11

Embodied Social Thought: Linking Social Concepts, Emotion, and Gesture

Autumn B. Hostetter, Martha W. Alibali, & Paula M. Niedenthal

Social concepts, from relatively simple ones such as "handshake" to more complex ones such as "international relations," are fundamental for successfully anticipating and negotiating the interactions and situations that take place in daily social life. The set of social concepts includes emotion concepts, bases of knowledge that are critical for understanding one's own feeling states and for anticipating and perceiving the feelings of others (e.g., Niedenthal, 2008). Such concepts guide an individual's social behavior because they support acts of categorization, interpretation, and prediction about the attitudes, behaviors, and intentions of other individuals. For example, upon accepting an invitation to a jazz concert, we rely on our concept of this type of social situation in order to choose what to wear, what time to arrive, and how and when to applaud once we are there. We further rely on the concept when we decide to encourage our friend André to come along, but not our friend George. Recent theories of embodied social cognition hold that using a social concept involves reactivating motor, perceptual, and emotional experiences in the brain and in the body's periphery. The neural and peripheral activation of these experiences serve to represent the concept for use in negotiating the social world.

An embodied view therefore has profound implications for how we understand our social world. In this chapter, we will begin by reviewing the evidence that speakers understand others' intentions, emotions, and language through simulated action and emotion. We then show how such simulations are embedded in the social environment so that they are functionally linked to the situations in which they are used. Finally, we explore how an embodied account of social cognition can be extended to apply to abstract concepts.

SIMULATING CONCEPTS IN SOCIAL THOUGHT AND LANGUAGE

Access to and use of the concept of *jazz concert* in our opening example is relatively easy to understand. Here, the concept is primed directly through the act of linguistic communication about it (i.e., "Do you want to come to a *jazz concert*?"). However, we also understand concepts that are not articulated in the speech of those around us; often, we must form an appropriate conceptualization of a situation based only on the non-linguistic behavior of those around us. Our ability to do so is complicated by the fact that observable behaviors and events are not always straightforward instances of any particular concept. When we see a woman holding five grocery bags and struggling outside a door to find something in her purse, how do we know – as we do with great accuracy much of the time – that she is searching for her keys? She could be looking for any number of things. We seem to "know" that she is looking for her keys because we have the ability to put ourselves "in her shoes," as the old saying goes, and imagine what we would likely be looking for if we were in a similar situation. We perform the same act of perspective taking in the domain of emotion. Although his overt behavior may be quite disorganized or ambiguous, we know what our son is feeling when he receives an award at a ceremony or trips during a soccer game. So, what is the relationship between using a concept and imagining ourselves in a similar situation? According to some recent theories of the conceptual system, there is not much difference at all.

The ability to imagine that we are in someone else's shoes is more than just a charming expression. Recent discoveries in neurophysiology have demonstrated that there are cells in the motor system of primate brains that are activated both when an action is observed and when the action is produced. These *mirror neurons* were first observed in the brains of monkeys (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti & Craighero, 2004; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). Mirror neurons in the monkey's motor cortex, and in particular in area F5, which is responsible for controlling the production of hand and mouth movements, are now considered part of the neural system for comprehending action and intentional movement (Gallese et al., 1996; Rizolatti et al., 1996). Mirror systems that could support both the perception and performance of action have also been described in humans (Fadiga et al., 1995; Gallese et al., 1996; Iacoboni, et al., 1999; Rizolatti et al., 1996). The proposed cellular link between action and perception is groundbreaking because it suggests that understanding the actions of others is fundamentally linked to the experience of our own actions.

But possible accounts go beyond the mirror neuron. Indeed, in recent years, there have been an increasing number of proposals for how our ability to *simulate*, or engage our neural systems in a meaningful way, forms the basis for our ability to understand the actions, intentions, emotions, and language of others (e.g., Barsalou, 1999; Hurley, 2008; Kaschak & Maner, 2009; Sommerville & Decety, 2006; Wilson & Knoblich, 2005). Sometimes referred to as "embodied cognition," the thesis of such views is that cognition is based in our perceptual and motor abilities. Rather than processing the world in abstract, amodal terms that are distinct from motor and perceptual experiences, embodied views propose that cognition occurs because we can recreate motor and perceptual experiences even in the absence of environmental input (see Wilson, 2002). This recreation, or simulation, relies on the same areas of the brain that are involved in actually experiencing the event.

To return to the jazz concert example, then, when we use this concept, we are not simply accessing a definition of jazz (i.e., *a style of music, native to America, characterized by a strong but flexible rhythmic understructure with solo and ensemble improvisations on basic tunes and chord patterns and, more recently, a highly sophisticated harmonic idiom*) and combining it with a definition of concert (i.e., *a performance given by one or more singers or instrumentalists or both*). Instead, according to these accounts, when we think about the concept *jazz concert*, we simulate the experiences we have had at these events, including how they look, sound, and smell, and of course how they make us feel. This simulation relies on the activation of neural states that are also activated when we are actually attending a jazz concert.

Thus, according to embodied views of social cognition, we understand social concepts by simulating the actions and emotions involved in experiencing the concept. These simulations occur both when we directly perceive the actions or emotions of another person and when we process language about actions and emotions.

Simulation in social information processing

What indicates that someone is simulating a social situation or entity? Perhaps the most obvious manifestation of simulation in social comprehension is overt mimicry. Individuals mimic the nonverbal behavior of those with whom they interact (e.g., Kimbara, 2008), particularly when they perceive a similarity between themselves and their interaction partner (Yabar, Johnston, Miles, & Peace, 2006). Furthermore, engaging in mimicry seems to have advantageous social consequences; we like people better when they have mimicked us (Lakin & Chartrand, 2003) and we are more successful in negotiations when we have mimicked others (Maddux, Mullen, & Galinsky, 2008). Chartrand and Bargh (1999) describe mimicry as facilitating a behavior → perception link; by mimicking the behaviors of those around us, our social perceptions are enhanced.

However, simulation need not be overtly expressed as mimicry in order to influence our social understanding and behavior. Evidence suggests that our behavior is influenced even when we simply think about a particular social concept. For example, Bargh, Chen, and Burrows (1996) found that participants walked significantly more slowly down a hallway when they had just been primed with the stereotype of the elderly than when they had not been primed. In this case, thinking about the elderly appears to have activated the motor system in a way that corresponds to how the elderly often move; the motor system activation then influenced the participants' own subsequent motor activity. In another compelling example, Dijksterhuis and van Knippenberg (1998) found that participants who were primed with the concept of college professors performed significantly better on a subsequent trivia test than did participants who were primed with the concept of soccer hooligans. Such evidence suggests that thinking about social categories unconsciously determines subsequent behavior.

The relation between embodied concepts and behavior holds in the opposite direction, as well. Engaging in a particular motor activity primes corresponding concepts of social situations. For example, Schubert (2004) found that males were more likely to interpret ambiguous situations as relating to the concept of power when they simultaneously made a fist gesture than when they were in a neutral posture. Similarly, in another study, participants were more likely to interpret an ambiguously hostile behavior as aggressive when they simultaneously extended their middle finger than when they did not (Chandler & Schwarz, 2009). These findings suggest that producing a particular action automatically activates knowledge of the situations that are associated with the action. This knowledge then influences the perception of an unrelated situation.

In addition to influencing the categorization of social situations, motor activity appears to guide the categorization of persons as well. In a recent study, Nussinson, Seibt, Häfner, and Strack (2010) had participants view photographs of target individuals while engaging in either an approach motion (flexing the arm in) or an avoidance motion (extending the arm out). Participants were then asked to evaluate how similar the targets were to themselves. Nussinson et al. found that participants believed that the targets were more similar to themselves when they had viewed them while engaged in an approach motion than when they had viewed them while engaged in an avoidance motion. Such findings suggest that when we first encounter someone, engaging in actions that we associate with approach makes us more prone to think that the person is worthy of approaching.

Simulations can also affect the level of specificity with which we think about the actions of others. Libby, Shaeffer, and Eibach (2009) compared participants' tendencies to describe the actions of others (e.g., a person mailing a letter) as concrete (e.g., mailing a letter) or abstract (e.g., communicating). Participants were more likely to interpret the actions of someone else in a concrete way when they imagined the actions from a first-person perspective. In contrast, when they imagined the actions from a third-person perspective, they were more likely to describe the actions in an abstract way. Thus, the specific nature of a particular simulation and whether it relies more on first-person motor simulation or third-person visual simulation influences how abstractly the action is thought about.

Taken together, the evidence outlined above suggests that current motor states, even if irrelevant to the task at hand, can influence and disambiguate social perceptions of situations and entities. Several recent proposals have built on this evidence to articulate how motor simulation might form the basis of all social understanding and interaction (e.g., Decety & Stevens, 2008).

For example, the Shared Circuits Model (SCM) (Hurley, 2008) proposes five layers of progressively more complex abilities that are necessary for human social interaction. First, the SCM proposes that the basis of social interaction is dynamic online motor control, or the ability to adjust motor output given various sensory input. Second, the SCM proposes that online motor control is extended to predict what sensory effects various motor actions will have on the system. Third, the ability to predict sensory effects from motor actions is reversed, so that it is also possible to predict motor actions that will cause various sensory effects. This reversal occurs through mirroring, or activating a motor signal in response to an input sensory signal. Fourth, inhibition is possible, in that it is possible to prevent the motor signals that are automatically generated in response to sensory input from being overtly produced as behavior. Fifth, counterfactual input is possible, such that it is possible to generate motor signals from imagined sensory inputs. Thus, according to the SCM, we understand the actions of others because our cognitive systems are highly adept at generating motor signals from sensory signals and vice versa. We understand one another's actions by engaging our own capacity for similar action, and this happens both when we see another individual's actions as well as when we imagine another individual's actions. Further, it happens regardless of whether we overtly mimic the behavior or inhibit the activated motor signal from being produced.

The Shared Circuits Model (Hurley, 2008) is only one model for how our ability to understand the actions of others might be rooted in the simulation of their actions in our own cognitive system, and to date, there have been no direct empirical tests of the model's claims. However, as the evidence reviewed above suggests, it appears that understanding of others' intentions and actions is connected to, and perhaps caused by, corresponding motor activity. We next consider whether similar motor activity is connected to our understanding of emotions.

Simulation in emotional understanding

Just as we understand the actions of others by simulating their movement in our own motor systems, we may understand the emotions of others by simulating their affective states in our own emotional systems. The idea that producing affective states in the brain and in the body's periphery is critical in representing emotional meaning, and therefore for understanding incoming emotional information, is gaining in popularity (e.g., Atkinson, 2007; Decety & Chaminade, 2003; Gallese, 2003, 2005; Goldman & Sripada, 2005; Keysers & Gazzola, 2007; Niedenthal, 2007; Winkielman, McIntosh, & Oberman, 2009). In this section we review empirical evidence for the claim that people simulate the emotional behaviors of others and that these simulations ground emotional information processing tasks. These behaviors may include, but are not limited to, facial expressions, postures, and vocal parameters that convey emotion. A full review of such effects can be found in Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric (2005). We focus in particular on facial expression here.

In a now classic study, Adolphs and colleagues (2000) instructed 108 patients with a variety of focal brain lesions and 30 normal control participants to perform three visual emotion recognition tasks. In the first task, participants evaluated the intensity of basic emotional facial expressions. In the second task, participants matched a facial expression to its name. In the third task, participants sorted facial expressions into emotional categories. Though each task identified a slightly different group of critical brain regions, damage to primary and secondary somatosensory cortices impaired performance in all three tasks. The finding is now seen as the empirical generator of the notion that emotional information processing involves simulating the relevant state in the perceiver using somatosensory resources (Niedenthal, 2007).

More recently, Pitcher, Garrido, Walsh, and Duchaine (2008) further explored the idea that facial expression recognition is supported by somatovisceral responses linked with the perceived expression. In that experiment, repetitive transcranial magnetic stimulation (rTMS) was used to temporarily inhibit the right occipital face area (rOFA) and the face area of the right somatosensory cortex (rSC) during a facial expression or facial identity discrimination task. Over trials, participants saw pairs of faces (sample and target pictures) separated by a brief interval. The faces expressed one of six emotions – happiness, sadness, surprise, fear, disgust, and anger – and participants had to recognize the emotion expressed in each face. Results showed that accuracy on the recognition task was reduced for stimulation of both rOFA and the face regions of the rSC. Other findings indicated that stimulation at these sites did not have similar disruptive effects on a face identity task.

There is also evidence for the selectivity of central mechanisms in embodied simulation of specific emotions. Wicker, Keysers, Plailly, Royet, Gallese, and Rizzolatti (2003) had participants inhale odors that generated feelings of disgust. The same participants were later exposed to videos of other individuals expressing disgust. Areas of the anterior insula and, to some extent, the anterior cingulate cortex were activated both when individuals experienced disgust themselves and when individuals observed disgust in others, presumably reflecting simulation. This interpretation is further supported by evidence that damage to the insula results in a corresponding impairment in the experience and recognition of disgust (Calder, Keane, Manes, Antoun, & Young, 2000).

Embodied simulations may be particularly important in decoding emotional signals that are nuanced and complex. Take, for example, the smile. Some smiles express happiness or enjoyment. Other smiles express friendliness or desire for affiliation. Still others express dominance or power (Niedenthal, Mermillod, Marginer, & Hess, 2010). Although the meaning of smiles can sometimes be inferred from the social situation in which they occur, there are few simple physiological markers that definitively distinguish between types of smiles. Yet, most people are able to interpret smiles correctly. For example, when our boss presents a dominance smile, we typically do not mistake it for an affiliative smile and invite him or her out to lunch.

The problem of interpreting nuances in facial expressions can be solved through the use of facial mimicry: i.e., by engagement of the body's peripheral systems as well as central ones. It seems that by mimicking the smiles and other facial expressions of those we encounter, we can gain a better understanding of the nuanced meaning of the expression. People do occasionally mimic the facial expressions of those around them; from the time they are only a few hours old, infants mimic the facial expressions of adults (Meltzoff & Moore, 1977). Adults also mimic facial expressions. For example, Dimberg, Thunberg, and Elmehed (2000) found that adults mimicked positive and negative facial expressions seen in photographs, even when the photographs were displayed for only 30 ms and were thus not consciously perceived. Taken together, this evidence suggests that humans have a tendency to mimic facial expressions that is both innate and unconscious. There is evidence that mimicking facial expressions can improve speed of recognition of the emotion displayed (e.g., Stel & van Knippenberg, 2008) as well as accuracy for fine-grained distinctions in facial expressions (e.g., Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001). Furthermore, facial mimicry is positively related to empathy (e.g., Sonnby-Borgström, 2002; Zajonc, Adelmann, Murphy, & Niedenthal, 1989).

The importance of facial mimicry in the processing of facial expression of emotion is supported empirically in a pair of studies by Maringer, Krumhuber, Fischer, and Niedenthal (2011). In their first study, they exposed participants to animated smiles that were empirically derived and validated as possessing the characteristics of "true" and "false" smiles (in Krumhuber, Manstead, & Kappas, 2007). The participants saw 20 smiles in all and judged the extent to which each seemed to be a "genuine" (i.e., true) smile. Half of the participants saw only true smiles and the other half saw only false smiles. Furthermore, type of smile was fully crossed with ability to mimic the smiles as they were presented. Thus, half of the participants could freely mimic these expressions, while the remaining participants held a pencil in their mouths so that facial mimicry was effectively inhibited. The results showed that, as expected, free mimicry participants perceived the "true" smiles as being significantly more genuine expressions than the "false" smiles, consistent with the validation studies. However, the mimicry-blocked participants did not perceive a distinction between the two types of smiles; they judged true and false smiles as being equally genuine. Thus, in this case, the perceptual differences did not do the work that feedback from mimicry could provide.

The second study by Maringer et al. (2011) demonstrated that when mimicry is blocked, other situational information is used rather than motor feedback. In that study, participants were exposed to only true smiles. However, they were told either that the smiles occurred in a social situation in which a true smile is expected (according to cultural beliefs and stereotypes) or that the smiles occurred in a social situation in which a false smile is expected. Free mimicry was again blocked in half of the participants, and all participants rated the genuineness of the smiles. The results of this second study demonstrated that free mimicry participants did not use their expectations of the likelihood of a true versus false smile in the given social situation to rate the genuineness of the smiles. On the other hand, when mimicry was inhibited, smiles that occurred in situations typically associated with true smiles were evaluated as more genuine than those that occurred in situations typically associated with false smiles.

The mimicry findings just reviewed are consistent with the Simulation of Smiles (SIMS) model (Niedenthal et al., in press). The SIMS model proposes that embodied simulations of smiles are triggered in the perceiver by eye contact with the person who is smiling. These simulations involve neural activation in the brain's reward centers of the basal ganglia and motor regions that support motor mimicry. Activation in the motor cortex then activates other relevant brain areas, depending on the type of smile. For example, enjoyment smiles activate the somatosensory cortex, while affiliative smiles also activate the orbitofrontal cortex, which is associated with attachment-related positive affect. This differential neural activity results in very different subjective feelings associated with each type of smile. For example, when the orbitofrontal cortex is activated during the simulation of an affiliative smile, the perceiver experiences positive emotions of attachment and intimacy.

An embodiment model such as the SIMS can be extended to define the neural and bodily "feeling" or meaning of different facial expressions, those other than smiles as well (e.g., Adolphs, 2002; Atkinson, 2007). In addition, all such models need to combine social behavior with the central and peripheral responses of the body in order to be productive.

The SIMS model and the evidence reviewed above suggest that individuals simulate or overtly mimic the facial expressions of those they see. There is also evidence, however, that individuals simulate facial expressions when they are merely thinking about a particular emotion concept. Niedenthal, Winkielman, Mondillon, and Vermeulen (2009) showed that the conceptual processing of emotions involves the production of a corresponding facial expression. For instance, in one study, some participants made emotion judgments about the meaning of emotional concepts such as *CUDDLE*, *SMILE*, *POCKET*, *VOMIT* or *MURDER*. Other participants saw the same concepts but had to indicate whether they were written in capital letters or not. During the emotion or typeface judgment task, the activation of muscles that support facial expressions of anger, disgust, and joy were measured with electromyographic (EMG) recording. Results showed that participants judging the emotional meanings of concepts produced corresponding facial expressions during this task. However, the participants who only had to judge the typeface made no such facial expressions. A follow-up study provided evidence that the simulation of the concept was functional and specific to the requirement of representing the emotional meaning of the word (see also Foroni & Semin, 2009).

Thus, the ability to simulate or mimic facial expressions is important, not only to the ability to process the emotional expressions of those around us but also to the ability to conceptually understand emotional concepts more generally. We next turn to the role of embodied simulation in understanding language about actions and emotions, with an emphasis on how simulations might be expressed in gesture.

Simulation in processing language and gesture

Over the past decade, it has become increasingly evident that the same embodied simulations that support processing of social actions and emotions are also involved in processing language about actions and emotions. Rather than manipulating amodal symbols, language comprehenders appear to run motor and emotion simulations that engage their brains in ways that mimic the behaviors they are reading or hearing about (see Spivey, Richardson, & Gonzales-Marquez, 2005 for a review). The evidence to support this claim comes from a variety of sources, which we review here.

First, studies demonstrate facilitation in sentence comprehension when speakers are engaged in a secondary task that involves their motor, perceptual, or emotional system in a manner complementary to the action, perception, or emotion implied in the sentence they are reading or hearing. In a classic demonstration of this phenomenon, Glenberg and Kaschak (2002) showed that readers are faster to comprehend a sentence like "Open the drawer," which implies motion toward the body, when they respond by moving their hand toward their body than when they respond by moving their hand away from their body. The effect also occurs for actions that are even more specific to particular objects. Masson, Bub, and Warren (2008) trained participants to engage in particular hand grasps following cues. They then cued participants to engage in particular grasps while simultaneously reading them sentences about different objects. They found facilitation for hand grasps that matched the grasp that would be used to manually interact with the object in the sentence. For example, hearing a sentence "The lawyer saw the calculator" primed participants to produce a motion in which their index finger pushed downward.

Similar findings have been reported for sentences about emotion. Havas, Glenberg, and Rinck (2007) had participants produce facial expressions of positive and negative emotions while reading sentences that described either positive or negative valence. They found that participants were faster to judge sentence valence and sensibility when there was a match between their facial posture and the sentence valence (e.g., smiling and reading a happy sentence) than when there was a mismatch (e.g., frowning and reading a happy sentence).

Second, participants experience modality-specific interference in comprehension and semantic judgment tasks. For example, Pecher, Zeelenberg, and Barsalou (2003) showed that people take longer to recognize *TART* as a characteristic of *CRANBERRIES* if they have just judged *RED* as a characteristic of *APPLES* than if they have just recognized *SWEET* as a characteristic of *APPLES*. This suggests that there is a cost involved in switching perceptual modalities, even when the particular perceptual modalities are not relevant to the task. More recently, Bergen, Lau, Narayan, Stojanovic, and Wheeler (2010) found that people have a harder time rejecting an image as corresponding to a particular verb if the action in the image is performed with the same effector as the verb. For example, a picture of a person kicking is harder to reject as being inconsistent with the verb *WALK* than is a picture of a person punching. This evidence suggests that language comprehension is not only facilitated by the engagement of motor and perceptual systems but also that the engagement is actually both modality and effector specific.

Finally, temporarily disabling the ability to simulate an action or emotion temporarily interferes with the ability to process words describing those actions or emotions. Neuroimaging studies have consistently demonstrated that the same cortical areas that are involved in producing an action are also involved in reading words that describe those actions (Pulvermüller, 2005). Delivering TMS to areas of motor cortex impairs the processing of words that describe actions that would be performed with that area (Pulvermüller, Hauk, Nikulin, & Ilmoniemi, 2005). For example, disabling the arm area of motor cortex inhibits recognition of the word *PICK* but not *KICK*. In contrast, disabling the leg area of motor cortex inhibits recognition of *KICK* but not *PICK*. Furthermore, Havas, Glenberg, Gutowski, Lucarelli, and Davidson (2010) examined the effects of BOTOX injections, which temporarily paralyze the facial muscles used in frowning, on sentence processing. They found that patients who had just received BOTOX were slower to read sentences that described negative affect than they were 2 weeks later when the paralyzing effect of BOTOX had worn off. This evidence suggests that simulation is not only involved in language processing, but that without it, language processing is actually impaired.

If the motor system is involved in comprehending sentences, why don't comprehenders routinely act out the sentences they read about? One possibility is that motor simulation may be enough to facilitate understanding; overt motor activity may not be necessary and thus would be a waste of resources in the majority of situations. For example, Willems, Hagoort, and Casasanto (2010) found that reading action verbs (e.g., *PICK*) activated premotor cortex areas that are associated with the hand, but forming an explicit motor image of performing the action activated hand-related areas of both premotor and motor cortex. Thus, it is possible that language comprehension does not necessarily rely on effortful imagery that involves the motor cortex, but instead relies on simulation that occurs less effortfully in the premotor cortex.

Although people do not generally act out the actions they read about, people do quite frequently act out the actions they talk about. Speakers often produce representational gestures that depict the information they are describing (McNeill, 1992). Hostetter and Alibali (2008) have argued that these hand gestures are actually visible reflections of the involvement of motor simulation during language production. According to their Gesture as Simulated Action (GSA) framework, thinking in the interest of producing language naturally relies on simulations of perception and action. These simulations activate the motor system, and when the activation reaches a certain threshold, the activation is produced as a co-speech manual gesture.

As evidence for this claim, Hostetter and Alibali (2010) had participants describe patterns of dots that were connected by lines to form shapes. In half of the trials, participants constructed the patterns by placing small wooden pieces on the table in the position of the dots in the pattern. In the remaining trials, participants only viewed the pattern on a computer screen before describing them. Hostetter and Alibali found that speakers gestured at a higher rate when describing the pattern they had physical experience making than when describing the pattern they had only viewed. This finding is in line with the GSA framework and suggests that speakers gesture when they are thinking about the information they are describing in terms of actions.

The GSA framework predicts that speakers should gesture more with speech about ideas that are highly activated, because motor activation from highly activated simulations should be more likely to exceed the threshold for overt production of gestures. This contrasts with other theories of gesture production, which predict that speakers should gesture more when speech is more difficult to produce (e.g., Krauss, Chen, & Gottesman, 2000). Sassenberg and Van der Meer (2010) addressed this issue in a study of the gestures that speakers produced as they described routes to a listener. Importantly, they compared the gestures that speakers produced the first time that a particular turn was described to those produced when the turn was re-described as the first part of another route. Speakers produced more gestures when re-describing a turn than when describing the turn initially, suggesting that gestures are more likely to accompany representations that are particularly active (because they have been imagined before) than to accompany representations that are particularly hard to describe (because they have never been described before).

If gestures are reflections of simulated action, as the GSA framework claims, why do speakers so frequently produce simulated actions as overt movements when they are speaking but not when they are reading or listening? There are a couple of possibilities. First, the GSA framework contends that it may be difficult to prevent the premotor activity involved in simulation from spreading to motor cortex when the motor system is engaged in the simultaneous task of speaking (Hostetter & Alibali, 2008). Second, it is possible that simulation during language production involves more effortful formation of imagery than does simulation during language comprehension. If this is the case, the simulations needed for successful production may require stronger activation than those required for successful comprehension, and this stronger activation may be more likely to result in gestures. Further research is needed to explore these two possibilities.

Although the GSA framework was conceptualized as a way of explaining how gestures come to be produced, its embodied cognition stance also has implications for how gestures are comprehended. There is much evidence that listeners have better comprehension for messages that are accompanied by gesture than for messages that are not accompanied by gesture (e.g., Church, Ayman-Nolley, & Mahootian, 2004; Hostetter, in press; Valenzeno, Alibali, & Klatzky, 2003). One possibility for why comprehension is facilitated when speech is accompanied by gestures is that listeners simulate a speaker's gestures the same way they simulate the actions of others more generally. This simulation may then result in understanding of the gesture's meaning, which facilitates comprehension of the message as a whole (see Alibali & Hostetter, in press).

In sum, there is much evidence to suggest that understanding the social world involves activation of motor and emotional simulations. Furthermore, these same simulations are involved when we produce and comprehend language about the social world. Next we review theory and research that suggests that simulations are embedded in the social environment, so that they are functionally linked to the situations in which they are used.

EMBEDDEDNESS OF SOCIAL THOUGHT AND LANGUAGE

One of the central tenets of embodied theories is that cognition is not isolated in the mind of the cognizer; instead, it is *situated*, or embedded in the context in which it occurs. Social cognition is intimately intertwined with the environment in that it depends on features of the physical and social environment, it is employed in service of adaptive action in the world, and it sometimes utilizes external objects and representational systems in the service of achieving goals (e.g., Anderson, 2003; Nathan, 2008; Wilson, 2002).

Many lines of research have shown that cognitive processes depend on the specifics of the current situation. Even basic perceptual processes show effects of context. For example, Goldstone (1995) showed that participants' perceptions of the colors of objects were influenced by their category membership as determined by their shape. Objects that belonged to categories that contained redder objects were judged as being more red than objects of the same hue that belonged to other categories. Context also influences higher-level processes, such as categorization, strategy choice, and logical reasoning (e.g., Barsalou, 1983; Carraher, Carraher, & Schliemann, 1985; Griggs & Cox, 1982; Kotovsky, Hayes, & Simon, 1985; McNeil & Alibali, 2005; Yeh & Barsalou, 2006). Many aspects of the context can be relevant, including the task, features of the physical environment, and features of the social context, such as the setting, the participants, their roles and goals, the nature of the social interaction, and the broader cultural norms for the activity and interaction. Another set of potentially relevant features includes the material tools, notational systems, and technological resources that are available in the context.

The notion of simulated action, discussed in the preceding section, is compatible with the view that cognition is embedded in situations. Thus, Barsalou (2008) argues that, "If a conceptual representation simulates a perceptual experience, it should simulate a situation, because situations provide the background of perceptual experience." (p. 241). From this perspective, concepts are never fully removed from the situations in which they are experienced and learned.

An embodied perspective also highlights the *functional* relevance of cognitive processes in enabling adaptive activity. One widely shared perspective is that cognition is "for" action – that is, we perceive, remember, categorize, and reason in order to act in the world in ways that promote our survival and well-being (e.g., Gibson, 1979). Glenberg (1997) argues that the function of memory is to encode and store information relevant to possible patterns of interaction in the physical and social world. Along similar lines, Barsalou (1983) holds that people construct categories online, as needed to achieve their goals. When important for intended action, people readily create "ad hoc categories," such as *items to sell at a garage sale* or *items to take out of a burning house*. Thus, cognitive processes such as perception, memory, and categorization are employed for practical ends that involve actions in the world.

Cognitive processes also sometimes utilize physical objects and external representational systems in strategic ways. People use the environment, either consciously or unconsciously, to store, represent, and manipulate information. For example, I might count on my fingers when determining the number of people who will be attending a party, or I might make a shopping list to help me remember items I wish to purchase at the grocery store. I might use pencil and paper – or perhaps a calculator or spreadsheet – to plan my monthly budget or to figure out how much money I should transfer between my savings and checking accounts. In each of these examples, some aspects of the cognitive work required for a task are *off-loaded* onto the environment (Kirsh & Maglio, 1994; Wilson, 2002). In this sense, the environment is part of the cognitive system.

This same sort of off-loading can also occur with the social environment, as illustrated by the phenomenon of *transactive memory*, which is memory that is shared across individuals (Wegner, Erber, & Raymond, 1991; Wegner, Giuliano, & Hertel, 1985). People in social structures such as dyads or groups need not encode or store all of the information that the structure needs to function. Instead, people store some information themselves, and they remember who in their social group has stored other important information. When that other information is needed, people rely on others' memories. For example, a husband may take the wheel of the car knowing that he does not know how to get to the current destination, but confident that his wife does know the way.

In the following sections, we review research on the ways in which social cognition is shaped, constrained, and even augmented by the physical and social situations in which it occurs. We also consider how language and gesture manifest the embedding of social cognition in situations.

Embeddedness of social and emotional information processing

Like all cognitive processes, social cognition is embedded in situations (Smith & Semin, 2004). As one illustration, a large body of work, reviewed by Blair (2002), suggests that "automatic" stereotypes and prejudice depend both on contextual factors and on the perceiver's goals and intentions. For example, in one study, Wittenbrink, Judd, and Park (2001) found that the same Black faces elicited different racial attitudes depending on the context in which they were presented (e.g., when shown on a street corner vs in a church). In another study, Richeson and Ambady (2003) provided White participants with different goals for an upcoming interaction with a Black partner: either to evaluate the partner's performance, to get along with the partner, or to manage the impression they would make on the partner, who would later evaluate them. Later, participants' implicit prejudice was assessed. Participants who expected to evaluate the partner showed a higher level of prejudice, and those who expected to be evaluated by the partner showed a lower level of prejudice. These studies demonstrate that activation of social stereotypes depends crucially on aspects of the current situation.

In turn, there is evidence that social aspects of situations affect other aspects of cognitive processing. For example, activating social stereotypes can affect basic perceptual processes. Chambon (2009) asked young participants to complete a task that covertly primed the stereotype of the elderly, and then asked them to estimate either the steepness of an incline, or the distance across a grassy field to a target cone. Compared to controls who were not primed, participants for whom the stereotype was primed estimated the inclines to be more steep, and the distance to be farther. Thus, activation of the stereotype affected perceptual judgments.

The processing of emotional information is also affected by context. In addition to (external) social context, researchers have been interested in the (internal) ambient emotional state of the individual as well as the emotional state of the group in which the individual is a member. Emotional state is itself a cognitive context and, as such, it guides the way in which incoming emotional information is encoded and represented.

That emotional information processing is embedded in the social context is well known. An old example is that of canned laughter. Canned laughter is intended to provoke an audience's mirth, positive affective state, and ultimately a positive attitude toward a television series or a product for sale. An experiment by Bush, Barr, McHugo, and Lanzetta (1989) is particularly relevant in demonstrating the information processing effects of canned laughter. Bush and colleagues had participants watch video excerpts of comedy routines. For half of the participants, the video excerpts included close-up images of the faces of various people laughing, and for half of the participants the excerpts contained no such images. The activity of participants' facial muscles involved in producing smiles and participants' evaluations of amusement were measured. Results showed that muscle activity associated with happiness as well as self-reported amusement were higher in the condition in which the videos contained close-up inserts of people laughing than when the images of laughing faces were not presented. Thus, the social context determines a perceiver's responses to incoming emotional information.

Emotional information processing is embedded in the social context in other ways as well. We noted previously that some early research suggested that facial mimicry is fast and often automatic (e.g., Dimberg et al., 2000): however, recent research has demonstrated that there are contextual constraints on facial mimicry. In a study by Likowski and colleagues (Likowski, Muhlberger, Seibt, Pauli, & Weyers, 2008), for instance, single word descriptors were paired with target faces to induce positive or negative attitudes towards the faces. Attitudes modulated facial mimicry of the targets' expressions, such that negative attitudes suppressed mimicry. Further studies have shown that mimicry can be moderated by meaning of the social context for the perceiver (Bourgeois & Hess, 2008), task relevance (Cannon, Hayes, & Tipper, 2009), the perceiver's emotional state (Moody, McIntosh, Mann, & Weisser, 2007), the subliminal priming of competition (Weyers, Muhlberger, Kund, Hess, & Pauli, 2009), empathy (Sonnby-Borgström, Jonsson, & Svensson, 2003), and by levels of circulating testosterone (Hermans, Putman, & van Honk, 2006). Thus, how emotional expressive information is processed depends also on the social context in which it is encountered and the goals and motives that the context engenders.

The internal emotional state of the individual has also long been considered a contextual determinant of emotional information processing. Halberstadt, Niedenthal, and Kushner (1995) showed, for instance, that participants who were in a sad emotional state were more likely to access the sad meanings of homophones (i.e., pairs of words that sound the same but have different meanings) than were participants in a happy emotional state. For instance, the sad individuals were more likely to write down the word *mourning* instead of *morning* when they heard the word/ môrnng/. The finding was recently replicated and extended using emotional prosody by Nygaard and Queen (2008), in a study involving words that had either a happy, sad, or neutral meaning. Emotional meanings were fully crossed with prosody of the utterance, such that each word was said in three tones of voice (happy, sad, and neutral). Latency to word naming (i.e., repeating the word that was heard) was the variable of interest. Emotional tone of voice facilitated linguistic processing of emotional words in an emotion-congruent way, suggesting that emotional vocal context determines the processing of linguistic content.

More recently, Halberstadt, Winkielman, Niedenthal, and Dalle (2009) recorded EMG of facial muscles to show how emotional language constrains the processing of facial expressions of emotion. In the study, participants first encoded emotionally ambiguous faces in terms of specific emotion concepts ("angry" or "happy"). They then later viewed the faces passively, without the concepts. Memory for the faces and facial muscle activity were measured. At initial encoding, participants displayed more smiling-related EMG activity when looking at faces paired with ''happy'' than when looking at faces paired with "angry." Later, in the absence of associated conceptual context, participants were perceptually biased to remember happiness-encoded faces as happier than anger-encoded faces. More importantly, during the passive re-exposure to the ambiguous faces, EMG measures indicated spontaneous emotion-specific mimicry, which in turn predicted perceptual memory bias. That is, when seeing a happiness-encoded expression, individuals spontaneously mimicked happiness, while those who had encoded the same face in terms of anger did not spontaneously mimic happiness. No specific EMG activity was observed when participants encoded or viewed faces with valenced concepts not related to emotion, or when participants encoded or viewed Chinese ideographs. The findings constitute evidence of context-driven changes in emotion perception; participants simulated (and perceived) facial expressions differently depending on the context in which they initially encountered the face.

Taken together, the studies summarized in this section suggest that the processing of emotional information is influenced and constrained by the external social and emotional context as well as the current internal, ambient state of the individual. In what follows, we argue that language and gesture are influenced and constrained in similar ways, as communication is also deeply embedded in context. Speakers' choices of particular ways of communicating depend crucially on aspects of the physical and social environment, and these choices profoundly influence the effectiveness of their communication.

Embeddedness of language and gesture

Communication always occurs in context. For communication to be successful, addressees must be able to reference the speaker's message to objects, events, or concepts that are currently present or that can be imagined or remembered. This is the central tenet of the Indexical Hypothesis (Glenberg & Robertson, 1999, 2000). For example, when a listener comprehends the statement, "Blue cheese is delicious", the listener may index the noun "blue cheese" to a wedge of cheese that is physically present, or to a mental representation of cheese that includes perceptual information, such as information about how blue cheese looks, tastes or smells. In order for the utterance "blue cheese is delicious" to be properly understood, the listener must know what cheese the speaker is referring to. One option, of course, would be for the speaker to clearly articulate precisely which cheese he or she is referring to (e.g., "The blue cheese on the cracker I am eating is delicious"). But such preciseness takes cognitive effort, and speakers are rarely this precise in their utterances.

Instead, research on *audience design* in language production (e.g., Clark & Murphy, 1982; Horton & Gerrig, 2005) suggests that speakers tailor their utterances to the knowledge and needs of their addressees. In the blue cheese example, the speaker may know that the listener has just seen him or her eat a particular blue cheese, and thus assumes that the listener will index "blue cheese" to the blue cheese that was just eaten.

Alternatively, rather than relying solely on the knowledge of the addressee, speakers may index their speech to the environment though gesture, for example, by pointing to the relevant cheese on the table. Speakers' spontaneous gestures are a concrete, physical manifestation of the indexing of speech to the physical environment. Pointing gestures are a prime example of what Goodwin (2007) has called "environmentally coupled gestures," because pointing gestures are generally uninterpretable without the environmental ground that gives them meaning. Speakers commonly use pointing gestures to directly index objects, people, or locations that are physically present, and as such, pointing gestures are deeply dependent on context.

Perhaps surprisingly, speakers can also use pointing gestures to index objects, events, and situations that are not present, in at least three distinct ways (Butcher, Mylander, & Goldin-Meadow, 1991; Morford & Goldin-Meadow, 1997). First, speakers point to perceptually similar objects to index non-present objects. For example, a speaker might point to the bleu cheese that is physically present, to refer to another variety of bleu cheese that she tasted on another occasion. Second, speakers sometimes point to physical locations to index objects or people that are associated with those locations. For example, a child may point to her father's place at the dinner table when referring to her father, even when he is not at home. Third, speakers sometimes metaphorically locate people or objects in their gesture space, and then point to these locations to index those objects or people. For example, McNeill (1992) described a speaker – talking about a movie plot – who used different spaces to represent the "bad guys" and the "good guys", and pointed to those spaces to index those characters over the course of his narrative (p. 155). As these examples illustrate, gestures "anchor" the information expressed in the verbal channel in the physical and material world, either literally or metaphorically (Williams, 2008). In so doing, such gestures manifest the grounding of speech in the physical environment.

Speakers produce other types of gestures besides pointing, and there is evidence that the meaning and production of other gestures is also embedded in the physical and social environment. Iconic gestures are movements that depict the semantic meaning of speech in some way (McNeill, 1992). For example, imagine a speaker who says, "That cheese was delicious" while making a circle of her thumbs and index fingers. The speaker is likely indicating that the particular cheese being referenced was in a circular wheel. Furthermore, the speaker may use this gesture with the referring expression "that cheese" because she knows that only one of the cheeses at the party that she and her listener just attended was presented in a wheel. Thus, the knowledge shared by speaker and listener shapes the gesture and linguistic expression the speaker uses to make reference.

The effects of shared knowledge on the production and interpretation of iconic gestures have been documented in several studies. For example, Gerwing and Bavelas (2004) found that the preciseness of a particular gesture is related to whether or not the gesture conveys information that is already known to the listener. As common ground between speaker and listener increases, gestures become less precise and informative, and also less frequent (see Holler & Stevens, 2007).

In addition to considering common knowledge, speakers are influenced by other characteristics of the social situation as well. Bavelas, Kenwood, Johnson, and Phillips (2002) asked speakers to describe a picture to a recipient who would either see a videotape of their description or hear an audiotape. Speakers gestured at a higher rate and used more non-redundant gestures when they expected that their listeners would see the videotape. Speakers also alter the size and orientation of their gestures as a function of characteristics of the audience. Hostetter, Alibali and Schrager (2011) found that speakers produced more "large" gestures (defined as gestures that crossed outside of neutral space) when they expected their listeners to cooperate with them than when they expected their listeners to compete with them in a game that involved navigating a complex spatial layout. Along similar lines, Özyürek (2002) found that speakers altered the orientation of their gestures depending how their gesture space intersected with the gesture space of their addressees. Taken together, these findings suggest that speakers tailor their gestures to the physical position, expectations, and information needs of their listeners. At a more general level, these findings support the view that cognitive processes such as language and gesture production depend on the particulars of the situation in which they occur.

More broadly, research on communication in language and gestures highlights the fact that cognition is deeply social (see Smith & Semin, 2007). In this regard, it is worth emphasizing that the social nature of cognition goes far beyond the constraining or augmenting effects of social context. Many tasks – for example, raising a barn, performing surgery, performing a military maneuver, navigating a large ship, perhaps even conducting a psychological experiment – extend beyond the capabilities of any single individual, and instead require collaborative action that is mediated by social communication with language and gesture (see Hutchins, 1995). In such cases, it is difficult to say where the cognitive system begins and ends. Cognition is located in the collaborative, communicative process, and in the technical tools that are utilized in the activity, rather than in the mind of any single individual. Communication is an integral aspect of cognition, and the situatedness of communication underscores the situatedness of cognition more generally.

EMBODIMENT AND ABSTRACTIONS

It seems straightforward for an embodied account of cognition to explain understanding of concepts that are concrete and directly based on perception or action. For example, it is easy to imagine how a person's concept of "jazz concert" could be based on perceptions of associated objects (e.g., saxophone, microphone), actions (e.g., dancing, playing music), and bodily experiences (e.g., the sound of the music, the smell of the night). However, it is more challenging for embodied theories to account for abstract concepts, which do not share diagnostic perceptual features, such as "mentor" or "fair-weather friend." Indeed, one of the most commonly raised objections to embodied theories is that they are not able to handle abstractions.

One response to this objection is that we understand abstract domains metaphorically, by analogy to experience-based domains (e.g., Boroditsky & Prinz, 2008). This view builds on the work of Lakoff and Johnson (1980), who argue that the human conceptual system is largely metaphorical. Importantly, many fundamental metaphors are based on image schemas for space, action, forces, and other aspects of bodily experience. For example, we conceive of ideas as objects, the mind as a container, the passage of time as movement in space, numbers as locations in space, mathematical operations as actions on objects, love as a journey, society as a person, and so forth (Boroditsky, 2000; Lakoff & Johnson, 1980; Lakoff & Núñez, 2001).

What is the evidence for the existence of such conceptual metaphors? Lakoff and Johnson (1980) present hundreds of example of such metaphors in everyday language. For example, the metaphor HEALTH IS UP, SICKNESS IS DOWN is manifested in expressions such as "she's in *top* shape" and "his health is *declining*"; the metaphor HAPPINESS IS UP, SADNESS IS DOWN is manifested in expressions such as "that *boosted* my spirits" and "she is feeling *low*." For such metaphors, ties to bodily experiences are quite obvious – when ill, people usually lie down; when sad, people's posture droops. Thus, these metaphors serve to ground abstract concepts in physical actions and perceptions.

Experimental evidence supports the claim that people understand abstract concepts in terms of spatial images. When asked to draw or to choose image schemas to represent abstract verbs, participants show highly consistent performance; for example, almost all participants draw or choose a vertical relationship to represent "respect" (Richardson, Spivey, Edelman, & Naples, 2001). Furthermore, comprehending abstract verbs that activate particular spatial axes (e.g., the vertical axis for *respect*) affects other cognitive processes that rely on those spatial axes, such as visual discrimination or picture memory (Richardson, Spivey, Barsalou, & McRae, 2003). These data support the claim that spatial image schemas underlie abstract verbs.

One abstract concept that has been extensively studied with regard to metaphoric structuring is *time* (e.g., Alverson, 1994; Casasanto & Boroditsky, 2008; Clark, 1973; Núñez & Sweetser, 2006). Experimental evidence indicates that people's conceptions of time are structured by metaphorical mappings to space. In one experiment, priming different spatial representations led participants to make different inferences regarding the following sentence, which is ambiguous about time: "Next Wednesday's meeting has been moved forward two days". Depending on the particular schema that was primed, participants tended to infer that the meeting was either Monday or Friday (Boroditsky, 2000).

Cross-linguistic studies also support the view that time is understood in terms of space. Different languages construe time in terms of space differently – for example, Mandarin Chinese construes time as vertical, whereas English construes it as horizontal. Consistent with these spatial metaphors, native speakers of Mandarin were faster to confirm that March comes before April if they had just seen a vertical array of objects rather than a horizontal array, and the reverse pattern held for native speakers of English (Boroditsky, 2001).

Abstract social and emotion concepts

Are abstract social concepts also understood by analogy to experience-based domains, such as space and action? Indeed, available evidence supports this view. Consider the concept of *social power*. A number of studies indicate that power is understood by metaphorical mappings to space, via the metaphor POWER (CONTROL) IS UP, WEAKNESS (LACK OF CONTROL) IS DOWN. Lakoff and Johnson (1980) highlighted the experiential basis of this metaphor, noting that "physical size typically correlates with physical strength, and the victor in a fight is typically on top" (p. 15). This suggests that people conceptualize power relationships between social groups with the more powerful individual (e.g., boss) above and the less powerful individual (e.g., secretary) below.

Experimental evidence supports the view that people's representations of social power are structured spatially. Schubert (2005) showed that participants' judgments about social power relationships were influenced by the relative vertical positions of the groups to be judged. When the task was to find the powerful group, participants were faster to respond when that group's name was at the top of the computer screen, and when the task was to find the powerless group, participants were faster to respond when that group's name was at the bottom. Similarly, participants were faster to make judgments of powerful groups (presented alone) when they responded with the "cursor up" key, and faster to make judgments of powerless groups (presented alone) when they responded with the "cursor down" key.

There is also evidence that participants' judgments about power are also affected by spatial cues. Schubert (2005) showed that participants rated powerful animals (e.g., lion, grizzly bear) as even more powerful when they were presented at the top of the screen than when they were presented at the bottom. Giessner and Schubert (2007) extended these findings to judgments of human leaders. They asked participants to evaluate a manager of a company, and provided participants with a short text and an organization chart. In the organization chart, boxes at the lower level, which represented employees, were connected by a horizontal line, and the middle box was connected by a vertical line to a box above it, which represented the manager. The length of the vertical line (short or long) was manipulated between participants, yielding either a small or a large vertical difference between the manager and employee in the organizational chart. Participants in the large vertical difference condition evaluated the leader as more powerful than participants in the small vertical difference condition. Moreover, these effects were not found for evaluations of charisma, which is not represented in terms of a vertical spatial schema.

It is not only the case that spatial representations influence evaluations of power; the opposite also holds. That is, judgments of power can influence the spatial representations that people construct. Giessner and Schubert (2007) manipulated whether a leader was described as powerful or non-powerful, and investigated how participants represented the leader's relationships to others spatially. In one study, participants were asked to place a box representing the leader in an organizational chart that included empty boxes to represent other employees the bottom. In another study, participants were asked to place a picture of the leader relative to a circle of six pictures representing the leader's team members, to represent the relation of the leader to the followers. In both studies, participants placed the more powerful leader higher along the vertical dimension than the less powerful leader.

Taken together, this evidence suggests that the abstract social concept of power is grounded by a metaphorical mapping to vertical space, via the metaphor POWER (CONTROL) IS UP, WEAKNESS (LACK OF CONTROL) IS DOWN. Thus, abstract social concepts can be grounded in embodied experience.

Metaphoric structuring has also been investigated in terms of abstract emotion concepts; in particular, concepts regarding emotional valence. These concepts appear to be structured by metaphorical mappings to space, in terms of the broad-based metaphor GOOD IS UP, BAD IS DOWN.

Riskind (1983) showed that people retrieve emotional memories with positive valence more efficiently when sitting erect, and they retrieve emotional memories with negative valence more efficiently when sitting in a slumped position. Along similar lines, Casasanto and Dijkstra (2010) showed that, when participants were given neutral-valence prompts, they retrieved more memories with positive valence when they were instructed to move a set of marbles upward (from one box to another), and they retrieved more memories with negative valence when they were instructed to move marbles downward. Likewise, latency to recall memories with positive valence was shorter when participants were instructed to move marbles upward, and latency to recall memories with negative valence was shorter when participants were instructed to move marbles downward (Casasanto & Dijkstra, 2010).

Embodiment of abstractions in language and gesture

The studies described above are primarily experimental manipulations that have yielded evidence about the conceptual metaphors that underlie abstract social and emotional concepts. However, one need not conduct experiments in order to "see" the metaphorical structuring of abstract concepts. Conceptual metaphors that involve action, space, and other bodily experiences are commonly expressed in everyday language. Indeed, Lakoff and Johnson (1980) based their arguments on evidence from everyday linguistic expressions. For example, the POWER IS UP, WEAKNESS IS DOWN metaphor (described above) is manifested in expressions such as "your *highness*," "*high* and mighty," and "he's *moving up* in the ranks." As another example, consider the metaphor FRIENDSHIP IS PHYSICAL CLOSENESS. This metaphor is manifested in everyday expressions that describe physical closeness, such as "we are really *tight*" or "he's being *distant*."

Conceptual metaphors that involve action, space, and bodily experiences are also commonly expressed in spontaneous gestures. McNeill (1992) was among the first to observe that representational gestures sometimes depict abstract concepts metaphorically; this insight has spawned a large body of research on metaphor in gesture (Cienki & Müller, 2008). One metaphor that McNeill discusses at length is the "conduit" metaphor (see Lakoff & Johnson, 1980; Reddy, 1979), which holds that IDEAS, CONCEPTS, MEANINGS (and so forth) ARE OBJECTS; WORDS, SENTENCES AND OTHER LINGUISTIC EXPRESSIONS ARE CONTAINERS; and COMMUNICATION IS SENDING AND RECEIVING. This metaphor is commonly expressed in gestures that represent holding or transferring objects. For example, a speaker might extend her hand as if holding something, while saying, "I have an idea" or "How shall I say this?"

Metaphors that involve spatial image schemas are also readily expressed in gestures. Consider spatial metaphors for time, as considered at the outset of this section. Núñez and Sweetser (2006) studied conceptual metaphors for time in Aymara, a language spoken in the Andean highlands of western Bolivia, southeastern Peru, and northern Chile. In Aymara, the word for front is also used to mean "past" and the word for back is also used to mena "future." Núñez and Sweetser examined the gestures that Aymara speakers produced to accompany verbal expressions about time, and found that Aymara speakers used the space behind them to represent the future, and the space in front of them to represent the past. Furthermore, Aymara speakers used locations in front of and closer to their bodies to represent more recent past times, and locations in front of and farther from their bodies to represent less recent past times. These gestures complement data from Aymara linguistic expressions to show that metaphoric construals of time in Aymara are quite different from those in other languages, including English.

Many other studies have documented gestures that reflect the metaphoric structuring of abstract concepts in terms of space and action. A few have investigated metaphoric gestures for abstract mathematical concepts. Núñez (2005) presents examples drawn from mathematics professors teaching at the university level. In one example, a professor describes an unbounded monotonic sequence that "goes in one direction," and he represents this sequence using a circular motion of his hand, which he produces while walking forward across the front of the classroom. This case illustrates the NUMBERS ARE LOCATIONS IN SPACE metaphor (Lakoff & Núñez, 2001). In another study, Alibali and Nathan (in press) present examples drawn from middle-school mathematics lessons. In one case, a teacher presents a figure of a (balanced) pan balance with two spheres on one side, and two cylinders and a sphere on the other side, and below it, the associated equation, $s + s = c + c + s$. The teacher first describes removing identical objects from both sides of the balance, saying, "I am going to take away a sphere from each side," while making a grasping motion over the spheres on each side. She then says, "Instead of taking it off the pans, I am going to take it away from this equation." With this utterance, she first mimes removing a sphere from each side of the pan balance figure, and then makes the same grasping handshapes over the *s* symbols on the two sides of the equation. With this last gesture, she expresses the metaphor of taking objects away – reflecting the ARITHMETIC IS COLLECTING OBJECTS metaphor described by Lakoff and Núñez (2001) – to give meaning to the abstract principle of subtracting equal quantities from both sides of an equation, by grounding it in the action of removing objects. As these examples show, metaphoric gestures can reflect the grounding of abstract mathematical concepts in space and action.

To our knowledge, there has been little research on gestural expression of metaphors for abstract social concepts, but it seems likely that such concepts would also be readily expressed in gestures. Consider the POWER IS UP, WEAKNESS IS DOWN metaphor, discussed extensively above. It is easy to imagine a speaker producing a gesture of upward movement while saying "she acts so *high* and mighty" or "he's *moving up* in the ranks." Or consider the metaphor FRIENDSHIP IS PHYSICAL CLOSENESS. It is easy to imagine a speaker producing a gesture that represents friendship in terms physical closeness – for example, pressing the palms together while saying "we are best buddies."

Metaphoric gestures may be most informative in situations where speakers do not express the corresponding metaphors overtly in their speech. In the "best buddies" example just described, the metaphor of FRIENDSHIP IS PHYSICAL CLOSENESS is not overtly expressed in speech; however, this metaphor might be manifested in the gestures that accompany that speech. Along similar lines, it would be interesting to ask scientists to describe the composition of their research groups, and to investigate the vertical positioning of their gestures in space, as a possible index of power within the group.

CONCLUSION

Current evidence suggests that we understand social concepts – both concrete and abstract – by simulating relevant motor, perceptual, and emotional experiences, and that our understanding and use of these concepts is embedded in the social and physical environment. The same reliance on simulation, and the same embedding of knowledge and performance, also characterize language comprehension and production. In this chapter we have highlighted gestures as a unique source of data, not only about the role of simulation in cognition but also about the embeddedness of cognition and about the metaphoric embodiment of abstract concepts.

To return once again to the example of the jazz concert, we understand a jazz concert because we can simulate what it is like to be at a jazz concert. Our simulations hearken back to particular situations in which we have experienced jazz concerts (or other sorts of concerts) in the past. We understand how the saxophonist plays by imagining ourselves pressing the keys. We understand the drummer's relaxed state because we can simulate his laid-back smile. And when we invite our friend Andre to join us at the concert, we just might convey the action of the saxophonist and the smile of the drummer in our own gesture and facial expression.

REFERENCES

Adolphs, R. (2002). Recognizing emotion from facial expressions: Psychological and neurological mechanisms. *Behavioral and Cognitive Neuroscience Reviews, 1*, 21–62.

Adolphs, R., Damasio, H., Tranel, D., Cooper, G., & Damasio, A. R. (2000). A role for somatosensory cortices in the visual recognition of emotion as revealed by 3-D lesion mapping. *Journal of Neuroscience, 20,* 2683–2690.

Alibali, M. W., & Hostetter, A. B. (in press). Mimicry and simulation in gesture comprehension. (Commentary on Niedenthal, Mermillod, Maringer, & Hess, The Simulation of Smiles Model.) *Behavioral and Brain Sciences.*

Alibali, M. W., & Nathan, M. J. (in press). Embodiment in mathematics teaching and learning: Evidence from students' and teachers' gestures. *Journal of the Learning Sciences.*

Alverson, H. (1994). *Semantics and experience: Universal metaphors of time in English, Mandarin, Hindi, and Sesotho*. Baltimore, MD: Johns Hopkins University Press.

Anderson, M. L. (2003). Embodied cognition: A field guide. *Artificial Intelligence, 149*, 91–130.

Atkinson, A. (2007). Face processing and empathy. *Empathy in mental illness* (pp. 360– 385). New York: Cambridge University Press.

Bargh, J. A., Chen, M., & Burrows, L. (1996). The automaticity of social behavior: Direct effects of trait concept and stereotype activation on action. *Journal of Personality and Social Psychology, 81*, 1014–1027.

Barsalou, L. W. (1983). Ad hoc categories. *Memory & Cognition, 11*, 211–227.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*, 577–660.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59*, 617–645.

Bavelas, J. B., Kenwood, C., Johnson, T., & Phillips, B. (2002). An experimental study of when and how speakers use gestures to communicate. *Gesture, 2*, 1–17.

Bergen, B. K., Lau, A., Narayan, S., Stojanovic, D., & Wheeler, K. (2010). Body part representations in verbal semantics. *Memory & Cognition, 38*, 969–981.

Blair, I. V. (2002). The malleability of automatic stereotypes and prejudice. *Personality and Social Psychology Review, 6*(3), 242–261.

Boroditsky, L. (2000). Metaphoric structuring: Understanding time through spatial metaphors. *Cognition, 75*, 1–28.

Boroditsky, L. (2001). Does language shape thought? English and Mandarin speakers' conceptions of time. *Cognitive Psychology, 43*(1), 1–22.

Boroditsky, L., & Prinz, J. (2008). What thoughts are made of. In G. Semin & E. Smith (Eds.), *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches.* New York: Cambridge University Press.

Bourgeois, P., & Hess, U. (2008). The impact of social context on mimicry. *Biological Psychology, 77*(3), 343–352.

Bush, L. K., Barr, C. L., McHugo, G. J., & Lanzetta, J. T. (1989). The effects of facial control and facial mimicry on subjective reactions to comedy routines. *Motivation and Emotion, 13*, 31–52.

Butcher, C., Mylander, C., & Goldin-Meadow, S. (1991). Displaced communication in a self-styled gesture system: Pointing at the nonpresent. *Cognitive Development, 6*, 315–342.

Calder, A. J., Keane, J., Manes, F., Antoun, N., & Young, A. W. (2000). Impaired recognition and experience of disgust following brain injury, *Nature Neuroscience, 3(11),* 1077–1078.

Cannon, P. R., Hayes, A. E., & Tipper, S. P. (2009). An electromyographic investigation of the impact of task relevance on facial mimicry. *Cognition and Emotion, 5,* 918–929.

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1985). Mathematics in the streets and in the schools. *British Journal of Developmental Psychology, 3*, 21–29.

Casasanto, D., & Boroditsky, L. (2008). Time in the mind: Using space to think about time. *Cognition, 106,* 579–593.

Casasanto, D., & Dijkstra, K. (2010). Motor action and emotional memory. *Cognition, 115*(1), 179–185.

Chambon, M. (2009). Embodied perception with others' bodies in mind: Stereotype priming influence on the perception of spatial environment. *Journal of Experimental Social Psychology, 45*, 283–287.

Chandler, J., & Schwarz, N. (2009). How extending your middle finger affects your perception of others: Learned movements influence concept accessibility. *Journal of Experimental Social Psychology, 45*(1), 123–128.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception– behavior link and social interaction. *Journal of Personality and Social Psychology, 76*, 893–910.

Church, R. B., Ayman-Nolley, S., & Mahootian, S. (2004). The role of gesture in bilingual education: Does gesture enhance learning? *Bilingual Education and Bilingualism, 7*, 303–318.

Cienki, A., & Müller, C. (Eds.). (2008). *Metaphor and gesture*. Amsterdam: John Benjamins.

Clark, H. H. (1973). Space, time, semantics, and the child. In T. Moore (Ed.), *Cognitive development and the acquisition of language* (pp. 27–63). New York: Academic Press.

Clark, H. H., & Murphy, G. L. (1982). Audience design in meaning and reference. In J.-F. L. Ny & W. Kintsch (Eds.), *Language and comprehension*. Amsterdam: North-Holland.

Decety, J., & Chaminade, T. (2003). Neural correlates of feeling sympathy. *Neuropsychologia, 41*, 127–138.

Decety, J., & Stevens, J. A. (2008). Action representation and its role in social interaction. In K. D. Markman, W. M. P. Klein, & J. A. Suhr (Eds.), *The handbook of imagination and mental simulation*. New York: Psychology Press.

Dijksterhuis, A., & van Knippenberg, A. (1998). The relation between perception and behavior or how to win a game of trivial pursuit. *Journal of Personality and Social Psychology, 74*, 865–877.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science, 11*, 86–89.

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor facilitation during action observation: A magnetic stimulation study. *Journal of Neurophysiology, 73*, 2608–2611.

Foroni, F., & Semin, G. R. (2009). Language that puts you in touch with your bodily feelings. The multimodal responsiveness of affective expressions. *Psychological Science, 20*, 974–980.

Gallese, V. (2003). The roots of empathy: The shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology, 36*, 171–180.

Gallese, V. (2005). "Being like me": Self-other identity, mirror neurons, and empathy. Perspectives on imitation: From neuroscience to social science. Vol. 1: *Mechanisms of imitation and imitation in animals* (pp. 101–118). Cambridge, MA: MIT Press.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain, 119*, 593–609.

Gerwing, J., & Bavelas, J. B. (2004). Linguistic influences on gesture's form. *Gesture, 4*, 157–195.

Gibson, J. J. (1979). *The ecological approach to visual perception*. Hillsdale, NJ: Erlbaum.

Giessner, S. R., & Schubert, T. W. (2007). High in the hierarchy: How vertical location and judgments of leaders' power are interrelated. *Organizational Behavior and Human Decision Processes, 104*(1), 30–44.

Glenberg, A. M. (1997). What memory is for. *Behavioral and Brain Sciences, 20*, 1–55.

Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin & Review, 9*, 558–565.

Glenberg, A. M., & Robertson, D. A. (1999). Indexical understanding of instructions. *Discourse Processes, 28*, 1–26.

Glenberg, A. M., & Robertson, D. (2000). Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning. *Journal of Memory and Language, 43*, 379–401.

Goldman, A., & Sripada, C. (2005). Simulationist models of face-based emotion recognition. *Cognition*, *94*, 193–213.

Goldstone, R. L. (1995). Effects of categorization on color perception. *Psychological Science, 6*, 298–230.

Goodwin, C. (2007). Environmentally coupled gestures. In S. Duncan, J. Cassell & E. Levy (Eds.), *Gesture and the dynamic dimensions of language* (pp. 195–212). Amsterdam/Philadelphia: John Benjamins.

Griggs, R. A., & Cox, J. R. (1982). The elusive thematic-materials effect in Wason's selection task. *British Journal of Psychology, 16*, 94– 143.

Halberstadt, J. B., Niedenthal, P. M., & Kushner, J. (1995). Resolution of lexical ambiguity by emotional state. *Psychological Science, 6*, 278–282.

Halberstadt, J., Winkielman, P., Niedenthal, P. M., & Dalle, N. (2009). Emotional conception: How embodied emotion concepts guide perception and facial action. Psychological Science, 20, 1254–1261.

Havas, D. A., Glenberg, A. M., Gutowski, K. A., Lucarelli, M. J., & Davidson, R. J. (2010). Cosmetic use of botulinum toxin-A affects processing of emotional language. *Psychological Science, 21*, 895–900.

Havas, D. A., Glenberg, A. M., & Rinck, M. (2007). Emotion simulation during language comprehension. *Psychonomic Bulletin & Review, 14*, 436–441.

Hermans, E. J., Putman, P., & van Honk, J. (2006). Testosterone administration reduces empathetic behavior: A facial mimicry study. *Psychoneuroendocrinology*, *31*(7), 859–866.

Holler, J., & Stevens, R. (2007). The effect of common ground on how speakers use gesture and speech to represent size information. *Journal of Language and Social Psychology, 26*, 4–27.

Horton, W. S., & Gerrig, R. J. (2005). The impact of memory demands on audience design during language production. *Cognition, 96*, 127–142.

Hostetter, A. B. (in press). When do gestures communicate? A meta-analysis. *Psychological Bulletin.*

Hostetter, A. B., & Alibali, M. W. (2008). Visible embodiment: Gestures as simulated action. *Psychonomic Bulletin & Review, 15*, 495–514.

Hostetter, A. B., & Alibali, M. W. (2010). Language, gesture, action! A test of the gesture as simulated action framework. *Journal of Memory and Language, 63*, 245–257.

Hostetter, A. B., Alibali, M. W., & Schrager, S. M. (2011). If you don't already know, I'm certainly not going to show you! Motivation to communicate affects gesture production. In G. Stam & M. Ishino (Eds.), *Integrating gestures: The interdisciplinary nature of gesture* (pp. 61–74). Amsterdam: John Benjamins.

Hurley, S. (2008). The shared circuits model (SCM): How control, mirroring, and simulation can enable imitation, deliberation, and mindreading. *Behavioral and Brain Sciences, 31*, 1–58.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.

Iacoboni, M., Woods, R., Brass, M., Bekkering, H., Mazziotta, J., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, *286*, 2526–2528.

Kaschak, M. P., & Maner, J. K. (2009). Embodiment, evolution, and social cognition: An integrative framework. *European Journal of Social Psychology, 39*(7), 1236–1244.

Keysers, C., & Gazzola, V. (2007). Integrating simulation and theory of mind: From self to social cognition. *Trends in Cognitive Science, 11*, 194–196.

Kimbara, I. (2008). Gesture form convergence in joint description. *Journal of Nonverbal Behavior, 32*(2), 123–131.

Kirsh, D., & Maglio, P. (1994). On distinguishing epistemic from pragmatic actions. *Cognitive Science, 18*(4), 513–549.

Kotovsky, K., Hayes, J. R., & Simon, H. A. (1985). Why are some problems hard? Evidence from Tower of Hanoi. *Cognitive Psychology, 17*, 248–294.

Krauss, R. M., Chen, Y., & Gottesman, R. F. (2000). Lexical gestures and lexical access: A process model. In D. McNeill (Ed.), *Language and gesture* (pp. 261–283). Cambridge, UK: Cambridge University Press.

Krumhuber, E., Manstead, A. S. R., & Kappas, A. (2007). Temporal aspects of facial displays in person and expression perception. The effects of smile dynamics, head-tilt and gender. *Journal of Nonverbal Behavior, 31*, 39–56.

Lakin, J. L., & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science, 19*, 816–822.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Lakoff, G., & Núñez, R. (2001). *Where mathematics comes from: How the embodied mind brings mathematics into being*. New York: Basic Books.

Libby, L. K., Shaeffer, E. M., & Eibach, R. P. (2009). Seeing meaning in action: A bidirectional link between visual perspective and action identification level. *Journal of Experimental Psychology: General, 138*(4), 503–516.

Likowski, K. U., Muhlberger, A., Seibt, B., Pauli, P., & Weyers, P. (2008). Modulation of facial mimicry by attitudes. *Journal of Experimental Social Psychology*, *44*(4), 1065–1072.

Maddux, W. W., Mullen, E., & Galinsky, A. (2008). Chameleons bake bigger pies: Strategic behavioral mimicry facilitates integrative negotiations outcomes. *Journal of Experimental Social Psychology, 44*, 461–468.

Maringer, M., Krumhuber, E., Fischer, A., & Niedenthal, P. M. (2011). Beyond smile dynamics: Mimicry and beliefs in judgments of smiles. *Emotion, 11*, 181–187.

Masson, M. E. J., Bub, D. N., & Warren, C. M. (2008). Kicking calculators: Contribution of embodied representations to sentence comprehension. *Journal of Memory and Language, 59*(3), 256–265.

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought*. Chicago, IL: University of Chicago Press.

McNeil, N. M., & Alibali, M. W. (2005). Knowledge change as a function of mathematics experience: All contexts are not created equal. *Journal of Cognition and Development, 6*, 285–306.

Meltzoff, A., & Moore, M. (1977). Imitation of facial and manual gestures by human neonates. *Science, 198*, 75–78.

Moody, E. J., McIntosh, D. N., Mann, L. J., & Weisser, K. R. (2007). More than mere mimicry? The influence of emotion on rapid facial reactions to faces. *Emotion*, *7*(2), 447–457.

Morford, J., & Goldin-Meadow, S. (1997). From here and now to there and then: The development of displaced reference in homesign and English. *Child Development, 68*, 420–435.

Nathan, M. J. (2008). An embodied cognition perspective on symbols, grounding, and instructional gesture. In M. DeVega, A. M. Glenberg & A. C. Graesser (Eds.), *Symbols and embodiment: Debates on meaning and cognition* (pp. 375–396). Oxford, UK: Oxford University Press.

Niedenthal, P. M. (2007). Embodying emotion. *Science, 316*, 1002–1005.

Niedenthal, P. M. (2008). Emotion concepts. In M. Lewis, J.M. Haviland-Jones, and L. F. Barrett (Eds.), *Handbook of emotion, 3rd Edition*. (pp. 597–600). New York: Guilford.

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review, 9*, 184–211.

Niedenthal, P. M., Brauer, M., Halberstadt, J. B., & Innes-Ker, A. H. (2001). When did her smile drop? Contrast effects in the influence of emotional state on the detection of change in emotional expression. *Cognition and Emotion, 15*, 853–864.

Niedenthal, P. M., Mermillod, M., Maringer, M., & Hess, U. (2010). The Simulation of Smiles (SIMS) model: Embodied simulation and the meaning of facial expression. Target article for *Behavioral and Brain Sciences, 33*, 417–480.

Niedenthal, P. M., Winkielman, P., Mondillon, L., & Vermeulen, N. (in press). Embodied emotion concepts. *Journal of Personality and Social Psychology*.

Núñez, R. (2005). Do real numbers really move? Language, thought, and gesture: The embodied cognitive foundations of mathematics. In F. Iida, R. Pfeifer, L. Steels & Y. Kuniyoshi (Eds.), *Embodied artificial intelligence* (pp. 54–73). Berlin: Springer-Verlag.

Núñez, R., & Sweetser, E. (2006). With the future behind them: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science, 30*, 401–450.

Nussinson, R., Seibt, B., Häfner, M., & Strack, F. (2010). Come a bit closer: Approach motor actions lead to feeling similar and behavioral assimilation. *Social Cognition, 28*, 40–58.

Nygaard, L. C., & Queen, J.S. (2008). Communicating emotion: Linking affective prosody and word meaning. *Journal of Experimental Psychology: Human Perception and Performance, 34*, 1017–1030

Özyürek, A. (2002). Do speakers design their co-speech gestures for their addressees? The effects of addressee location on representational gestures. *Journal of Memory and Language, 46*(4), 688–704.

Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2003). Verifying different-modality properties for concepts produces switching costs. *Psychological Science, 14*, 119–124.

Pitcher, D., Garrido, L., Walsh, V., & Duchaine, B. (2008). TMS disrupts the perception and embodiment of facial expressions. *Journal of Neuroscience, 28*(36), 8929–8933.

Pulvermüller, F. (2005). Brain mechanisms linking language and action. *Nature Reviews, 6*, 1–6.

Pulvermüller, F., Hauk, O., Nikulin, V. V., & Ilmoniemi, R. J. (2005). Functional links between motor and language systems. *European Journal of Neuroscience, 21*, 793–797.

Reddy, M. J. (1979). The conduit metaphor: A case of frame conflict in our language about language. In A. Ortony (Ed.), *Metaphor and thought* (pp. 164–201). Cambridge, UK: Cambridge University Press.

Richardson, D. C., Spivey, M. J., Barsalou, L. W., & McRae, K., (2003). Spatial representations activated during real-time comprehension of verbs. *Cognitive Science, 27*, 767–780.

Richardson, D. C., Spivey, M. J., Edelman, S., & Naples, A. (2001). "Language is spatial": Experimental evidence for image schemas of concrete and abstract verbs. *Proceedings of the Twenty-third Annual Meeting of the Cognitive Science Society* (pp. 873–878). Mahwah, NJ: Erlbaum.

Richeson, J. A., & Ambady, N. (2003). Effects of situational power on automatic racial prejudice. *Journal of Experimental Social Psychology, 39*, 177–183.

Riskind, J. (1983). Nonverbal expressions and the accessibility of life experience memories: A congruence hypothesis. *Social Cognition, 2*(1), 62–86.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience, 27*, 169–192.

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research, 3*, 131–141.

Sassenberg, U., & van der Meer, E. (2010). Do we really gesture more when it is more difficult? *Cognitive Science, 34*, 643–664.

Schubert, T. W. (2004). The power in your hand: Gender differences in bodily feedback from making a fist. *Personality and Social Psychology Bulletin, 30*, 757–769.

Schubert, T. W. (2005). Your Highness: Vertical positions as perceptual symbols of power. *Journal of Personality and Social Psychology, 89*(1), 1–21

Smith, E., & Semin, G. (2007). Situated social cognition. *Current Directions in Psychological Science, 16*(3), 132–135.

Sommerville, J. A., & Decety, J. (2006). Weaving the fabric of social interaction: Articulating developmental psychology and cognitive neuroscience in the domain of motor cognition. *Psychonomic Bulletin & Review, 13*, 179–200.

Sonnby-Borgström, M. (2002). Automatic mimicry reactions as related to differences in emotional empathy. *Scandinavian Journal of Psychology*, *43*, 433–443.

Sonnby-Borgström, M., Jonsson, P., & Svensson, O. (2003). Emotional empathy as related to mimicry reactions at different levels of information processing. *Journal of Nonverbal Behavior*, *27*(1), 3–23.

Spivey, M. J., Richardson, D. C., & Gonzales-Marquez, M. (2005). On the perceptual-motor and image-schematic infrastructure of language. In D. Pecher & R. A. Zwaan (Eds.), *Grounding cognition: The role of perception and action in memory, language, and thinking* (pp. 246–281). Cambridge, UK: Cambridge University Press.

Stel M., & van Knippenberg, A. (2008). The role of facial mimicry in the recognition of affect. *Psychological Science, 19*, 984–985.

Valenzeno, L., Alibali, M. W., & Klatzky, R. (2003). Teachers' gestures facilitate students' learning: A lesson in symmetry. *Contemporary Educational Psychology, 28*, 187–204.

Wegner, D. M., Erber, R., & Raymond, P. (1991). Transactive memory in close relationships. *Journal of Personality and Social Psychology, 61*, 923–929.

Wegner, D. M., Giuliano, T., & Hertel, P. (1985). Cognitive interdependence in close relationships. In W. J. Ickes (Ed.), *Compatible and incompatible relationships* (pp. 253–276). New York: Springer-Verlag.

Weyers, P., Muhlberger, A., Kund, A., Hess, U., & Pauli, P. (2009). Modulation of facial reactions to avatar emotional faces by nonconscious competition priming. *Psychophysiology*, *46*, 328–335.

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in my insula: The common neural basis of seeing and feeling disgust. *Neuron, 40*, 655–664.

Willems, R. M., Hagoort, P., & Casasanto, D. (2010). Body-specific representations of action verbs: Neural evidence from right- and left-handers. *Psychological Science, 21*, 67–74.

Williams, R. F. (2008). Gesture as a conceptual mapping tool. In A. Cienki & C. Müller (Eds.), *Metaphor and gesture* (pp. 55–92). Amsterdam: John Benjamins.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review, 9*, 625–636.

Wilson, M., & Knoblich, G. (2005). The case for motor involvement in perceiving conspecifics. *Psychological Bulletin, 131*, 460–473.

Winkielman, P., McIntosh, D. N., & Oberman, L. (2009). Embodied and disembodied emotion processing: Learning from and about typical and autistic individuals. *Emotion Review, 2*, 178–190.

Wittenbrink, B., Judd, C. M., & Park, B. (2001). Spontaneous prejudice in context: Variability in automatically activated attitudes. *Journal of Personality and Social Psychology, 81*, 815–827.

Yabar, Y., Johnston, L., Miles, L., & Peace, V. (2006). Implicit behavioral mimicry. *Journal of Nonverbal Behavior, 30*, 97–113.

Yeh, W., & Barsalou, L. W. (2006). The situated nature of concepts. *American Journal of Psychology, 119*, 349–384.

Zajonc, R., Adelmann, P., Murphy, S., & Niedenthal, P. (1987). Convergence in the physical appearance of spouses. *Motivation and Emotion, 11*, 335–346.