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SOCIAL EMBODIMENT

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I. Introduction

Please adopt the following positions while reading this chapter. First, sit upright in your chair—do not slump. Second, place a hand beneath the table top and press upward with your palm. Third, hold a pen in your teeth with the tip pointing forward. If you adopt these positions while reading this chapter, the optimal result will be achieved. We will explain later.

Over the years, numerous findings have implicated embodiment in social cognition. By *embodiment* we will simply mean that states of the body, such as postures, arm movements, and facial expressions, arise during social interaction and play central roles in social information processing. Across diverse paradigms, social psychologists have reported four types of embodiment effects. First, perceived social stimuli do not just produce cognitive states, they produce bodily states as well. Second, perceiving bodily states in others produces bodily mimicry in the self. Third, bodily states in the self produce affective states. Fourth, the compatibility of bodily states and cognitive states modulates performance effectiveness.

Although these four findings have been well known for many years, they have remained relatively disparate. No single theory has integrated them, nor explained them in a unified manner. Recent research on embodiment in cognitive psychology, cognitive science, and cognitive neuroscience offers a framework for doing so. Increasingly these researchers are developing

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embodied theories of cognition (e.g., Barsalou, 1999a,b, 2000a; Damasio, 1989, 1994, 1999; Glenberg, 1997; Lakoff & Johnson, 1980, 1999; Mandler, 1992; Newton, 1996; Simmons & Barsalou, 2003b; Wilson, 2003). Furthermore, empirical evidence is accumulating for these theories (a few examples include Barsalou, Solomon, & Wu, 1999; Glenberg & Kaschak, 2002; Martin, 2001; Spivey, Tyler, Richardson, & Young, 2000; Stanfield & Zwaan, 2001; Zwaan, Stanfield, & Yaxley, 2003). For a more extensive review of relevant empirical findings, see Barsalou (2003).

Embodied theories of cognition depart from traditional theories in their assumptions about knowledge representation. In traditional theories, knowledge consists of amodal symbols that *redescribe* sensory, motor, and introspective states.[1] On seeing a smiling infant, for example, a parent has sensory experiences of the infant (e.g., visual, auditory, tactile, olfactory). The parent may also initiate motor actions (e.g., cuddling) and experience introspective states as a result (e.g., happiness). Traditional theories assume that *knowledge* of such experiences does not consist of the sensory, motor, and introspective states that constituted the experiences originally. Instead these theories assume that a symbolic system redescribes these states, producing amodal descriptions that reside separately from sensory, motor, and introspective systems and that operate according to different principles. For example, sensory, motor, and introspective states could be redescribed as feature lists, networks of propositions, fired sets of productions, instantiated schemata, statistical vectors, and so forth. In all cases, knowledge of the original experience is a redescription in an amodal representation language. Furthermore, later processing of the event operates on these redescriptions—not on the sensory, motor, and introspective states that produced them. In memory, recalling an episode activates an amodal redescription of the episode. In language, comprehending a text produces amodal propositions that represent its meaning. In thought, reasoning proceeds via symbolic operations over amodal redescriptions of a situation or problem.

Conversely, embodied theories represent knowledge as partial simulations of sensory, motor, and introspective states (e.g., Barsalou, 1999a,b; 2002, in press; 2003; Damasio, 1989; Simmons & Barsalou, 2003b). When an event is experienced originally, the underlying sensory, motor, and introspective states are partially stored. Later, when knowledge of the event becomes relevant in memory, language, or thought, these original states are partially simulated. Thus, remembering an event arises from partially simulating the sensory, motor, and introspective states active at the time. Similarly,

[1] Introspective states include events perceived inside the mind and body that typically lack counterparts in the external world, such as emotions, affects, appetitive states, cognitive operations, and beliefs (Barsalou, 1999b).

understanding a text about an event induces a simulation of the experience. Finally, reasoning about an event proceeds by simulating it and then transforming the simulation.

As described later, this approach does not entail that actual bodily states are executed obligatorily, as in James' (1890) ideomotor theory. Instead *simulations* of bodily states in modality-specific brain areas may often be the extent to which embodiment is realized. Depending on the situation, embodiment may range from simulation, to traces of execution, to full-blown execution. As we will also see, these embodiments are not merely peripheral appendages or epiphenomena of social information processing—they constitute the core of it.

The theme of this chapter is that embodied theories of knowledge have the potential to explain and integrate social embodiment effects. The remaining sections first review these effects and then sketch a theory of social embodiment based on the assumption that simulations represent knowledge of social situations. Finally, we illustrate how this theory explains and unifies social embodiment effects.

II. Social Embodiment Effects

Four types of embodiment effects have been reported in the social psychology literatures: (1) perceived social stimuli produce bodily states; (2) perceiving bodily states in others produces bodily mimicry in the self; (3) bodily states in the self produce affective states; and (4) the compatibility of bodily and cognitive states modulates performance effectiveness. We do not review the literatures for these effects exhaustively. Instead we simply present examples to illustrate the phenomena and motivate theoretical integration later.

A. Social Stimuli Elicit Embodied Responses in the Self

In this first embodiment effect, people perceive a social stimulus, or receive language that describes a social stimulus. For example, a person might perceive an elderly person, or receive a description of one. Clearly social stimuli produce cognitive responses such as trait inferences, causal attributions, stereotypes, and so forth. Notably, however, social stimuli also produce bodily responses. In most of the studies to follow, actual social stimuli are rarely presented. Instead subjects mostly receive words that describe social stimuli; occasionally they receive pictures. While this might lead to some concern about ecological validity, the fact that words consistently produce embodied responses is impressive. Presumably the effects of actual social stimuli would be stronger.

1. *Bodily Responses*[2]

Wiesfeld and Beresford (1982) reported a bodily response to a social stimulus that any student or former student will recognize. On receiving their grades for a midterm exam, high school students adopted a more erect posture after receiving good grades, but adopted a less erect posture after receiving poor grades. The grades did not merely produce cognitive and affective responses in the students—they produced bodily responses as well.

A central issue is whether social events, such as receiving a grade, trigger bodily reactions directly or whether mediating mechanisms exist. For example, receiving a grade might trigger an emotional state, which in turn produces a bodily state. Throughout our review of embodiment effects, this issue will not concern us—our goal will simply be to document the ubiquitous presence of bodily states in social phenomena. Later, after presenting a theory of these phenomena, we will return to this issue.

In seminal studies, Bargh, Chen, and Burrows (1996) brought the social elicitation of bodily responses under experimental control. Using a paradigm that many researchers have since adopted, Bargh and colleagues had subjects form sentences from short word lists. In the critical conditions, a subset of words was related to a social stereotype or trait (e.g., "gray," "Florida," and "bingo" for the *elderly* stereotype).[3] In the control conditions, subjects received all neutral words. Of interest was whether the critical words primed the stereotypes relative to the neutral words, and if so, whether this priming produced embodiment effects.

When Bargh et al. (1996) primed subjects with the *elderly* stereotype, an embodied effect did indeed occur. Once the experiment was over, critical subjects took longer to walk from the laboratory to the elevator than control subjects. Processing words about a social stimulus—the *elderly* population—induced a related embodiment effect. Because the *elderly* stereotype specifies that the elderly tend to move slowly, this knowledge about movement became active and affected subjects' actual movements.

Many subsequent experiments have demonstrated similar effects (for a review, see Dijksterhuis & Bargh, 2001). In the same basic paradigm, Aarts and Dijksterhuis (2002) primed subjects with the names of either fast or slow

[2] As will be seen, we distinguish among bodily, facial, and communicative forms of embodiment for each of the four embodiment effects. Clearly, facial and communicative actions occur on the body, and thus could potentially be included under *bodily* effects. For lack of a better term, however, we will use "bodily" in referring to embodiment effects that largely occur with the arms, legs, and torso, thereby contrasting these effects with facial and communicative ones.

[3] Italics are used to indicate concepts, and quotes are used to indicate linguistic forms (words, sentences). Thus, *elderliness* in this sentence indicates a concept, whereas "gray" indicates a word.

animals (e.g., "cheetah" versus "snail"). Subjects primed with fast animals subsequently took less time walking to another room than subjects primed with slow animals. Again words about a stimulus activated knowledge about movement, which in turn produced an embodiment effect.

Dijksterhuis, Spears, and Lepinasse (2001) showed that the speed effect occurs for actions besides walking. Their subjects first viewed photographs and later performed a lexical decision task (i.e., judging whether letter strings form words or not). When subjects first viewed pictures of the elderly, their later lexical decision responses were slower than those of subjects who had viewed nonelderly photographs instead. Again a social stimulus activated knowledge that produced an embodied effect.

Even subliminal social stimuli trigger embodied responses. In Winkielman, Berridge, and Wilbarger (2002), happy or angry faces were presented to subjects subliminally as they judged visible faces for gender. When subjects were later offered a flavored drink, subjects who saw happy faces poured and drank more than subjects who saw angry faces. Even though the subliminal faces were not recognized above chance on a later test, they affected subjects' drinking behavior.

Because of the cover stories and indirect measures in these experiments, subjects were probably unaware that social stimuli affected the speed of their actions. In the Winkielman et al. (2002) study, subjects could not even see the stimuli that modulated their behavior. This suggests that the priming in these studies occurred automatically, a conclusion reached by Dijksterhuis and Bargh (2001) in their review of the literature. Since the advent of modern psychology, theorists have argued that much action arises automatically (e.g., James, 1890; Jeannerod, 1997; LaBerge & Samuels, 1974; Schneider & Shiffrin, 1977; Stroop, 1935). Many embodiment phenomena appear to arise largely in this manner.

2. *Facial Responses*

It is well known that perceived stimuli produce facial responses. In Cacioppo, Petty, Losch, and Kim (1986), subjects viewed visual scenes that were either pleasant or unpleasant while electromyography (EMG) monitored their facial musculature. A cover story and bogus electrodes led subjects to believe that the experiment addressed brain responses to perceptual stimuli. As predicted, pleasant scenes tended to produce positive facial expressions on subjects' faces, whereas negative scenes tended to produce negative expressions. The perceived scenes modulated facial reactions.

Pictures of people have similar effects. In Vanman and Miller (1993), subjects viewed pictures of people from the same versus a different fraternity, sorority, university, or race. EMG showed that the pictures modulated subjects' facial expressions. When a picture depicted a person from a subject's fraternity, sorority, university, or race, the subject's facial expression tended to be positive. Conversely, when a picture depicted a person from a different fraternity, sorority, university, or race, the subject's facial expression tended to be negative.

Just imagining a person produces facial responses—actually seeing a person is not necessary. In further experiments, Vanman, Paul, Ito, and Miller (1997) had subjects imagine various people who might later work with them to solve problems. A variety of variables moderated subjects' facial expressions, as measured by EMG. In particular, subjects were most likely to produce positive facial expressions when their imagined partners were competent on the task, exerted high effort, or belonged to the same race. Conversely, subjects were most likely to produce negative facial expressions when their imagined partners were incompetent, exerted low effort, or belonged to a different race.

Simply having subjects read about a fictional character produces facial responses. Andersen, Reznik, and Manzella (1996) obtained personality descriptions about significant others in a subject's life and then developed fictional characters who partially resembled them. On a later occasion, subjects read about these fictional characters, not realizing that they were related to their significant others. Most importantly for our purposes here, these fictional characters modulated the facial expressions on subjects' faces, as coded by a naive judge. When subjects read about characters based on significant others they liked, they tended to adopt positive facial expressions. Conversely, when subjects read about characters based on significant others they disliked, they tended to adopt negative facial expressions. Simply reading about social stimuli modulated facial responses.

As these studies illustrate, social stimuli do not just produce bodily responses, they also produce facial ones. Again these effects are likely to be relatively automatic and unconscious. In the Vanman studies, subjects typically claimed that they had no racial prejudice on explicit questionnaires, yet exhibited subtle racial bias in their facial musculature (cf. Greenwald, Banaji, Rudman, Farnham, Nosek, & Mellott, 2002). In the Andersen studies, subjects did not know that the fictional characters were related to their significant others. Furthermore, these subjects probably were not aware that they were even producing facial responses to the characters. Under such experimental conditions, it is likely that facial responses to social stimuli result automatically, at least to some extent.

3. *Communicative Responses*

Social stimuli also affect embodied aspects of communication. For example, Bargh et al. (1996) manipulated whether subjects were primed with words related to rudeness (e.g., "aggressively") or with words related to politeness (e.g., "patiently"). A control group received words unrelated to rudeness and politeness. After constructing sentences from the word lists, subjects were supposed to meet with an experimenter in another room, whom they found engaged in a contrived conversation with a confederate. The critical measure was whether subjects interrupted the conversation. Subjects receiving rude words were more likely to interrupt than subjects receiving neutral words, whereas subjects receiving polite words were less likely to interupt. As in previous studies, words activated social knowledge that culminated in an embodied effect, this time one associated with communication.

Dijksterhuis and van Knippenberg (2000) reported a similar communicative effect. In the critical conditions, subjects were primed with words related to the *politician* stereotype. Subsequently subjects wrote essays on nuclear testing. Subjects primed with the *politician* stereotype wrote longer essays than subjects primed with neutral words. Because politicians are associated with long windedness (as Dijksterhuis and van Knippenberg established in previous work), activation of this knowledge produced corresponding embodied effects.

Again such effects are likely to result from automatic processing. Subjects probably were not aware that stereotypes were being primed and affecting their behavior.

4. *Related Nonsocial Effects*

The adult cognitive literature similarly demonstrates that nonsocial stimuli produce embodied responses. Chao and Martin (2000) had subjects name objects implicitly while lying passively in an fMRI scanner (i.e., functional magnetic resonance imaging). When subjects saw manipulable objects, such as a hammer, a grasping circuit in the brain became active (e.g., Rizzolatti, Fadiga, Fogassi, & Gallese, 2002). Although subjects were instructed to lie still and simply perform visual categorization, a motor circuit nevertheless became active, preparing subjects for functional use of the object (e.g., grasp and swing a hammer). Similar to the findings just reviewed, visual categorization of a functional artifact produced an implicit embodied response.

In an eye movement study, Spivey et al. (2000) also observed this effect. Subjects listened to vignettes about the top of a skyscraper, the bottom of a canyon, etc. As subjects listened to a vignette, their eyes tended to look in the direction of the focal entity, as if they were actually in the setting. For vignettes about the top of a skyscraper, subjects tended to look up; for vignettes about the bottom of a canyon, subjects tended to look down. Simple descriptions of a physical setting produced an embodied effect, causing subjects to orient perceptually as if present in it. Barsalou and Barbey (2003) similarly found that subjects look up while describing the properties of birds, but look down while describing the properties of worms.

B. Embodiment in Others Elicits Embodied Mimicry in the Self

In the studies just reviewed, social stimuli produced embodied responses in the perceiver. Social stimuli similarly produce embodied responses in this next embodiment effect. The following studies differ, however, in that the embodied responses mimic perceived social stimuli. In the previous section, embodied responses were not mimicry—typically they went beyond the social stimulus in some way. For example, when subjects received words that primed *rudeness*, or a picture that depicted a member of a social group, the stimulus did not literally contain an embodied action. For example, words about *rudeness* did not directly demonstrate interrupting behavior, nor did a picture about a fraternity member depict frowning. Rather these stimuli triggered knowledge that contained embodied responses, which then played out in behavior.

In contrast, these next embodiment effects mimic embodied states perceived in social stimuli. For example, an emotional expression on another person's face produces the same expression on the perceiver's face. Increasingly, theorists believe that these effects arise from brain circuits specialized for mimicry. For example, Rizzolatti and his colleagues have identified a mirror neuron circuit that produces motor mimicry in response to perceived actions (e.g., Rizzolatti et al., 2002; also see Chao & Martin, 2000). Such circuits could play two important roles in intelligent organisms. First, they provide a fast learning mechanism, whereby an organism learns new actions through imitation (e.g., Meltzoff, 2002). Second, these circuits produce social contagion, inducing similar emotional states in conspecifics, as well as empathy and cooperation (e.g., Dijksterhuis & Bargh, 2001; Hatfield, Cacioppo, & Rapson, 1992; Neumann & Strack, 2000). Later we return to the theoretical implications of these effects. First, however, we review the specific forms they take.

1. *Bodily Mimicry*

When two people interact, their bodily actions often become entrained. Although the literature reports much anecdotal evidence for bodily mimicry, controlled laboratory demonstrations exist as well. In Bernieri (1988), judges coded the postural synchrony of two people interacting. In the control condition, the same two target individuals were judged, but as each interacted with another person (to the judges, it appeared that the two target individuals had actually interacted with each other). Bernieri found that postural synchrony was higher for two individuals engaged in an actual interaction than for two individuals in a contrived interaction. As each individual perceived the other performing bodily actions, mimicry resulted to some extent. Bernieri, Reznick, and Rosenthal (1988) reported related results for mother–child interactions (also see Bernieri & Rosenthal, 1991).

Subsequent research has continued to demonstrate bodily mimicry in dyadic interactions. In Chartrand and Bargh (1999), the experimenter either rubbed her nose or shook her foot while interacting with subjects. As predicted, subjects mimicked the experimenter. When the experimenter scratched her nose, subjects were more likely to scratch their nose than to shake a foot. Conversely, when the experimenter shook her foot, subjects were more likely to shake a foot than to scratch their nose. Watching a social stimulus produce an action tended to induce the same action in the perceiver.

2. *Facial Mimicry*

As people interact, their facial expressions become entrained as well. In Bavelas, Black, Lemery, and Mullett (1986), a confederate experienced a fake injury and winced. As subjects viewed the wince, they often winced in response, with the size of their wince increasing with how clearly they could see it on the confederate's face. In Provine (1986), subjects yawned more often when the people they were watching yawned than when they did not. In O'Toole and Dubin (1968), mothers tended to open their mouths after their infants opened their mouths to feed. The inclination to mimic perceived facial expressions is a powerful force in human interaction that has been documented widely (also see Bush, Barr, McHugo, & Lanzetta, 1989; Dimberg, 1982). People even mimic faces presented subliminally (Dimberg, Thunberg, & Elmehed, 2000).

Indeed this force is so powerful that it leaves permanent records on people. Zajonc, Adelmann, Murphy, and Niedenthal (1987) studied the facial similarity of couples married 25 years or more. Zajonc and his colleagues predicted that facial mimicry should cause married partners' faces to become increasingly similar over time. Because establishing empathy with each other is important, married partners should frequently mimic each other's facial expressions, such that their facial musculatures settle into similar entrenched states. After 25 years, the similarity of their faces should be greater than at the time of their marriage, and also more similar than random people of the same age. Zajonc et al. (1987) indeed found that facial similarity increased within couples over time, implicating the constant presence of facial mimicry.

3. *Communicative Mimicry*

Embodied mimicry also occurs during communication. During conversations, partners tend to match each other on latency to speak, speech rate, utterance duration, and so forth (e.g., Cappella & Planalp, 1981; Matarazzo & Wiens, 1972; Webb, 1972). Listeners similarly attempt to match emotional tone in the voices of the speakers they hear (e.g., Neumann & Strack, 2000). Listeners also mimic speakers' manual gestures (e.g., Bavelas, Black, Chovil, Lemery, & Mullett, 1988; Maxwell, Cook, & Burr, 1985) and even their syntactic constructions (e.g., Bock, 1986). Across many levels of analysis, mimicry helps speakers and listeners achieve synchrony during communication. Many theorists further argue that such synchrony helps conversational partners establish rapport, empathy, and cooperation (e.g., Bernieri, 1988; LaFrance, 1985; LaFrance & Ickes, 1981; Neumann & Strack, 2000; Semin, 2000).[4]

C. Embodiment in the Self Elicits Affective Processing

The previous two sections showed that social stimuli produce embodied responses. In this next section, we see that embodiment is not just a response to social stimuli, but in turn constitutes a potent stimulus. Embodied states in the self trigger a wide variety of affective states. At least since James (1890), researchers have reported such phenomena and developed theories of them. In reviewing these phenomena, we do not commit to any particular account, such as the importance of the autonomic nervous system in James' view. Instead our goal is simply to illustrate that bodily states constitute a powerful trigger for affective states.[5]

[4] Gesture in communication constitutes another important area of social embodiment. Communicative gestures appear to play important roles in language use, such as helping speakers retrieve words (e.g., Krauss, Chen, & Chawla, 1996) and helping speakers convey ideas (e.g., McNeill, 1992). Because embodiment in language lies beyond the scope of our review, we do not address it further. Nevertheless embodiment plays diverse roles in language that we do not address here (also see Lakoff & Johnson, 1980, 1999).

[5] We further assume that bodily states induce cognitive states, not just affective ones. For example, performing the action of dancing might activate knowledge of associated settings, entities, and events (e.g., nightclubs, bands, and drinking). Because work in social psychology has focused primarily on how bodily states produce affective states, we do not focus on how bodily states produce cognitive states. Nevertheless we assume that the latter effects are ubiquitous and constitute an important topic for future study. The final paper in this section, Strack and Neumann (2000), addresses embodied effects in fame judgment, which could be construed as a cognitive task, although it clearly has an evaluative component as well.

1. *Bodily Elicitation*

When people adopt a particular posture, it influences their affective state. In Duclos, Laird, Schneider, Sexter, Stern, and Van Lighten (1989), subjects were led to believe that the study addressed whether performing multiple tasks simultaneously produced unilateral or bilateral brain activity, as measured by bogus electrodes. One of the multiple tasks was to adopt various bodily positions, which subjects did not realize were associated with fear, anger, or sadness. As predicted, the postural states modulated affect. When subjects were induced to hold postures associated with fear, their rated fear was higher than when they adopted other postures. Analogous results occurred for postures associated with sadness and anger.

Many additional studies demonstrate that embodiment not only produces affect per se, but propagates this affect to other cognitive processes. In Riskind and Gotay (1982), subjects were induced into an upright or slumped posture under the cover story that galvanic skin responses to different muscle positions were of interest. After resuming normal posture, subjects attempted to solve puzzles in a "separate experiment." Subjects who were earlier induced into an upright posture persisted longer on the puzzles than subjects induced into a slumped posture. Riskind and Gotay (1982) concludeed that subjects' posture modulated their confidence, thereby affecting task performance.

In Stepper and Strack (1993), subjects were induced into an upright or slumped posture under the cover story that task performance under different ergonomic conditions was of interest. While upright or slumped, subjects performed an achievement test and received bogus feedback that they had done well. Later subjects rated their feeling of pride at the time. Subjects who had been upright while receiving task feedback experienced more pride than subjects who had been slumped. As in Riskind and Gotay (1982), subjects' posture affected their affective state.

Arm motions can similarly induce affective states. Typically, when people encounter a desirable object, they use their arms to pull it toward themselves (approach behavior). Conversely, when people encounter an undesirable object, they push it away (avoidance behavior). Cacioppo, Priester, and Bernston (1993) explored the relation between such arm motions and affective evaluation. While viewing neutral Chinese ideographs, subjects either pushed upward on the table surface (approach) or downward on the table (avoidance). Later subjects rated how much they liked the ideographs. Consistent with the embodiment hypothesis, ideographs seen during the approach movement received higher ratings than ideographs seen during the avoidance movement. Another experiment showed that the approach movement made subjects' overall attitude more positive, relative to performing no action, whereas the avoidance movement made their overall attitude more negative. Similar to posture, arm motion induced affective states.

Finally, head movements induce affective states as well. In Wells and Petty (1980), subjects were induced to nod their heads vertically or to shake their heads horizontally under the cover story that the experiment assessed the ability of headphones to stay on the head while bopping to music. While wearing the headphones, performing a head movement, and listening to music, subjects also heard a message about a university issue. Later, when subjects rated how much they agreed with the message, their earlier head movements moderated their judgments. Subjects who had nodded vertically while hearing the message were more favorable than subjects who had shaken their heads horizontally. Although subjects believed that these actions were testing headphone use, the effect associated with these actions nevertheless influenced message evaluation.

Tom, Pettersen, Lau, Burton, and Cooke (1991) replicated Wells and Petty's finding. Again subjects were induced to nod their heads vertically or to shake their heads horizontally under the cover story about headphones falling off while listening to music. While subjects performed the action and listened to music, a pen lay on the table before them. Afterward a naive experimenter offered the subject either the pen they had seen or one they had not seen. Subjects who had nodded vertically were more likely to take the original pen, whereas subjects who had shaken their heads were more likely to take the new pen. When subjects had seen the original pen earlier, their head movement affected their evaluation of it.

2. *Facial Elicitation*

A large literature demonstrates that adopting facial expressions produces affective responses, what has often been referred to as *facial feedback* (for a review, see Adelmann & Zajonc, 1987). Although accounts of these effects differ (e.g., Buck, 1980; Kraut, 1982; Laird, 1984; Winton, 1986), many studies show that configuring the face into an emotional expression tends to produce the corresponding affective state.

Consider another study from the Duclos et al. (1989) work described earlier. Again, subjects believed that the study addressed whether performing multiple tasks simultaneously produces unilateral or bilateral brain activity, where one of the tasks was to adopt various bodily states. Under this cover story, subjects were induced indirectly to adopt facial expressions associated with fear, anger, disgust, or sadness. As predicted, subjects experienced each emotion most strongly while holding the respective facial expression.

Again such effects go beyond the production of affective states per se, propagating to other cognitive processes. Strack, Martin, and Stepper (1988) provided a particularly compelling demonstration. Subjects held a pen either in their teeth or lips, with the writing tip pointing out (similar to smoking a cigar). Subjects were led to believe that the study assessed methods for teaching paraplegics to write with their mouth. Unbeknownst to subjects, holding a pen with one's teeth tends to trigger the musculature associated with smiling, whereas holding a pen with one's lips tends to trigger the frowning musculature. During the study, subjects were asked to actually use the pen as a paraplegic might for drawing lines, underlining items in a search task, and so forth. In the critical task, subjects viewed cartoons and rated how funny they were, again writing with the pen held in their teeth or lips. Consistent with the embodiment hypothesis, subjects holding the pen with their teeth rated the cartoons as funnier than subjects holding the pen with their lips. Although subjects were not aware that their musculature had been manipulated into an emotional expression, the expression associated with the musculature affected evaluation.

In Strack and Neumann (2000), subjects believed that the experiment addressed whether computer work causes forehead tension. While sitting in front of a computer, subjects received photos of famous and nonfamous people and judged how famous each one was. Subjects were further told that EMG would be used to monitor their forehead tension. The key manipulation was whether subjects were asked to furrow or raise their eyebrows, with both groups being told that this action produces forehead tension. In previous work, furrowing the brow has been shown to occur while exerting effort, whereas raising the eyebrows has not. Of primary interest was the effect of this manipulation on fame judgments. In classic work, Jacoby, Kelley, Brown, and Jasechko (1989) showed that subjects attribute fame to a name they process effortlessly. Strack and Neumann (2000) reasoned analogously that if furrowing the brow induces the affect of exerting effort, then subjects who furrow their brows should perceive the faces as less famous than subjects who raise their brows (which does not occur while exerting effort). Strack and Neumann (2000) obtained this finding. Fame judgments were significantly lower while furrowing the brow than while raising it.

D. The Compatibility of Embodiment and Cognition Modulates Performance Effectiveness

We have seen thus far that embodiment can function both as a response and as a stimulus. A wide variety of social stimuli produce embodied responses in the self, with a subset of these responses constituting mimicry.

Conversely, an embodied state in the self can induce a variety of affective states. We next see how these three previous types of embodiment effects enter into more complex relationships with cognitive processing. In general, when embodied and cognitive states are compatible, processing proceeds smoothly. When embodied and cognitive states are incompatible, less efficient processing results.

Not only do these relationships demonstrate important interactions between the body and higher cognition, they further suggest that higher cognition utilizes embodied representations. If higher cognition used disembodied representations, interference between incompatible bodily and cognitive states would not be expected. Previous research on modality-specific interference shows that when working memory content and response mode utilize different representational formats, no interference occurs between them (e.g., Brooks, 1968; Segal & Fusella, 1970). Conversely, when working memory content and response mode share a common representational format, interference occurs. It follows that if higher cognition uses embodied representations, then interference should often be expected between embodiment and higher cognition. Compatibility effects between embodiment and cognition should be widespread.

Before reviewing these studies on embodiment–cognition compatibility, it is first worth making a preliminary point. All of the studies to follow further demonstrate the phenomena in the preceding three sections. Each finding could have been included for a previous embodiment effect, given that it illustrates either an embodied response to a social stimulus or an embodied state that triggers an affective state. We have held off describing most of these findings until now, given that they also demonstrate embodiment–cognition compatibility. It is important to remember that they demonstrate the earlier embodiment effects as well.[6]

1. Motor Performance

Further results from the Wells and Petty (1980) study discussed earlier demonstrate an embodiment–cognition compatibility effect. In that study, some subjects received an agreeable message, whereas other subjects received a disagreeable one. This manipulation was crossed with whether subjects nodded their head vertically or shook it horizontally while attempting to test whether headphones fall off. Of interest here is that head movements were faster when compatible with the message than when incompatible. While nodding vertically, subjects nodded faster for the agreeable message than for the disagreeable one. Conversely, while shaking horizontally, subjects shook faster for the disagreeable message. This result demonstrates that bodily states interacted with cognitive processing. When the agreeableness of the message was compatible with the head action, subjects were able to perform the action faster than when the message was incompatible. Embodiment–cognition compatibility affected performance efficiency.

Chen and Bargh (1999) reported a similar result [as did Neumann and Strack (2000) and Wentura, Rothermund, and Bak (2000)]. In Experiment 1, Chen and Bargh's subjects received positively or negatively valenced words (e.g., "love," "hate") and had to indicate each word's valence. Subjects responded either by pulling a lever toward them or pushing it away. If embodiment and cognition interact, then positively valenced stimuli should be associated with pulling things toward oneself, whereas negatively valenced stimuli should be associated with pushing things away. Thus subjects should respond fastest to positive words when pulling the lever toward them, but should respond fastest to negative words when pushing the lever away. Consistent with the embodiment prediction, Chen and Bargh (1999) obtained this result.

In Experiment 2, Chen and Bargh (1999) obtained a similar result when subjects simply had to indicate when a word appeared on the screen—subjects made the same response to all words regardless of their affective valence. When subjects indicated a word's appearance by pulling the lever toward them, they responded faster to positive words than to negative ones. When subjects indicated a word's appearance by pushing the lever away, they responded faster to negative words. Automatic activation of a word's meaning implicitly affected subjects' ability to simply indicate stimulus presentation. Most importantly, embodiment—as realized in drawing positive things closer and pushing negative things away—interacted with the cognitive task that subjects performed. In general, all of these results show that motor performance is optimal when compatible with cognitive processing.

2. Memory Performance

Similar interactions occur between embodiment and memory. In Laird, Wagener, Halal, and Szegda (1982), subjects read both anger-provoking passages and humorous passages. Subsequently, under the guise of a cover story, subjects' smiling or frowning musculature was activated while they attempted to recall the earlier material. Consistent with the embodiment prediction, facial expression modulated recall. Whereas humorous passages were recalled better while smiling than frowning, anger-provoking passages were recalled better while frowning. Interestingly, this effect only occurred

[6] As will become evident, some compatibility effects result from interactions between bodily and *affective* states, whereas others result from interactions between bodily and *nonaffective* states. We use "cognition" in referring inclusively to both affective and nonaffective states, as we review "embodiment–*cognition* compatibility effects."

when subjects' facial expressions influenced their mood, indicating that mood moderated the relation between embodiment and memory. Most importantly, though, when embodiment, mood, and memory were compatible, performance was optimal.

A study described by Zajonc, Pietromonaco, and Bargh (1982) illustrates a similar effect in face recognition (cf. Graziano, Smith, Tassinary, Sun, & Pilkington, 1996). Subjects were asked to perform various motor actions while viewing pictures of faces. Whereas some subjects had to mimic the head orientations and facial expressions of the faces, other subjects had to chew gum or squeeze a sponge (i.e., motor controls). A fourth group had to judge the head orientations and facial expressions of the faces (i.e., nonmotor controls). After studying the pictures, subjects received a recognition test. As the embodiment view predicts, picture memory was best when subjects' embodiment was compatible with the pictures—the group mimicking the pictures scored highest. The worst performance occurred for subjects who performed the most competitive motor response—chewing gum. Subjects who squeezed a sponge or judged the faces fell in between. As in the Laird et al. (1982) study, performance was optimal when embodiment and memory were compatible.

Förster and Strack (1996) demonstrated a similar compatibility effect in word recognition. Subjects were induced either to nod their heads vertically (as in agreement) or to shake their heads horizontally (as in disagreement) while studying a list of positively valenced and negatively valenced adjectives. To disguise the study's intent, subjects were told that its purpose was to assess whether headphones fall off under various head movements. On a later recognition test, memory sensitivity was higher for compatible movement–adjective pairings than for incompatible pairings. Specifically, when subjects nodded their heads vertically, their memory for positive adjectives was better than their memory for negative ones. Conversely, when subjects shook their heads horizontally, their memory for negative adjectives was better. Again memory performance was optimal under conditions of embodiment–cognition compatibility.

Embodiment also affects memory for real-life events, not just laboratory ones. In Riskind (1984), subjects recalled past experiences from their life that were pleasant or unpleasant. While recalling memories, embodiment was manipulated by having subjects adopt different postures and facial expressions. Whereas subjects in the positive embodiment condition adopted an expansive posture and a smiling expression, subjects in the negative embodiment condition slumped and frowned. As predicted, this manipulation affected memory, modulating the latencies to retrieve positive versus negative life experiences. Adopting an expansive posture and smiling increased the speed of recalling positive experiences relative to recalling negative ones.

Finally, Förster and Strack (1997, 1998) demonstrated a compatibility effect in retrieval from long-term knowledge. Subjects were instructed to generate the names of famous people and to write them in one of three columns labeled "like," "dislike," and "neutral." While retrieving these names from memory and writing them down, subjects either pulled up on the table surface (approach) or pushed down on it (avoidance). The intent of the study was disguised by telling subjects that optimizing the writing behavior of disabled people was of interest. As the embodiment hypothesis predicts, subjects who performed the approach action retrieved more names of people they liked, whereas subjects who performed the avoidance action retrieved more names of people they disliked. Again memory performance was optimal when motor and cognitive factors were compatible.

3. *Facial Categorization Performance*

Interactions between embodiment and cognition also occur during face processing. Wallbott (1991) asked subjects to categorize the emotional expressions of pictured individuals (i.e., whether an individual was happy, sad, angry, etc.). As subjects judged emotional expressions, their own faces were videotaped. Judges later found that subjects tended to mimic the facial expressions they were judging. Even more interestingly, subjects' accuracy in judging facial expressions increased as their mimicry increased. Although subjects were not required to produce facial expressions and simply had to perform visual categorizations, perceiving a facial expression tended to induce the same expression in the perceiver. Presumably this effect would even be stronger in the presence of an actual individual as opposed to a picture. Regardless, compatibility between embodiment and visual categorization optimized performance.

Adolphs, Damasio, Tranel, Cooper, and Damasio (2000) reported a related finding. When clinical patients have lesions in somatosensory cortex, they are deficient in judging the facial expressions of others. Although it might seem surprising that a lesion in the somatosensory cortex affects visual categorization, Adolphs et al. (2000) argued that simulating emotional expressions on one's own face and experiencing the somatosensory feedback facilitate this process. Similar to Wallbott (1991), facial mimicry arises spontaneously while perceiving faces, with the resultant feedback enhancing the ability to categorize emotional expressions.

Niedenthal and her colleagues demonstrated the compatibility effect for face processing under controlled laboratory conditions (Niedenthal, Halberstadt, Margolis & Innes-Ker, 2000; Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001). In these studies, subjects watched one facial expression morph into another and had to detect when the expression changed. In some studies, subjects were simultaneously under a mood induction, where the mood was compatible or incompatible with the initial expression. For example, subjects might watch a happy face morph into a sad or neutral face while in a happy mood (compatible). Alternatively, subjects might watch a happy face morph into a sad or neutral face while sad (incompatible). Across experiments, Niedenthal et al. (2000, 2001) found that compatibility between judged expressions and mood speeded the detection of changed expressions.

In a final study, Niedenthal et al. (2001) demonstrated that embodiment underlies this effect. Whereas some subjects were free to move their mouth, others had their mouth frozen by having to hold a pen in it. Consistent with the embodiment hypothesis, subjects detected change faster when their mouth was free to move than when it was frozen. Similar to Wallbott (1980) and Adolphs et al. (2000), compatibility between visual categorization and embodiment optimized visual categorization.

4. *Reasoning Performance*

Embodiment–cognition compatibility also affects reasoning. In Riskind (1984), subjects first performed a spatial reasoning test that was either easy or difficult and then predicted how well they would perform on a similar test later. Subjects who received easy tests predicted success on the future task, whereas subjects who received difficult tests predicted failure. Subsequently subjects participated in a bogus biofeedback experiment that involved taking either an upright or a slumped posture while hooked up to electrodes. Most importantly, initial success or failure on the reasoning test was crossed with the subsequent upright or slumped posture, thereby implementing compatibility. Of interest was whether compatibility between initial reasoning performance and embodiment affected performance on the subsequent reasoning task. Compatibility was defined as subjects succeeding and then having to take an upright posture or failing and having to take a slumping posture. Incompatibility was defined as either success/slumping or failure/upright. Consistent with the embodiment view, subjects persisted longer at trying to solve the later puzzles when reasoning performance and embodiment had been compatible earlier. Riskind (1984) concluded that compatibility helps subjects strategize about the reasoning task effectively, such that they are more likely to persist in solving problems.

5. *Secondary Task Performance*

Thus far we have seen that compatibility between embodiment and cognition optimizes performance. These next studies point toward one possible explanation of compatibility effects. Specifically, these studies show that compatibility minimizes the amount of processing resources needed to manage embodied and cognitive tasks performed simultaneously. Conversely, when embodiment and cognition are incompatible, more processing resources are necessary. To assess processing resources, the following studies measure secondary task performance while embodiment and cognition are either compatible or incompatible. If compatibility modulates the availability of processing resources, performance on the secondary task should be worse under incompatible task conditions than under compatible ones.

Förster and Strack (1996) were the first to assess this hypothesis. As described earlier, they manipulated whether head movements (nodding versus shaking) were performed while studying positive versus negative adjectives. As also described, Förster and Strack found that compatibility between the head movements and the adjectives optimized later recognition memory. In Experiment 3, they used a secondary task—placing pegs into holes on a board—to assess the availability of processing resources. As subjects moved their heads and studied adjectives, their performance on the secondary task indexed the remaining capacity available and, inversely, the capacity used by the primary tasks.

As predicted, subjects were poorer at the secondary task when their head movements were incompatible with the adjectives than when they were compatible. For example, when subjects nodded their heads and studied negative adjectives, their secondary task performance was lower than when they nodded their heads and studied positive adjectives. This finding suggests that processing resources moderated the memory compatibility effect. When embodiment and word valence were compatible, more processing resources were available to encode the adjectives into memory. When embodiment and word valence were incompatible, fewer resources were available for learning.

Förster and Stepper (2000) offered further evidence for this conclusion. In one study, subjects stood upright (positive posture) or knelt (negative posture) while learning positive and negative words. As subjects studied the words, they performed the same secondary task of placing pegs in holes. Similar to Förster and Strack (1996), compatibility between posture and word valence modulated secondary task performance. The minimal processing resources were required for compatibility, whereas more were required for incompatibility.

In another experiment, Förster and Stepper (2000) replaced the upright versus kneeling manipulation with the experience of a sweet versus a bitter taste, respectively. When both the taste and the words were positive or both negative, secondary task performance was higher than when one was positive and the other negative. Again more processing resources were free when embodiment and cognition were compatible.

6. Related Nonsocial Effects

A variety of embodiment–cognition compatibility effects have been reported for nonsocial stimuli. In Tucker and Ellis (1998), subjects were instructed to detect whether a cup was right side up versus upside down. Although the handle of the cup was irrelevant to the decision, it nevertheless interacted with the motor response that indicated the vertical orientation of the cup. Specifically, subjects responded faster when the handle was on the same side of the display as the response hand than when the handle was on the opposite side. For example, right-handed responses were faster when the handle of the cup was on the right side of the screen than when the handle was on the left. On perceiving the cup, the cognitive system immediately detected the embodied implication of the handle, namely whether the handle would be easily graspable by the response hand or not. Although grasping the handle was irrelevant, its embodied implications were computed automatically and immediately. As for the social phenomena just reviewed, embodiment–cognition compatibility optimized performance. Tucker and Ellis (2000, 2001) reported similar compatibility results for other types of embodied responses.

Glenberg and Kaschak (2002) reported a similar phenomenon in language comprehension. When subjects judged the sensibility of a sentence that described a forward hand movement (e.g., "close the drawer"), they responded faster when using a forward hand movement than a backward one. Conversely, when subjects judged the sensibility of a sentence that described a backward hand movement (e.g., "open the drawer"), they responded faster when using a backward hand movement.

Finally, Simmons and Barsalou (2003a) found that compatible embodiment facilitates the visual categorization of artifacts. When subjects performed an arm movement that was compatible with a visually presented object, they categorized the object faster than when they performed an incompatible action. For example, subjects categorized a picture of a faucet faster when performing the action of turning a faucet than when making a comparable but unrelated movement.

In summary, the embodiment–cognition compatibility that we saw for social stimuli also occurs for nonsocial stimuli. This broader pattern suggests two general conclusions: First, a common mechanism appears to produce compatibility effects across diverse domains. Second, embodiment appears to enter centrally into cognitive processing, given that bodily states interact widely with cognitive ones. As described earlier, if cognitive states were amodal and disembodied, they should not interact with bodily states. Given embodiment's ubiquitous interactions with cognition, it can hardly be viewed as peripheral, as in most current theories.

III. A Theory of Social Embodiment

Although the phenomena just reviewed all involve embodiment, no unified account of them exists. Furthermore, embodiment is often viewed as peripheral to these phenomena, namely as an appendage that accompanies more central representations of social entities and events. This next section presents a theory in which embodiment resides at the heart of social representations, contributing directly to their meaning. The subsequent section shows how this account explains social embodiment phenomena.

According to most theories, knowledge consists of amodal symbols that *redescribe* modality-specific states. On interacting with a person in a social event, an amodal redescription of the perceptions, actions, and introspections in the event becomes established in memory to support social processing. Nearly all accounts of social cognition represent knowledge this way, using feature lists, propositions, productions, schemata, statistical vectors, and so forth to redescribe perceptual, motor, and introspective states. Many examples of such theories can be found in the edited volumes of Wyer and Srull (1984a,b,c). According to these views, amodal redescriptions of social experience constitute social knowledge.

A few notable exceptions have stressed the importance of embodied representations in social cognition. Early accounts of attitudes proposed that motor movements are central components of attitudes (for a review, see Fleming, 1967). Darwin (1872/1904) used *attitude* to mean the collection of motor behaviors, especially posture, that conveys an organism's affective response toward an object. Subsequent accounts similarly stressed the importance of motor behavior in attitudes (e.g., Sherrington, 1906; Washburn, 1926). More recently, Zajonc and Markus (1984) have argued that motor behavior and affect represent themselves in higher cognition rather than amodal symbols standing in for them. Similarly, Damasio (1994, 1999) argued that somatic markers are central to higher cognition and that without them, rationality is compromised. All of these views are closely related to the theory we propose.

A. Modal Reenactments of Perception, Action, and Introspection

The modal reenactment of perceptual, motor, and introspective states constitutes the central mechanism in our theory (e.g., Barsalou, 1999a,b; in press; Damasio, 1989). Rather than amodal redescriptions of perceptual, motor, and introspective states representing knowledge, reenactments of these states do. We further assume that the reenactment process underlying knowledge is roughly the same as the reenactment process underlying mental imagery (e.g., Deschaumes-Molinaro, Dittmar, & Vernet-Maury, 1992;

Farah, 2000; Finke, 1989; Grezes & Decety, 2001; Jeannerod, 1995; Kosslyn, 1994; Shepard & Cooper, 1982; Zatorre, Halpern, Perry, Meyer, & Evans, 1996). Damasio (1989) sketched a preliminary account of the reenactment process. Simmons and Barsalou (2003b) offered a more developed account, although full-fledged computational models remain to be built.

As Figure 1 illustrates in a highly simplified and schematic manner, the reenactment process has two phases: (1) the storage of modality specific states and (2) the partial reenactment of these states on later occasions. Each phase is addressed in turn.

1. Storage of Modality-Specific States That Arise in Feature Maps

When a physical entity is experienced, it activates feature detectors in the relevant feature maps (Fig. 1a). During visual processing of a face, for example, some neurons fire for edges and planar surfaces, whereas others fire for color, configural properties, and movement. The global pattern of activation across this hierarchically organized distributed system represents the entity in vision (e.g., Palmer, 1999; Zeki, 1993). Analogous patterns of activation on other sensory modalities represent how the face might sound and feel. Activation in the motor system similarly represents embodied responses to the face, such as the formation of a facial expression, and approach/avoidance behavior. A similar mechanism underlies the introspective states that arise while interacting with an entity. For example, activation patterns in the amygdala and orbitofrontal areas represent emotional reactions to social stimuli. Much neuroscience research documents the structure of feature maps across modalities and the states that arise in them.

In the simplified and schematic illustration of a visual feature map in Fig. 1a, the neural activation resembles a face. This might seem naîve. In vision, however, feature maps are often organized topographically. The visual system alone contains many topographically mapped feature areas. The motor, somatosensory, and auditory modalities analogously contain somatotopic and tonotopic maps organized according to external physical structure. Motor and somatosensory maps follow bodily structure to a considerable extent, and auditory maps are laid out according to pitch. Thus it is quite reasonable to assume that modality-specific representations take topographic forms, at least to some extent. Nevertheless, *nothing* in the account to follow depends on topographically mapped representations. If these representations were completely arbitrary, having nothing to do with topography, the account would work the same. The critical assumptions are that modality-specific states arise to represent experience, regardless of whether they are topographical, and that higher cognitive processes reenact them to represent knowledge.

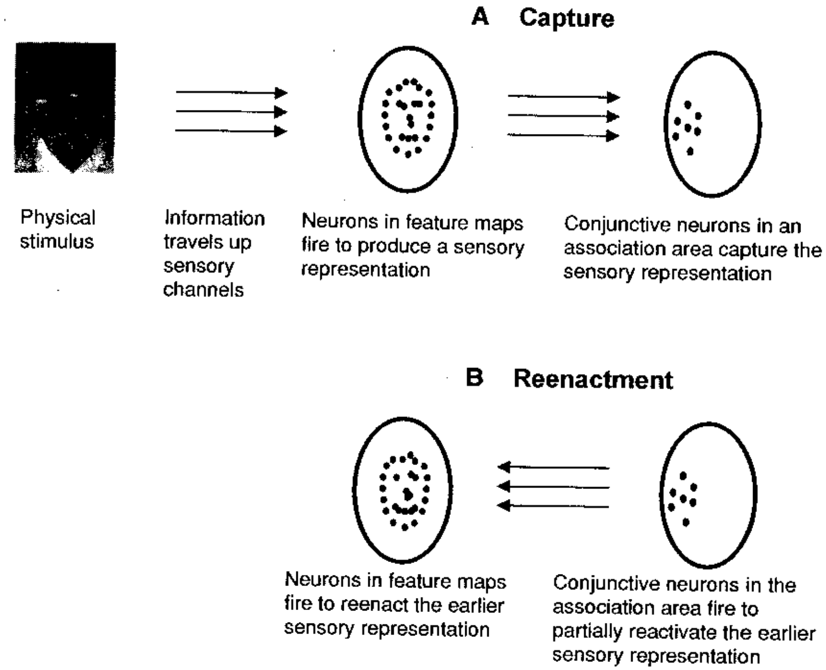

Fig. 1. Illustration of how modality-specific information is captured (A) and reenacted (B) in Damasio (1989) and Barsalou (1999b).

When a pattern becomes active in a feature map during perception or action, conjunctive neurons in an association area capture the pattern for later cognitive use. As Fig. 1a illustrates, conjunctive neurons in the visual system capture the pattern active for a particular face. A population of conjunctive neurons together codes a particular pattern, with each individual neuron participating in the coding of many different patterns (i.e., coarse coding; Hinton, McClelland, & Rumelhart, 1986). Damasio (1989) called these association areas *convergence zones* and proposed that they exist at multiple hierarchical levels in the brain, ranging from posterior to anterior (for a specific proposal, see Simmons & Barsalou, 2003b). Most locally, convergence zones near a modality capture activation patterns within it. Association areas near the visual system, for example, capture patterns there, whereas association areas near the motor system capture patterns there. Downstream in more anterior regions, higher association areas, including the temporal and frontal lobes, integrate activation *across* modalities.

2. *Reenactments of Modality-Specific States*

The convergence zone architecture has the functional capability to produce modality-specific reenactments. As Fig. 1b illustrates, once a set of conjunctive neurons captures a feature map pattern, the set can later activate the pattern in the absence of bottom-up stimulation. When retrieving the memory of a person's face, for example, conjunctive neurons can partially reactivate the visual state active while perceiving it. Similarly, when retrieving an action, conjunctive neurons partially activate the motor state that produced it. A given reenactment is never a complete reinstatement of an original modality-specific experience. Furthermore, biases may enter into the reenactment process. Thus all reenactments are partial and potentially inaccurate. At least some semblance of the original state, however, is partially activated—it is not represented as an amodal redescription.

The reenactment process is not necessarily conscious. Although conscious reenactment is viewed widely as the process that underlies mental imagery, reenactments need not always reach awareness. *Unconscious* reenactments may often underlie memory, conceptualization, comprehension, and reasoning (Barsalou, 1999b, 2003). Although explicit attempts to construct mental imagery may create vivid reenactments, many other cognitive processes may rely on less conscious reenactments or reenactments that are largely unconscious (e.g., Solomon & Barsalou, 2003; Wu & Barsalou, 2003).

In the account of social embodiment to follow, the neural reenactment of modality-specific states is the critical mechanism, *not* the experience of conscious mental images. Many of the social embodiment effects reviewed here appear to result from relatively unconscious simulations for two reasons. First, experimental cover stories tend to minimize conscious strategic processing, drawing subjects' attention away from the critical processes under study. Second, much evidence exists that embodiment effects result from automatic processes (e.g., Bargh & Chartrand, 1999; Dijksterhuis & Bargh, 2001; Hatfield et al., 1992). Both factors suggest that the reenactments underlying social embodiment phenomena may often be relatively unconscious.

B. Simulators and Simulations

Barsalou (1999b) developed a theory of knowledge based on the neural reenactment of modality-specific states (also see Barsalou, in press). These articles show that a fully functional conceptual system can be built on the reenactment mechanism just presented. Using this mechanism, it is possible to implement the type-token distinction, categorical inference, productivity,

propositions, and abstract concepts. Contrary to previous arguments, amodal symbols are not necessary for implementing these classical conceptual functions.

The two central constructs in this theory are *simulators* and *simulations*. Whereas simulators integrate information across a category's instances, simulations are specific conceptualizations of the category. Each is addressed in turn.

1. *Simulators*

Much work has shown that categories tend to have statistically correlated features (e.g., Chin-Parker & Ross, 2000; McRae, de Sa, & Siedenberg, 1997; Rosch & Mervis, 1975). Thus, when multiple instances of the same category are encountered, they tend to activate similar neural patterns in feature maps (cf. Farah & McClelland, 1991; McRae & Cree, 2002). As a result, similar populations of conjunctive neurons in convergence zones—tuned to these specific conjunctions of features—tend to capture these patterns (Damasio, 1989; Simmons & Barsalou, 2003b). Over time, this population of conjunctive neurons integrates modality-specific features across category instances and settings, establishing a multimodal representation of the category. Figure 2a provides a highly simplified and schematic illustration of the resultant distributed system. Barsalou (1999b) referred to these distributed systems as *simulators*. Conceptually, a simulator functions as a type, integrating the content of a category across instances and providing the ability to interpret later individuals as tokens of the type (Barsalou, in press).

Consider the simulator for the social category *face*. Over time, visual information about how faces look becomes integrated in the simulator, along with auditory information for how they sound, somatosensory information for how they feel, motor programs for interacting with them, emotional responses to experiencing them, and so forth. The result is a distributed system throughout the brain's association and modality-specific areas that establishes conceptual content for the general category of *face*.

2. *Simulations*

Once a simulator becomes established for a category, it can reenact small subsets of its content as specific *simulations* (Fig. 2b). All of the content in a simulator never becomes active at once. Instead only a small subset becomes active to represent the category on a given occasion (cf. Barsalou, 1987, 1989, 1993). For example, the *face* simulator might simulate a smiling face on one occasion, whereas on others it might simulate an angry face, a yelling face, or a kissing face. Although all the experienced content for faces resides

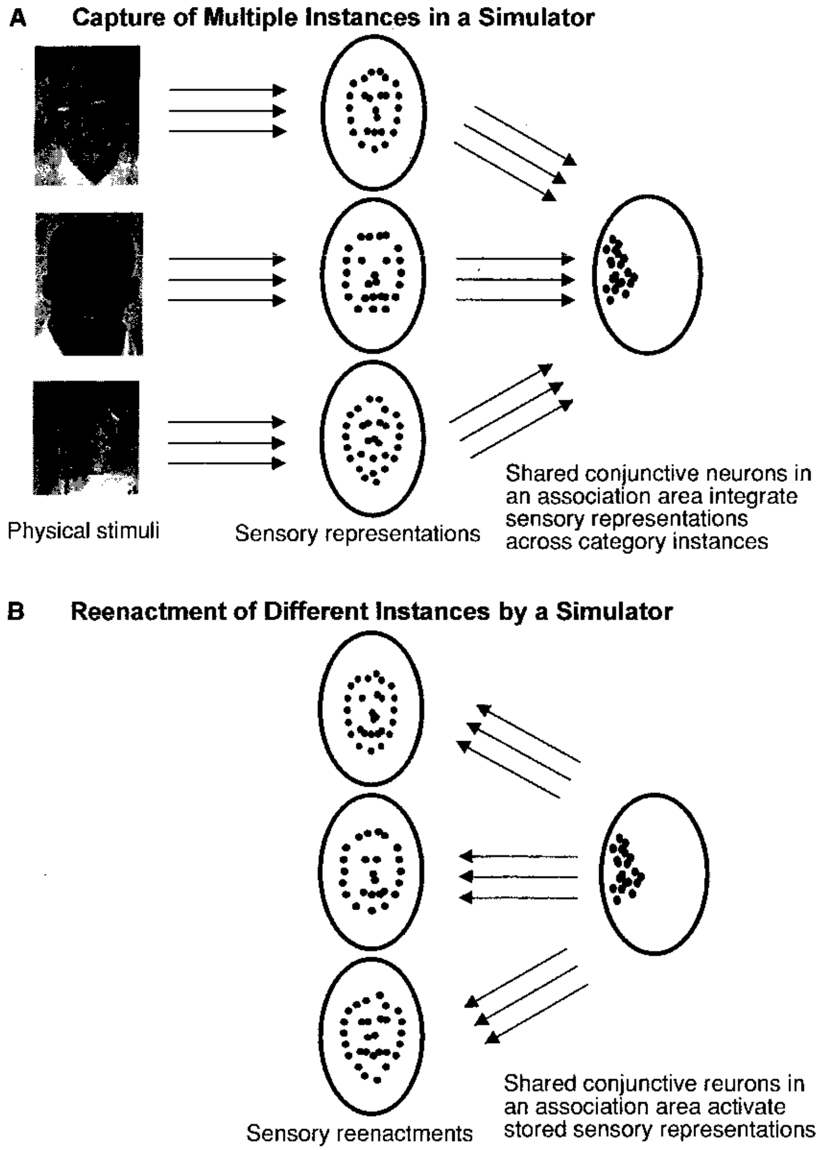

Fig. 2. Illustration of simulators (A) and simulations (B) in perceptual symbol systems (Barsalou, 1999b).

implicitly in the *face* simulator, only a specific subset is reenacted on a given occasion.

Once a simulation becomes active, it serves a wide variety of cognitive functions (Barsalou, 1999b). Of particular interest later, simulations can be used to draw inferences about a category's perceived instances. Additionally, simulations can represent a category's instances in their absence during memory, language, and thought.

Simulations can go considerably beyond the information stored originally in a simulator—they are not mere reenactments of previously experienced events. Information stored on different occasions in a simulator may merge together at retrieval, thereby producing reconstructive and averaging effects. Remembering a face seen once, for example, may be distorted toward a similar face seen many times. Furthermore, intentional attempts to combine simulations from different simulators productively can produce infinite simulations never experienced (Barsalou, 1999b, in press). For example, people can simulate a rug and then systematically simulate its color and pattern to represent a wide variety of novel rugs (e.g., a blue shingle-patterned rug, a red hardwood floor-patterned rug).

3. *Types of Simulators*

In principle, an infinite number of simulators can be established in memory and can develop for all forms of knowledge, including objects, properties, settings, events, actions, introspections, and so forth. According to Barsalou (1999b, in press), a simulator develops for any component of experience that attention selects repeatedly. Thus, if attention focuses repeatedly on a type of object in experience, such as *face*, a simulator develops for it. Analogously, if attention focuses on a type of action (*kissing*) or a type of introspection (*happiness*), simulators develop to represent them as well. Such flexibility is consistent with Schyns, Goldstone, and Thibaut's (1998) argument that the cognitive system learns new features as they become relevant for higher categorization. Because selective attention is so flexible and open-ended, a simulator can develop for any component of experience selected repeatedly.

A key issue concerns which components of experience develop simulators and why attention focuses on them and not others. Many factors potentially influence this process, including genetics, language development, culture, and goal achievement. A complex set of factors determines where attention focuses consistently, such that simulators develop for those components of experience. A further account of these mechanisms lies beyond the scope of this chapter. Essentially this is the problem of what constrains knowledge (e.g., Goodman, 1972; Murphy & Medin, 1985), and any theory—not just an embodied one—must resolve it.

Another key issue concerns simulators for abstract concepts. Barsalou (1999b) proposed that these simulators generally construct complex multimodal simulations of temporally extended situations, with simulated introspective states being central. What distinguishes abstract from concrete concepts is that abstract concepts tend to contain more situational and introspective state information than concrete concepts (Wiemer-Hastings, Krug, & Xu, 2001). For example, one sense of *truth* refers to a speaker making a claim about a situation, followed by a listener representing the claim, comparing it to the actual situation, and deciding if the claim interprets the situation accurately (e.g., the claim that it is snowing outside). This sense of *truth* can be represented as a simulation of the temporally extended situation, including the relevant introspective states (e.g., representing, comparing, deciding). Many abstract social concepts, such as *love*, *cooperation*, and *aggression*, can similarly be viewed as complex simulations of social situations, with simulated introspective states being central.

C. Situated Conceptualizations: Multimodal Simulations of Social Situations

Barsalou (2003) contrasted two ways of thinking about concepts. Nearly all theories view concepts as *detached databases*. As a category is experienced, its properties and/or exemplars are encoded and stored into a global database for the category, along the lines of an encyclopedia entry. As a result, a global description develops for a category that is relatively detached from the goals of specific agents.

Alternatively, a concept can be viewed as an *agent-dependent instruction manual*. According to this view, knowledge of a category is not a global description of its members. Instead a concept is more like an ability or skill that delivers specialized packages of inferences to guide an agent's interactions with specific category members in specific situations. Across situations, a concept delivers different packages of inferences, each tailored to current goals and constraints.

1. Situated Conceptualizations

Barsalou (2003) referred to a package of situation-specific inferences as a *situated conceptualization*. Consider the concept of *anger*. According to traditional views, *anger* is represented as a detached collection of amodal facts that become active as a whole every time the category is processed. Alternatively, a simulator for *anger* produces many different situated conceptualizations, each tailored to helping an agent handle anger in a specific context—no global description of the category exists. For example, one situated conceptualization for *anger* might support interacting with an angry child, whereas others might support interacting with an angry spouse, an angry colleague, or one's own anger. On this view, the concept for *anger* is not a detached global description of the category. Instead the concept is the ability to produce a wide variety of situated conceptualizations that support goal achievement in specific contexts.

2. Multimodal Simulations Implement Situated Conceptualizations

Following Barsalou (2003), we assume that an integrated simulation becomes active across modalities to implement a situated conceptualization. Consider a situated conceptualization of *anger* for interacting with an angry child. One thing that this conceptualization must simulate is how the child might appear perceptually. When children are angry, their faces and bodies take particular forms, they execute certain actions, and they make distinctive sounds. All these perceptual aspects can be represented as modal simulations in knowledge about the situation. Rather than amodal descriptions representing these perceptions, simulations of them do.

A situated conceptualization about an angry child is also likely to represent actions that the agent could take in handling the situation, such as consoling and restraining. Modal simulations, too, can represent these actions. Knowledge of what an agent can do is represented by simulations of the actions themselves rather than as amodal redescriptions of them.

A situated conceptualization about an angry child is also likely to include introspective states of both the child and the parent. Because the parent knows what anger feels like, she can run simulations of her own anger to project what the child is feeling. The situated conceptualization for this situation might further include simulations of what the parent might be feeling, such as compassion, frustration, or annoyance. Again, modal simulations of these states represent knowledge of them in the situated conceptualization.

Finally, this situated conceptualization for *anger* in a child specifies a setting where the event is taking place—the event is not simulated in a vacuum. Thus the event might be simulated in a bedroom, classroom, toy store, etc. Again such knowledge is represented as simulations, this time as reenactments of particular settings.

According to Barsalou (2003), a situated conceptualization typically contains simulations of the four basic components just described: (1) people and objects, (2) agentive actions and other bodily states (embodiment!), (3) introspective states, such as emotions and cognitive operations, and (4) settings. Putting it all together, a situated conceptualization is essentially a multimodal simulation of a multicomponent situation, with each modality-specific component being simulated in the respective brain area.

Furthermore, such simulations place the agent directly in them, creating the experience of "being there" (Barsalou, 2002, 2003). Because these simulations reenact agentive actions and introspective states, they create the experience of the conceptualizer being in the situation—the situation is not represented as something detached from the conceptualizer.

Finally, a given situated conceptualization typically consists of simulations from many different simulators. For example, a situated conceptualization for handling an angry child is likely to include simulations from simulators for people, objects, actions, introspections, and settings. Rather than a single simulator producing a situated conceptualization, many simulators contribute to the broad spectrum of components that a situated conceptualization contains.

3. *Entrenched Situated Conceptualizations for Repeated Social Situations*

For decades, social theorists have argued that entrenched situations play central roles in personality and social interaction (e.g., Andersen & Glassman, 1996; Sullivan, 1953). Over the course of life, people experience many social situations repeatedly, such as those involving significant others. As a result, knowledge of these situations becomes entrenched in memory, thereby supporting skilled performance. Entrenched knowledge can also guide interactions with novel people who are similar to known individuals in entrenched situations. Even though entrenched knowledge may not always provide a perfect fit, it may often fit well enough to provide useful inferences.

We assume that situated conceptualizations represent the entrenched knowledge in these theories. As a situation is experienced repeatedly, multimodal knowledge accrues in the respective simulators for the people, objects, actions, introspections, and settings experienced in it. The components of the conceptualization become entrenched in their respective simulators, as do the connections between these components. Eventually the situated conceptualization becomes so well established that it comes to mind automatically and immediately as a unit when the situation arises. After a parent frequently experiences an angry child, for example, the situated conceptualization for this situation becomes entrenched in memory, with minimal cuing bringing it all to mind on subsequent occasions. Thus an entrenched situated conceptualization can be viewed as a frequently associated configuration of modality-specific representations, distributed across a diverse collection of simulators for people, objects, actions, introspections, and settings.[7]

Over time, a wide variety of situated conceptualizations becomes entrenched, reflecting the many social situations a person experiences frequently. Together this collection of situated conceptualizations constitutes a form of social expertise.

4. *Simulation as Meaning*

In the papers reviewed earlier, researchers often view embodiment as separate from social knowledge. Often researchers assume that bodily states are *associated* with traits and stereotypes rather than *constituting* their core conceptual content. Often researchers seem to assume that traits and stereotypes contain distilled amodal information that constitutes the core concepts, with embodiment being peripheral.

In contrast, we propose that multimodal simulations constitute the core knowledge of traits and stereotypes. Rather than amodal redescriptions of embodied states constituting traits and stereotypes, embodied states represent themselves in these constructs. Consider the trait of *slow movement* in the *elderly* stereotype. On the embodied view, *slow movement* is not represented by an amodal redescription, which in turn implements associated movements in the motor system. Instead knowledge of *slow movement* resides in simulations of seeing and executing slow movements—no further amodal descriptions exist or are necessary. Similarly, knowledge about *anger* resides in simulations of what anger looks like, how one acts, and how one feels introspectively. On this view, simulations of perception, action, and introspection directly constitute the conceptual content of social knowledge. Knowledge is not a redescription of these states in an amodal language, but is the ability to partially reenact them.

D. Inference Via Pattern Completion

Once situated conceptualizations become entrenched in memory, they play important roles in social processing. Of particular interest here is their support of social inference through pattern completion. As we will see, social inference via pattern completion plays the central role in our account of the social embodiment phenomena described earlier. This account can also be viewed as one way to implement priming, a ubiquitous phenomenon

[7] As described later, we do not assume that just a single situated conceptualization represents a repeated situation. Instead we assume that an entrenched attractor in a dynamic system develops to produce related but different conceptualizations (Barsalou, in press). Thus the conceptualizations for interacting with an angry child are likely to be similar in many ways but also to be different, at least subtly.

in social cognition (e.g., Bargh & Pietromonaco, 1982; Devine, 1989; Higgins, Rholes, & Jones, 1977; Srull & Wyer, 1979).

1. *Pattern Completion with Entrenched Situated Conceptualizations*

Situated conceptualizations that become entrenched in memory support successful social interaction through pattern completion. On entering a familiar situation and recognizing it, an entrenched situated conceptualization that represents the situation becomes active. Typically not all of the situation is perceived initially. A relevant person, setting, or event may be perceived, which then suggests that a particular situation is about to play out. It is in the agent's interests to anticipate what will happen next so that optimal actions can be executed. The agent must draw social inferences that go beyond the information given (e.g., Griffin & Ross, 1991).

The situated conceptualization that becomes active constitutes a rich source of social inference. The conceptualization can be viewed as a pattern (i.e., as a complex configuration of multimodal components that represent the situation). Because part of this pattern matched the current situation initially, the larger pattern became active in memory. The remaining parts of the pattern—not yet observed in the situation—constitute inferences, namely educated guesses about what might occur next. Because the remaining parts cooccurred frequently with the perceived parts in previous situations, inferring the remaining parts from the perceived parts is reasonable. As a partially viewed situation activates a situated conceptualization, the conceptualization completes the pattern that the situation suggests.

To the extent that a situated conceptualization is entrenched in memory, pattern completion is likely to occur at least somewhat automatically. As a situation is experienced repeatedly, its simulated components and the associations linking them increase in potency. Thus when one component is perceived initially, these strong associations complete the pattern automatically.

Consider the example of seeing a friend. His face, clothing, and bodily mannerisms initially match modality-specific simulations in one or more situated conceptualizations that have become entrenched in memory. Once one of these wins the activation process, it provides inferences via pattern completion, such as actions that the friend is likely to take, actions that the perceiver typically takes, affective states that are likely to result, and so forth. The unfolding of such inferences—realized as simulations—produces social prediction.

2. *Pattern Completion with Biologically Based Mechanisms*

Thus far we have assumed that pattern completion proceeds largely through situated conceptualizations that have become entrenched through learning.

We further assume, however, that pattern completion can also occur with minimal learning via mechanisms that arise biologically. One modality-specific component of a situated conceptualization may activate another, even when they have not been associated through extensive learning.

Such inferences could arise in at least two ways. In some cases, perceptual information triggers emotional reactions and/or motor responses automatically—a releasing stimulus elicits a fixed action pattern. In humans, emotional states may follow from perceiving particular facial expressions, as may approach/avoidance behavior, sexual arousal, and so forth. On seeing an angry adult face, for example, biologically based circuitry may produce fear and retreat. Similarly, when an angry face is simulated in a situated conceptualization, it may trigger simulations of fear and retreat through the same mechanism. Although learning may play a role in establishing and strengthening these circuits (e.g., Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996), biologically based mechanisms appear to at least anticipate them. Most importantly for our purposes, the activation of a fixed action pattern to a releasing stimulus can be viewed as an inference. Given initial information, an organism infers a likely outcome and takes the appropriate action.

Another likely candidate for such inferencing is biologically based imitation. At birth, human infants imitate adults, suggesting that a nonlearned mechanism is responsible (Meltzoff, 2002). Much recent work in neuroscience suggests the mirror-neuron circuit as a likely candidate for this mechanism (Rizzolatti et al., 2002). As the visual system processes another person's action, the brain automatically simulates an analogous action in the perceiver's motor system. Such simulations, too, can be viewed as inferences, namely the brain perceives a person performing an action and infers what it would be like for the perceiver to perform it.

Both types of biologically based responses can be viewed as inferences via pattern completion. Certain social situations become so important over evolution that the brain evolves to represent them with minimal learning. For example, a releasing stimulus and its fixed action sequence form a larger pattern. When the releasing stimulus is perceived, the pattern completes itself by running the fixed-action sequence. Imitation can be viewed similarly. When an action is perceived, the pattern completes itself by running the action in the perceiver's motor system. In both cases, the patterns are multimodal, where one modal component triggers another via biologically based circuits. In both cases, responses can be viewed as inferences to perceived information via pattern completion.

3. The Statistical Character of Representation and Inference

We assume that everything about the production of inferences via pattern completion has a statistical character (e.g., Barsalou, 1987, 1989, 1993; Smith & Samuelson, 1997). A simulator is essentially a dynamical system capable of producing infinite simulations (Barsalou, in press). On a given occasion, the simulation constructed reflects the current state of the simulator, its current inputs, and its past history. An entrenched situated conceptualization is an attractor in this system, namely a state that is easy to settle on, because the associations representing it have become strong through frequent use. Furthermore, infinitely many states near the attractor offer different versions of the same conceptualization, each a different adaptation to the situation. Thus the entrenched conceptualization for interacting with an angry child is not a single simulation but rather the ability to produce many related simulations. Across different instances of the same situation, the situated conceptualizations that guide an agent vary dynamically, depending on all relevant factors that influence the system.

As a result, the inferences that arise via pattern completion vary as well. Because the conceptualizations that represent a situation vary across occasions, so do the completions that follow from them. In different instances of the same situation, somewhat different inferences may result from completing somewhat different patterns.

Finally, the individual inferences that arise from pattern completion vary statistically in strength. Whereas some inferences may appear highly likely, others may seem tentative. Many factors probably affect inferential strength, including how automatically an inference is produced, how connected it is to other information, and whether competing inferences exist. In this spirit, Dijksterhuis, Aarts, Bargh, and van Knippenberg (2000) showed that the strength of an embodied inference increases as it co-occurs more often with a social stimulus. Specifically, words about the elderly prime elderly behavior in young subjects when their contact with the elderly has been frequent but not when their contact has been infrequent.

4. Simulation versus Execution of Inferences

Thus far we have assumed that inferences are realized via simulation. When perception triggers a situated conceptualization, nonperceived components of the situation are simulated, thereby providing inferences about it. Seeing one's infant, for example, might activate a situated conceptualization that simulates cuddling, without any actual cuddling movements occurring. On many other occasions, however, once motor simulations become active, they may initiate actual actions. Thus the simulation of cuddling one's infant

might eventually trigger actual cuddling. In these cases, the motor inferences that arise during pattern completion eventually become realized as behaviors.

The literature on motor imagery demonstrates that the distinction between motor imagery and motor behavior is far from discrete. When people imagine simple actions, such as finger tapping, not only does the motor cortex become active, so do spinal neurons and the peripheral musculature (e.g., Jeannerod, 1995, 1997). When expert marksmen imagine shooting a gun, their heart rate and breathing fluctuate as if they were actually shooting one (Deschaumes-Molinaro et al., 1992). As such findings illustrate, simulated movements are close to being realized as actual movements, thereby readying agents for action.

Thus when the pattern completion process provides motor inferences, it may realize them in a variety of ways. On some occasions, actions may only be simulated. On others, actions may be simulated with only traces appearing in behavior—not full-blown execution. On still other occasions, simulations may trigger full execution of the respective actions. As the literature on the motor system illustrates, a complex set of mechanisms represents, gates, executes, and monitors action at multiple levels. As a result, action takes many forms, both in representation and in execution. We assume that all these different realizations constitute possible inferences via the pattern completion process.

IV. Explaining Social Embodiment Effects

The theory of social embodiment just presented explains and unifies the four social embodiment effects presented earlier. After applying the theory to each effect, we address two further issues that arise in doing so.

A. Social Stimuli Elicit Embodied Responses in the Self

Earlier we saw that social stimuli produce embodied responses. For example, hearing an examination grade affects posture; thinking about the elderly induces slow movement; being reminded of a liked significant other produces positive facial expressions; thinking about rudeness increases the willingness to interrupt; and thinking about politicians increases long windedness.

All of these effects can be explained as pattern completion across the modality-specific components of a situated conceptualization. In each case, a situated conceptualization that has become entrenched in memory mediates the effect. When part of the situated conceptualization is perceived, the larger pattern becomes active, with its nonperceived components constituting inferences in their respective modality-specific systems. In all cases for the first embodiment effect, one of these inferences is a bodily state. In many cases, these inferences may arise automatically, as the result of strong links between the conceptualization's modality-specific components.

For example, receiving a low grade activates a situated conceptualization associated with poor school performance. For some people, this situation may have been experienced directly on many occasions. For others, it may have been experienced vicariously when others performed poorly. A variety of modality-specific components may reside in this situated conceptualization, such as feeling ashamed and slumping. In some cases, the links between modality-specific components may be learned, such as coming to believe that a low grade is undesirable. In other cases, the links may have a biological basis, such as performing poorly and feeling ashamed and also feeling ashamed and slumping. Regardless, because all of these modality-specific components are experienced together frequently in this repeated situation, they become increasingly associated through learning, such that an entrenched conceptualization of the situation develops. Later this entrenched pattern produces inferences via pattern completion. Once part of the situation is experienced, such as a low grade, the conceptualization becomes active, which then produces modal inferences, including a slumped posture.

All of the other cases for the first embodied effect can be explained similarly. In each case, a social stimulus triggers an entrenched situated conceptualization, which then produces inferences via pattern completion. What makes this particular set of studies interesting is that some of these inferences are embodied states. Rather than being represented as amodal descriptions, these inferences are represented as states in the motor system.

B. Embodiment in Others Elicits Embodied Mimicry in the Self

Earlier we saw that people mimic the embodied states that they perceive in others, including their postures, facial expressions, and communicative manners. One likely mechanism responsible for mimicry is the mirror neuron circuit (e.g., Rizzolatti et al., 2002). Independent of learning, this circuit may induce mimicked actions. We hasten to add, however, that this circuit is likely to operate in the context of situated conceptualizations.

Consider the mimicry of wincing. Narrowly speaking, seeing someone wince may simply reproduce wincing in the self. More broadly, however, wincing belongs to situated conceptualizations that represent larger situations. For example, wincing may belong to situations where an entity or event physically causes pain in an agent, who then attempts to withdraw. On seeing

someone else wince, activation of this situated conceptualization may induce empathy for "feeling the other person's pain." It may further induce cooperation in helping remove the source of the pain. For example, seeing a child wince from a splinter might not only induce wincing in a parent, but also induce empathy and the goal of removing the splinter.

In principle, just the perception of wincing may be sufficient to trigger this situated conceptualization. Mimicry of the wincing, however, may provide an even stronger cue for triggering it. Two triggers (perception plus mimicked movement) are better than one (perception alone). Furthermore, embodied cues may be more potent than perceptual ones. Actual wincing may be more likely to activate relevant situated conceptualizations than simply perceiving it.

The point is that mimicry may typically not be an end in itself, at least in complex social situations. Instead mimicry may typically play the role of helping retrieve situated conceptualizations that are useful for processing the current situation effectively.

Another effect of mimicry is to induce social contagion, a point central in many reviews (e.g., Dijksterhuis & Bargh, 2001; Hatfield et al., 1992; Neumann & Strack, 2000; Semin, 2000). If different people learn similar conceptualizations for the same situation, then when two people share an embodied state, they are likely to activate they same conceptualization, thereby achieving synchrony, coordination, and empathy. Imagine that two people have similar situated conceptualizations that include yawning. Further imagine that this conceptualization becomes active in one person and induces yawning in the other via mimicry. Once yawning is induced in both people, it may induce a similar conceptualization, such that they perceive the situation similarly and coordinate their emotions and activities.[8]

C. Embodiment in The Self Elicits Affective Processing

Earlier we saw that embodied states induce affective responses. For example, upright posture induces pride and confidence, whereas slumped posture induces shame and uncertainty. Head nods, arm pulls, and the

[8] Clearly emotional and behavioral mimicry do not always arise between two individuals, as when one feels angry and the other guilty. In some such cases, biologically based mechanisms may produce complementary states in two individuals, as when a hunter experiences aggressiveness and a prey experiences fear. In other cases, entrenched situated conceptualizations may be responsible, as when a parent models calmness for a child who shows fear at an insignificant threat. An interesting question is whether mimicry mechanisms nevertheless become active automatically in these situations and are then overridden by other more powerful mechanisms that produce complementary states.

smiling musculature induce positive affect, whereas head shakes, arm pushes, and the frown musculature induce negative affect.

Again, all of these effects can be explained as pattern completion across the modality-specific representations of a situated conceptualization. In all of these cases, an embodied state activates a situated conceptualization that includes an affective state. For each effect, the affective state is an inference to an embodied cue. On the one hand, bodily states such as upright posture, arm pulls, head nods, and smiling activate situated conceptualizations associated with positive affect. On the other hand, bodily states such as slumping, arm pushes, head shakes, and frowning activate situated conceptualizations associated with negative affect. Whatever entities and events happen to be present when one of these situated conceptualizations becomes active then acquires the affect associated with it. Again the underlying mechanism is pattern completion via a situated conceptualization.

What makes the third embodiment effect different from the first two is simply the direction of pattern completion. In the first two effects, social stimuli produce embodied states. In the third effect, embodied states produce affective responses.

D. The Compatibility of Embodiment and Cognition Modulates Performance Effectiveness

Earlier we saw that performance is optimal when embodiment and cognition are compatible. Motor movements are faster when they are compatible with affective states. Memory is optimal when movements are compatible with the affective valence of remembered material. Face processing is optimal when the perceiver's expression matches the perceived expression on a face. In general, greater capacity is available for secondary tasks when embodiment and cognition are compatible.

Several factors may underlie these effects. In some cases, redundancy may strengthen a motor response. Consider the task of pulling versus pushing a lever to indicate whether a word is valenced positively or negatively. In this task, perceiving a word triggers a situated conceptualization for its meaning that includes a simulated motor response. On seeing a positive word, for example, a situated conceptualization becomes active for its meaning, which includes bodily motions associated with positive affect. When the response is a similar motion, its redundancy with the simulated action speeds actual movement. Conversely, when the two mismatch, the motor system must simulate one movement while executing a different one, with the resulting movement being less efficient.

Another benefit of compatible embodiment may be redundant cues for retrieval. In face processing, visual cues alone can be used to identify the

emotion expressed. If, however, the visual cues induce the same emotion on the perceiver's face, these embodied cues may help the visual ones activate the correct categorization. Again the embodied cues may be even stronger than the visual ones.

Finally, when embodiment and cognition are redundant, greater processing resources may be available for processing each individually. Consider the encoding of words while performing an action. On seeing a word, a situated conceptualization for its meaning becomes active that includes simulated movements. When these simulated movements are consistent with an action being performed, a common motor process can contribute to both. Conversely, when a situated conceptualization becomes active whose simulated action is incompatible with a current action, the supervisory attentional system must manage two competing actions. As a result, fewer resources are available for performing each individual task. If the cognitive task is learning words for a later memory test, fewer resources are available for encoding the words into memory.

In general, because higher cognition utilizes the motor system for simulating conceptual knowledge, cognition and action function optimally when they perform common motor activities. When they perform different activities, performance suffers, analogous to previous findings that working memory and response mode suffer when their representations compete for common modality-specific resources (e.g., Brooks, 1968; Segal & Fusella, 1970).

E. Direct versus Indirect Embodiment Effects

In the social literatures, theorists have discussed whether embodiment affects cognition directly or indirectly. For example, unconsciously adopting the facial musculature for a smile could directly produce positive evaluation of an object, such as a pen. Alternatively, adopting this facial musculature could activate an emotional state, such as happiness, which in turn produces positive evaluation. In this latter case, the effect of embodiment on evaluation is indirect, mediated by emotion.

Within the framework presented here, this is not a major issue. Indeed we would predict that both direct and indirect effects of embodiment should occur ubiquitously (which appears consistent with conclusions in the literature; e.g., Wheeler & Petty, 2000). There are at least two reasons why embodiment effects should sometimes be direct. First, automaticity is often defined as the withdrawal of mediating states between a stimulus and a response (e.g., Logan, 1988; Schneider & Shiffrin, 1977). The more a stimulus is consistently mapped to a response, the less necessary mediating states are for making the mapping. Instead the mapping can be made directly. Second, neuroscientists frequently note that the brain does not consist of a rigid set of linearly organized modules. To the contrary, pathways tend to link brain systems in a nonlinear, nonhierarchical manner. Many long-distance connections exist directly between brain systems that are not adjacent. Such an architecture is consistent with the view that the motor system is linked directly to many other brain systems, without mediating systems residing between them. From an evolutionary perspective, direct links would be advantageous for speeding actions related to survival and reproduction. Not surprisingly, evidence for direct links in social situations exists (e.g., Kawakami, Young, & Dovidio, 2001).

However, mediating structures may often link embodiment and cognition. In particular, pattern completion via situated conceptualizations offers a natural mediating mechanism. For example, bodily movements associated with positive emotion (e.g., upright posture, smiling, arm pulls) may activate situated conceptualizations that include positive affect. In turn, these affective states may become vicariously associated with neutral objects in the environment, such as a pen, thereby making these objects attractive.

Clearly it is important to identify the specific processing sequence that produces a particular embodiment effect. Sometimes these effects may be direct, and sometimes they may be indirect. To our minds, the more important finding is that embodiment plays a ubiquitous role in cognitive processing, both directly and indirectly. Even in indirect cases, embodied representations in situated conceptualizations are central to reasoning and behavior.

F. Amodal Accounts of Embodiment Effects

Some readers have undoubtedly been thinking throughout this chapter that classic amodal theories of representation can explain all of these embodiment effects. Technically they are right. Increasingly, however, their position faces challenges (e.g., Barsalou, 1999b; Glenberg, 1997; Lakoff, 1987; Newton, 1996).

One problem is that amodal theories can explain embodiment results because, in principle, they can explain anything. As theorists have noted, amodal theories have Turing machine power, which means that they can mimic any systematic pattern of results (e.g., Anderson, 1978; Pylyshyn, 1981). This power, however, comes at the cost of unfalsifiability. Because these theories can explain anything, it is impossible for any result to disconfirm them. Put in this light, the ability to explain embodiment effects is not particularly impressive. Amodal theories do not just explain embodiment effects, they explain all sorts of effects that may never occur.

When a theory is unfalsifiable, it can gain credence if it predicts crucial findings a priori. Thus we could ask whether amodal theories naturally

predict embodiment effects. To our knowledge, they do not. Researchers did not derive predictions for embodiment effects from amodal theories and then set out to test them. Furthermore, embodiment effects do not follow naturally from amodal theories for two reasons. First, these theories assume that knowledge and modality-specific systems are separate. Second, they tend to view knowledge as abstracting over modality-specific details. For these reasons, embodiment effects strike us, at least, as violating the a priori spirit of classic amodal theories.

Another problem for amodal theories is that, so far, little if any direct empirical evidence exists for amodal symbols in the brain. Instead researchers have adopted amodal representation languages for theoretical reasons (Barsalou, 1999b). Clearly, though, one would expect such an important theoretical assumption to have direct empirical support. The gaping lack of direct empirical evidence for amodal symbols suggests that something is amiss.

Perhaps powerful amodal accounts of embodiment effects will develop. Perhaps they will make striking predictions confirmed by the data. Perhaps direct evidence for amodal symbols will be found in the brain. Perhaps both modal and amodal symbols will be part of the theoretical story (Simmons & Barsalou, 2003b).

In the meantime, embodied theories naturally predict and explain these findings. Embodied theories not only anticipate the behavioral findings reported in this chapter a priori, they also anticipate large bodies of related neural evidence (e.g., Martin, 2001; Simmons & Barsalou, 2003b). In our opinion, embodied theories constitute a natural and motivated account of these findings. Furthermore, an increasingly strong empirical case can be made for modality-specific symbols in the cognitive system (e.g., Barsalou, 2003). Finally, embodied theories have inspired a considerable amount of research in recent years that probably would not have been conceived within the amodal framework (for reviews, see Barsalou, 2003; Glenberg, 1997; Martin, 2001; Richardson & Spivey, 2002).

V. Conclusion

Now that you have reached this point in the chapter, please relax in your chair, release your palm from pressing up on the table top, and remove the pen from your teeth. Hopefully, the desired effect has been achieved, namely for the first time in your career, you agree with every point stated in an article.

Social embodiment effects can be explained and unified with a few basic assumptions. First, the body is involved extensively in human activity. For this reason alone, it should not be surprising that bodily states have a central presence in human knowledge.

Second, people develop entrenched knowledge about frequently experienced situations—what we referred to as *situated conceptualizations*. Furthermore, this knowledge is likely to be represented as modality-specific simulations of situational components for the relevant people, objects, actions, introspections, and settings.

Third, when one of these components activates a situated conceptualization, inferences about the situation arise via pattern completion, with unperceived components simulated or executed as inferences. Embodied states can function as cues that trigger situated conceptualizations, or they can be the inferences that result from other components triggering conceptualizations.

Fourth, when current embodied states match those in the current conceptualization, processing is optimal. Embodied states facilitate processing via redundant states, multiple cues, and more available resources for individual tasks. Conversely, when embodied states are inconsistent with the current conceptualization, these benefits do not result.

Rather than being peripheral appendages to social cognition, embodied states appear central. As we have also seen briefly, embodied states are central to nonsocial cognition. We assume that our account of social embodiment provides an analogous account of nonsocial embodiment effects, with pattern completion via situated conceptualizations again providing the basic mechanism. In general, adopting an embodied view changes one's theorizing considerably and inspires empirical studies that would not otherwise be conceived. Given the fundamental importance of action for effective intelligence, it should not be surprising that embodiment is central to cognition in both social and nonsocial domains.

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