

5 Grounding Social Cognition

Synchronization, Coordination, and Co-Regulation

Gün R. Semin and John T. Cacioppo

The tabula of human nature was never rasa.

W. D. Hamilton

INTRODUCTION

Understanding the social in *social cognition* has presented a number of challenges that have been with us from the very beginnings of “modern” psychology (cf. Semin, 1986). The first challenge is to come to terms with what the “social” means. As Gallese noted recently: “The hard problem in ‘social cognition’ is to understand how the epistemic gulf separating single individuals can be overcome” (Gallese, 2006, p. 16). The foundations of *Völkerpsychologie* in the 1850s (Lazarus, 1861; Lazarus & Steinhilber, 1860; Wedewer, 1860; Waitz, 1859) constituted an attempt to overcome the then prevailing individual-centered psychology in German psychology by introducing a social level of analysis. The emerging modern social psychology in the early 20th century grappled with this problem, fluctuating between notions of “group mind” and “instinct,” with Durkheim, LeBon, Ross, Tarde, and Wundt arguing in different voices for collective representations, group mind, collective mind, collective consciousness, or *Völkerpsychologie*. Of these various influences, the prevailing view that emerged was driven by Allport’s vision of a social psychology that was individual-centered and regarded as a subdiscipline of psychology (Allport, 1924; cf. Post, 1980; Graumann, 1984, *inter alia*). This has very much remained the dominant view of mainstream social cognition and is underlined with reference to the biological finitude of the individual.

The second challenge is to be found in the traditional perspective in social psychology that social cognition is best understood in terms of an individual’s internal mental representations, with the “social” in social cognition

referring to the external stimulus being a person, dyad, group, collective, or social event. Characteristically, traditional models of information processing are symbolic, and knowledge is represented in an amodal fashion, namely, dissociated from any sensory and motor bases. Consequently, a translation must take place between the symbolic representational system and the experienced event, with high-level symbolic processes driving cognition – a view that is modeled upon fundamental concepts and principles from computer science (e.g., Fodor, 1975; Newell & Simon, 1972; Marr, 1982; Vera & Simon, 1993). The treatment of social cognition as equivalent to the information processing of social stimuli is compatible with this traditional perspective.

A third challenge is presented by a representational or symbolic perspective on social cognition that does not take into account the fact that cognition did not evolve as an end in itself but rather to foster adaptive action. The result is the relative neglect of the dynamic and adaptive functions of social cognition (cf. Smith & Semin, 2004). Recent developments in cognitive sciences (e.g., A. Clark, 1997; Clancey, 1993, 1997; Kirshner & Whitson, 1997; Barsalou, 1999; Yeh & Barsalou, 2000), neuroscience (e.g., Adolphs, 2006; Amodio & Firth, 2006; Rizzolatti & Craighero, 2004; Firth & Firth, 2006; Gallese, 2006; Sommerville & Decety, 2006), and primate cognition (e.g., Barrett & Henzi, 2005) have introduced different ways of looking at social cognition and have contributed to the social cognition model advanced in this chapter (see Semin & Cacioppo, 2007, in preparation).

As detailed elsewhere in this book (e.g., Barsalou, this volume; Glenberg, this volume), our representations of the social world are fundamentally connected with the actions that our bodies perform. An adaptive and dynamic view suggests that a model of social cognition should address the constraints and capacities provided by the perceptuomotor apparatus and the complex and continuously changing demands of the social environment in which social cognition evolved. We argue here that neural systems evolved that were tuned to particular embodiments and environments. In this view, social cognition is best understood as grounded in (rather than abstracted from) perceptuomotor processes and intertwined with a wealth of interpersonal interaction and specialized for a distinctive class of stimuli. In the course of our lives, we are exposed to a vast range of stimuli: cars, buildings, household objects, books, and, of course, other humans and an array of other life forms. Other human beings and their bodily movements constitute a distinctive class of stimuli, because the movements of other human beings can be mapped onto our own bodies.

The interindividual mapping of observed movements to the observer's mirror neuron system leads to the final challenge, namely, social cognition

is not driven entirely by inner processes and representations but relies on resources that are distributed across neural, bodily, and environmental features (e.g., Hutchins, 1995; Kirsch, 1995; Brooks, 1999; Agre, 1997) with the social and physical environment supporting social action and interaction (Smith & Semin, 2004). That is, two or more individuals are capable of joint work to perform a feat that supersedes their individual capabilities, and co-cogitate and co-regulate to achieve this joint feat.

In this chapter, we advance a model of social cognition that is driven by the above considerations and their implications. We argue that social cognition is embodied; consists of affective, cognitive, behavioral, and neurophysiological processes whose organization and function within brains and bodies are promoted by an analysis across brains and bodies; and is manifested in synchronization, coordination, and co-regulation of behaviors.

The aim is to supplement individualistic accounts in embodiment research with a social framework that promotes the rigorous study of processes ranging from joint perception to joint action as well as temporally distributed regularities. To this end we present a *social cognition model* (SC model), which conceptualizes social cognition as an emergent product of jointly recruited and time-locked processes rather than individual ones. Contrary to Floyd Allport's individualistic perspective, such an analysis takes the dyad as the smallest possible unit of analysis. Moreover, the model provides an embodied grounding of social cognition by anchoring these jointly recruited processes at the sensory motor level and constrained by the types of "tasks" (e.g., dancing, playing tennis, a resource conflict, a dialogue).

In the first part, we put forward the outline of our SC model (cf. Semin & Cacioppo, 2008, in press). There is considerable empirical evidence from diverse research traditions, ranging from neurophysiology to social, developmental, and ecological psychology that speak to different parts of the model. The relevant literatures are often nonintersecting and, as such, provide only preliminary evidence for the proposed model. Representative studies from this literature are reviewed in the second part in relation to the SC model. In the final section, we shall draw further conceptual and research implications of the model.

THE SOCIAL COGNITION (SC) MODEL

Two important functions of social cognition are the adaptive regulation of the behavior of another person (e.g., issuing instructions to another person) and adaptive co-regulation (e.g., the regulation of social interaction). For action to be efficient and adaptive, it must be closely tuned to the relevant social

synchronization promotes partial, not full, correspondence between producer and perceiver (see 2a, Figure 5.1).

The complexity of the social environment and the adaptiveness required of social cognition is not only to continuously monitor but also to selectively respond to significant features of a dynamic social environment by setting goals for action. It is important to address how adaptive action is induced in response to "significant" stimuli. Visualize a table tennis game in which your partner makes a backhand smash. Whereas monitoring that action is critical, it will not win you the game. You must take effective complementary actions. Thus, if the stimulus is goal-relevant, then higher-level cognitive processes are recruited that entail goal-mediated synchronization of neurophysiological activations whose specific form need not mirror the actions that are observed. Whereas the monitoring process is critical, adaptive action is not merely a product of monitoring processes. We therefore propose that the identification of significant stimuli recruits goal-driven higher-level decision processes that can run in addition to continuous monitoring processes (see 2b, Figure 5.1).

The higher-order goal-mediated synchronization and adaptive action (2b) depicted in Figure 5.1 are separable functionally from the monitoring synchronization (2a) depicted in Figure 5.1. One reason for this functional distinction is that the processes depicted in (2a) are thought to be automatic, whereas those depicted in (2b) involve automatic and controlled processes. In terms of the table tennis example, this means that the backhand smash of the opponent is monitored – a process that is achieved by the nonconscious synchronization of neurophysiological activations corresponding to that motor movement. Synchronization as a continuous monitoring process serves a predictive function by detecting changes in the environment. Yet, the table tennis player must make a decision about how to counter the backhand and defend themselves. This decision to counter the backhand leads to the requisite neurophysiological activation for the execution of the countermove rather than simply the mirror image of the observed action. Although specific aspects of goal-mediated synchronization can be automated, the act as a whole is not.

- *Synchronization and higher-level processes are dissociated but jointly shape the mental representation of the stimulus and are both subject to inhibitory and excitatory influences (3, Figure 5.1) before they shape these mental representations (4, Figure 5.1) that is then translated to action in the form of a motor response.*

Both goal-mediated synchronization processes and monitoring synchronization recruit neurophysiological activity and jointly contribute to the

shape of the representations that are translated into motor action (4, Figure 5.1). In the absence of goal-mediated synchronization, the neurophysiological activation from monitoring synchronization shapes the representation. However, this does not necessarily mean the automatic execution of the observed action because other factors can contribute to the representation. Moreover, both excitatory and inhibitory factors can modulate the contributions of the processes (2a) and (2b) depicted in Figure 5.1 to the representation. For instance, inhibitory processes can contribute to blocking continuous automatic reproduction of what is observed (e.g., Baldissera, Cavallari, Craighero, & Fadiga, 2001).

- *The structural features of the environment or task will contribute to the type of co-regulation processes that will emerge.*

The type of task environment requiring two or more persons that can be socially shaped (e.g., dancing, playing tennis, conversation) or by the physical characteristics of a joint task (e.g., carrying a large and heavy object) presents distinctive affordances that shape the co-regulation of the social interaction.

- *The behavior of one individual becomes the stimulus for the other when the individuals are actively interacting, with each iteratively producing co-action effects. Consequently, synchronization and adaptive co-regulation of behaviors are detectable when the unit of analysis is at the social rather than the individual level.*

This yields the emergent social cognition as represented in Figure 5.1 with direct loops from (5) to (1), namely, where the behavior of a member of the dyad provides information pickup for the other member in an iterative process.

In the following section, we shall examine the proposed model in the light of the existing empirical evidence. In referring to the empirical evidence, we shall also contrast the SC model with different models that have been developed for specific phases (e.g., synchronization, entrainment, task driven joint action) of the general model we have outlined.

THE SC MODEL: THE EVIDENCE

The evidence for the SC model comes from research at neural, emotional, and behavioral levels. The empirical evidence adduced here in terms of the SC model comes in three sections. The first has to do with synchronization processes advanced in the model. These are neurophysiological studies highlighting synchronization in the face of action observation as well as the

observation of emotions. The second section is empirical evidence pertaining to goal-driven processes exclusively. The final section is about behavioral processes displaying entrainment, "mimicry," and coordination.

Synchronization of Action

The neural basis of synchronization processes can be understood based on neurophysiological evidence with human and nonhuman primates. This evidence suggests that intentional action, and the perception of such action, has a shared neural notation. This line of research gained momentum with the discovery of mirror neurons in area F5 of the monkey premotor cortex (e.g., di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, Fogassi, 1996). Rizzolatti et al. (1996) demonstrated the existence of a particular class of visuomotor neurons (in the F5 area of the macaque monkey premotor cortex) that discharge when the monkey engages in a particular action (e.g., grasping a peanut) and when it observes another monkey engaging in the same action (for a review, see Rizzolatti & Craighero, 2004).

A subset of these neurons – termed '*mirror neurons*' – also become active even when the final part of the action (e.g., grasping the peanut) is hidden (Umiltà, Kohler, Gallese, Fogassi, Fadiga, Keysers, & Rizzolatti, 2001). Critically, in the hidden condition the monkey must "know" that an object (peanut) is behind the occluder and must observe the experimenter's hand going behind the occluder without seeing the completion of the action. More recently, Keysers and his colleagues (Keysers, Kohler, Umiltà, Nanetti, Fogassi, & Gallese, 2003) have reported that specific populations of neurons (audiovisual mirror neurons) in the ventral premotor cortex of the monkey discharge not only when a monkey performs a specific action but also when it sees or hears another monkey perform the same action. These neurons therefore represent actions independently of whether these actions are performed, heard, or seen. Converging evidence about the adaptive nature of the mirror neuron system comes from Kohler, Keysers, Umiltà, Fogassi, Gallese, and Rizzolatti (2002), where monkeys were trained to rip a piece of paper. It was shown that once trained, the mirror neurons involved in the execution of this action were recruited in response to only the sound of ripping. These studies suggest that single neurons in the premotor cortex synchronize not only to the actions that the other is executing but also that the action along with the "goal" is represented and inferred across different modalities. The correlation between mirror neuron activation in partially observed or merely heard conditions corresponds largely to the pattern of neurons recruited in

the full performance of the actions, which result in a sound (peanut cracking) or complete action (grasping food). These studies suggest that single neurons in the premotor cortex synchronize not only to the actions that the other is executing but also that the action "goal" is represented and inferred in different modalities.

There are specific features of the neurophysiological evidence on synchronization processes for action. First of all, it is correlational. Second, it is based on the observation and execution of single, discrete behaviors. Third, the behaviors that serve as stimuli are either transitive (e.g., cracking a peanut) or intransitive (i.e., mouth movements such as lip smacking, biting, licking; Ferrari, Gallese, Rizzolatti, & Fogassi, 2003; Ferrari, Maiolini, Addressi, Fogassi, Visalberghi, 2005). Finally, this research underlines the multimodal (e.g., visual, auditory) quality of synchronization processes.

Whereas the evidence noted above is from nonhuman primates, there is also an emerging body of evidence indicating the neural substrates of general action in humans, supporting the notion that a system of neurons synchronize to observed actions. The human premotor cortex, which is involved in voluntary movements of the body, is organized somatotopically. Using functional magnetic resonance imaging (fMRI), Buccino, Binkofski, Fink, Fadiga, Fogassi, Gallese, Seitz, Zilles, Rizzolatti, and Freund (2001) localized areas of the brain that were active during the observation of movement by another individual. They found that regions of the premotor cortex were activated when individuals observed the actions of another and, more specifically, that the areas activated in the premotor cortex corresponded to the regions that would be active were the individual to have executed the observed actions. The findings of Buccino et al. (2001) are in accord with the hypothesis that there is a brain circuit that extracts and neurologically represents the motor commands of another individual's observed actions – the so-called "direct matching hypothesis." The type of "mirroring" noted by Buccino et al. (2001) does not require voluntary control.

Evidence from other researchers indicates that imitative reactions are faster than simple visual reaction times, and that people's awareness of their own imitative reactions occurs significantly later than their imitative reactions. Indeed, there is considerable cumulative evidence revealing that observing movements of the finger, hand, arm, mouth, or foot leads to the activation of motor-related areas of the cortex (e.g., Grafton, Arbib, Fadiga, & Rizzolatti, 1996; Iacoboni et al., 1999; Manthey, Shubotz, & von Cramon, 2003; Stevens, Fonlupt, Shiffrar, & Decety, 2000). These findings hold in the case of movements that are biologically possible and not for impossible movements, as for instance an arm passing through a leg (Stevens et al., 2000).

recruited sensory motor processes that give partial access between producer and perceiver at a neural level and are predictive of the other's actions or states. However, in the case of the SC model, we regard synchronization as a monitoring mechanism, which is paralleled by goal-mediated complementary neurophysiological processes that jointly contribute to "mutual understanding" in context, which also involves mental representations that result in co-cogitation and co-regulation of action.

Gallese's model of social cognition is informed by a research paradigm in which the agent is a passive observer contemplating the "essence of existence" rather than an agent in interaction with another agent involved in a continuously unfolding dynamic monitoring process of co-regulation. That is, the unit of analysis is the individual. The function of synchronization in this co-regulation process is to put both agents on the same sensorimotor page and serve the anticipation of what is to follow next. However, monitoring alone does not shape unfolding interaction.

While in agreement with Gallese's account of the simulation process inducing a "shared bodily state," which we refer to here as synchronization, the proposed SC model has a broader framework that consequently situates "embodied simulation" mechanisms within a different functional context. Whereas understanding how two or more agents achieve "being on the same somatic state-page" is important in identifying mechanisms by which the epistemic gulf separating single individuals is bridged at a biological level, it does not address or incorporate the general process of what social cognition covers and the multitude of bridging layers that exist at a behavioral and linguistic level (Semin, 2007).

Moreover, the SC model specifies the interaction between goal-driven synchronization and monitoring synchronization, namely, processes that shape ideomotor representations and contribute to the formation and subsequent impact of motor responses.

Goal Mediated Synchronization

There is substantial research literature on how explicitly provided goals drive co-regulation of behavior in dyads. A considerable amount of the research speaking to this issue relies on an experimental paradigm involving an explicit imitation instruction of touching a body part or an object on the child's left or right side with a left or right hand movement (e.g., Swanson & Benton, 1955; Wapner & Cirillo, 1968). Thus, the experimental conditions induce an explicit motor response goal that is further specified by the body part or object that defines the motor responses' designation (for an overview, see Wohlschläger,

Gattis, & Bekkering, 2003). This research has a bearing on the SC model we advance here because it constitutes an instance of behavior that is driven by externally set goals. In that context, we make the assumption that under certain circumstances the behavior shown subsequent to the observed action is a reflection of the neurophysiological activation that has been induced by the observed action.

Two features of the research in this field are relevant for the examination of what it means when a model and a participant perform the very same movement. These two features are the goal of the movement (i.e., the object or body part to be touched) and the hand movement (i.e. right or left hand movement). The research reveals that if there is a goal to the executed movement – for instance, two adjacent dots are stuck on a table and the model covers one of the dots with a hand movement – then the child (average age 4.4 years) always covers the correct dot. However, if the model executed a contralateral hand movement to cover the dot, then the child uses an ipsilateral hand movement (Bekkering, Wohlschläger, & Gattis, 2000, Experiment 3; Schofield, 1976). If the goal (dot) is removed and the same hand movements are executed, then the child performs the same movement. Ipsilateral movements produce ipsilateral performance, and contralateral model movements lead to the production of contralateral hand movements.

Thus, in terms of the SC model one finds that the presence of a goal (instructionally provided significant stimulus, e.g., a dot) inhibits the production of the very same behavior under these experimental conditions. Obviously, the important caveat in the context of "imitation" experiments is that participants receive explicit instructions to "imitate" the model. Consequently, reproduction of the same movement in such conditions is not automatically driven but explicitly instructed. Interestingly, the same hand movements ensue when a "higher" goal (dot) is not present. Here, we make the assumption that participants synchronize to the behavior that they automatically simulate when they observe the behavior and that they subsequently reproduce this previously simulated behavior, at least when there are no external cues (e.g., dots) that provide significant alternative, higher-order goals.

CO-REGULATION OF BEHAVIOR: ENTRAINMENT, MIMICRY, AND COORDINATION

The SC model we have advanced configures the steps from perception to production, incorporating its expression in joint action. In this section, we review evidence on the co-regulation of behavior (see 5, Figure 5.1), which is

a dynamic and emergent process. To this end, we distinguish between three qualitatively different forms of co-action as instances of co-regulation. The first is *entrainment* and is exemplified by periodic co-action and occurs in cycles. This can be illustrated with the example of rhythmic clapping. The second form is when co-action is nonperiodic, as in the case of *mimicry*. The third case is exemplified in situations that involve a number of people who have to interface each others' actions in the course of performing a complex task (e.g., open-heart surgery, playing tennis). This is the functional effect of co-action, namely, *coordination*, which entails the execution of complementary actions in the pursuit of accomplishing the task (e.g., successful surgery, winning the game). These different forms of the co-regulation of behavior can obviously all occur simultaneously and to different degrees. In the following, we present the distinctive features of each of these three forms and the related research.

Entrainment

We refer to *entrainment* as the alignment of behaviors or rhythms during social interaction, borrowing the term from earlier work (e.g., Condon & Ogston, 1966, 1967).² The earliest reference to entrainment is by McDougall (1908), who noted that spectators assume the postural manner of athletes they were observing. It is a multimodal form of co-action (verbal, affective, movement) and refers to a state between two persons that results when the cyclical behavioral movements of one person influence the cyclical movements of another person and they oscillate in rhythm. A typical example of entrainment is provided in the spontaneous transition of an applauding audience from disordered clapping to entrained clapping (Neda, Ravasz, Brechet, Vicsek, & Barabasi, 2000) and then back again to disordered clapping only for entrained clapping to reemerge again a little later. This remarkable phenomenon is evidenced despite considerable individual differences in clapping tempos. It would appear that the transition to entrained clapping enhances noise intensity and requires less effort, whereby each clapper affects the other both locally and globally. Entrained behavior occurs rhythmically, and one way of capturing their regularities is to model its cycles, periods, frequencies, and amplitudes. Depending on the particular behavior and interaction in question, behavioral cycles of entrainment in interpersonal behavior can range from milliseconds to hours. Entrainment is not specific to human social behavior alone (cf. Strogatz, 2003), and its investigation can focus on

² Subsequently used as synchrony specifically referring to the judged "gestaltlike harmoniousness or meshing of interpersonal behaviors" (Bernieri et al., 1988).

the degree to which behavioral cycles of a couple are in phase or not (e.g., early developmental work by Brazelton, Koslowski, & Main, 1974; Bullowa, 1975; Davis, 1982; Rosenfeld, 1981; Stern, 1974).

Recent work from an ecological perspective has revitalized research on entrainment. This approach has treated interaction as the unit of analysis with the objective of modeling the temporal organization of the movements of two (or more) people. This research often relies on instructionally induced periodic co-action (but not always, e.g., Shockley et al., 2007), thus supplying a goal (2b, Figure 5.1) and revealing the systematic temporal dynamics of behavior (5, Figure 5.1). However, the processes by which two agents pick up information from each other and how this information shapes the different phases of movements do not present any specific theoretical interest from this perspective. This approach is equally mute about the processes that contribute to the temporal co-organization of these movements (cf. Marsh et al., 2006). From an ecological perspective, the suggestion is that movement is "lawfully" constrained by other people's movements (Marsh et al., 2006) and best modeled in terms of coupled oscillator theory without any recourse to any jointly recruited intrapersonal processes, may these be neural or psychological.

For instance, Shockley and his colleagues (2003; Shockley, Baker, Richardson, & Fowler, 2007) examined whether conversation fosters interpersonal postural entrainment (postural sway) and revealed that convergent speaking patterns mediate interpersonal postural entrainment (see also Condon & Ogston, 1966; Kendon, 1970; LaFrance, 1982). Postural sway is not the only behavior that entrains outside of conscious access but also speech rate (Street, 1984). Similarly, pausing frequency (Cappella & Planalp, 1981) has been shown to entrain. Entrainment has also been shown to hold for gestural (see Furuyama, Hayashi, & Mishima, 2005) movements of interacting individuals without the individuals intending to entrain. Spontaneous entrainment occurs when interactants have full visual access to each other (i.e., joint attention, cf. Sebanz et al., 2006), but the previous studies suggest that visual information is not the only medium recruited by participants to entrain.

The ecological perspective on this research draws on human movement science and coupled oscillator theory to explain periodically recurring regularities in the movements of two persons (for an overview, see Marsh et al., 2006) by focusing exclusively on behavioral data. Their argument is that an embodied approach to uncovering perception-action systems resulting in entrainment must rely on the examination of dynamic properties of actual behavior taking place between individuals rather than mentalistic, representational constructs. Whereas modeling the temporal organization

of movement provides an insight into the regularities, their cycles, the breakdown of regularities, and relies on very sophisticated technology to record joint movements, it makes no attempt to understand the neural and psychological forces driving such behavior. Consequently, specific phenomena such as the affective and motivational precursors – as well as consequences of entrainment, the contribution of entrainment, and coordination to socially distributed knowledge and more complex multimodal processes such as conversation and dialogue – do not currently seem to feature as relevant phenomena in this approach. Thus, while convergent with the perspective adopted in the SC model, that the object of social cognition is an emergent interaction unit – an outcome of joint action – this approach differs in that the primary focus is the analysis of behavior.

Mimicry

Interest in nonperiodic co-action seems to have gone in ebbs and tides since the 1960s (e.g., Bernieri, 1988; Bernieri, Reznick, & Rosenthal, 1988; Bernieri, Davis, Rosenthal, & Knee, 1994; Condon & Ogston, 1966, 1967; Kendon, 1970; Tickle-Degnen & Rosenthal, 1987; Bavelas, Black, Chovil, Lemery, & Mullett, 1988; Bavelas, Black, Lemery, & Mullett, 1986). Notably, this early research uses “social interaction” as the unit of analysis rather than the individual (e.g., Schefflen, 1982). Among these, a line of research is to be found running under the labels of *mirroring* or *mimicry* (e.g., Bavelas, Black, Lemery, & Mullett, 1986; Dabbs, 1969; O’Toole & Dubin, 1968), namely, a focus on an individual’s imitation or mimicking of the limb movements performed by another. This focus was reintroduced in the 1990s (e.g., Chartrand & Bargh, 1999; Hatfield et al., 1994; van Baaren, Maddux, Chartrand, de Bouter, & van Knippenberg, 2003). For instance, Chartrand and Bargh (1999) had a trained experimenter rubbing her nose or shaking her foot while interacting with a participant. Their results revealed that when the experimenter rubbed her nose, then participants were more likely to do so as well rather than shake their foot, and in the experimental condition when the experimenter shook her foot, then the likelihood of participants shaking their foot was higher than rubbing their nose.

Earlier research by Bavelas and her colleagues (e.g., Bavelas, Black, Chovil, Lemery, & Mullett, 1988; Bavelas, Black, Lemery, & Mullett, 1986) examined what they also refer to as “motor mimicry,” defined as behavior by an observer that is appropriate to the situation of another (e.g., wincing at the other’s injury or ducking when the other does). They argue that the function of such motor mimicking is primarily communicative (Bavelas et al., 1988). They created a situation with a victim of an apparently painful injury and

controlled the amount of eye contact that the victim had with a participant observing the victim. They were able to reveal that motor mimicry displayed by the observing participant was significantly shaped by the visual availability of the victim, suggesting that mimicry may serve a communicative function.

The research evidence to date suggests that mimicry occurs outside of conscious awareness and without any intent to mimic or imitate. Numerous studies have investigated the diverse moderating conditions and consequences of “mimicry” such as self-monitoring (Cheng & Chartrand, 2003) and type of self-construal (van Baaren, Maddux, Chartrand, de Bouter, & van Knippenberg, 2003; van Baaren, Horgan, Chartrand, & Dijkmans, 2004). One of the interesting consequences of mimicry or entrainment is that it leads to an increased liking of an interaction partner (Chartrand & Jefferis, 2003; Dijksterhuis & Bargh, 2001). Indeed, there appears to be reliable evidence for the relationship between liking and the entrainment or mimicry of different types of movements (Bernieri & Rosenthal, 1991; Chartrand & Bargh, 1999; Julien, Brault, Chartrand, & Begin, 2000; LaFrance, 1982; LaFrance & Broadbent, 1976; Lakin & Chartrand, 2003).

Currently, mimicry research, which has the individual as the unit of analysis, relies on a priming account. The assumption is that “perceiving an action activates the mental representation of this action, which in turn leads to the performance of the action” (Dijksterhuis & Bargh, 2001, p. 8). Indeed, this account of entrainment shows no theoretical interest in the temporally distributed regularities in joint movement – a central focus in ecological work – nor does it show an interest in jointly recruited mediating processes as advanced by the SC model. Indeed, the so-called “perception-action expressway” (Dijksterhuis & Bargh, 2001) has an uncomplicated approach to explaining how an individual’s behavior affects the behavior of another individual. Thus, in this view the temporal dynamics of interpersonal entrainment do not feature. There is no distinction between coordination and entrainment, though the data on which the mimicry research relies consists of the frequency with which a target displays the same behavior as a confederate.

Coordination

Coordination of behavior can take a great variety of manifest forms, ranging from a dialogue, talking and walking, a soccer game, the performance of open-heart surgery, two people moving a very heavy object, to implementing a war strategy. Four features of coordination stand out. One is that the participants in a joint action must be on the same page regarding the “task” at hand, namely, share a “common ground” and engage in joint action abiding by the rules pertinent to the “task” (dialogue, tennis, surgery, pushing a large object,

and so on) that are quintessential to grounding the task. The second feature is that joint action is an open system (whatever the task) and can lead to the same result (goal or end state) despite differences in the initial conditions. In other words, coordination is not a determinate path but is characterized by equifinality. Third, coordination can take place over behavioral cycles that can vary from milliseconds to hours or longer. The temporal nature of these cycles is a function of the type of "task" that is being performed. This can be illustrated with any type of social interaction that consists of situated linguistic or behavioral exchanges, such as a dialogue or a tennis game. Finally, coordination in social interaction is multimodal (e.g., verbal, motor movement).

Co-regulation of Behavior

Entrainment, mimicry, and coordination are simultaneously occurring processes during social interaction. For instance, consider a dialogue. Any dialogue features a variety of instances of multimodal coordination, entrainment, and mimicry. A dialogue can simultaneously manifest coordination, as in the case of turn-taking in a conversation (e.g., Sachs, Schegloff, & Jefferson, 1974) or introducing a new topic, at a syntactic level (e.g., syntactic priming; Bock, 1986, 1989; Bock & Loebell, 1990), or an affective level (e.g., mood contagion, Neumann & Strack, 2000). Simultaneously, it is possible to see cyclically occurring instances of affective facial expressions (e.g., Dimberg et al., 2000) and breathing movements (e.g., Furuyama, Hayashi, & Mishima, 2005). Coordination and entrainment can converge when joint behavior is goal-driven (e.g., playing tennis versus choral singing), be consciously accessible, or escape conscious access (two people moving a heavy object versus emotional contagion), or a combination of both.

In presenting the SC model, we argued that the goal of joint action along with the type of task environment (social or physical features of the task) contributes to the shape and nature of cognition and joint action. The nature of coordination, mimicry, and entrainment in co-regulation will obviously vary depending on whether two people are attempting to move a heavy stone, a large table, an abstract idea, or a concrete business plan. Of course, there is a well-established tradition on how language is used to coordinate joint action and establish what is termed "common ground" (H. Clark, 1996). A significant portion of this work has relied on the transmission of "representations" in interpersonal communication (cf. Krauss & Chiu, 1998; Krauss & Fussell, 1996). A recurrent theme in this field is what one may be referred to as "coordination in communication," namely, the different ways in which "representational correspondence" can be established in joint action by, for

instance, "audience design" (e.g., Krauss & Fussell, 1996), "referential communication" (Clark & Brennan, 1991; Fussell & Krauss, 1989a, 1989b), and "grounding" (e.g., Clark, 1996; Keysar, 1997).

In contrast, the approaches to co-action (e.g., Sebanz et al., 2006; Marsh et al., 2006) do not speak to how the different pathways activated by significant goals and synchronization processes contribute to the shape of entrainment and coordination. The SC model specifies these conditions. In the absence of goal activation that recruits coordination (e.g., playing table tennis), synchronization processes (subject to inhibitory and excitatory influences) contribute to the shape of the cognitive, co-native, and affective mental representations that configure the motor responses of the perceiver. Arguably, this is what is noted in the mimicry research. This is argued to be the result of a semistochastic transduction process leading to some nonperiodic co-action.

Obviously, there are numerous naturally occurring instances where the behavioral goals of co-actors are explicitly prescribed, as in the case of gospel singing and dancing, *inter alia*. These are instances where behavior entrainment (entrainment of motor responses) is likely to occur when goal-mediated neurophysiological activation is synchronized with the stimulus as a function of appropriate relevance and significance. A consequence of entrainment involving such fusion of action is the emergence of considerable identity overlap resulting in the reduction of psychological distance, increased proximity, and heightened rapport between co-actors, as the early and recent research on mimicry has demonstrated. These are situations where the boundaries between self and other are reduced or on extreme occasions nearly dissolve, such as in religious rituals.

CONCLUSION

The cognitive revolution led by psychologists, anthropologists, and linguists in the 1950s was a response to the claim by behaviorists that mental processes did not fall under the purview of science (e.g., Chomsky, 1959). Mental representations and processes were rendered testable through the use of mathematical and computer models that specified stimulus inputs, information processing operations that acted on and transformed these inputs to produce and change representational structures, and information processing operations that led to observable responses. Accordingly, the dominant metaphor for the mind became the solitary computer – a device with massive information processing capacities in which knowledge is represented in an amodal fashion, divorced from the building blocks of behaviorism – sensory and motor bases.

The past decade has seen a sea change in theory and research on embodied cognition, as evidenced by the other contributions to this volume. Humans are also a fundamentally social species. Human cognitive capacities not only evolved as a means of increasing the adaptive possibilities between stimuli and responses but do so through adaptive dyadic and collective action. Accordingly, we have argued that to fully understand social cognition, one must extend the levels of analysis beyond the study of the solitary individual. This suggested expansion of focus has a metaphorical counterpart in computer science, where the notion of the solitary computer now seems antiquated. Computers today are massively interconnected devices with capacities that extend far beyond the resident hardware and software of any single computer. For instance, the rapid evolution of the Internet has led to possibilities and capacities that could not have been envisioned a few decades ago. The hominid brain and telereceptors (e.g., eyes, ears) have provided wireless broadband interconnectivity among conspecifics for millions of years. Just as computers have capacities and processes that are transduced through but extend far beyond the hardware of a single computer, the human brain has evolved to promote cognitive, social, and cultural capacities and processes that are transduced through but that extend far beyond a solitary brain (Cacioppo & Hawley, 2005). By extending the level of analysis of social cognition beyond the study of solitary individuals, these capacities and the mechanisms responsible for them can be more completely discerned (see also chapters by Smith and Schubert et al., this volume).

Indeed, our environment consists of a boundless array of variegated sources of stimulation ranging from diverse inanimate artifacts to the cosmos of nature. Within this boundless diversity, human beings and their bodily movements constitute a distinctive class of stimuli (e.g., Buccino et al., 2004). The architecture of the human perceptual and neural system is specifically designed for the recognition of species-specific movements in a privileged way, thereby establishing a type of knowledge that has an entirely different ontological status than knowledge about the world in general (Semin, 2007). The SC model we advanced in this chapter builds upon the work on embodied cognition to argue that cognition is social – in the sense that it is the consequence of interactions among individuals – because neurophysiological mechanisms exist that facilitate achieving some common or symmetrical base between individuals. Consequently, the model relies on an analytic unit that is different from the traditional Western focus – evident in the writings of Plato and Aristotle – of the isolated, thinking individual. The individual is also a prominent unit for practical methodological reasons. Such an analytic incision offers itself readily given the biological finitude of

the individual. However, it does not necessarily lend itself as readily for conceptualizing what it means to be a “social species” and the analysis of social cognition in general. Consequently, a complete understanding of social cognition may require an analytic unit that includes coupled individuals and jointly recruited processes. We hope this is one of the contributions of the SC model to the emerging embodiment literature.

References

- Adolphs, R., & Spezio, M. (2007). The neural basis of affective and social behavior. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed.) (pp. 540–554). New York: Cambridge University Press.
- Adolphs, R. (2003). Cognitive neuroscience of human social behaviour. *Nature Reviews Neuroscience*, 4, 165–178.
- Adolphs, R. (2006). How do we know the minds of others? Domain specificity, simulation, and enactive social cognition. *Brain Research*, 1079, 25–35.
- Agre, P. E. (1997). *Computation and human experience*. New York: Cambridge University Press.
- Allport, F. H. (1924). *Social psychology*. Boston: Houghton Mifflin.
- Amodio, D. M., & Firth, C. D. (2006). Meeting of minds: The medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, 7, 268–277.
- Andrews, T. J., & Coppola, D. M. (1999). Idiosyncratic characteristics of saccadic eye movements when viewing different visual environments. *Vision Research*, 39, 2947–2953.
- Andrews, J. T., & Purves, D. (2005). The wagon-wheel illusion in continuous light. *Trends in Cognitive Sciences*, 9, 261–263.
- Baldissera, F., Cavallari, P., Craighero, L., & Fadiga, L. (2001). Modulation of spinal excitability during observation of hand actions in humans. *European Journal of Neuroscience*, 13, 190–194.
- Barrett, L., & Henzi, P. (2005). The social nature of primate cognition. *Proceedings of the Royal Society: Biological Sciences*, 272, 1865–1875.
- Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral & Brain Sciences*, 22, 577–660.
- Bavelas, J. B., Black, A., Chovil, N., Lemery, C. R., & Mullett, L. (1988). Form and function in motor mimicry: Topographic evidence that the primary function is communicative. *Human Communication Research*, 14, 275–299.
- Bavelas, J. B., Black, A., Lemery, C. R., & Mullett, L. (1986). I show how you feel: Motor mimicry as a communicative act. *Journal of Personality and Social Psychology*, 50, 322–329.
- Bekkering H., Wohlschläger A., & Gattis M. (2000). Imitation of gestures in children is goal-directed. *Quarterly Journal of Experimental Psychology*, A53, 153–164.
- Bernieri, F., & Rosenthal, R. (1991). Interpersonal coordination, behavior matching, and interpersonal synchrony. In R. Feldman & B. Rime (Eds.), *Fundamentals of nonverbal behavior* (pp. 401–433). Cambridge, UK: Cambridge University Press.
- Bernieri, F. J. (1988). Coordinated movement and rapport in teacher student interactions. *Journal of Nonverbal Behavior*, 12, 120–138.

- Bernieri, F. J., Davis, J. M., Rosenthal, R., & Knee, C. R. (1994). Interactional synchrony and rapport: Measuring synchrony in displays devoid of sound and facial affect. *Personality and Social Psychology Bulletin*, 20, 303–311.
- Bernieri, F. J., Reznick, J. S., & Rosenthal, R. (1988). Synchrony, pseudosynchrony, and dissynchrony: Measuring the entrainment process in mother infant interactions. *Journal of Personality and Social Psychology*, 54, 243–253.
- Bock, L. J. (1986). Syntactic priming in language production. *Cognitive Psychology*, 18, 355–387.
- Bock, L. J. (1989). Close class immanence in sentence production. *Cognition*, 31, 163–189.
- Bock, L. J., & Loebell, H. (1990). Framing sentences. *Cognition*, 35, 1–39.
- Brazelton, T. B., Koslowski, B., & Main, M. (1974). Origins of reciprocity: The early mother-infant interaction. In M. Lewis & L. Rosenblum (Eds.), *The effect of the infant on its caregiver* (pp. 49–76). New York: Wiley.
- Brooks, R. (1999). *Cambrian intelligence*. Cambridge, MA: MIT Press.
- Buccino, G., Binkofski, F., Fink, G. R., Fadiga, L., Fogassi, L., Gallese, V., Seitz, R. J., Zilles, K., Rizzolatti, G., & Freund, H. J. (2001). Action observation activates premotor and parietal areas in a somatotopic manner: An fMRI study. *European Journal of Neuroscience*, 13, 400–404.
- Buccino, G., Lui, F., Canessa, N., Patteri, I., Lagravinese, G., Benuzzi, F., Porro, C. A., & Rizzolatti, G. (2004). Neural circuits involved in the recognition of actions performed by nonconspecifics: An fMRI study. *Journal of Cognitive Neuroscience*, 16, 114–126.
- Bullowa, M. (1975). When infant and adult communicate, how do they synchronize their behavior? In A. Kendon, R. M. Harris, & M. R. Keys (Eds.), *Organization of behavior in face-to-face interaction* (pp. 95–127). The Hague, Netherlands: Mouton.
- Cacioppo, J. T., & Hawley, L. C. (2005). People thinking about people: The vicious cycle of being a social outcast in one's own mind. In K. D. Williams, J. P. Forgas, and W. von Hippel (Eds.), *The social outcast: Ostracism, social exclusion, rejection, and bullying* (pp. 91–108). New York: Psychology Press.
- Cappella, J., & Planalp, S. (1981). Talk and silence sequences in informal conversations. III. Interspeaker influence. *Human Communication Research*, 7, 117–132.
- Carr, L., Iacoboni, M., Dubeau, M.-C., Mazziotta, J. C., & Lenzi, G. L. (2003). Neural mechanisms of empathy in humans: A relay from neural systems for imitation to limbic areas. *Proceedings of the National Academy of Sciences of the United States of America*, 100, 5497–5502.
- 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.
- Chartrand, T. L., & Jefferis, V. E. (2003). Consequences of automatic goal pursuit and the case of nonconscious mimicry. In J. P. Forgas (Ed.), *Social judgments: Implicit and explicit processes* (pp. 290–305). New York: Cambridge University Press.
- Cheng, C. M., & Chartrand, T. L. (2003). Self-monitoring without awareness: Using mimicry as a nonconscious affiliation strategy. *Journal of Personality and Social Psychology*, 85, 1170–1179.
- Chomsky, N. (1959). A Review of B. F. Skinner's verbal behavior. *Language* 35(1), 26–58.
- Clancey, W. J. (1993). Situated action: A neuropsychological interpretation. Response to Vera and Simon. *Cognitive Science*, 17, 87–116.
- Clancey, W. J. (1997). *Situated cognition: On human knowledge and computer representations*. New York: Cambridge University Press.
- Clark, A. (1997). *Being there*. Cambridge, MA: MIT Press.

- Clark, H. H. (1996). *Using language*. New York: Cambridge University Press.
- Clark, H. H., & Brennan, S. E. (1991). Grounding in communication. In L. Resnick, J. Levine, & S. Teasley (Eds.), *Perspectives on socially shared cognition*. Washington, DC: American Psychological Association.
- Condon, W. S., & Ogston, W. D. (1966). Sound film analysis of normal and pathological behavior patterns. *Journal of Nervous and Mental Diseases*, 143, 338–457.
- Condon, W. S., & Ogston, W. D. (1967). A segmentation of behavior. *Journal of Psychiatric Research*, 5, 221–235.
- Critchley, H. D., Wiens, S., Rotshtein, P., Oehman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, 7, 189–195.
- Dabbs, J. M. (1969). Similarity of gestures and interpersonal influence [Summary]. *Proceedings of the 77th Annual Convention of the American Psychological Association*, 4, 337–338.
- Davis, M. (1982). *Interaction Rhythms: Periodicity in Communicative Behavior*. New York: Human Sciences Press.
- De Gelder, B., Snyder, J., Greve, D., Gerard, G., & Hadjikhani, N. (2004). Fear fosters flight: A mechanism for fear contagion when perceiving emotion expressed by a whole body. *Proceedings of the National Academy of Sciences of the United States of America*, 101, 16701–16706.
- Decety, L. (2005). Perspective taking as the royal avenue to empathy. In B. F. Malle & S. D. Hodges (Eds.), *Other minds: How humans bridge the divide between self and other* (pp. 135–149). New York: Guilford Publications.
- Decety, J., & Grèzes, J. (2006). Multiple perspectives on the psychological and neural bases of understanding other people's behavior. *Brain Research*, 1079, 4–14.
- di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: A neurophysiological study. *Experimental Brain Research*, 91, 176–180.
- Dijksterhuis, A., & Bargh, J. A. (2001). The perception-behavior expressway: Automatic effects of social perception on social behavior. *Advances in Experimental Social Psychology*, 33, 1–40.
- Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science*, 11, 86–89.
- Ferrari, P. F., Gallese, V., Rizzolatti, G., & Fogassi, L. (2003). Mirror neurons responding to the observation of ingestive and communicative mouth actions in the monkey ventral premotor cortex. *European Journal of Neuroscience*, 17, 1703–1714.
- Ferrari, P. F., Maiolini, C., Addressi, E., Fogassi, L., & Visalberghi, E. (2005). The observation and hearing of eating actions activates motor programs related to eating in macaque monkeys. *Behavior & Brain Research*, 161, 95–101.
- Firth, C. D., & Firth, U. (2006). How we predict what other people are going to do. *Brain Research*, 1079, 36–46.
- Fodor, J. A. (1975). *The language of thought*. Cambridge, MA: Harvard University Press.
- Furuyama, N., Hayashi, K., & Mishima, H. (2005). Interpersonal coordination among articulations, gesticulations, and breathing movements: A case of articulation of /a/ and flexion of the wrist. In H. Heft & K. L. Marsh (Eds.), *Studies in perception and action* (pp. 45–48). Mahwah, NJ: Erlbaum.
- Fussell, S. R., & Krauss, R. M. (1989a). The effects of intended audience on message production and comprehension: Reference in a common ground framework. *Journal of Experimental Social Psychology*, 19, 509–525.

- Fussell, S. R., & Krauss, R. M. (1989b). Understanding friends and strangers: The effects of audience design on message comprehension. *European Journal of Social Psychology*, 19, 509–526.
- Gallese, V. (2001). The “shared manifold” hypothesis: From mirror neurons to empathy. *Journal of Consciousness Studies*, 8(5–7), 33–50.
- Gallese, V. (2003). The manifold nature of interpersonal relations: The quest for a common mechanism. *Philosophical Transactions of the Royal Society London, Series B Biological Sciences*, 358, 517–528.
- Gallese, V. (2005). Embodied simulation: From neurons to phenomenal experience. *Phenomena of Cognitive Science*, 4, 23–48.
- Gallese, V. (2006). Intentional attunement: A neurophysiological perspective on social cognition and its disruption in autism. *Brain Research*, 1079, 15–24.
- Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, 119, 593–609.
- Goldman, A. I. (2002). Simulation theory and mental concepts. In J. Dokic & J. Proust (Eds.), *Simulation and knowledge of action* (pp. 1–19). Amsterdam: John Benjamins Publishing Company.
- Goldman, A. I. (2005). Imitation, mind reading, and simulation. In S. Hurley & N. Chater (Eds.), *Perspective on imitation, from neuroscience to social science*, Vol. 2 (pp. 79–93). Cambridge, MA: MIT Press.
- Grafton, S. T., Arbib, M. A., Fadiga, L., & Rizzolatti, G. (1996). Localization of grasp representations in humans by PET. 2. Observation compared with imagination. *Experimental Brain Research*, 112, 103–111.
- Graumann, C. (1984). The individualization of the social and the desocialization of the individual: Floyd H. Allport's contribution to the history of social psychology. *Archiv für die Geschichte der Psychologie, Historische Reihe*, No. 10. Heidelberg: Institute of Psychology.
- Grèzes, J., & Decety, J. (2001). Functional anatomy of execution, mental simulation, observation, and verb generation of actions: A meta-analysis. *Human Brain Mapping*, 12, 1–19.
- Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). *Emotion contagion*. Cambridge, UK: Cambridge University Press.
- Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.
- Hutchison, W. D., Davis, K. D., Lozano, A. M., Tasker, R. R., & Dostrovsky, J. O. (1999). Pain-related neurons in the human cingulate cortex. *Nature-Neuroscience*, 2, 403–405.
- Iacoboni, M. (2005). Neural mechanisms of imitation. *Current Opinion in Neurobiology*, 15, 632–637.
- Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, 286, 2526–2528.
- Jabbi, M., Swart, M., Keysers, C. (2007). Empathy for positive and negative emotions in the gustatory cortex. *Neuroimage*, 34, 1744–1753.
- Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005). How do we perceive the pain of others: A window into the neural processes involved in empathy. *Neuroimage*, 24, 771–779.
- Jannerod, M. (1999). The 25th Bartlett Lecture. To act or not to act: Perspectives on the representation of actions. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 52, 1–29A.

- Julien, D., Brault, M., Chartrand, E., & Begin, J. (2000). Immediacy behaviours and synchrony in satisfied and dissatisfied couples. *Canadian Journal of Behavioural Science*, 32, 84–90.
- Kendon, A. (1970). Movement coordination in social interaction: Some examples described. *Acta Psychologica*, 32, 100–125.
- Keysar, B. (1997). Unconfounding common ground. *Discourse-Processes*, 24, 253–270.
- Keysers, C., & Gazzola, V. (2006). Towards a unifying neural theory of social cognition. *Progress in Brain Research*, xxx.
- Keysers, C., Kohler, E., Umiltà, M. A., Nanetti, L., Fogassi, L., & Gallese, V. (2003). Audiovisual mirror neurons and action recognition. *Experimental Brain Research*, 153, 628–636.
- Kirsch, D. (1995). The intelligent use of space. *Artificial Intelligence*, 73, 31–68.
- Kirshner, D., & Whitson, J. A. (1997). *Situated cognition: Social, semiotic, and psychological perspectives*. Mahwah, NJ: Lawrence Erlbaum Assoc.
- Kohler, E., Keysers, C., Umiltà, M. A., Fogassi, L., Gallese, V., Rizzolatti, G. (2002). Hearing sounds, understanding actions: Action representation in mirror neurons. *Science*, 297, 846–848.
- Krauss, R. M., & Fussell, S. R. (1996). Social psychological models of interpersonal communication. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 655–701). New York: Guilford.
- Krauss, R. M., & Chiu, C. (1998). Language and social behavior. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *Handbook of social psychology* (4th ed., Vol. 2) (pp. 41–88). New York: McGraw-Hill.
- LaFrance, M. (1982). Posture mirroring and rapport. In M. Davis (Ed.), *Interaction rhythms: Periodicity in communicative behavior* (pp.). New York: Human Sciences Press.
- LaFrance, M., & Broadbent, M. (1976). Group rapport: Posture sharing as a nonverbal indicator. *Group and Organization Studies*, 1, 328–333.
- Lakin, J. L., & Chartrand, T. L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science*, 14, 334–339.
- Lazarus, M. (1861). Über das Verhältnis des Einzelnen zur Gesamtheit. *Zeitschrift für Völkerpsychologie und Sprachwissenschaft*, 2, 393–453.
- Lazarus, M., & Steinhil, H. (1860). Einleitende Gedanken über Völkerpsychologie als Einladung zu für Völkerpsychologie und Sprachwissenschaft. *Zeitschrift für Völkerpsychologie und Sprachwissenschaft*, 1, 1–73.
- Lieberman, A. M., & Mattingly, I. G. (1985). The motor theory of speech perception revised. *Cognition*, 21, 1–36.
- Lieberman, A. M., & Whalen, D. H. (2000). On the relation of speech to language. *Trends in Cognitive Sciences*, 4, 187–196.
- Lipps, T. (1903). Einfühlung, innere Nachahmung, und Organempfindungen. *Archiv für die gesamte Psychologie*, 2, 185–204.
- Manthey, S., Schubotz, R. L., & von Cramon, D. Y. (2003). Premotor cortex in observing erroneous action: An fMRI study. *Cognitive Brain Research*, 15, 296–307.
- Marsh, K. L., Richardson, M. J., Baron, R. M., & Schmidt, R. C. (2006). Contrasting approaches to perceiving and acting with others. *Ecological Psychology*, 18, 1–38.
- McDougal, W. (1908). *An introduction to social psychology*. London: Methuen.

- Neda, Z., Ravasz, E., Brechet, Y., Vicsek, T., & Barabasi, A. L. (2000). The sound of many hands clapping: Tumultuous applause can transform itself into waves of synchronized clapping. *Nature*, *403*, 849–850.
- Neumann, R., & Strack, F. (2000). "Mood contagion": The automatic transfer of mood between persons. *Journal of Personality and Social Psychology*, *79*, 211–223.
- Newell, A., & Simon, H. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.
- O'Toole, R., & Dubin, R. (1968). Baby feeding and body sway: An experiment in George Herbert Mead's taking the role of the other. *Journal of Personality & Social Psychology*, *10*, 59–65.
- Post, D. L. (1980). Floyd H. Allport and the launching of modern social psychology. *Journal for the History of the Behavioral Sciences*, *16*, 369–376.
- 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.
- Rosenfeld, H. M. (1981). Whither interactional synchrony? In K. Bloom (Ed.), *Prospective issues in infancy research* (pp. 71–97). Hillsdale, NJ: Erlbaum.
- Sachs, H. A., Schegloff, E. A., & Jefferson, G. (1974). A Simplest systematics for the organization of turn-taking for conversation. *Language*, *50*, 696–735.
- Schefflen, A. E. (1982). Comments on the significance of interaction rhythms. In M. Davis (Ed.), *Interaction rhythms: Periodicity in communicative behavior* (pp. 13–22). New York: Human Sciences Press.
- Schofield, W. N. (1976). Do children find movements which cross the body midline difficult? *Quarterly Journal of Experimental Psychology*, *28*, 571–582.
- Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: Bodies and minds moving together. *Trends in Cognitive Sciences*, *10*, 70–76.
- Semin, G. R. (1986). The individual, the social and the social individual. *British Journal of Social Psychology*, *25*, 177–180.
- Semin, G. R. (2007). Grounding communication: Synchrony. In A. Kruglanski & E. T. Higgins (Eds.), *Social psychology: Handbook of basic principles* (2nd edition) (pp. 630–649). New York: Guilford Publications.
- Semin, G. R., & Cacioppo, J. T. (2007). From representation to co-regulation. In J. A. Pineda (Ed.), *Mirror neuron systems: The role of mirroring processes in social cognition*. Totowa, NJ: Humana Press.
- Semin, G. R., & Cacioppo, J. T. (in prep). Social cognition: A model. (In prep).
- Shockley, K., Santana, M. V., & Fowler, C. A. (2003). Mutual interpersonal postural constraints are involved in cooperative conversation. *Journal of Experimental Psychology: Human Perception and Performance*, *29*, 326–332.
- Shockley, K., Baker, A. A., Richardson, M. J., & Fowler, C. A. (2007). Articulatory constraints on interpersonal postural coordination. *Journal of Experimental Psychology: Human Perception and Performance*, *33*, 201–208.
- Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. F. (2004). Empathy for pain involves the affective but not the sensory components of pain. *Science*, *303*, 1157–1162.
- Smith, E. R., & Semin, G. R. (2004). Socially situated cognition: Cognition in its social context. *Advances in Experimental Social Psychology*, *36*, 53–117.
- 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 and Review*, *13*, 179–200.
- Stern, D. N. (1974). Mother and infant at play. In M. Lewis & L. Rosenblum (Eds.), *The effect of the infant on its caregiver* (pp. 187–213). New York: Wiley.
- Stevens, J. A., Fonlupt, P., Shiffrar, M., & Decety, J. (2000). New aspects of motion perception: Selective neural encoding of apparent human movements. *NeuroReport*, *11*, 109–115.
- Street, R. L., Jr. (1984). Speech convergence and speech evaluation in fact-finding interviews. *Human Communication Research*, *11*, 139–169.
- Strogatz, S. (2003). *SYNC: Rhythms of nature, rhythms of ourselves*. London: Allen Lane: Penguin
- Swanson, R., & Benton, A. L. (1955). Some aspects of the genetic development of right-left discrimination. *Child Development*, *26*, 123–133.
- Tickle-Degnen, L., & Rosenthal, R. (1987). Group rapport and nonverbal behavior. *Review of Personality and Social Psychology*, *9*, 113–136.
- Umiltà, M. A., Kohler, E., Gallese, V., Fogassi, L., Fadiga, L., Keysers, C., & Rizzolatti, G. (2001). "I know what you are doing": A neurophysiological study. *Neuron*, *32*, 91–101.
- van Baaren, R. B., Maddux, W. W., Chartrand, T. L., de Bouter, C., & van Knippenberg, A. (2003). It takes two to mimic: Behavioral consequences of self-construals. *Journal of Personality and Social Psychology*, *84*, 1093–1102.
- VanRullen, R., & Koch, C. (2003). Is perception discrete or continuous? *Trends in Cognitive Sciences*, *7*, 207–213.
- Vera, A., & Simon, H. A. (1993). Situated action: A symbolic interpretation. *Cognitive Science*, *17*, 7–48.
- Waits, T. (1859). In Gerland, G. *Psychologische Anthropologie. Zeitschrift für Völkerpsychologie und Sprachwissenschaft*, *1*, 387–412.
- Wapner, S., & Cirillo, L. (1968). Imitation of a model's hand movements: Age changes in transposition of left-right relations. *Child Development*, *39*, 887–894.
- Wedewer, H. (1860). Über die Wichtigkeit und Bedeutung der Sprache. *Zeitschrift für Völkerpsychologie und Sprachwissenschaft*, *1*, 180.
- 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.
- Wilson, S. M., Saygin, A. P., Sereno, M. I., & Iacoboni, M. (2004). Listening to speech activates motor areas involved in speech production. *Nature Neuroscience*, *7*, 701–702.
- Wohlschläger, A., Gattis, M., & Bekkering, H. (2003). Action generation and action perception in imitation: An instance of the ideomotor principle. *Philosophical Transactions of the Royal Society of London, Series B*, *358*, 501–515.
- Yeh, W., & Barsalou, L. W. (2000). The situated nature of concepts (unpublished), Department of Psychology, Emory University, Atlanta, GA.