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Embodiment in Attitudes, Social Perception, and Emotion

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Findings in the social psychology literatures on attitudes, social perception, and emotion demonstrate that social information processing involves embodiment, where embodiment refers both to actual bodily states and to simulations of experience in the brain's modality-specific systems for perception, action, and introspection. We show that embodiment underlies social information processing when the perceiver interacts with actual social objects (online cognition) and when the perceiver represents social objects in their absence (offline cognition). Although many empirical demonstrations of social embodiment exist, no particularly compelling account of them has been offered. We propose that theories of embodied cognition, such as the Perceptual Symbol Systems (PSS) account (Barsalou, 1999), explain and integrate these findings, and that they also suggest exciting new directions for research. We compare the PSS account to a variety of related proposals and show how it addresses criticisms that have previously posed problems for the general embodiment approach.

Consider the following findings. Wells and Petty (1980) reported that nodding the head (as in agreement) while listening to persuasive messages led to more positive attitudes toward the message content than shaking the head (as in disagreement). Cacioppo, Priester, and Berntson (1993) observed that novel Chinese ideographs presented during arm flexion (an action associated with approach) were subsequently evaluated more favorably than ideographs presented during arm extension (an action associated with avoidance). Duclos et al. (1989) led participants to adopt various bodily positions associated nonobviously with fear, anger, and sadness and found that these postural states modulated experienced affect. Strack, Martin, and Stepper (1988) unobtrusively facilitated or inhibited the contraction of the zygomaticus (smiling) muscle by asking participants to hold a pen in their mouth while they evaluated cartoons. Participants judged cartoons to be funnier when smiling was facilitated rather than inhibited (see Stepper & Strack, 1993, for related findings). Bargh, Chen, and Burrows (1996) showed that participants in whom the elderly stereotype had been primed subsequently walked down a hallway more slowly than did participants in whom the stereotype had not been primed. And Schubert (2004) showed that making a fist influenced men's and women's automatic processing of words related to the concept of power.

All such findings suggest that the body is closely tied to the processing of social and emotional information. No single theory, however, has integrated the findings or explained them in a unified manner. Recent theories of embodied cognition, which view knowl-

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edge acquisition and knowledge use as processes grounded in the brain's modality-specific systems, hold promise of accounting for such findings and, perhaps most important, predicting the effects explicitly and a priori (Barsalou, Niedenthal, Barbey, & Ruppert, 2003; Smith & Semin, 2004). Further, these recent theories are able to successfully address conceptual issues that doomed previous embodiment proposals, making them attractive alternatives to widely accepted amodal theories of cognition. The aim of this article is to show how that is so and to propose new ideas for the study of information processing in social psychology.

The Notion of Embodied Mind

The nature of knowledge—the basic representational elements of cognitive operations—lies at the core of psychology and cognitive science. Our view of what knowledge is determines how we conceptualize perception, memory, judgment, reasoning, and even emotion. It is generally agreed that the processing of any mental content, including social and emotional content, involves internal symbols of some sort—mental representations. But this really just begs the question. What are mental representations? Further, how do they derive their meaning?—an issue known as the symbol grounding problem (Harnad, 2003; Searle, 1980). If we can make progress on these questions, we can put psychology in general and social psychology in particular on firmer theoretical footing.

Amodal Architectures

Most models guiding current cognitive and social psychology are based on the traditional computer metaphor. This popular metaphor makes two major claims about the mind. The first is that the software of the mind is independent of the hardware of the body and the brain (Block, 1995; Dennett, 1969). Thus, cognitive operations are arbitrarily related to their physical instantiations so that any sufficiently complex physical system could have human intelligence. In principle, the software that constitutes the mind (including the "social mind") could run on anything—neurons, silicon, or even wooden gears—as long as the elements were arranged in proper functional relations. The second claim of the computer metaphor is that high-level cognition, such as inference, categorization, and memory, is performed using abstract, amodal symbols that bear arbitrary relations to the perceptual states that produce them (Newell & Simon, 1972; Pylyshyn, 1984). Mental operations on these amodal representations are performed by a central processing unit that is informationally encapsulated from the input (sensory) and output (motor) subsystems (Fodor, 1983). The only function of sensory systems is to deliver detailed representations of the external world to the central unit. The only function of the motor system is to dutifully execute the central executive's commands.

Recent years have witnessed a crumbling of the first claim of the computer metaphor—that of software–hardware independence. Research in cognitive and social neuroscience has led to a growing appreciation that most phenomena are best understood by jointly considering neural, psychological, and situational constraints (e.g., Brooks, 1991; Kosslyn, 1994; Winkielman, Berntson, & Cacioppo, 2001). Nevertheless, the second claim of the computer metaphor lives on, and many theories continue to assume that higher-order cognition operates on amodal symbols. Noncontroversially, these theories assume that the actual experience of a current situation is initially represented in the brain's modality-specific systems. More controversially, standard theories of cognition assume that the modality-specific states experienced during an actual situation are redescribed and preserved in an abstract, amodal, language-like form, which we will refer to as amodal symbols (Fodor, 1975). For example, on interacting with a particular individual, amodal symbols redescribe the experienced perceptions, actions, and introspections to establish a conceptual representation of the interaction in long-term memory.

As a person's knowledge about such interactions grows, the underlying amodal symbols become organized into structures that represent concepts extracted across experience (e.g., Collins & Quillian, 1969). These abstracted concepts constitute the person's knowledge and allow the person to engage in inference, categorization, memory, and other forms of higher cognition. Nearly all accounts of social cognition represent knowledge this way, using feature lists, semantic networks, schemata, propositions, productions, frames, statistical vectors, and so forth, to redescribe people's perceptual, motor, and introspective states (for discussions of such models, see Kunda, 1999; Smith, 1998; Wyer & Srull, 1984). According to all such views, amodal redescriptions of social experience constitute social knowledge.

The amodal architecture, although widely used, has recently been criticized on several grounds. One set of problems concerns the redescription process that produces amodal symbols from modality-specific states in the first place. No direct empirical evidence exists for such a process in the brain. Indeed, surprisingly few theoretical accounts of this redescription process exist in the literature. More basically, there is no strong empirical case that the brain contains amodal symbols. In fact, arguments for amodal architectures are mostly theoretical, based on assumptions about how cognition should work, rather than on empirical evidence that it actually works this way. Further, as we discuss shortly, empirical findings increasingly challenge the basic assumptions of the amodal architecture.

Given the lack of empirical evidence, why is the amodal architecture so widely accepted in both cognitive and social psychology? There are a number of important reasons. First, representations that employ amodal symbols, such as semantic networks, feature lists, schemata, and propositions, provide powerful ways of expressing the content of knowledge across various domains of knowledge, from perceptual images to abstract concepts. Second, amodal symbols provide a simple way to account for important functions of knowledge, such as categorization, categorical inference, memory, comprehension, language, and thought (e.g., Anderson, 1983; Chomsky, 1959; Newell, 1990; Newell & Simon, 1972). Third, amodal symbols have allowed computers to implement knowledge. Because frames, semantic networks, and property lists have many similarities to programming languages, these representations can be implemented easily on computers, not only for theoretical purposes, but also for applications (e.g., intelligent systems in industry, education, and medicine). Fourth, until recently there were no compelling alternatives that could account for the representation and function of knowledge. For all these (good) reasons, amodal approaches have dominated theories of representation for decades, even though little positive empirical evidence has accrued in their favor. Indeed, the theoretical virtues of amodal approaches have been so compelling that it has not occurred to most researchers that seeking empirical support might be necessary. Instead, researchers typically assume that the amodal architecture is roughly correct and then go on from there to pursue their specific questions.

Amodal models of knowledge are widespread in social psychology. This is true despite the fact that social psychology has provided some of the most compelling evidence for what we present here as an alternative view, namely, theories of embodied cognition. As we summarize later, experimental findings consistent with embodiment theories abound in research on attitudes, empathy, and emotion. Thus, we contend that continuing with the common assumption of amodal representation will lead us down a false path and that advances in the understanding of knowledge, in general, and social knowledge, in particular, can be made if social psychology starts to question the amodal architecture or at least looks elsewhere for further inspiration.

Embodied Architectures

In recent years, researchers in psychology (Barsalou, 1999; Glenberg & Robertson, 2000; Parsons et al., 1995), philosophy (Churchland, Ramachandran, & Sejnowski, 1994; Clark, 1997; Prinz, 2002; Varela, Thompson, & Rosch, 1991), robotics (Brooks, 1991), and linguistics (Lakoff & Johnson, 1999) have started to take seriously the notion that knowledge is "embodied" or grounded in bodily states and in the brain's modality-specific systems.[1] It is important to note that the term "embodiment" has been used in multiple ways across the literature (Wilson, 2002). Many earlier embodiment theories emphasized the role of actual bodily states in cognition. Examples of such theories include Piaget's (1972) sensory–motor account of infant memory, and Zajonc and Markus's (1984) hard-interface account of the interaction between affect and cognition. In contrast, more contemporary embodiment theories emphasize simulations of experience in modality-specific systems. Examples include Damasio's (1994) theory of emotion, Glenberg's (1997) theory of memory, Barsalou's (1999) theory of perceptual symbol systems, and Gallese's (2003) theory of intersubjectivity. In the remainder of this article, we offer many specific examples and evidence for embodiment processes in both peripheral (body-based) and central (modality-based) senses of the term embodiment. However, as will be described in detail, our own theoretical perspective primarily focuses on the central sense of embodiment, or the brain's modality-specific systems. Those systems include the sensory systems that underlie perception of a current situation, the motor systems that underlie action, and the introspective systems that underlie conscious experiences of emotion, motivation, and cognitive operations.

The main idea underlying all theories of embodied cognition is that cognitive representations and operations are fundamentally grounded in their physical context. Rather than relying solely on amodal abstractions that exist independently of their physical instantiation, cognition relies heavily on the brain's modality-specific systems and on actual bodily states. One intuitive example is that empathy, or understanding of another person's emotional state, comes from mentally "re-creating" this person's feelings in ourselves. The claim made by modern embodiment theories is that all cognition, including high-level conceptual processes, relies heavily on such grounding in either the modalities or the body (Wilson, 2002). This claim is significant given that embodiment theories have traditionally been viewed as having little to say about higher cognitive functions, not just empathy, but also abstract concepts, categorical inference, and the ability to combine internal symbols in novel, productive ways. As we will see, theories of embodied cognition are increasingly able to explain how such phenomena can be based in modality-specific systems and bodily states.

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[1] Some of the more recent philosophical predecessors of embodiment theories can be found in writings of Ryle (1949), Merleau-Ponty (1963), and Heidegger (1962). For further discussion, see Prinz (2002).

Embodiment Effects in Cognitive Psychology

Recent studies in cognitive psychology have demonstrated that conceptual knowledge is embodied (we address the social literature shortly). As we review some of these studies, we ask the reader to note two things. First, note that these effects cannot be easily predicted a priori by amodal theories, although as Barsalou (1999) notes those theories can explain any effect post hoc by adding increasingly complex assumptions about representation and processing. Second, note that whereas some studies we cite only show a correlation between conceptual operations and modality-specific systems, others provide direct causal evidence. The correlational results are useful because they confirm a priori predictions derived from the embodiment account. But, it is increasingly essential to demonstrate the causal roles of embodiment in higher cognition. Fortunately, as we will see, many studies experimentally manipulate embodiments across randomly assigned groups of participants, thereby demonstrating causal effects.

Online Embodiment and Offline Embodiment

Wilson (2002) distinguished between online and offline embodiment. The term *online embodiment*, and the related term, *situated cognition*, refer to the idea that much cognitive activity operates directly on real-world environments. Accordingly, cognitive activity is intimately tied to the relevant modality-specific processes required to interact with the environment effectively. For example, when meeting a new individual (e.g., a tall and imposing person), a perceiver spontaneously produces in vivo sensory and somatic responses (e.g., looking up and feeling apprehensive) as well as motor responses (e.g., stepping back to keep distance). The embodiment account views these sensory, somatic, and motor responses as necessary for the encoding and interpretation of the new individual, not simply as a by-product of a purely amodal analysis. Another useful way to conceptualize online embodiment is as knowledge acquisition, with the perceiver acquiring and modifying a repertoire of modality-specific responses to stimuli as he or she interacts actively with the social environment (also see Gallese, 2003). A central tenet of recent theories is that the establishment of this repertoire plays a central role in higher cognition.

The term *offline embodiment* refers to the idea that when cognitive activity is decoupled from the real-world environment, cognitive operations continue to be supported by processing in modality-specific systems and bodily states. Just thinking about an object produces embodied states as if the object were actually there. Thus, perceiving a symbol, for example the name of the previously met tall and imposing individual, can produce embodied responses in the perceiver that underlie representation of the symbol's meaning. For example, upward head orientation and defensive bodily responding might implicitly contribute to the inferences that the individual is tall and imposing. A strong embodiment view argues that the modality-specific states engaged in during online cognition constitute the knowledge that is acquired and later used in offline cognition. According to this view, stored embodiments constitute the basic elements of knowledge. To establish the meaning of symbols during offline processing, people rely on repertoires of modality-specific responses acquired previously during online processing of these symbols' referents.

Online Effects

The idea that modality-specific processes participate in the conceptual processing of real world objects can be illustrated with research on the compatibility between motor actions and conceptual tasks. Tucker and Ellis (1998) asked participants to detect whether a cup was right side up or upside down. Although the handle of the cup was irrelevant to the judgment, participants responded faster when the cup's handle was on the same side of the display as the response hand than when the handle was on the opposite side. This result indicates that representations of possible actions (e.g., reaching for the cup) influence a perceptual judgment even when these actions are not relevant to the judgment. Reed and Farah (1995) asked participants to judge whether two human figures depicted the same posture. Participants asked to move their own arms performed relatively better at detecting changes in the arm position of a visually presented figure, whereas participants asked to move their own legs did relatively better at detecting changes in the figure's legs. Again, this finding suggests that representations of participants' own bodies contribute to the performance on the visual task.

The just described behavioral studies are consistent with neuroimaging research that found activation of the grasping circuit when participants viewed manipulable objects while lying passively in an fMRI scanner (Chao & Martin, 2000). Related research with monkeys shows that motor neurons involved in controlling tool use fire when the tools are merely perceived and no motor response is possible (Rizzolatti & Arbib, 1998).

Offline Effects

Numerous studies have also documented offline embodiment or the involvement of modality-specific states when processing is decoupled from the environment (as when the object is absent or represented solely by a symbol, such as a word or a picture). For example, in a study by Rauscher, Krauss, and Chen (1996), participants first watched an animated action cartoon. After a break, with the cartoon no longer present, participants were then asked to describe the cartoon to a listener. When participants were prevented from gesturing (under the guise of recording skin conductance from their palms), they were significantly slower to describe spatial elements of the cartoon. Presumably, blocking the embodiment impaired access to the conceptual elements of the representation. In another example, Spivey and his colleagues report that participants who listen to vignettes including spatial descriptions, such as "the top of a skyscraper" or "the bottom of a canyon," perform appropriate eye movements up or down, respectively, as if actually present in the situation (Spivey, Tyler, Richardson, & Young, 2000). Finally, Glenberg and Kaschak (2002) found that participants were faster at judging the sensibility of a sentence when its meaning was compatible with the hand movement required for the response (e.g., "Close the drawer"—forward movement; "Open the drawer"—backward movement). Remarkably, this action–sentence compatibility effect occurred even when the sentences referred to abstract actions that involved directional communication (i.e., participants were fastest in judging the sensibility of the sentence "You told Liz the story" with a forward movement and the sentence "Liz told you the story" with a backward movement). Richardson, Spivey, Barsalou, and McRae (2003) report an analogous set of findings.

Again, these behavioral studies are consistent with neuroscientific data. In the brain lesion literature, many studies have found high-level cognitive impairments as a result of neurological damage to modality-specific systems. Lesions in these systems produce systematic deficits in category knowledge (e.g., Cree & McRae, 2003; Damasio & Damasio, 1994; Farah, 1994; Humphries & Forde, 2001; Simmons & Barsalou, 2003; Warrington & Shallice, 1984). Lesions in modality-specific areas also produce deficits in the representation of episodic memories (e.g., Rubin & Greenberg, 1998). Recently, activation of modality-specific areas has been observed when people perform abstract conceptual tasks, such as concept property verification, that require deep, nonassociative processing of target stimuli (Kan, Barsalou, Solomon, Minor, & Thompson-Schill, in press).

In sum, accumulating evidence from cognitive psychology and cognitive neuroscience supports embodiment theories of knowledge. For more extensive reviews of such findings, see Martin (2001), Barsalou (2003b), and Hegerty (2004). Importantly, such findings are not predicted a priori by amodal accounts. Accordingly, these results are increasingly shaping theorizing in cognitive psychology and cognitive science, as well as in philosophy and linguistics. For examples of these theoretical accounts, see Barsalou (1999, 2003a), Churchland et al. (1994), Clark (1997), Glenberg (1997), Lakoff and Johnson (1999), Prinz (2002), and Varela, Thompson, and Rosch (1991).

Embodiment Effects in Social Psychology

Our primary argument here is that social psychology could profit from theories of embodied cognition. In particular, such theories can help integrate and account for the findings listed willy-nilly at the beginning of this article, as well as those just described. Furthermore, these theories can help us generate interesting predictions that cannot be derived a priori from the amodal accounts of knowledge representations that currently dominate social psychology. To support our argument, we next summarize findings that illustrate embodiment in three traditional areas of social psychology: attitudes, social perception, and emotion. Then, we present a specific theory of embodiment, Barsalou's (1999) PSS account of conceptual processing. We compare PSS to some views already present in the social psychology and related literatures and explain how this account deals with prior criticisms of the embodiment approach. Finally, we show how PSS sheds new light on classic phenomena in social psychology.

In the following sections, we organize embodiment findings around the themes of attitude, social perception, and emotion. Within each group of findings, we distinguish again between online embodiment that occurs in the presence of real external stimuli and offline embodiment that occurs during the use of symbols that refer to real stimuli not actually present. For example, imitation of another person's happy facial expression is an example of online embodiment. On the other hand, understanding the word "happiness" or recalling a happy experience by recruiting modality-specific systems is an example of offline embodiment. We find the online/offline distinction useful in organizing the social psychology literature, in part because it can serve as a way to conceptualize knowledge acquisition and knowledge use and to see similarities in their underlying mechanisms. Before we start, we hasten to add that our summaries of these empirical literatures should by no means be viewed as exhaustive. We simply try to highlight findings that are representative for each category (see Barsalou et al. 2003, for additional discussion of these literatures).

Embodiment of Attitudes

Charles Darwin (1904) defined attitude as a collection of motor behaviors—especially posture—that convey an organism's affective response toward an object. Thus, it would not have come as any surprise to him that the body is involved in the acquisition and use of attitudes. Subsequent accounts similarly stressed the importance of motor behavior in attitudes (e.g., Sherrington, 1906; Washburn, 1926). Francis Galton (1884), for example, also defined attitude in terms of posture (literally, as a bodily inclination). He believed that the way to quantify a person's attitude toward another individual was to sit the two individuals in adjacent chairs and then measure the weight that they applied to the edge of the chair nearest to the other individual (vs. the back of the chair). Individuals who like one another should put more weight on the edge of the chair facing the other person, he argued, thus manifesting their positive attitude toward each other. Ironically, because a focus on posture no longer figures into the definition of attitude, the following studies may have more novelty value now than 100 years ago.

Online embodiment in the acquisition and processing of attitudes. The studies we summarize in this section suggest that bodily responses during interaction with novel objects influence later-reported attitudes and impressions. In an early demonstration of such an effect, Wells and Petty (1980) instructed participants to nod their heads vertically or to shake their heads horizontally while wearing headphones, under the pretext that the research was designed to investigate whether the headphones slipped off as listeners moved to the music. While nodding or shaking their heads, participants then heard either a disagreeable or an agreeable message about a university-related topic. Later, they rated how much they agreed with the message. Wells and Petty found that the earlier head movements later modulated participants' judgments. Specifically, participants who had nodded while hearing the message were more favorable than participants who had shaken their heads.

Tom, Pettersen, Law, Burton, and Cook (1991) extended this study and induced participants to nod their heads (in agreement) or to shake their heads (in disagreement) while placing a pen on the table in front of participants. After the purported testing of the headphones, a naive experimenter offered to give the participant the "old" pen that had been placed on the table during the experiment or a "new" pen that the participant had never seen. Individuals who had nodded during the testing of the headphones preferred the old pen, whereas participants who had shaken their heads preferred the new one. Presumably, whether participants nodded or shook their heads during initial exposure to the pen influenced the attitude that they developed toward it, as revealed in their later preference.

Cacioppo et al. (1993) explored the relation between a different attitude-relevant motor behavior and the development of attitudes toward completely novel stimuli—Chinese ideographs. Participants were induced to push upward on a table from underneath (an action typically associated with approach, reflective of positive attitudes) or to push downward on the tabletop (an action typically associated with avoidance, reflective of negative attitudes) while they were exposed to the ideographs. Consistent with an embodiment hypothesis, ideographs seen during the approach behavior were later rated more positively than were ideographs seen during the avoidance behavior. A subsequent study in which a control group (that engaged in no behavior) was added to the experimental design demonstrated that both approach and avoidance behaviors had a significant influence on attitudes.

As all these studies illustrate, bodily postures and motor behavior are associated with positive and negative inclinations and action tendencies toward objects. Furthermore, these inclinations and tendencies influence attitudes toward those objects as expressed by self-report and attitude ratings. Thus, attitudes appear to be determined, at least in part, by embodied responses. We next look at the role of embodiment when attitude objects are not present.

Offline embodiment in attitude processing. As mentioned previously, the notion of offline embodiment is that modality-specific systems are engaged even when people process symbolic entities, such as words. This is because conceptual processing draws on the modality-specific patterns established earlier during online acquisition processing. Furthermore, the embodiment view proposes that conceptual processing is maximally efficient when relevant conceptual information is consistent with current embodiments.

This hypothesis is supported by the findings of Chen and Bargh's (1999) study in which participants were exposed to words with positive or negative valence (e.g., *love*, *hate*) and had to report the valence by pulling a lever toward them or by pushing it away. Consistent with an embodiment prediction, participants made pulling responses faster when responding to positive words, compared to negative, and made pushing responses faster to negative words compared to positive ones. In a second study, Chen and Bargh had participants indicate when a word merely appeared on the computer screen—participants made the same response to all words regardless of their affective valence. Subjects who indicated a word's appearance by pulling the lever toward them responded faster to positive words than to negative ones. Participants who indicated a word's appearance by pushing the lever away responded faster to negative words. Thus, there was a systematic relationship between the processing of the word and the compatibility between the valence of the word and the behavior used in response to it (see also Neumann & Strack, 2000; Wentura, Rothermund, & Bak, 2000).

Förster and Strack (1997, 1998) demonstrated a similar effect in the retrieval of information from long-term memory. Participants in their study generated the names of famous people and later classified the people according to whether they liked, disliked, or were neutral about them. During the name generation task, participants either pulled up on the table in front of them from underneath its bottom surface (an approach behavior, as described earlier) or pushed down on its top surface (an avoidance behavior). Participants who performed the approach behavior during name generation retrieved more names of people they liked. Conversely, participants who performed the avoidance action retrieved more names of people they disliked. Thus, participants' motor behavior influenced the retrieval of attitude objects from long-term memory in an attitude-congruent manner.

In sum, the studies described in this section on attitudes demonstrate the two embodiment effects of interest. First, during online exposure to objects, the production of motor movements associated with positive attitudes leads to the later expression of positive attitudes, and the production of motor movements associated with negative attitudes leads to the later expression of negative attitudes. Second, during offline cognition, processing symbols that stand for absent attitude objects are most efficient when a congruent motor behavior is maintained, suggesting that representing the conceptual knowledge involves the relevant motor behavior.[2]

Social Perception[3]

It may feel intuitively correct to learn that individuals embody the behaviors of others online or when those others are physically present. Researchers have long argued for the role of mimicry and imitation in social modeling, social coordination, and empathy (e.g., Bandura, 1977; Lipps, 1907). It is perhaps more counterintuitive to imagine how embodiment enters into social perception offline, or when other people are present only symbolically. This notion has some interesting historical precursors. Freud, of course, thought that the sensory–motor symptoms of hysterics were in fact unconscious enactments of thoughts and memories involving other significant people (Breuer & Freud, 1983-95/1955). And in a more general embodiment account, psychoanalyst Felix Deutsch (1952) proposed that "all automatic … movements represent in some way the search for a desired … [person] … from the past" (p. 210). He argued, based on clinical cases, that parts of the body actually personify members of one's family (even, or especially, when they are not physically present) and that sensations and movements in those body parts express feelings toward and memories of those people. These unique perspectives have rarely been integrated explicitly with empirical research on social perception and impression formation. Still, the social psychology literature is replete with examples that are consistent with such a view.

Online embodiment in social information processing: Mimicry and imitation. Research has consistently shown that perceivers imitate the facial gestures of perceived others. O'Toole and Dubin (1968) demonstrated that mothers open their mouths in response to the open mouth of their infant who is about to feed. These imitative behaviors occur very early in development. In classic studies, Meltzoff and Moore (1977, 1989) showed that neonates imitate basic facial gestures such as tongue protrusion and mouth opening, suggesting a biological basis of basic imitation skills (for a review, see Meltzoff & Prinz, 2002). The biological argument is strengthened further by observations of basic imitative behaviors in other primates (Preston & de Waal, 2002) and by the impairments of basic imitation as a result of developmental disorders such as autism (McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2004; Rogers, 1999; Sigman, Kasari, Kwon, & Yirmiya, 1992).

Importantly, imitation extends beyond facial behavior. Individuals engaged in conversation tend to synchronize their latency and rate of speech, the duration of their utterances, and other speech characteristics (e.g., Capella & Planalp, 1981; Matarazzo & Wiens, 1972; Webb, 1972). Listeners also tend to mimic talkers' emotional prosody (e.g., Neumann & Strack, 2000), manual gestures (e.g., Bavelas, Black, Chovil, Lemery, & Mullett, 1988; Maxwell, Cook, & Burr, 1985), and even their syntactic constructions (e.g., Bock, 1986). Much research has focused on postural synchrony. For example, in one study Bernieri (1988) had judges code the postures of two individuals filmed while they were actually interacting with each other and the same two individuals who appeared to be interacting with each other but who were actually interacting with different people. Supporting the idea of imita-

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[2] As we discuss later, the embodiment view allows for substantial flexibility in terms of what specific modality states and physical movements are associated with specific concepts. For example, under different task settings, positive versus negative concepts might be associated with different bodily movements (push or pull, up or down, toward or away). The main message of the embodiment view is that conceptual representations are supported by simulations in modality systems, not that they are rigidly tied to specific bodily states. This view is consistent with recent findings on flexibility of the link between valence and specific bodily movement (Markman & Brendl, in press).

[3] Niedenthal and Halberstadt (2004) have argued that the term *social perception* as used in social psychology is a misnomer, because rarely have perceptual processes actually been examined. Here, similar to most other researchers, we use this term broadly in referring to impression formation and social information processing.

tion, the results revealed greater postural synchrony for two individuals engaged in actual interaction than for two individuals in a contrived interaction (for related results, see Bernieri, Reznick, & Rosenthal, 1988; Bernieri & Rosenthal, 1991). In a more recent study by Chartrand and Bargh (1999), a trained experimenter rubbed her nose or shook her foot while she interacted with participants. When the experimenter scratched her nose, participants were more likely to scratch their nose (than to shake their foot). And when the experimenter shook her foot, participants were more likely to shake their foot (than to scratch their nose). This result further suggests that the mere observation of another person engaging in a particular action facilitates the same action in the perceiver.

It is widely believed that synchrony facilitates cooperation and empathy among interaction partners (e.g., Hatfield, Cacioppo, & Rapson, 1993; LaFrance, 1985; LaFrance & Ickes, 1981; Neumann & Strack, 2000; Semin, 2000). Consistent with this belief, enhancing mimicry increases smoothness of interaction and liking between partners (Chartrand & Bargh, 1999). It is also believed that interpersonal closeness facilitates mimicry (Bush, McHugo, & Lanzetta, 1989; McIntosh, Druckman, & Zajonc, 1994; van Baaren, Maddux, Chartrand, de Bouter, & Knippenberg, 2003). Consistent with this assumption, participants show more spontaneous mimicry of a model's behavior when their liking for the model is experimentally enhanced or when the model is the participant's friend (McIntosh, in press).

A specific neural mechanism appears to underlie imitation. Rizzolatti and his colleagues have observed that certain circuits involved in the production of an organism's motor behavior also become active in response to perceived intentional motor behavior (e.g., Rizzolatti, Fadiga, Fogassi, & Gallese, 2002; also see Chao & Martin, 2000). Such mirror neuron circuits could play two important adaptive roles in social life. First, they may support fast learning, such that an organism learns new actions through imitation (Gallese, 2003). This is consistent with our idea of online embodiment as knowledge acquisition. Second, these circuits may be responsible for social contagion, such as the induction of congruent emotional states in others, especially if those others are psychologically close (Decéty & Chaminade, 2003). If so, then these circuits should be centrally implicated in empathy and social cooperation (Hatfield, Cacioppo, & Rapson, 1992).

More generally, the growing evidence for the close involvement of mirror neurons in empathy, imitation, and attribution of mental state supports the embodiment view. Reflecting on this evidence, Gallese (2003) noted that according to amodal accounts of social cognition,

> when faced with the problem of understanding the meaning of others' behaviors, adults humans must necessarily translate the sensory information about the observed behavior into a series of *mental representations* that share, with language, the propositional format. This enables one to ascribe others' intentions, desires and beliefs, and therefore to understand the *mental antecedents* of their overt behavior … [but this is a] *disembodied view* … I think that there is now enough empirical evidence to reject a disembodied theory of the mind as biologically implausible.

Offline embodiment in social information processing: Category priming and motor responding. In a recent and already classic series of studies, Bargh, Chen, and Burrows (1996) demonstrated embodiment in social information processing when the actual social stimuli were not present. Participants in one study were instructed to form sentences from groups of words presented in random order. In the critical conditions, many of the sentences contained words related to the stereotype of the elderly (e.g., *gray*, *Florida*, and *bingo*). Importantly, those words were not specifically related to motor movement. In the control conditions, the sentences that participants constructed contained neutral words unrelated to the elderly stereotype. Results showed that when participants had been primed with the elderly stereotype, they actually took longer to walk from the experimental room to the elevator than did control participants. Presumably, this occurred because the priming task activated the elderly stereotype which contains knowledge that old people tend to move slowly. In turn, this knowledge activated action schemas, which caused the embodiment effect of slow walking. Studies in the same research project have demonstrated embodiment effects of processing other social categories on other kinds of behavior, including rudeness and aggressiveness (for a review, see Dijksterhuis & Bargh, 2001).

Another class of embodiment effects in offline social perception occurs during activation of evaluative knowledge. In one demonstration, Vanman, Paul, Ito, and Miller (1997) instructed participants to form images of people with whom they might later work on a problem-solving task. A number of different variables moderated participants' facial responses, as measured by EMG. For example, participants were most likely to display positive facial reactions when their imagined partners, who were competent (vs. incompetent), exerted high (vs. low) effort, or belonged to the same (vs. different) racial category. Thus embodiment occurred when individuals activated representations of people who were not actually present.

Finally, Andersen, Reznik, and Manzella (1996) obtained personality descriptions about significant others in their participants' lives, and then developed descriptions of fictional characters who partially resembled them. In a later experimental session, participants read the descriptions of these fictional characters, not realizing that they were in any way related to their significant others. In line with an embodiment account, participants' facial expressions, as coded by a naive judge, were influenced by what they read. When participants read about characters based on significant others they liked, they tended to produce positive facial expressions. Conversely, when participants read about characters based on significant others who they disliked, they tended to produce negative facial expressions. Thus, again, simply reading about abstract social stimuli influenced facial responding, suggesting an embodied representation of social knowledge.

To conclude this section, we have described illustrative studies showing, first, that individuals tend to mimic the motor behavior of other individuals when those others are actually present and, second, that embodied responses are engaged when individuals manipulate information offline about other people stored in long-term memory. Recent findings in social neuroscience also provide strong evidence for this interpretation. All these findings are closely related to the research findings on emotion and empathy that we address next.

Emotion

Students of emotion most often associate the idea of embodiment with William James (1890). According to James, the basis of emotion is the bodily activity that occurs in response to an emotional stimulus. Thus, James was claiming that emotions are embodiments.[4] Our goal here is not to assess whether everything about James's theory is correct. In particular, we are not endorsing James's claim about the necessity of the autonomic nervous system for emotion. We are also not endorsing a strong mapping between specific emotions and specific embodiments. We do suggest, however, that embodiment is critically involved in information processing about emotion—not only "online," when people respond to real emotion objects, but also "offline," when people represent the meanings of emotional symbols, such as words. Furthermore, as described shortly, we propose a concrete embodiment account grounded in current research in psychology and neuroscience that allows us to make specific predictions about the role of embodiment in emotion phenomena.

Online embodiment in emotion processing.

We have already discussed the ubiquity of embodied responses to nonemotional actions and gestures. In this section, we focus on embodied responses to emotion stimuli. Evidence is accumulating that people mimic others' emotional facial expressions (Bush, Barr, McHugo, & Lanzetta, 1989; Dimberg, 1982). In Bavelas, Black, Lemery, and Mullett (1986), for example, a confederate faked an injury and then grimaced in pain. When participants observed the grimace, they grimaced themselves. Furthermore, the magnitude of participants' grimaces increased with how clearly they could see the confederate's grimace. Emotion imitation appears to be relatively automatic and to even be elicited outside awareness, as when participants react with slight smiles and frowns to subliminal happy and angry expressions (Dimberg, Thunberg, & Elmehed, 2000). Further evidence suggests that embodied consequences of subliminal facial expressions extend beyond facial mimicry. In one study, for example, participants were first subliminally exposed to happy or angry faces and were then asked to try a novel beverage. The results showed that participants exposed to subliminal happy faces later behaved more in an approach-oriented fashion (by pouring and drinking more beverage) than subjects who were exposed to subliminal angry faces (Winkielman, Berridge, & Wilbarger, in press).

According to embodiment views, bodily responses should facilitate cognitive processing of emotion stimuli. In one demonstration of this effect, Wallbott (1991) had participants categorize the emotional facial expressions displayed in photographs of other people. As participants categorized the photographed expressions, their own faces were surreptitiously videotaped. Results showed that the participants tended to mimic the facial expressions as they categorized them. When they categorized happy faces, for example, they smiled themselves. Furthermore, participants' accuracy in classifying the facial expressions was positively correlated with the extent of mimicry. The more participants mimicked the faces, the better they were at discerning what expression the face was displaying.

Niedenthal, Brauer, Halberstadt, and Innes-Ker (2001) demonstrated that this mimicry plays a causal role in the processing of emotional expression. Participants watched one facial expression morph into another and had to detect when the expression changed. Some participants were free to mimic, whereas others were prevented from mimicking by holding a pencil laterally between their lips and teeth. Consistent with the embodiment hypothesis, participants free to mimic the expressions detected the change in emotional expression earlier (more efficiently) for any facial expression than did participants who were prevented from mimicking the expressions (for further discussion see Niedenthal, Ric, & Krauth-Gruber, 2002).

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[4] More specifically, James argued that the conscious experience of emotion (the subjective feeling component of emotion) derives from the conscious perception of embodiments. Note, however, that emotion can be embodied without these embodiments being consciously represented as feelings (for discussion, see Berridge & Winkielman, 2003).

Adolphs, Damasio, Tranel, Cooper, and Damasio (2000) report further evidence for the causal involvement of somatosensory processes in recognition of facial expressions. Clinical patients with lesions in somatosensory cortex showed poorer performance in classifying facial expressions than individuals without such lesions. Presumably, simulating emotional expressions on one's own face, and experiencing the resulting somatosensory feedback, is necessary for the process of recognition.[5] In short, the results reported by Wallbott (1991), Niedenthal et al. (2001), and Adolphs and his colleagues all converge on the conclusion that feedback from facial mimicry is importantly involved in a perceiver's ability to process emotional expressions. Carr, Iacoboni, Dubeau, Mazziotta, and Lenzi (2003) have begun to explore the neural circuit that underlies this process.

We have noted several times that the mimicry of emotional gestures has been proposed as a mechanism that supports empathy (Lanzetta & Englis, 1989; McIntosh et al., 1994; Vaughan & Lanzetta, 1980; see Levenson, 1996 for discussion). Zajonc, Adelmann, Murphy, and Niedenthal (1987) further demonstrate this relationship. These researchers compared the facial similarity of couples at the time of their marriage to their facial similarity after 25 or more years of marriage. Zajonc et al. reasoned that married partners should frequently mimic each other's facial expressions, presumably because they are particularly motivated to empathize with each other. As a consequence of this frequent mimicry, the couples' faces should grow more similar over time. Consistent with this reasoning, Zajonc et al. found that after 25 or more years of marriage, facial similarity between couples was greater than at the time of their marriage and also greater than between random people of the same age. Furthermore, this effect was correlated with the quality of the marriage and therefore presumably success in empathizing.

The rather indirect finding of Zajonc and his colleagues (1987) is supported by recent studies on the neural basis of mirroring effects. One fMRI study observed very similar changes in brain activity of a female participant while painful stimulation was applied to her own hand or to her partner's hand (Singer et al., 2004). A related study used single cell recording and found activation of pain-related neurons when a painful stimulus was applied to the participant's own hand and when the patient watched the painful stimulus applied to the experimenter's hand (Hutchison, Davis, Lozano, Tasker, & Dostrovsky, 1999). Yet another study found activation in the insula (a brain area responsible for processing somatosensory information) when the participant was exposed to disgusting odors and when the participant simply watched a movie of other people's expressions of disgust (Wicker et al., 2003). All these findings were interpreted as evidence of an embodied simulation in the perceiver of what was happening to the perceived person (for summaries of related research, see Gallese, 2003; Iacoboni, in press). In short, there is now converging evidence that embodiment, in the sense of actual motor and somatosensory responses, is involved in empathy.

Offline embodiment in emotion. As discussed earlier, offline embodiment is the use of modality-specific representations to represent the meaning of symbols whose referents are absent. Offline embodiment often appears central to the representation of emotion knowledge. In a study by Laird, Wagener, Halal, and Szegda (1982), participants studied both anger-provoking and happiness-provoking material. Later, participants were covertly induced to smile or frown and then were instructed to recall the earlier learned material. Results showed that the induced expression moderated recall. Participants induced to smile recalled the happy material better than those induced to frown, whereas participants induced to frown recalled the angry material better than those induced to smile. Importantly, this effect was found only when participants' facial expressions were accompanied by a congruent emotional state. That is, participants' memory performance was maximized when the motor behavior, the emotional state, and the emotional meaning of the learned material were all compatible (see related studies by Strack et al., 1988; Zajonc, Pietromonaco, & Bargh, 1982).

In a similar study by Riskind (1984), participants were instructed to retrieve pleasant or unpleasant autobiographical memories while they adopted different postures and facial expressions. The embodiment manipulation was expected to influence the emotional nature of the memories recalled. As predicted, postural and facial manipulations modulated the latencies to retrieve positive versus negative life experiences. Adopting an erect posture and smiling speeded the retrieval of pleasant autobiographical memories, relative to the speed of retrieving unpleasant autobiographical memories.

Research by Stepper and Strack (1993) generalized these effects to how people respond emotionally to evaluations of their performance. Participants were led to sit in an upright or slumped position under the pretext that the experimenters were concerned with task performance under varying ergonomic conditions. While upright or slumped, participants performed an achievement test and received bogus feedback that they had done well. Later, participants rated their feeling of pride at the time. Participants who had sat upright while receiving task feedback reported experi-

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[5] Somatosensory mechanisms are not only involved in recognizing facial expressions. Similar effects of damage to the somatosensory cortex have also been obtained with tasks requiring emotion recognition from prosody and body movement (Adolphs, Damasio, & Tranel, 2002; Heberlein, Adolphs, Tranel, & Damasio, in press).

encing more pride than participants who had sat in a slumped position (see also Riskind & Gotay, 1982).

To summarize, these findings provide strong evidence for the embodiment of emotion processing. This evidence also suggests that embodiment supports important cognitive and social functions, such as recognition, memory, empathy, and understanding. As such, the research on emotion embodiment is consistent with earlier reviewed research on embodiment in social perception and attitudes and points to the critical importance of modality-specific states in the representation and processing of social knowledge. But just how does this work?

An Integrative Theory of Embodiment

For over 30 years, evidence has accumulated that implicates embodiment centrally in the acquisition and expression of attitudes, in social perception, and in the learning and use of emotion knowledge. Despite all this evidence, however, no major theory has explained it (Smith & Semin, 2004). Furthermore, the common interpretation of such findings is that embodiment effects arise “simply” as peripheral by-products of conceptual knowledge, which is typically viewed as the critical cause of social cognition. Important accounts of the relationship between perception and action have been proposed in recent years (e.g., Bargh & Chartrand, 1999; Neumann, Förster, & Strack, 2003). These accounts, however, have emphasized the direct and automatic nature of the relation between perceptual and motor processes. In contrast, we explicitly focus on the dynamical role of modality-specific systems in representing and manipulating conceptual knowledge. In what follows, we describe the PSS theory, which puts embodiment at the core of information processing, including attitudes, social perception, and emotion. Comprehensive presentation of PSS can be found elsewhere (e.g., Barsalou, 1999, 2003a, 2003b). Our purpose here is to describe the account in enough detail to show how it explains embodiment effects in social psychology, how it predicts novel phenomena, and how it compares to other accounts of social information processing (also see Barsalou et al., 2003).

Overview of the PSS Theory

According to PSS, the modality-specific states that represent perception, action, and introspection in online situations are also used to represent these situations in the offline processing that underlies memory, language, and thought. Rather than using amodal redescriptions of online modality-specific states to represent these situations, the cognitive system uses reenactments (simulations) of them instead. Thus, the key notion in PSS is that simulations of perceptual, motor, and introspective experience underlie the representation and processing of knowledge. In the following sections, we describe what we mean by modality-specific representations in further detail and then address how such representations are used in the simulations that underlie conceptual processing.

Feature Maps and Convergence Zones

The PSS account takes as a starting point Damasio’s (1989) theory of convergence zones (CZ) proposed by Damasio and his colleagues (see Simmons & Barsalou, 2003, for an elaborated account). CZ theory assumes that the perception of an object activates relevant feature detectors in the brain’s modality-specific systems. The populations of neurons that code featural information in a particular modality are organized in hierarchical and distributed systems of feature maps (Palmer, 1999; Zeki, 1993). When a stimulus is perceived on a given modality, populations of neurons in relevant maps code the stimulus’ features on that modality in a hierarchical manner. For example, visual processing of a happy face activates feature detectors that respond to the color, orientation, and planar surfaces of the face. Whereas feature detectors early in the processing stream code detailed perspective-based properties of the face, higher-order detectors code its more abstract and invariant properties. The pattern of activation across relevant features maps represents the face in visual processing.

Analogously, CZ theory assumes that systems of feature maps reside in the other sensory–motor modalities and in the limbic system for emotion. All these maps operate in parallel, so that while a face is being represented in visual feature maps, sounds produced by the face are being coded in auditory feature maps, affective responses to the face are being coded in limbic feature maps, bodily responses to it are being coded in motor feature maps, and so forth.

CZ theory further proposes that conjunctive neurons in the brain’s association areas capture and store the patterns of activation in feature maps for later representational purposes in language, memory, and thought. Damasio (1989) referred to these association areas as *convergence zones*. Like feature maps, CZs are organized hierarchically such that the CZs located in a particular modality-specific system (e.g., vision) capture patterns of activation in that modality. In turn, higher-level CZs conjoin patterns of activation across modalities. What this means is that when we hear a sound (e.g., a fire cracker exploding), conjunctive neurons in auditory CZs capture the pattern of activation in auditory feature maps. Other conjunctive neurons in motor CZs capture the pattern of activation caused by jumping away from the location of the sudden sound. And at a higher level of associative processing, conjunctive neurons in modality-specific CZs conjoin the two sets of modality-specific conjunctive neurons for the combined processing of sound and movement.

It is worth highlighting how the CZ architecture differs from traditional ways of conceptualizing knowledge acquisition and use. First, during knowledge acquisition (perception and learning), all relevant processing regions participate in knowledge representation—there is no single "final" region where all experience is abstracted and integrated together. Higher level CZs capture only conjunctions of lower-level zones (so that CZs can later coordinate their feature-level reactivation)—they do not constitute some form of "grand" representation that independently represents all lower levels of the representational hierarchy. Second, during knowledge use (e.g., conceptual processing and recall), the cognizer activates the multiple modality-specific regions that encoded the experience, rather than, as traditionally assumed, only the "final" abstract regions at the end of the processing streams.

Reenactments of Modality-Specific States

What is important about the CZ architecture is the idea that conjunctive neurons can later reactivate the states of processing in each modality and across modalities, without any input from the original stimulus. This mechanism provides a powerful way to implement offline embodiment. The modality-specific processing that occurred in reaction to a previously encountered stimulus can be reenacted without the original stimulus being present. For example, when retrieving the memory of a person's face, conjunctive neurons partially reactivate the visual states active while perceiving it. Similarly, when retrieving an action, conjunctive neurons partially activate the motor states that produced it. Indeed, this reentrant mechanism is now widely viewed as underlying mental imagery in working memory (e.g., Farah, 2000; Grezes & Decéty, 2001; Kosslyn, 1994).

Importantly—and different from typical assumptions about imagery—the CZ architecture and PSS do not require the reenactment process to be conscious. Explicit construction of mental imagery can certainly produce compelling reenactments, which are often viewed as the process that underlies, for example, counterfactual simulations. Nevertheless, memory, conceptualization, comprehension, and reasoning processes may rely heavily on unconscious reenactments (e.g., Barsalou, 1999, 2003b). Many of the demonstrations illustrated in the previous sections of this article may primarily reflect spontaneous and unconscious reenactments (e.g., several phenomena reported by Bargh and his colleagues).

Simulators and Simulations

The CZ architecture describes how knowledge is distributed across the brain's feature and association areas. To explain how the cognitive system actually uses that knowledge, PSS relies on two central constructs: *simulators* and *simulations* (Barsalou, 1999). Simulators integrate modality-specific information across a category's instances. Simulations implement specific conceptualizations of a category. We describe these constructs in turn.

Simulators. A sizable literature on concepts has demonstrated that categories possess statistically correlated features (e.g., Chin & Ross, 2002; Rosch & Mervis, 1975). Thus, when different instances of the same category are encountered over time and space, they activate similar neural patterns in feature maps (cf., Cree & McRae, 2003; Farah & McClelland, 1991). One result of this repeated firing of similar neural patterns is that similar populations of conjunctive neurons in CZs respond to these regular patterns (Damasio, 1989; Simmons & Barsalou, 2003). Similar to the notion of abstraction, over time, these groups of conjunctive neurons integrate modality-specific features of specific categories across their instances and across the situations in which they are encountered. This repetition establishes a multimodal representation of the category: a concept.

PSS refers to these multimodal representations of categories as simulators (Barsalou, 1999, 2003a). A simulator integrates the modality-specific content of a category across instances and provides the ability to identify items encountered subsequently as instances of the same category. Consider a simulator for the social category, politician. Following exposure to different politicians, visual information about how typical politicians look (i.e., based on their typical age, sex, and role constraints on their dress and their facial expressions) becomes integrated in the simulator, along with auditory information for how they typically sound when they talk (or scream or grovel), motor programs for interacting with them, typical emotional responses induced in interactions or exposures to them, and so forth. The consequence is a system distributed throughout the brain's feature and association areas that essentially represents knowledge of the social category, politician.

According to PSS, a simulator develops for any aspect of experience attended to repeatedly. Because attention is highly flexible, it can focus on diverse components of experience, including objects (e.g., chairs), properties (e.g., red), people (e.g., politicians), mental states (e.g., disgust), motivational states (e.g., hunger), actions (e.g., walking), events (e.g., dinners), settings (e.g., restaurants), relations (e.g., above), and so forth. Across development, a huge number of simulators develop in long-term memory, each drawing on the relevant set of feature and association areas needed to represent it. Once this system is in place, it can be used to simulate those aspects of experience for which simulators exist. Furthermore, as discussed later, simulators can combine to construct complex representations that are componential, relational, and hierarchical. Thus PSS is not a theory of holistic images. In contrast to how theories like PSS are often mistakenly viewed, photo-like images of external scenes do not underlie knowledge. Instead, componential bodies of accumulated information about the modality-specific components of experience underlie knowledge, where these components can represent either the external environment or the internal states of the agent.

Computational implementations of simulators have not yet been developed. Clearly such development is important for many reasons. Nevertheless a variety of computational architectures exist that could potentially be used to implement them. For example, object-oriented (as opposed to bit-mapped) drawing programs contain much of the componential, relational, and hierarchical structure that underlies PSS's productive use of simulations. Although this architecture has not been developed as a psychological theory, its functionality closely resembles many of PSS's conceptual operations. Another relevant computational approach is the interactive neural network architecture, which represents categories as distributed feature profiles across modality-specific areas (Farah & McClelland, 1991; O'Reilly & Munakata, 2000). In these networks, modality-specific representations are used not only for establishing conceptual knowledge, but also for performing high-level conceptual operations. The success of these existing architectures offers evidence for the mechanistic plausibility of the simulators and simulations in PSS.

Simulations. The use of simulators in conceptual processing is called simulation. A given simulator can produce an infinite number of simulations, namely, specific representations of the category that the simulator represents. On a given occasion, a subset of the modality-specific knowledge in the simulator becomes active to represent the category, with this subset varying widely across simulations. For example, a simulator that represents the social category, my significant other, might be used to simulate love making with a significant other on one occasion, to simulate fights on another, to simulate quiet togetherness on another, and so forth. A simulation can be viewed as the reverse process of storing modality-specific information in a simulator. Whereas learning involves feature map information becoming linked together by conjunctive units in CZs, simulation involves later using these conjunctive units to trigger feature map information. Thus, a simulation, too, is a distributed representation.

According to PSS, the simulation process is highly dynamic and context dependent. It is dynamic in that a given simulator can, in principle, produce an infinite number of simulations. Depending on the current state of the simulator, the current state of associated simulators, the current state of broader cognitive processing, and so forth, a unique simulation results (Barsalou, 1987, 1989, 1993, 2003b). The simulation process is context dependent in that the simulation constructed on a given occasion is tailored to support situated action (Barsalou, 2002, 2003b). Ideally, the current simulation of a category should provide useful inferences about specific category members currently being experienced (or likely to be experienced), actions that could be performed on them, mental states that might result, and so forth. Thus, PSS does not view the simulation process as producing a static, generic category representation. Instead, PSS views simulation as a skill or competency for representing a particular category flexibly in myriad ways that support successful interactions with its members.

Notably, simulations do not implement a single representational type, such as exemplars. Instead, simulations can implement a variety of representational types, including exemplars, prototypes, and rules (Barsalou, 1999, 2003a). To the extent that a simulation reenacts the modality-specific states of a particular experience with a category member, it represents an exemplar.[6] If a simulation, however, draws on multiple exemplar memories to produce a simulation that is an average of them, then it functions more as a prototype. Similarly, various types of rules can be implemented when relational structures construe particular regions of simulations as required for category membership. Depending on the information simulated and how it is interpreted, a wide variety of representational types can in principle be implemented. Although computational accounts of these different representational types remain to be developed, this approach, in principle, is capable of implementing them.

Using simulators and simulations to implement basic conceptual functions. Once a collection of simulators exists in long-term memory, it can implement basic functions that are central to a conceptual system: types versus tokens, categorical inference, productivity, propositions, and abstract concepts. We address each briefly in turn (for further detail, see Barsalou, 1999, 2003b).

In the type–token distinction, type representations stand for categories (e.g., politicians), whereas token representations stand for individual category members

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[6] When a simulator represents an exemplar, it only produces a partial simulation that is typically relatively sketchy and that may be distorted by a variety of factors. We do not assume that complete veridical records of perception are reproduced.

(e.g., Napoleon), and more specifically, for individuals on particular occasions (e.g., Napoleon at Waterloo). In PSS, simulators represent types because they aggregate modality-specific information across category members. Conversely, simulations represent tokens, namely, specific category members, along with specific category members on particular occasions. Thus, the simulator–simulation distinction in PSS naturally implements the classic type–token distinction essential for a conceptual system.

In categorical inference a category member is perceived, which activates the category representation. In turn, knowledge likely to be true for the category is extended to the category member. On seeing a particular dog, for example, category knowledge about dogs becomes active, which might then produce inferences about the dog being likely to bark, wag its tail, and so forth. In PSS, such inferences arise as simulations drawn from the modality-specific content of a simulator. Once the perception of the dog activates the dog simulator (via similarity between the content of the perception and the content of the simulator), the simulator runs a simulation of likely perceptual content that has not yet been experienced. A major issue for PSS (and for any theory of knowledge) is how the correct inferences are generated. In general though, PSS can produce categorical inferences via the simulation process, simulating likely modality-specific content that has not yet been experienced for the perceived individual.

In productivity, concepts are combined systematically to construct complex conceptual representations (e.g., productively combining striped and purple with waterfall and river yields striped waterfall, purple waterfall, striped river, and purple river). Notably, the conceptual combination process is capable of representing an infinite number of concepts whose referents have never been experienced, such as purple waterfall. Because PSS establishes simulators for individual components of experience, it has the necessary building blocks for implementing productivity. Once simulators for striped, purple, waterfall, and river exist, they can be combined to form more complex concepts. For example, a person could run the waterfall simulator to produce a particular waterfall simulation. Once this simulation is in place, then the color of the waterfall can be systematically varied, using simulators for color, such as purple, orange, and gold, to differentially simulate the waterfall's color.

Central to productivity is having relational knowledge about how various components combine to form more complex structures. Just as PSS establishes simulators for objects and properties, however, it also establishes simulators for a wide variety of relations, such as the aforementioned. To productively simulate different above relations, PSS first uses the simulator to construct a configuration of two regions that were previously established as one instance of this relation (e.g., two spherical regions equal in horizontal position, different in vertical position, nearly touching each other). Once this relational simulation is in place, its regions can be systemically filled with simulations of different objects, such as birds, planes, barns, and trees, to represent above relations such as above (bird, barn), above (bird, tree), and so forth. Thus, by combining simulations hierarchically in simulated relational structures, productivity results.

The most basic form of propositional interpretation results from applying the type–token distinction to the process of categorization. Essentially, the categorization process binds a type for a category to one of its tokens, thereby establishing a type–token proposition. On seeing a particular overhead projector, for example, categorizing it as an overhead projector binds category knowledge about overhead projectors to the object. This binding represents the proposition that this particular object is a member of this particular category. Note that the proposition could be false. The object could actually be a piece of abstract art that someone has mistakenly categorized as an overhead projector. In this case, the proposition that represents the agent's belief is false, not true.

Most notably, the type–token proposition established constitutes one possible interpretation of the object. To see this, consider the infinite number of interpretations of an actual overhead projector that can be implemented with type–token propositions. The projector could be interpreted correctly as an overhead projector, as an office tool, as an artifact, as an increasingly dated piece of technology, and so forth. Similarly, the projector could be interpreted incorrectly as a piece of art, as a mammal, or as a space alien. In each case, different categorical knowledge is applied to the same object to create a different type–token proposition. In each case, a different interpretation results, accompanied by a different family of categorical inferences.

It has been widely argued that modality-specific approaches to knowledge cannot implement propositions, because these approaches implement holistic images that record experience, rather than implementing concepts that interpret it (e.g., Pylyshyn, 1973). In PSS, however, the binding of simulators to perceived or simulated individuals naturally implements propositions. Because PSS implements the type–token distinction using simulators and simulations, type–token propositions are a natural consequence.

Finally, it is often argued that modality-specific approaches fail because they cannot represent abstract concepts such as truth. Furthermore, it is often assumed that these approaches fail because representations of the external world cannot be used to represent abstract ideas. As we have seen, however, PSS establishes simulators, not only for components of the external world, but also for components of introspection, including emotions, motivational states, cognitive operations, and so forth. Barsalou (1999) proposes that abstract concepts are abstract because they focus heavily on introspections and complex situational events. In contrast, concrete concepts are concrete because they focus on physical entities, settings, and simple behaviors in the external world. Because simulators can be established for introspections and events (not just for concrete objects), they can in principle represent the conceptual content of abstract concepts (not just the content of concrete concepts).

To assess this hypothesis, Barsalou and Wiemer-Hastings (in press) used the property listing task to assess the content of abstract concepts (truth, freedom, invention) and of concrete concepts (car, sofa, bird). After participants listed the properties of these concepts, detailed coding schemes were applied to assess the content produced. Most notably, the general types of content for abstract and concrete concepts were highly similar. For all concepts, participants tended to describe situations that included objects, people, settings, behaviors, events, mental states, and relations. For both types of concepts, participants situated their conceptualizations of them, not just representing the focal category content, but also representing extensive background situational content relevant to understanding and using the category.

The two types of concepts differed in their focus on this content. Whereas concrete concepts focused on entities, settings, and simple behaviors, abstract concepts focused on introspections, social entities, and complex events. Furthermore, the abstract concepts were more complex, including greater relational structures, organized in greater hierarchical depth.

This exploratory study did not assess how participants represented this content. In principle, though, it seems possible that all of this content—for both concrete and abstract concepts—could be simulated. Everything that participants mentioned is something experienced either in the external or internal world. As a result, the process that establishes simulators could act on this content and establish simulators for it, thereby making it possible for a theory like PSS to explain it. Notably, amodal theories face the same problem of specifying the content of abstract concepts and of explaining how their representations implement this content, something that is far from having been accomplished satisfactorily.

Situated Conceptualizations

As we just saw, people situate their representations of categories. Thus, situated conceptualizations constitute another central construct in the PSS framework. A situated conceptualization is one particular simulation of a category in a background situation, where the specific content of the category and situation prepare the conceptualizer for action in it (Barsalou, 2002, 2003b). In representing the category of chairs, for example, a conceptualizer does not just simulate a generic representation of chairs in a vacuum. Instead, the conceptualizer simulates one particular kind of chair in a particular setting, along with actions and mental states likely to occur while interacting with it. For example, if the conceptualizer were on a jet, a chair simulation would take the form of a jet chair, along with the relevant actions and mental states for interacting with it effectively. Conversely, if the conceptualizer were in a movie theater, a chair simulation would take the form of a theater chair, along with the appropriate actions and mental states. Thus, a situated conceptualization simulates the focal category entity, along with simulations of the likely setting, actions, and introspections. Because the simulation includes the conceptualizer's actions and introspections, the simulation creates the experience of "being there" with the category member. As a result, the conceptualizer is well prepared to interact with the entity in the anticipated situation.

Barsalou et al. (2003) propose that the construct of situated conceptualization is useful in explaining the wide variety of embodiment effects reported in social psychology. Specifically, they propose that situated conceptualizations for repeated social situations become entrenched in memory. Consider, for example, the repeated situation of parents dealing with an upset child. Across these repeated situations, a situated conceptualization becomes entrenched that represents how the child typically appears, how the parents feel, what the parents do, and so forth. Because these situations contain many embodiments (e.g., perceptual simulations of events, bodily states associated with emotion and action), these embodiments become represented in the situated conceptualization. Later, these embodiments, when experienced, can trigger the situated conceptualization via the inference process of pattern completion. Specifically, the experienced embodiment activates a larger pattern that contains it, with nonperceived aspects of the pattern constituting inferences about the situation. Conversely, if through linguistic conversation, the situated conceptualization becomes active, it can, in turn, produce corresponding embodiments via the same inference process.

The PSS framework, with its construct of multimodal, situated conceptualization, accounts for the diverse collection of social embodiment effects reported in the literature. Consider priming effects on behavior, as when exposure to words associated with the elderly stereotype produces slower walking (Bargh et al., 1996). On the PSS account, stereotypes are situated multimodal conceptualizations of social categories. In the case of the elderly stereotype, its content includes embodiments of slow motor movements. Activating these embodiments during conceptualization of the stereotype influences action, via top-down processing, in related modality-specific systems, as when walking slowly toward the elevator. In another example, consider how bodily movements influence conceptual processing, as when head nodding during a persuasive message leads to more positive attitudes (Wells & Petty, 1980). On the PSS account, understanding a message produces a multimodal situated conceptualization to represent the messages' meaning. Nodding while representing the message's meaning activates multimodal conceptualizations for prior situations in which positive affect occurred. Once positive affect becomes active, it influences both how the message is represented and how it is evaluated, producing greater positivity than if no action or a negative action were performed instead.

Shallow Versus Deep Processing

Another important construct in the PSS framework is the distinction between shallow versus deep processing. PSS does not require that all cognitive tasks utilize simulation. Following Paivio (1986) and Glaser (1992), PSS assumes that people can also use word-level representations to perform superficial "conceptual" processing when task conditions permit. Conversely, when task conditions block superficial word strategies and force people to perform conceptual processing, simulations come into play. Not surprisingly, participants adapt flexibly to task conditions. When they can use shallow processing, they do, but when they cannot, they perform deep processing.

To see how participants adapt flexibly to task conditions, consider an experiment by Solomon and Barsalou (2004; also see Niedenthal et al., 2002). On each trial, participants read the word for a concept (e.g., "CHAIR"), and then verified whether a subsequently presented property (e.g., "seat") was true of the concept (where the correct response on true trials, such as this one, was "yes"). The key manipulation was whether the properties tested on false trials (where the correct response was "no") were completely unrelated to the target concept (e.g., CHAIR–feathers), or were associatively related to it (e.g., CHAIR–table; note that a true property had to be a part of the target concept). Whereas some participants only received unrelated false properties, others received only related false properties, with both groups verifying the same true properties.

Solomon and Barsalou (2004) predicted that the relatedness of the false properties would determine whether participants used a shallow or deep strategy for verifying the true properties. When the false properties were completely unrelated (e.g., CHAIR–feathers), participants could employ a shallow processing strategy. Because all the true properties were related to their respective concepts, whereas all the false properties were unrelated, simply detecting an association between the concept and property words was adequate for determining the correct response. Whenever an association was detected, participants could correctly respond true; whenever they did not detect one, they could correctly respond false. Participants did not need to access conceptual knowledge about the concept and the property to assess whether the property actually belonged to the concept. Consistent with this prediction, Solomon and Barsalou (2004) found that, under these task conditions, the associative strength between concept and property words best predicted verification times and errors.

When, however, the false properties were always related to their concepts, participants could not rely on superficial associations between the concept and property words, given that the false trials possessed them too, not just the true trials. As a result, participants had to access conceptual knowledge to verify that the concepts indeed possessed the properties. Solomon and Barsalou (2004) predicted that if simulators represent conceptual knowledge, then perceptual variables should become the best predictors of verification time and errors under these task conditions—not the associative strength between concept and property words. In support of this prediction, perceptual variables, such as property size, became the best predictors of performance. When participants were forced to abandon the superficial word association strategy, the conceptual knowledge they used appeared to take the form of perceptual simulation.

To corroborate this conclusion, Kan et al. (in press) ran the same experiment in an fMRI scanner. When participants received only related false properties, visual processing areas in the fusiform gyrus became active to simulate the properties conceptually. When participants received only unrelated false properties, however, these areas were no longer active, supporting the conclusion that participants were using the superficial word association strategy instead, given that task conditions allowed. As all these experiments illustrate, conceptual processing is flexible, and participants need not always use simulation. When conditions allow, participants adopt more superficial strategies.

Support for the Simulation Hypothesis

Increasing evidence supports the central assumption of PSS that simulation underlies conceptual processing. Here we focus on several lines of supporting evidence reported by Barsalou and his colleagues, although much evidence has been accumulating in other laboratories as well (for reviews, see Barsalou, 2003b; Hegerty, 2004; Martin, 2001). In particular, we focus on three types of evidence for simulation: modality switching costs, instructional equivalence, and perceptual effort.

Modality Switching Costs

PSS predicts that switching costs should occur when people verify properties on different modalities. Pecher, Zeelenberg, and Barsalou (2003, 2004) tested this prediction in a series of studies using the property verification task (also see Marques, 2004). Participants were first asked to verify a property of a concept that requires simulation in one modality, such as BLENDER–loud (which requires an auditory simulation). Next, participants were asked to verify a property of a second concept, which either required simulation in the same modality, such as LEAVES–rustling (again requiring an auditory simulation), or in different modality, such as LEMON–sour (requiring a gustatory simulation).

As PSS predicts, switching costs occurred. When the modality of the property changed from the first trial to the second, participants were slower to verify the second property than when the modality stayed the same. This finding suggests that when people represent properties, they simulate them in the respective modality-specific systems. Amodal theories of knowledge do not predict switching costs a priori. Instead, these theories assume that properties are represented amodally and can be verified without activating modality-specific systems. For a review of modality switching effects and for further discussion of their theoretical interpretation, see Barsalou, Pecher, Zeelenberg, Simmons, and Hamann (in press).

Instructional Equivalence

PSS predicts that people, by default, engage in perceptual simulation. One test of this prediction involves examining instructional equivalence, or whether participants perform similarly under instruction conditions that emphasize or do not emphasize simulation (Barsalou, Solomon, & Wu, 1999). Recent research has recently used the property verification task to assess instructional equivalence (Krauth-Gruber, Ric, & Niedenthal, 2004; Wu & Barsalou, 2004). Across studies, participants in the imagery condition were explicitly asked to image a referent of a concept before listing its properties (e.g., construct an image of a chair and then describe properties in the image). Much previous work indicates that imagery instructions typically induce participants to construct images, which are typically heavily visual. In contrast, participants in the concept condition received no special instructions and were simply asked to produce properties that are typically true of the concept. The primary prediction from PSS is that concept participants will spontaneously, by default, construct simulations, much like those constructed by imagery participants, although perhaps less vivid and less conscious. Finally, participants in the word association condition were asked to generate words associated with the concept name. In each instructional condition, participants' protocols were coded using a detailed coding scheme that established a profile of the conceptual content produced.

PSS predicts that participants in the imagery and concept conditions should produce similar profiles of properties. If concept participants produce simulations by default, the representations that they use to produce properties should be highly similar to those that imagery participants produce. Furthermore, the profiles in the concept and imagery conditions should differ from those in the word association condition. Because word association participants rely primarily on the associative lexical system, they minimize use of the conceptual system, adopting a shallow processing strategy that produces the requested responses.

Amodal theories most naturally make a different a priori prediction (e.g., feature list and semantic network models). According to these theories, concept participants should, by default, use amodal representations, not simulations. As a result, their property profiles should differ significantly from the property profiles of imagery participants. Furthermore, some amodal approaches, at least, predict that the profiles of concept participants should be similar to those of word association participants. Because amodal theories often assume that symbols for concepts bear a systematic relation to the units of language, they lend themselves to the prediction that the default strategy of concept participants is to activate symbols that correspond to the words produced in the word association condition.

Findings from Wu and Barsalou (2004) and Krauth-Gruber et al. (2004) support the PSS predictions. Across multiple experiments, the property profiles for the concept and imagery conditions were more highly correlated with each other than with the profiles for the word association condition. Furthermore, the correlations between the concept and imagery condition were high, suggesting that concept participants adopted the same representational strategy used in the imagery condition by default (i.e., simulation).

Perceptual Effort

Perceptual effort constitutes another indicator of simulation by default (Barsalou et al., 1999). If people spontaneously use simulations to represent concepts, then these representations should have perceptual qualities. As a result, manipulating perceptual variables should affect the ease of conceptual processing, much like manipulating these variables affects the ease of processing of mental images in working memory (e.g., Finke, 1989; Kosslyn, 1980; Shepard & Cooper, 1982). Manipulating perceptual variables such as size, orientation, and occlusion should influence the ease of processing concepts and their properties. As simulations of a property become increasingly large, for example, greater time and effort are needed to construct it. Similarly, the more an object simulation must be rotated to achieve an upright position, the greater the time and effort needed to complete this operation.

Wu and Barsalou (2004) reasoned that if people are representing object properties with simulations, the perceptual variable of occlusion should affect the ease generating properties in the property generation task. To see this, imagine participants being asked to produce the properties of, say, watermelons. If perceptual effort affects this task, then participants should produce the properties that require the least effort to perceive in their simulations, namely, those that are unoccluded. Producing occluded properties should require more perceptual effort, because simulation must be transformed to reveal them. Thus, for watermelons, participants should produce outer unoccluded properties, such as green and stripes more often than occluded properties such as red and seeds. Across several experiments, Wu and Barsalou found evidence for this prediction. Unoccluded properties were produced more often than occluded properties, and also earlier and in larger clusters.

Wu and Barsalou (2004) also tested a second prediction. If the normally occluded properties of an object become unoccluded, they should require less perceptual effort to produce and therefore be produced more often. Thus, in some conditions of these experiments, participants produced properties of the same objects but where the name of each object included a revealing modifier. Rather than producing the properties of watermelons, for example, these participants were asked to produce the properties of a half watermelon. Because the normally occluded inner parts of a watermelon become unoccluded in a half watermelon, less effort is required to perceive them in a simulation. Thus, normally occluded properties should increase in production rates, becoming more comparable to normally unoccluded properties. Across several studies, Wu and Barsalou (2004) observed this pattern, consistent with the prediction that participants were using simulations to represent the concepts.

Krauth et al. (in preparation) found that producing the properties of an emotional state produced a similar occlusion effect. When participants were asked to describe properties of "his anger," they produced occluded properties of the other's mental state less often than when they produced properties of "my anger," when these mental state properties are unoccluded. Again, the amount of effort required to simulate properties determined their rates of production.

To further explore perceptual effort, Solomon and Barsalou (2004) again employed the property verification task (also see Solomon & Barsalou, 2001). If people simulate properties to verify them in their respective objects (e.g., PONY–mane), then perceptual variables should explain the time to verify properties, and also the accompanying error rates. To assess this issue, Solomon and Barsalou regressed verification RTs and error rates onto potential factors that could predict performance, including linguistic, perceptual, and expectancy variables. Under conditions that required conceptual processing (i.e., related false properties as described earlier), the perceptual variables predicted performance better than the linguistic and expectancy variables. In particular, the size of properties was important in predicting performance. As properties became larger, they took increasingly longer to verify and led to higher rates, presumably because large properties take more time and effort to represent than small ones. Under conditions that did not require conceptual processing (i.e., unrelated false properties), the linguistic variables best predicted performance, suggesting that participants used the superficial word association strategy instead of deeper conceptual processing, as described earlier.

Related Views

In this article, we propose that the PSS account is productive for understanding embodiment phenomena in social psychology. Previous theories in social psychology, however, have made related proposals. Thus, it is useful to compare and contrast PSS with these related accounts. The two accounts most relevant are the Hard Interface Theory (Zajonc & Markus, 1984) and the Associated-Systems Theory (Carlston, 1994).

Hard Interface Theory (HIT)

In 1984, Zajonc and Markus published an influential chapter titled "Affect and cognition: The hard interface." In this chapter, Zajonc and Markus encouraged social psychologists to pay more attention to embodiment, and in this spirit they introduced the HIT. Although, Zajonc and Markus focused primarily on the interaction between emotion and cognition, they also made general proposals about the representation of social knowledge, which can be viewed as precursors to more recent developments. In particular, Zajonc and Markus (1984) declared that purely propositional, "disembodied" theories of social knowledge are unsatisfactory for several reasons.[7] For one, propositional theories rarely address how abstract representations are connected to actual behavior. Thus, in the emotion domain, there is no clear account of how cognition (e.g., "hearing an insult") elicits bodily components of anger (clenched fists, red faces, bulging veins, etc). A

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[7] The term *propositional* is used widely throughout cognitive and social psychology when referring to amodal theories of knowledge, even though, as we have seen, embodied theories can also be propositional (Barsalou, 1999, 2003a).

related problem arises when one tries to understand the influence of emotion on cognition. In propositional theories, the problem is reduced to the influence of one associative structure on another by assuming that the bodily (muscular, hormonal) components of emotion somehow get transduced into a propositional form. Finally, propositional theories have a hard time accounting for embodiment phenomena in cognition. Why, for example, Zajonc and Markus asked, “do people engaged in an arithmetic problem often gnash their teeth, bite their pencils, scratch their heads, furrow their brows or lick their lips?” (p. 74), “Why do people scratch their heads and rub their chins when they try to remember something?” (p. 84).

Zajonc and Markus’s (1984) response is that bodily states constitute “hard representations.” According to this view, bodily states have representational content. When a dog hears a bell, for example, and withdraws a leg to avoid shock, this leg flexion can be said to represent the dog’s knowledge of the bell–shock relation. Importantly, HIT proposes that the bodily movement itself has representational content and does not require a more cognitive “soft representation” to have representational value. A purely hard representation, such as the dog’s leg flexion, can guide behavior in a dangerous situation as effectively as an abstract soft representation of the event. Individual hard representations can also interact with one another, as when, for example, muscles associated with a forward movement (hard representation of positivity) interfere with muscles associated with a backward movement (hard representation of negativity).

Probably the best known empirical illustration of HIT is the “chewing gum” experiment (Zajonc et al., 1982; cf. Graziano, Smith, Tassinary, Sun, & Pilkington, 1996). Participants were first asked to study 78 photographs of faces in four between-participant conditions. One group imitated the targets’ head and gaze orientations and their facial expressions (instructed mimicry). A second group chewed gum (blocked mimicry). A third group squeezed a sponge with their nonpreferred hand (motor control). A fourth group judged the head orientations and facial expressions in the photographs (judgment control). After studying the pictures, participants received a recognition test. As the embodiment view predicts, memory was best when participants’ embodiments were compatible with the pictures—the instructed mimicry group scored highest (73% correct). The worst performance occurred for participants who performed the most competitive motor response—chewing gum (59%). Participants who squeezed a sponge fell in between (65%) as did participants who judged the faces (64%). This pattern of results suggests that participants represented properties of the perceived faces in their musculature, such that when their musculature was consistent with a face, it enhanced memory via consistent elaboration.

Another important aspect of HIT is that it provides intriguing accounts of classic psychological phenomena that differ considerably from standard accounts. For example, Zajonc and Markus (1984) proposed that people’s particularly good memory for faces reflects their ability to imitate perceived faces and to create hard muscular representations that complement soft representations. In a similar fashion, Zajonc and Markus proposed that mood congruence effects occur because affective states create bodily configurations that facilitate the production of compatible responses. The state of happiness, for example, creates a specific posture and muscle tone, which facilitates “happy” muscular responses to objects. In yet another example, Zajonc and Markus suggested that the mere-exposure effect results from the gradual relaxation of bodily responses to a stimulus as a result of habituation, thereby making positive evaluation more compatible with the bodily state.

Despite the shared affinity for embodiment, differences exist between HIT and PSS. Perhaps most significantly, HIT assigns representational functions to actual bodily states. This includes not only muscles, but also gastrointestinal, glandular, and cardiovascular systems. In the original PSS account (Barsalou, 1999), the critical mechanism is simulation in the brain, where the body plays a role only as represented in neural systems. A related difference is that HIT allows representational functions of bodily states to work “by themselves,” without translation into “soft” representations. In contrast, the original PSS account required that bodily states are first encoded into neural representations in modality-specific systems, which then allow bodily states to interact with cognition. In subsequent developments of PSS, however, bodily states have been central to the situated conceptualizations that underlie higher cognition—not just simulations of these states (e.g., Barsalou, 2003b; Barsalou et al., 2003).

Another difference in relative emphasis between the two theories concerns associative versus dynamic processing. HIT is fundamentally associative, establishing relatively stable associations between particular cognitions and their accompanying embodiments. PSS contains many associative mechanisms as well, but focuses more on the dynamic construction of situational conceptualizations and on the productive construction of simulations into complex relational structures that function propositionally. Analogously, HIT has focused more on explaining social phenomena, whereas PSS has focused more on explaining a variety of higher cognitive functions, such as type–token processing in categorization and the productive construction of complex simulations in language comprehension.

Associated-Systems Theory (AST)

AST provides a multimodal model of how the cognitive system represents other people in person perception (Carlston, 1994). According to AST, representations of other people develop through the use of four primary mental systems: (a) the visual system, (b) the verbal/semantic system, (c) the affective system, and (d) the action system. Each system captures the relevant features of external stimuli and produces representations that are specific to it. Thus, the visual system represents a target person's appearance, the action system represents an action sequence directed at the target person, the affective system represents affect to the target, and the verbal system represents the target's personality traits.

Each system in AST is hierarchically organized. Whereas the lowest levels contain highly specialized structures used to perceive stimuli and produce responses, the highest levels contain abstract concepts related associatively to perceptual or response processes. At the lowest levels, the four primary systems are independent of each other. At higher levels, however, they become progressively intertwined, interacting to produce hybrid forms of representation. When categorizing individuals into social groups, for example, a perceiver accesses both an image of the group (in the visual system) and descriptive labels for their traits (from the verbal system). Similarly, when evaluating a target person, a perceiver uses both the verbal and the affective systems. Categorizations and evaluations, together with orientations (a hybrid of affect and action system) and behavioral observations (a hybrid of visual and action systems), constitute the four products of AST's secondary systems.

According to AST, the representations that one establishes for a target person typically utilize one distribution of the four primary systems more than other possible distributions. For instance, passive observation of a target person produces appearance representations grounded mainly in the visual system. In contrast, actually interacting with a person activates not only the visual system, but also the action system, thereby producing a different distribution. In a related manner, responses to a target person depend on the distribution of system(s) solicited in the response situation.

Furthermore, because AST's systems can function independently of each other, the representations in different systems can potentially conflict when processing a given individual. When such contradictions occur, judgments of the target depend on which of the conflicting systems dominates the judgment situation. If the visual system dominates (e.g., because the target is presented via a picture), responses to the target will be based on appearance, even when contradictory judgments arise in other systems. If, however, the verbal system dominates (e.g., because the target is presented via text description), responses to the target will be based on personality traits. To demonstrate the relative independence of the four systems and the potential for one to dominate others, Claypool and Carlston (2002) showed that interference in the visual system at encoding decreased the influence of visual information in liking judgment but did not alter the influence of verbal information. Conversely, Claypool and Carlston found that interference in the verbal system decreased the influence of verbal information but not the influence of appearance information. Depending on the information presented and the availability of relevant systems, different profiles of processing for a target ensued.

AST shares many assumptions with PSS, in particular, the central assumption that multiple modality specific systems underlie cognitive processing. Both theories also view CZ theory as an appropriate description of knowledge representation in the brain (Damasio, 1989). Finally, AST and PSS both assume that processing is dynamic. Depending on current task conditions, different representations and different forms of processing control task performance.

AST and PSS differ, however, on other points. First, AST gives primacy to the abstract verbal system, with its representational elements of words and personality traits. According to PSS, however, even abstract concepts like personality traits are grounded in modality-specific systems, as are the representation of words in the respective modalities (e.g., orthographic representations of the word in the visual system and acoustic representations of words in the auditory system; Barsalou, 1999; Simmons & Barsalou, 2003). Thus, PSS is somewhat more radical than AST in its reliance on the modalities as the basis of representation, whatever its degree of abstractness.

Second, AST, as its name implies, attempts to explain the role of modal information in terms of associative processes. Accordingly, the previously mentioned limitations of HIT also apply to AST. In particular, it is not clear how AST accounts for classic conceptual functions such as the type–token distinction, productivity, propositional interpretation, and the representation of abstract concepts.

Criticisms of Embodiment Theories

Theories of embodied cognition have appeared regularly in the cognitive and social literatures. So far, however, these theories have not become a major force in explaining cognition, in general, and social cognition, in particular. The major reason is previous accounts have had trouble dealing with certain classes of criticism. In the preceding sections, we have already mentioned how PSS goes beyond earlier proposals in social psychology. Here we list criticisms that have been raised against embodiment theories and show how PSS addresses them.

Selective Embodiment

Embodiment theories need to solve the problem of how some cognitive activity can proceed without involvement of bodily states and modality-specific simulations. PSS addresses this issue with the distinction between shallow versus deep processing. A perceiver simulates primarily when needed. When conceptual tasks can be solved using shallow strategies, such as word association, simulations of conceptual content are not recruited or play only peripheral roles.

Dynamic Use of Embodiment

A related challenge to embodiment theories arises from findings suggesting that perceivers are quite flexible in their use of embodied information. For example, when empathizing with others, people typically rely on their own modality-specific reactions, suggesting use of a simulation strategy (Decéty & Chaminade, 2003; Gallese, 2003). However, the exact nature of the stimulation depends on task goals. For example, in some cases, people empathize by simulating emotional states, whereas in other cases people empathize by simulating cognitive states. In some situations, people may decide not to simulate at all (e.g., when dealing with a mass murderer). More generally, according to modern embodiment theories such as the PSS, whether or not people decide to simulate, what specific modality people decide to simulate in, and how they are going to use the products of the simulation is open to task goals.

The notion of goal-driven stimulation allows modern embodiment theories to account for social psychological findings showing people's flexibility in using experiential sources of information in judgment. Thus, people typically draw on experiential feedback (mood, feelings of processing difficulty, etc.) when solving a variety of cognitive tasks, including frequency judgments, self-assessment, and value judgments (see Schwarz, Bless, Waenke, & Winkielman, 2003). When people realize that their experiential reactions are not diagnostic, however, they switch to alternative sources of judgments, making less use of current experience. Critics could interpret this finding as suggesting that people use simulation only under default conditions, and that under conditions that produce misattributions, people fall back on amodal processing. Instead, we propose that such findings reveal people's flexibility in their use of the simulation strategy. When an external factor compromises validity of a simulation in one modality, people can switch to a simulation in an alternative modality.

Representational Limitations of the Body

Embodiment theories must address the problem of the body's representational capacity. Starting with Cannon (1927, 1929), critics have argued that bodily feedback is too undifferentiated and too slow to serve as the basis of experience. Furthermore, there is the problem that the same bodily state may be associated with different cognitive and emotional representations (Zajonc & McIntosh, 1992). These issues are actually quite old and have been effectively used by Cannon and many others to argue against the James–Lange theory of emotion (James, 1896/1994).

Several responses to this criticism are possible. Zajonc and Markus (1984) note that the motor system can support extremely subtle distinctions, as the sophistication of sensory-motor processing in spoken language illustrates. Further, even a limited number of bodily states can support a very large number of representational distinctions. (Consider how many melodies can be played with 88 piano keys—a number much lower than the number of muscles in the body.)

More important, recent embodiment approaches, such as PSS, CZ theory, and Somatic Marker Theory (Damasio, 1999), avoid the "body-is-too-crude-too-slow-and-too-varied" criticisms by focusing on the brain's modality-specific systems, instead of on actual muscles and viscera. The circuits in modality-specific brain areas are as fast and refined as any other form of cortical representation and are thus able to flexibly process a large number of modal states at the same time (Damasio, 2003).

Higher Cognitive Functions

Embodiment theories must account for the basic functions of higher cognition, such as the type–token distinction, categorical inference, productivity, propositional interpretation, and abstract concepts. As discussed earlier, PSS uses the constructs of simulators and simulations to explain these phenomena. Because simulators develop for components of experience, categorical knowledge results that represents types, produces categorical inference, and combines productively. Furthermore, simulators become bound to both perceived and simulated individuals to implement type–token propositions. Because PSS uses selective attention to break experience into components and then establish categorical knowledge about them, it develops the classic capabilities of a conceptual system.

Perhaps the most common criticism of theories of embodied cognition concerns their ability to represent abstract concepts. An implicit assumption of these criticisms, however, is that only simulations of external experience can be used for representational purposes in embodiment theories. As we have seen throughout this article, however, simulations of introspective experience are also available for representational purposes. Furthermore, as we saw earlier, simulations of introspections are central to the representation of abstract concepts (Barsalou & Wiemer-Hastings, in press). More generally, the simulation of situations appears to provide a natural approach to representing a wide variety of concepts, including abstract ones.

Regressing to Behaviorism or Mere Associationism?

Closely related to the issue of higher cognitive functions is the worry that embodiment theories advocate a return to the view that simple associations between sensory and motor processes underlie all cognition. Long ago, behaviorist theories were conclusively shown to be incapable of explaining cognitive achievements such as memory, language, and thought (Chomsky, 1959). We endorse these conclusions strongly and agree that simple associations between sensory–motor states, drawn only from experience, cannot explain cognitive processes. What we propose here shows how the sophisticated symbolic processing characteristic of human cognition is grounded in embodied representations. An associationist account is as inadequate now as it was 50 years ago.

Are Observed Mind-Body Relationships Epiphenomenal?

Embodiment theories make clear claims of causality (e.g., “modality-specific systems areas are critical for conceptual processing”). Nevertheless, supporting evidence has sometimes been viewed as only correlational in nature, consisting mainly of observations of co-occurrence between embodiment and cognition. Thus, critics have argued that perceptual representations are not constitutive of concepts but only become active epiphenomenally during the processing of amodal symbols, which themselves do the work of high-order cognitive processing. As reviewed throughout this article, however, theories of embodied cognition can now draw on many experimental findings that show that manipulations of embodiment causally modulate cognitive and social performance. Demonstrating that the inhibition or facilitation of a specific motor behavior, or a specific modality-specific resource, correspondingly inhibits or facilitates conceptual processing indicates relations between embodiment and cognition that are not merely epiphenomenal.

Amodal Theories Make the Same Predictions

One primary criticism of embodiment theories is that the empirical evidence for them can be explained by amodal theories. For example, critics often suggest that semantic network models (Collins & Quillian, 1969) and emotional memory models (Bower, 1981) can account for embodiment effects. Although this is technically right, such an objection is being taken to task (e.g., Barsalou, 1999; Glenberg, 1997; Lakoff, 1997; Newton, 1996).

One problem for these accounts is their unconstrained expressive power. In theory, amodal theories can mimic any observed (or even never-observed!) finding (e.g., Anderson, 1978; Pylyshyn, 1981). This makes these models eminently powerful but also unfalsifiable. Because these models can explain anything, it is impossible for any given result to disconfirm them entirely. Thus, simply saying that semantic memory models, or any other amodal model, can account for embodiment effects is not very compelling.

Second, the older and entrenched status of amodal theories does not necessarily endow greater credibility. What would give them more credibility is the ability to predict embodiment effects a priori. Notably, however, amodal theories were not developed with embodiment effects in mind and thus have not been used to predict and explain such effects. For example, even though associative models of emotion memory can in principle explain embodiment effects in emotion, such models, to our knowledge, have never motivated researchers to predict embodiment effects in an experiment. If anything, in fact, such models have been repeatedly criticized for their implausible use of informational units to stand for expressive and autonomic processes and for their somewhat vague declaration of interactions between those types of units and representations of more abstract information (Niedenthal, Setterlund, & Jones, 1994). Just because amodal theories can be configured post hoc to explain any embodiment effect is not impressive. What would be more impressive is if they predicted these effects a priori. Again, to our knowledge, they never have.

Finally, unless one is very impressionistic in his or her reading of amodal theories, embodiment effects simply do not follow naturally from them. At the heart of these theories lie two assumptions of modularity: (a) the conceptual system is functionally and physically separate from modality-specific systems, and (b) knowledge abstracts over the details of experience. For these reasons, we believe that embodiment effects violate the very spirit of amodal theories. Although there may not be a ‘killer” empirical finding that the amodal approach cannot explain (to the extent that the whole framework can ever be challenged by an empirical finding), it is becoming increasing clear, at a minimum, that the embodiment approach offers great value in pointing out new and exciting research directions.

Explaining Embodiment Effects in Social Psychology

The prevailing theoretical approaches in social psychology view modality-specific and bodily states as peripheral to social knowledge. The findings reviewed here, however, indicate that these states play a more important role in information processing than previously imagined. Here we come full circle and suggest how theories of embodied cognition contribute to the understanding of social phenomena.

Stereotypes and Traits

Many researchers assume that distilled amodal representations constitute the core conceptual representations of stereotypes and traits, with embodiments being irrelevant. Other researchers assume that embodiments have some relevance for social processing but that embodied states are associated peripherally with traits and stereotypes, rather than constituting their core conceptual content. In contrast to both views, embodiment theories hold that multimodal simulations of perception, action, and introspection directly constitute the core conceptual content of social knowledge (Barsalou et al., 2003). To understand the meaning of a trait or stereotype is to have the ability to simulate the experiences of them competently.

Consider the *elderly* stereotype and the associated trait of slow movement. According to embodied views, amodal redescriptions of the modality-specific states associated with experiencing this stereotype and its associated trait do not represent them. Instead, knowledge of elderly and slow movement resides in simulations of seeing and executing slow movements and, to some extent, in experiencing them in bodily states—no further amodal descriptions of this trait are necessary.

Furthermore, theories such as PSS motivate novel predictions about when stereotypes will produce embodiment effects (e.g., under deep, but not shallow, processing conditions) and what particular aspects of a stereotype will be embodied on a particular occasion (e.g., depending on what needs to be simulated in the situated conceptualization). And embodiment theories may also suggest factors that facilitate a revision of a stereotype (e.g., change in the simulations strategy or change in the modality-specific states underlying the stereotype).

Attitude Change

In a similar fashion, theories of embodied cognition can help us understand the learning and the unlearning of affectively charged cognition. In particular, such theories may help us better understand social attitudes and prejudice, as well as the conditions that allow different elements of an attitude to be expressed. According to PSS, the modality-specific states captured during exposure to attitude objects constitute the core representation of the attitude. This implies, therefore, that unlearning attitudes, including prejudicial ones, should involve more than a list of persuasive arguments. Interventions targeting the modality-specific bases of those concepts may also be useful.

Mood Congruence

One of the most studied effects in social psychology is mood congruence—the influence of previously induced emotion or mood on subsequent judgments. The literature, however, is replete with inconsistent results and accounts (Forgas, 1995). Embodied accounts can explain why and when emotion congruence occurs. This has useful implications for understanding a wide range of specific congruency effects, including the influence of mood on judgments (Bless & Fiedler, 1995; Schwarz & Winkielman, 1999), affective priming (Niedenthal, 1990; Winkielman, Zajonc, & Schwarz, 1997), and affect and memory (Eich & Macaulay, 2000).

Specifically, Niedenthal et al. (2002) propose that emotion congruence is determined by whether the target stimulus must be simulated to produce the response. During a mood induction, participants' affective systems enter a particular emotional state (e.g., happiness, sadness). When participants are subsequently asked to judge a target that has particular emotional properties (e.g., a happy person), they may represent the target with associated words (shallow processing), or they may construct a simulation of the target (deep processing). Because the simulation relies on the same modality-specific systems that represent the induced emotion, a judge's current mood and the simulation have the potential to interact. For example, when the judge is feeling happy and is judging a happy person, the mood and the target are consistent, such that the happiness judgment of the target is unusually high. Conversely, if the judge were sad when judging a happy person, the mood and the target stimulus conflict, thereby lowering the judgment. Most important, if the target stimulus can be represented superficially with words—a simulation is unnecessary—the potential for interaction between the mood and the stimulus representation does not exist, and mood congruency effects do not occur. Such effects should only occur when shared representational systems are used both to represent the current mood and the target.

Conclusion

At first pass, theories of embodied cognition might seem a radical way to reconceptualize social meaning. We believe, however, that these theories should be viewed not as threatening recent advances in social cognition, but as evolving from them toward comprehensive accounts of embodied phenomena that, traditionally, have been difficult to explain. Similarly, other contemporary researchers argue that the central problems of intersubjectivity (i.e., understanding others' intentions), empathy, and sympathy cannot be understood functionally if we do not take embodied accounts seriously (Gallese, 2003; Decéty, in press). Furthermore, these notions are only radical if one ignores the many theoretical musings about the role of embodiment in social interaction that preceded the dominance of the computer metaphor in cognitive psychology (e.g., McDougall, 1908; Spencer, 1870). We believe, therefore, that the theories of embodied cognition can provide social psychologists with powerful new ways of theorizing about social representations and the mechanisms that process them. These theories also offer new ways of conceptualizing major social psychological constructs, such as attitudes, attitude change, impression formation, stereotyping, emotion, and empathy.

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