinking involves the reactivation and reuse of processes and representations involved in perception and action. For example, Hauk, Johnsrude, and Pulvermüller (2004) recorded neural activity while readers listened to action verbs such as *kick* and *pick*. They found that as readers read those action verbs, there was greater activation in the specific part of the motor cortex responsible for producing that action than other motor cortex areas. This suggests that understanding an action concept may be grounded in action-specific motor neurons.

The discovery of mirror neurons in the motor cortex of monkeys may help us understand a similar neural system in humans that would allow us to comprehend others' actions, goals, and intentions (e.g., Gallese, Keysers, & Rizzolatti, 2004; Iacoboni, 2009; Rizzolatti & Craighero, 2004). In monkeys, single-cell recordings from mirror neurons show that a neuron in this tract is similarly active when a monkey is performing a task as when the monkey is observing another monkey engage in the same task. Researchers have suggested that the purpose of having mirror neurons that are active both during action and during observation is that this provides the animal with the ability to infer goals and emotions to another. If an animal acts in a purposeful way, the neurons that fire during that action, and then are later "reused" while observing another's action, must reflect the meaning of that action. This is evidence for that neuron serving both action and cognition, supporting the view that the body plays a constitutive role in cognition.

This evidence seriously challenges the view that conceptual representations are abstract and amodal. Of course there are quite disparate views of the extent to which mental representations are modal or both amodal and modal. And even those that argue that meaning is found in modality-specific representations have quite different approaches to the theory of embodiment (see Gentsch, Weber, Synofzik, Vosgerau, & Schütz-Bosbach, 2016; A. D. Wilson & Golonka, 2013).

Tripartite Framework of the Theory

In this book, I will take a three-pronged approach to organizing and synthesizing the extensive experimental results concerning this theory. This is not entirely original, as others have noticed this tripartite distinction in the embodiment literature. Although the experimental work can be loosely organized within this tripartite framework, I will continue to remind the reader that these approaches are not contradictory but instead complementary.

These three approaches are represented by

- Arthur Glenberg's (2010, 2015) view that *the body* is essential to knowledge (Chapters 2, 3, 4, and 5);
- Lawrence Barsalou's (1999) perceptual symbol system hypothesis (PSS), which relies on representations that come about from perceptual experiences and *sensorimotor simulation* as the "core computational" process of thought (Chapters 6 and 7); and
- Lakoff and Johnson's (1980) *Metaphors We Live By* proposal that *language* reflects our representation of knowledge (Chapter 8).

Although this book will allow the reader to compare and contrast these three approaches to embodiment, there is no attempt to choose one as the prominent or more persuasive perspective. Because it is at the core of my presentation of this topic, I will say it again: These approaches are not contradictory, but instead are complementary.

This book organizes results from different laboratories of experimental psychology examining multiple types of cognitive processes to give *weight* to the theory of embodiment. Why would I use such a metaphor concerning the weight of a topic? Very intentionally—it provides a way to illustrate what I am trying to do in this book. For instance, if I want you to understand the role of the body in this theory of embodiment, I would emphasize that when we hold something heavy, the perceived value of that which we are holding is increased compared with when it is light (Jostmann, Lakens, & Schubert, 2009). Further, our judgments concerning the importance of an object affect how heavy we believe that object to be (Schneider, Parzuchowski, Wojciszke, Schwarz, & Koole, 2015). These empirical examples suggest that our body is essential to our conceptualization of importance.

However, if I want you to understand that thinking involves Barsalou's (1999) PSS hypothesis of sensorimotor simulation, I would argue that it is the simulation of a prior experience of weight that underlies a judgment of value. In our life's physical experiences, more likely than not, heavier objects have been more important than lighter objects (e.g., full bottles of milk compared with empty ones), and these patterns of experience are reenacted in thinking about value (Barsalou, 2008b).

Or, if I wanted you to understand how we give meaning to something abstract, like importance, I would emphasize that we do this by linking abstract concepts to superficially dissimilar but understood concrete concepts. This is reflected in our language. For example, our metaphors concerning "weighty decisions" and "heavy topics" reflect that our mental representation of value or importance is linked to the concrete property of weight. Abstract concepts can be understood in terms of multiple linkages with concrete concepts, yielding expressions that could not be easily explained by embodied simulations (Landau, Meier, & Keefer, 2010).

In Chapters 2 through 5 of this book, I present material that supports the role of the body in different cognitive processes—perception of distance, perception of size—but also how our bodies affect our sense of control, power, even judgments about free will and include a discussion of how culture may mediate some of these judgments. Chapters 6 and 7 address how empirical results can demonstrate that sensorimotor simulation is the mechanism that provides meaning. Evidence will include such research as that demonstrating that emotional facial responses are simulations of others' emotional reactions even in the absence of motoric mimicry. Or how simulation, in the form of how we imagine our bodies moving in space, may determine our conceptual representation of time more so than the actual movement of our bodies.

Finally, in Chapter 8, I explore how language, specifically metaphor, reflects the grounding of meaning. In this chapter, I present results that demonstrate the bidirectionality of metaphor-consistent psychological effects. For example, in exploring the common metaphor that someone we care for is "warm," it has been shown that if we are physically warm (e.g., holding a hot cup of coffee), we feel closer to people in our lives (even strangers in our physical space) than when holding something cold, and when we are thinking about a time in which we were included in a social experience, we judge the temperature of a room to be physically warmer than when we remember a time of social exclusion. It appears that the conceptualization of affiliation may be grounded in the physical experience of temperature (Williams & Bargh, 2008).

I conclude with Chapter 9 that addresses the current status of embodiment and attempts to simplify the complex reactions to the theory. In the end, it will be left to experimental cognitive psychologists, cognitive neuroscientists, and cognitive scientists to continue with the empirical investigations and modeling of cognitive processes to determine if the theory of embodiment will in fact be the paradigm shift that unifies psychology as a discipline.

One final note about the book: At the end of each of these content Chapters 2–8, I have left a "takeaway" for the reader. This is simply a statement or two that represents the "big picture" of the chapter; the intent was to capture the essence of the empirical work discussed in that chapter. You will find some redundancy in these takeaways because they all are describing how embodiment theory explains cognition—and yet each explanation is within a specific area (e.g., perception, emotion, language) or specific to a concept (e.g., simulation). The takeaway pays homage to the primary theorists in each of the areas by simply stating their names, but of course the reader will understand that many others are cited in the chapter to support these views. I hope these takeaways serve as reminders of the overarching principles guiding the empirical investigations of the theory of embodied cognition.