Introduction: The Importance of Imitation

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Imitation is often thought of as a low-level, cognitively undemanding, even childish form of behavior, but recent work across a variety of sciences argues that imitation is a rare ability that is fundamentally linked to characteristically human forms of intelligence, in particular to language, culture, and the ability to understand other minds. This burgeoning body of work has important implications for our understanding of ourselves, both individually and socially. Imitation is not just an important factor in human development, it also has a pervasive influence throughout adulthood in ways we are just starting to understand.

These two volumes present papers by researchers working in disciplines that include neuroscience and brain imaging, psychology, animal behavior, philosophy, computer science, education studies, anthropology, media studies, economics, sociology, and law. Among the authors are many who are leading figures in imitation research and who have produced seminal work on imitation. They also include younger researchers and scholars commenting on work in disciplines other than their own. One of our main aims in these volumes has been to provide a resource that brings together important work on this topic from various disciplines, makes it accessible across disciplines, and fosters interdisciplinary cross-fertilization. In particular, we want to convey why imitation is a topic of such intense current interest in the cognitive sciences and how important this work is for the social sciences and for philosophy, where it has yet to be assimilated.

This introduction surveys the central themes of the volumes, chapter by chapter, and then distills some of the important issues on which they bear, both methodological and substantive. En route, the following questions are addressed:

Which actions count as imitation and which are better understood in other terms?

What is imitated—the goals of action or the movements that are the means to goals, or both?
How is imitation achieved? By what neural mechanisms, in the contexts of what cognitive architectures or social environments?
Who imitates—only human beings, or other animals?
When does imitation occur—only in development, or also in adulthood?
Why does imitation occur—what are its evolutionary and cultural functions?

The structure of this introduction largely follows the structure of the two volumes. In volume 1, part I focuses on the subpersonal mechanisms by which imitation is achieved, and part II on imitation in animals. In volume 2, part I is on the role of imitation in human development and part II is on the role of imitation in human culture. This introduction concludes with a broad view of why imitation matters and highlights themes and questions that unite the two volumes.

Volume 1, Part I Mechanisms of Imitation

What exactly is imitation? Imitation may be presumed to require at least *copying* in a generic sense. The observer's perception of the model's behavior causes similar behavior in the observer, in some way such that the similarity between the model's behavior and that of the observer plays a role, though not necessarily at a conscious level, in generating the observer's behavior.[1] More than that we will not try to say at the outset. As we will explain below, imitation needs to be distinguished from other forms of social learning that may look superficially similar, and there are different accounts, in part motivated by the aims of different disciplines, of what is distinctive about imitation. However, even the generic idea of copying perceived behavior poses a certain immediate problem, which thus provides a natural starting place.

Imitation appears to require the solution to a difficult *correspondence problem*. How is the perceived action of another agent translated into similar performance by the observer? When I imitate your hand movements at least I can see my own hands, even though my visual perspective on the

1. Although even this generic formulation may include controversial elements. See W. Prinz in vol. 1, ch. 5 on how similarity can be functional in imitation, and Meltzoff in vol. 2, ch. 1 cf. Heyes in vol. 1, ch. 6 who questions the role of similarity in generating the observer's response, and Whiten's comments on Heyes in vol. 1, ch. 8.

two actions is different; but when I imitate your facial gestures, I cannot see my own face. How is the perceptual-to-motor mapping achieved? Moreover, when an infant imitates an adult, the two have very different body structures and dynamics. What information and mechanisms are needed to solve this problem?

Striking discoveries in neuroscience suggest a possible answer. Certain neurons appear to constitute a direct link between perception and action; their firing correlates with specific perceptions as well as specific actions. Some of these, *canonical neurons*, can be thought of as reflecting affordances (in Gibson's sense, 1986); they fire when a certain type of action is performed, but are also triggered by perception of objects that afford such actions. Others, *mirror neurons*, fire when a certain type of action is performed, but also when another agent is observed performing the same type of action. That is, mirror neurons are sensitive both to others' actions and to equivalent actions of one's own. They can be very specifically tuned. For example, certain cells fire when a monkey sees an experimenter bring food to her own mouth with her own hand *or* when the monkey brings food to its own mouth (even in the dark, so that the monkey cannot see its hand).

When mirror neurons were discovered by a group of scientists in Parma, Italy, it was tempting to suggest that they enable imitation by avoiding the correspondence problem. If the same neurons code for perceived action and matching performance, it may seem that no neural translation is needed. However, things are not quite that simple. Neuroscientist Giacomo Rizzolatti, one of the Parma group, addresses the relationship between the ability to understand another agent's action and the ability to replicate it, both of which he holds are required for imitation. In his view, action understanding phylogenetically precedes imitation and is subserved by mirror systems, which are necessary but not sufficient for imitation. Indeed, imitation has not been demonstrated in the macaque monkeys in which mirror neurons were discovered (but see Voelkl & Huber 2000). Rizzolatti suggests that the motor resonance set up by mirror neurons makes action observation meaningful by linking it to the observer's own potential actions.

Mirror neurons were discovered in monkeys by single-cell recording. Evidence for human mirror systems includes brain imaging work, as well as demonstrations that observing another agent act primes the muscles the observer would need to do the same thing. Rizzolatti describes mirror neurons in the monkey frontal brain area F5 as part of a neural circuit, including also parietal area PF and the superior temporal sulcus (STS) visual area. In human beings, he suggests, a similar circuit constitutes a comparator

system in which an intended imitative movement is controlled by reference to an observed target movement, enabling imitative learning. (Others have postulated similar control systems, although they differ on details; e.g., Rizzolatti locates the comparator site in PF, while Marco Iacoboni locates it in STS.) In monkeys, mirror neurons display *high-level resonance;* they code for the goals or ends of performed or observed actions. By contrast, in human beings, the mirror system displays both high-level resonance and *low-level resonance;* it extends to the specific movements that are the means to achieving goals.

This difference between mirroring the ends of action and mirroring the means of action is important for Rizzolatti's argument that action understanding precedes imitation. His view faces the objection that many animals to whom it would be implausible to attribute action understanding can nonetheless replicate movements. Consider response priming, by which observing a movement "primes" the same movement by the animal, independently of any understanding of the goal of the movement (as in the flocking of birds). In response to this objection Rizzolatti suggests that such low-level mirroring of movements could be present without high-level mirroring of goals, or vice versa. Action understanding requires high-level mirroring of goals, which is found in macaque monkeys. However, genuine imitative learning has not been found in these monkeys and would require the interplay of mirroring for both the ends and the means of action, which is found in human mirror systems (again see and cf. Voelkl & Huber 2000). Rizzolatti's argument here finds an ally in the views of Michael Tomasello, who links the phylogenetically rare capacity for imitative learning to the flexible recombinant means and ends structure of intentional action: the ability to use a given movement for different ends and pursue a given end by a variety of means.

Psychologist Paul Harris has suggested an experimental assessment of the extent to which mirror neurons subserve action understanding in monkeys.[2] Monkey mirror neurons fire when a monkey reaches for an apple, or when it sees the experimenter reach for the apple. The same mirror neurons also fire when a monkey sees a screen come down in front of the apple, so that it is no longer visible, and then sees the experimenter's hand reach behind the screen to where the apple is hidden. But they do not fire when the monkey first sees that there is no apple, and then the screen comes down and the monkey sees the experimenter's hand reach behind

2. This was in a discussion at the Royaumont conference, 2002.

the screen in the same way. The mirror neurons, that is, appear to code for the goal of the action. Harris suggests a variant that would address how insightfully the monkey attributes goals to others. Suppose the monkey and experimenter look at a nut and see the screen come down in front of it. Then the experimenter leaves the room. The monkey is permitted to remove the nut. Now the experimenter returns and the monkey sees the experimenter reach behind the screen for the nut, which the monkey knows is no longer there. Will the monkey's mirror neuron for reaching for the nut fire? If so, this would suggest that the monkey attributes the goal of reaching for the nut to the experimenter, who "doesn't know" that the nut is no longer there. Or will it not fire, because the nut is not there? Does the mirror neuron, that is, code for the *intended goal* of the observed action, or merely its *result?*[3]

Neuroscientist Marco Iacoboni also characterizes the ends-means comparator structure of the neural circuit for imitation, drawing on human brain imaging studies. He suggests a division of labor within the mirror system—that frontal areas of the mirror system code for the ends or goals of action, and parietal areas for movements and means. To enable imitation, both areas generate motor signals relating to a planned imitative action for comparison with the observed action; the motor plan is then adjusted until a match is obtained. Iacoboni compares this neural architecture for imitation to current ideas about functional motor control architectures that combine inverse and forward models. *Inverse models* estimate what motor plan is needed to reach a certain goal from a given state of affairs. They can be adjusted by comparison with real feedback from motor activity, but this is slow. It is often more efficient to use real feedback to train *forward models,* which take copies of motor plans as input and simulate or predict their consequences. Forward models can then be used with inverse models to control goal-directed behavior more efficiently. In particular, forward models can predict the consequences of a planned imitative action for comparison with the observed action, so that the motor plan can be adjusted until a match is obtained. Iacoboni is optimistic that imaging work will contribute to mapping this functional architecture for motor control onto the neural mirror system.

Mirror neurons were discovered in the monkey homologue of part of Broca's area, one of the primary language areas of the human brain. Broca's

3. See Nicholas Rawlins in vol. 1, ch. 8.1 for another means of assessing mind reading by animals, via recordings from hippocampal place cells rather than mirror neurons.

area is among those areas activated when human participants perform imitative tasks, and Iacoboni's group has recently shown that transient lesions of this area made by transcranial magnetic stimulation interfere with imitative tasks. As Iacoboni explains, when imaging techniques are used to morph a chimp brain onto a human brain, the areas that expand most are the perisylvian brain areas occupied by the mirror system, which are extremely important for language. Now a broadly nativist view of language *could* motivate a kind of protectiveness about Broca's area as the best candidate for an innate language module in the brain. However, the discovery that Broca's area is occupied by the mirror system and has an essential role in imitation has underscored questions about how language might depend on the capacity for imitation, either in evolutionary or developmental time frames. To what extent might language acquisition exploit imitative learning mechanisms rather than expressing innate linguistic knowledge? Iacoboni argues that evolution leads from action recognition through imitation to language.

What are the key features of imitation and the human mirror system that language might build on or exploit? First, if imitative learning requires flexible relations between means and ends, such flexibility could be an evolutionary precursor of the arbitrary relations between symbol and referent. Second, as Iacoboni (vol. 1, ch. 2) and Michael Arbib (2002, and in press) argue in different ways, the mirror system provides a common code for the actions of self and other, hence for production and perception of language. By thus enabling action understanding, the mirror system may be the basis for the intersubjective "parity" or sharing of meaning that is essential to language. Third, as Arbib has suggested, the flexible recombinant structure of ends and means in imitation may be a basis for recombinant grammatical structure in language. Here Iacoboni provides an alternative suggestion. He regards actual conversation as more like a dance than a formal structure, an embodied practice of social interaction with essential motor elements, and in this way dependent on action recognition and the mirror system.[4]

Vittorio Gallese, another member of the Parma group who discovered mirror neurons, concurs with Rizzolatti, Iacoboni, and Jean Decety and Thierry Chaminade in hypothesizing that extensions of the mirror system provide a plausible neural basis for emotional understanding and empathy.[5] Gallese's *shared manifold hypothesis* generalizes the empathic role of the mirror system, postulating a primitive intersubjective information space that develops out of the modeling of environmental interactions in biological control systems. This shared manifold arises prior to self–other distinctions, both phylogenetically and ontogenetically, softening the contrast between adult human mind reading and mere responses to others' behavior as found in other social animals. Nevertheless, the shared manifold is preserved in human adults. It supports automatic intersubjective identifications, not just across different perceptual modalities and action, but also for sensations and emotions. There is evidence, for example, of mirror mechanisms for pain and disgust, and hearing an expression of anger increases the activation of muscles used to express anger. Gallese argues that the extended mirror system is the neural basis of the shared manifold.

Neuroscientists Decety and Chaminade invoke single-cell, imaging, and behavioral evidence in support of the shared neural coding of action and the perception of action in a mirror system. They also regard such automatic motor resonance as a necessary basis for intersubjectivity in understanding action and in emotional empathy. But while Gallese's focus is on how the blended intersubjective space that precedes the self–other distinction is established, Decety and Chaminade focus on the characteristically human self–other distinction, and the way it is imposed on what is common to the representation of self and other. They report imaging experiments that probe the neural bases of the self–other distinction and reveal the relevance of left-right lateralization.

As Marcel Kinsbourne comments, their work dissects out the neural substrate of the self–other distinction by setting up conditions that differ only in this respect, so that the few nonoverlapping areas of brain activation they observe code for this difference. For example, they compare participants imagining performing an act themselves with participants imagining someone else performing the same act. In addition to the mostly common areas of activation, they find differential left inferior parietal activation for imagining oneself performing an act and differential right inferior parietal activation for imagining someone else performing the same act. Similarly, they compare participants imitating an act with participants being imitated in performing the same act, and again find mostly common activation but also some lateralized differential activation. Left inferior parietal areas enable you to imitate, they suggest, while right inferior parietal

4. See also the comments by Pickering on Pepperberg in vol. 1, ch. 12.4; Donald in vol. 2, ch. 14 and Christiansen's comments in vol. 2, ch. 19.8; Claxton's comments on Kinsbourne in vol. 2, ch. 8.9; and Chater in vol. 2, ch. 18.

5. Susan Jones in vol. 1, ch. 8.4, likes the idea that mirror neurons underlie intersubjective empathy, but is skeptical about their role in imitation.

areas enable you to recognize that you are being imitated. Decety and Chaminade regard the capacity to identify with others as especially dependent on right hemisphere resources.

Well before mirror neurons were discovered and invoked in neuroscientific arguments for the common coding of perception and action, psychologists argued for common coding from behavioral evidence. Meltzoff and Moore (1977) postulated a common "supramodal" code underlying early imitation (see Meltzoff, vol. 2, ch. 1). Wolfgang Prinz (1990) developed an argument for common coding to explain the reaction time advantage of imitative tasks and imitative interference effects, and related it to William James's views on ideomotor action. Common coding, Prinz reasoned, would facilitate imitation by avoiding the need for sensory-to-motor translation.[6] Here Prinz provides a definitive statement of his common coding view applied to imitation and further behavioral evidence for it from recent experiments.

In imitation, when an observed act *a* leads to performance of a similar act *b*, it seems to be no accident that *a* and *b* are similar. How, Prinz asks, can the similarity of observed and performed acts have a functional role in imitation? An approach that conceives of actions as responses to prior stimuli and of perceptions and actions as separately coded faces the problem of how correspondence between perceptions and similar actions is achieved. By contrast, the *ideomotor approach* Prinz favors conceives of actions as the means to realizing intentions and postulates the common coding of perception and action, so that a representation of movement observed in another agent tends inherently to produce a similar movement by the observer. The regular concurrence of action with perceived effects enables the prediction of the effects of an action (as in a forward model) and the selection of an action, given an intention to produce certain effects (as in an inverse model). As a result, the representation of a regular effect of action, whether proximal or distal, acquires the power to evoke a similar action if it is not inhibited. By explaining how perception and action share representational resources, the ideomotor view avoids the correspondence problem and explains the functionality of similarity in imitation.

6. Prinz argued that we should expect common codes for perception and action to code for distal events rather than for proximal events, such as patterns of activation of sensory receptors or of muscle neurons. Note that the mirror neurons discovered in monkeys appear to code distally, although, as Rizzolatti (vol. 1, ch. 1) and Iacoboni (vol. 1, ch. 2) explain, the human mirror system appears to code for the results or goals of action in some brain areas and the movements that are the behavioral means to such goals in others.

In this view, as Kinsbourne comments, when automatic imitative effects are held covert, inhibition occurs at the level of motor output rather than centrally, between separate perceptual processing and action processing. This point has implications for how we understand failures to inhibit imitation, whether pathological or normal. More generally, the common coding approach challenges standard Humean assumptions about the intrinsic motivational inertness of perception.

The consequences of damage to the mechanisms that normally inhibit automatic imitative tendencies in adults are revealed in classic studies of patients with frontal or prefrontal lesions. Luria's patients[7] found it very difficult not to imitate what the experimenter was doing, even when they were instructed to do something else. Lhermitte's imitation syndrome patients[8] imitated gestures the experimenter made, although they were not instructed to do so, and even when these gestures were socially unacceptable or odd. When asked why they did this, they did not disown their behavior but explained that they felt that the gestures they saw somehow included an order to imitate them; that their response was the reaction called for.

However, there are both theoretical and empirical reasons to hold that the automatic tendency of human adults to imitate is not confined to those with brain damage. The philosopher, and proponent of the idea that we understand other minds by mental simulation, Robert Gordon (1995a) argues that it takes a special containing mechanism to keep the emotion recognition process from reverting to ordinary emotional contagion, and this mechanism is not fail-safe. If simulation theory is right, he holds, there is only a delicate separation between one's own mental life and one's representation of the mental life of another; "offline" representations of other people have an inherent tendency to go "online." Moreover, striking similarities have been observed between the behavior of Lhermitte's patients and that of normal college students in priming experiments by social psychologists.[9]

Normal adults are studied in three experimental paradigms described by Prinz that provide evidence for the ideomotor approach. This work shows how an action by normal adults is spontaneously induced or modulated by the perception of a similar action. Perception has effects on action that are automatic but nevertheless have cognitive depth in that they

7. See Kinsbourne, vol. 2, ch. 7; see also L. Eidelberg (1929).
8. Lhermitte (1986), Lhermitte et al. (1986).
9. As Bargh (in press) comments; see also Dijksterhuis in vol. 2, ch. 9.

depend on the way participants understand what they are perceiving and doing.

First, in imitative interference paradigms, both the initiation and selection of gestures are faster when participants are primed by perception of similar gestures or of their results or goals, even if such primes are logically irrelevant to their task.

Second, induction paradigms examine when spontaneous movements are induced by actions you actually perceive (perceptual induction, or involuntary imitation) as well as when movements are induced by actions you would like to perceive (intentional induction, as when moviegoers or sports fans in their seats make gestures they would like to see made). Both types of induction are found and are modulated by various contextual factors. It is interesting that perceptual induction is stronger than intentional induction when participants observe the results of a task performed by another person, especially when the participants have practiced the task earlier, but it is absent when participants believe that otherwise similar observed results have been generated by a computer rather than a person! Thus, perceptual induction appears to depend in part on background beliefs about whether what is perceived is the result of agency.

Third, coordination paradigms adapt imitative interference paradigms to tasks in which labor is divided and coordinated across two persons. Participants are asked to press the left key when a red cue is given and the right key when a green cue is given, while also observing irrelevant but distracting pointing cues. When a single participant does this task, the responses are faster and the errors less frequent when the irrelevant cues point toward the key called for by the relevant color cues. What happens when two participants sit side by side and one is asked to respond to red, the other to green? The interference effect persists, as if the two participants composed one agent with a unified action plan. The left-right response dimension extends across the two participants, and the irrelevant pointing cues interfere with both participants' responses. Remarkably, the interference effect disappears if the participants sit side-by-side but one is asked to respond to red only and the other to do nothing. While the "red" participant's partial task is unchanged, in the absence of coordination across the two participants, the left-right response dimension is lost and the irrelevant pointer cues no longer produce interference.

These results suggest that the automatic effects of perception on action depend on social context in a strong sense. Whether an individual's action is subject to interference by given perceptions can depend on whether her actions are part of a collective action with which those perceptions interfere. Understanding what you are doing in terms of a team effort can alter the ways in which your actions are automatically influenced by perception (see Bacharach, 1999; Hurley, 1989).

The correspondence problem posed by imitation is also addressed by the psychologist Celia Heyes in her *associative sequence learning model*. By what mechanism are perceptions linked to similar actions in imitation? Must such correspondences be innate? Heyes thinks not, and aims to show how they could be acquired, in the right environment, through general-purpose associative learning mechanisms whereby "neurons that fire together, wire together." In this respect her account allies her with the minority[10] who are skeptical about influential evidence[11] of imitation by human newborns. Her account is compatible with the common coding of perception and action, but regards neural mirror properties as acquired through association rather than based on intrinsic similarity. In effect, from this point of view Humean associationism may be on the right track, even if a Humean view of perception as inert turns out not to be.

A general solution to the correspondence problem must cover imitation of *perceptually opaque* acts such as facial gestures, which cannot be seen by their agent, as well as of *perceptually transparent* acts such as hand gestures, which can be seen by their agent. It must cover imitative learning of novel acts, as well as imitation of acts already in an agent's repertoire. Heyes's account aims to satisfy these demands. It characterizes both direct and indirect routes by which sensorimotor associations can be acquired. Direct associations are formed when someone watches her own hand gesture, for example. But this won't work when the agent cannot perceive her own actions, as in facial gestures. Here the association can be mediated by a third item, such as a mirror, an action word, or a stimulus that evokes the same behavior in the actor and in other agents the actor observes. Moreover, adult imitation of infants is common, and can perform the associative function of a mirror (see also Meltzoff, vol. 2, ch. 1 on the importance of being imitated).

In effect, the associative mechanism that enables opaque imitation extends into the cultural environment. Novel acts can be learned by

10. Including Moshe Anisfeld in vol. 2, ch. 4 and Susan Jones, commenting on Whiten in vol. 1, ch. 12.6.

11. From work by Andrew Meltzoff and others; see Meltzoff, vol. 2, ch. 1. Note that Meltzoff argues that the correspondence between perception and action expressed by mirror neurons may be learned rather than innate, and that it remains an open question what the role of experience is in forming mirror neurons.

observing another agent perform an unfamiliar sequence of familiar elements of an act, where each perception of an element already has a motor association, resulting in a new sequence of motor elements that become linked through repetition to give rise to a novel act. Thus, given interactions with the right environment, imitation emerges.

Heyes sharpens issues faced by other views, but as she recognizes, her account also faces several challenges. If imitation does not require dedicated evolved mechanisms, why is it so rare in the animal kingdom? It is greatly facilitated, she suggests, by cultural environments; enculturated chimps raised like human children are better imitators than other chimps. By arguing that the emergence of imitation from general learning mechanisms may depend on cultural environments, Heyes turns the tables on the view that imitation is the copying mechanism that drives cultural accumulation and evolution.[12] In her view, the similarity of what is perceived and what is done in imitation is emergent rather than functional, in Prinz's sense. But can imitation both emerge from culture in this way and provide its engine in some complex dynamic process? (Does it help in considering this question to consider analogies to genetic copying and evolution?)

Philosopher Susan Hurley's *shared circuits hypothesis* draws together various threads from early chapters and elsewhere, concerning the relationships among control, imitation, and simulation within a complex comparator architecture. Her shared circuits model can be regarded as a dynamic descendent of the common coding theory, and is also a close relative of Gallese's shared manifold hypothesis.

Hurley describes a subpersonal functional architecture in five layers, starting with adaptive feedback control such as that found in a thermostat, where real sensory feedback is compared with a target behavior and motor output is adjusted until feedback and target match. At the second layer, internally simulated motor-to-sensory feedback or "prediction" is added to speed and smooth motor control; affordance neurons with both sensory and motor fields are predicted at this layer. At the third layer, the sensorimotor links between one's own actions and one's observations of them or their consequences are instead activated in reverse, so that one's observation of others' actions results in the priming of similar movements, emulation of similar goals, and imitation. Mirror systems are predicted at this layer, which realizes a version of the primitive intersubjective space

12. For discussion see Sugden (vol. 2, ch. 15), Gil-White (vol. 2, ch. 16), Greenberg (vol. 2, ch. 17), Chater (vol. 2, ch. 18) and comments by Blackmore (vol. 2, chs. 19.9, 19.12, 19.13).

postulated by Gallese (see also Meltzoff, vol. 2, ch. 1 on the fundamental self–other equivalence exploited by early imitation). Via indirect links, associations could also be formed between one's own perceptually opaque acts, such as facial gestures, and similar acts by others. At the fourth layer, the tendency to copy the acts of others can be inhibited or "taken offline," so that observing another's act creates a simulation of that act. Simulation for action understanding requires the system to track whether copying is offline or not, so that a self–other distinction would come to overlay the self–other similarities registered in the more basic intersubjective space.

Finally, at the fifth layer, input can be simulated as well. A distinction between the imagined and the real requires the system to track whether an input is simulated, so that counterfactual situations can be simulatively entertained and assessed in deliberation, planning, and hypothetical and instrumental reasoning. Variations of the specified structure could be repeatedly implemented in a linked network of such circuits, yielding the flexible recombinant properties characteristic of intentional action.

Hurley is concerned to advance understanding of the way descriptions of the mind at neural, functional, and personal levels can be related to one another while avoiding oversimple assumptions of isomorphism between levels of description. Her midlevel, functional subpersonal architecture holds promise here. It lends itself to neural mapping exercises and also raises issues concerning mind reading and higher cognitive abilities. It shows how an intersubjective space can be distilled out of the shared information space for perception and action and used in simulation. Moreover, it suggests how the self–other and the imagined/real distinctions, which are essential to the cognitive abilities of persons, can emerge from these prior shared information spaces. Hurley's hypothesis provides a subpersonal parallel to Robert Gordon's[13]; understanding other agents depends at the most fundamental level on multiplying first person information through simulation rather than on building an inferential bridge between first person and third person information. Subpersonal information about persons arrives in the first person plural, without distinction or inference between self and other.

Volume 1, Part II Imitation in Animals

Vol. 1, part I discusses work in neuroscience and psychology concerning what mechanisms could solve the perception-action correspondence

13. Gordon (1995a,b, 2002) and volume 2, chapter 3.

problem for imitation. By contrast, studies of social learning in animals often focus on distinguishing true imitation from other superficially similar behaviors, and in particular on the requirement of novelty for imitative learning. Sophisticated experimental and theoretical work on different kinds of copying behavior in animals helps to clarify the nature and varieties of imitation in human development (see vol. 2, part I) and in human adults, as well as in nonhuman animals. It also sheds light on the role of varieties of imitative behavior in the generation and transmission of culture (see vol. 2, part II) and poses the question of how far imitation can explain what is distinctive about human cultural transmission.

It has proved remarkably difficult to find evidence of true imitation in nonhuman animals, and for a long while sceptics who regarded the capacity for imitation as exclusively human had the upper hand. A new consensus is emerging as a result of painstaking work showing imitation in some great apes and monkeys (see Byrne, vol. 1, ch. 9 and Whiten et al., vol. 1, ch. 11; see also Voelkl & Huber, 2000), dolphins (Herman, 2002), and birds such as some parrots, corvids, and quail (Pepperberg, 1999; G. Hunt & Gray, 2003; Weir et al., 2002; Akins & Zentall, 1996). Cautious moves are being made to describe continuities along a spectrum from the capacities of other social animals to the interrelated capacities for imitation, mind reading, and language that appear to be characteristically human. To understand the significance of this work with animals, it is necessary to understand some of the distinctions that have been drawn between imitation and other forms of social learning.

The concept of "true imitation" is contested, owing in part to the different theoretical aims and methodologies of those concerned with imitation.[14] What matters for present purposes is not what deserves this label, but that relevant distinctions be recognized. The most restrictive understanding of true imitation requires that a novel action be learned by observing another perform it, and in addition to novelty, requires a means/ends structure. You copy the other's means of achieving her goal, not just her goal or just her movements.

A variety of other less cognitively demanding forms of learning in social contexts might look superficially similar. For example, in *stimulus enhancement*, another's action draws your attention to a stimulus that triggers an innate or previously learned response; you do not thereby learn a novel action by observing the other. In *emulation*, by contrast, you observe another achieving a goal in a certain way, find that goal attractive, and attempt to achieve it yourself by whatever means (cf. the very different sense of "emulation" used in Grush, 1995 and forthcoming). Individual trial-and-error learning may then lead you to the other's means of achieving the goal. In both stimulus enhancement and emulation, any coincidence of the movements between learner and model is incidental. A further contrast is with mere *response priming*, as in flocking behavior or contagious yawning, where bodily movements are copied but not as a learned means to a goal.

14. See Rizzolatti (vol. 1, ch. 1), Byrne (vol. 1, ch. 9), and Thomas Zentall's comments on Byrne (vol. 1, ch. 12.1); Heyes (2001) and Heyes and Galef (1996).

Goal emulation and response priming can be thought of as the ends and means components, respectively, of full-fledged imitation. The distinction between ends and means is not absolute; a movement can be a means to adopting a posture, for example, which may in turn be a means to bring about an effect on an external object or conspecific. We can understand more complex forms of imitation in terms of a structured sequence of means/ends relationships in which one acquires a goal, learns how to achieve it by achieving several subgoals, learns how to achieve the subgoals by certain means, and so on. More complex forms of imitation are methodologically important for animal research (and, as we will see in part III, for research on imitation in human development) because they reduce the plausibility of explanations of mirroring behaviors in terms of mere stimulus enhancement, emulation, or response priming. For example, the more complex the movements modeled in a goal-directed behavior that is emulated, the more implausible it is that trial-and-error learning would reproduce these specific movements. Similarly, certain complex patterns of movement are unlikely to be reproduced by response priming because the learner is unlikely to have a prespecified matching response that merely needs to be triggered. True imitation can make sense of the copying of such complex patterns of movement as the learned means to an end.

Response priming, goal emulation, and stimulus enhancement are certainly found in nonhuman animals, and careful experiments are needed to obtain evidence of imitation in a more restricted sense. For this purpose, the *two-action* experimental paradigm has become the tool of choice. When two models illustrate two different means of obtaining the same attractive result, will animals who observe one or the other model differentially tend to copy the specific method they have seen demonstrated? If not—if they use either method indifferently to achieve the goal, or converge on one method despite the different methods modeled—they may be displaying mere goal emulation plus trial-and-error learning, or stimulus enhancement, rather than imitative learning.

Psychologist and primatologist Richard Byrne explains some of the limitations of the two-action experimental criterion for imitative learning and in particular questions its usefulness in demonstrating novelty. Success on the two-action criterion, Byrne suggests, is consistent with an alternative account in which a modeled action primes rare preexisting acts in a large repertoire, which may be further amplified by individual trial-and-error learning, so that no imitative learning of a genuinely novel skill has occurred.[15] We may note, in addition, that with merely *two* actions to be distinguished by the learner, even a very partial grasp of the means used by the model may suffice to bias the learner toward that means—and the rest might then be acquired by individual trial-and-error learning.

What naturally occurring examples of imitative learning might resist such an alternative explanation? The persistence of a less efficient method of performing a given task in a particular population, such as apes using one short stick instead of two long sticks to fish out insects, might be evidence for imitative as opposed to trial-and-error learning. But, as Byrne explains, it will be hard to rule out the possibility that environmental differences rather than imitation explain such behavioral differences among populations.

He finds better evidence for imitative learning of novel skills in his field observations of what he calls *program-level imitation*, in which animals imitatively learn a specific organization of a complex process. Gorillas, he argues, learn to prepare particular types of plants for eating using a standardized, complex organization of manual processing stages, despite idiosyncratic lower-level differences among individual gorillas; the standard processing pattern is even learned by gorillas whose hands have been maimed by snares, who might be expected to find different processing techniques through individual trial-and-error learning. Byrne argues that such program-level imitation cannot be explained in terms of socially guided priming, emulation, and trial-and-error learning; it illustrates imitative learning of genuinely novel skills.[16] This capacity to transmit complex techniques for processing food, he suggests, may have helped apes compete with monkeys in exploiting shared food resources, despite the lesser mobility and other feeding disadvantages of apes.

From the question of what behavior distinguishes imitation from other forms of social learning, Byrne returns to the question of subpersonal

15. See and cf. Meltzoff on infant imitation of novel acts in volume 2, chapter 13.

16. See various comments on Byrne and Russon (1998) for assessments of the evidence for program-level imitation in gorillas and orangutans.

mechanisms of imitation. His focus is on the mechanisms needed to enable program imitation rather than those needed to solve the correspondence problem. A mirror mechanism could recognize elements in fluid movements and find corresponding units in the existing action repertoire, which could be strung together in observed new ways. But Byrne argues that for program-level imitation, a further *behavior parsing* mechanism is also needed, which would statistically parse many such observed strings to extract their shared organization or deep structure from the idiosyncratic surface variation. Skilled action has a modular structure that facilitates flexible recombinant functioning. The behavior parsing mechanism could detect module boundaries in observed behavior, the points at which links between behavior strings are weakest, by registering points of smooth resumption after interruption of behavior; clusters of pauses; and patterns of substitution, omission, or repetition. Alternatively, as the developmental psychologist Birgit Elsner suggests on the basis of work with human children, modules might be parsed by reference to subgoals. Byrne sees behavior parsing capacities as an important precursor to more sophisticated human abilities for high-level perception of an underlying structure of intentions and causes in the surface flux of experience.

It is tempting also to regard behavior parsing and the recombinant structure of program-level imitation as precursors of syntactic parsing and the recombinant structure of language. Michael Arbib (2002) explains the neural intertwining of human mirror and language systems along related lines. Moreover, the problem of finding recombinant units of action in apparently smooth streams of bodily movement has many parallels with the problem of finding linguistic units such as words in the apparently continuous acoustic stream of speech.

A quite different slant on the relations between imitation and language is provided by the psychologist Irene Pepperberg's pioneering work with the African Grey parrot Alex. African Greys have walnut-sized brains with very little that resembles primate cortex. Yet Alex does what bigger-brained animals cannot; he acquires significant fragments of English speech by listening in on conversations between human trainers, and he uses it to perform cognitive tasks put to him in English. Alex's well-known accomplishments are described in detail elsewhere (Pepperberg, 1999). He can both comprehend and produce words for fifty objects; seven colors; five shapes; numerals up to 6; the categories of color, shape, material, and number; plus the words "no," "come," "go," "want," etc. He can combine these words in new ways to identify, request, comment, refuse, alter his environment, add objects to categories, or process queries. For example, from an array of red

and blue balls and blocks, he can quantify a subarray, such as the set of blue blocks, on request.

Does Alex imitate? He learns the specific vocalizations of another species and uses them functionally. Such exceptional vocalizations are unlikely to occur in normal development and cannot plausibly be explained as the priming or evoking of innate behaviors. Pepperberg locates Alex's vocal abilities in relation to three different levels of imitation and shows that the similarity of African Grey speech to human speech is not an artifact of human perception, but shares acoustic characteristics with human speech. Alex derives new sounds from old ones by babbling, but in ways that respect English rules for building words. Byrne considers whether Alex's copying of the structure of English speech can be regarded as emulation or as program-level imitation comparable to that displayed by human children.

One of the most thought-provoking aspects of Pepperberg's work is the model/rival training method on which Alex's success depends. Standard behavioral training techniques were unsuccessful. Moreover, just being part of a standard referential triangle, in which two participants refer to the same object, does not enable Alex to learn as he does. Rather, what is essential is that Alex be able to eavesdrop on a referential triangle composed of two human English users referring to an object. One plays the role of trainer, the other models the learning process and acts as a rival to Alex for the trainer's attentions and rewards. The trainer gives feedback to the model, scolding for errors such as the bird might make, or providing rewards for correct responses, and the pair demonstrate the referential and functional use of the label. It is essential that the bird observe role reversal between trainer and model; otherwise, the bird does not learn both parts of the interaction, and does not learn to transfer responses to new trainers. Moreover, it is essential that the objects referred to are themselves used as rewards, to avoid confusion between labeled objects and different rewards. When any of these elements of model/rival training are omitted, training is unsuccessful. When such birds are given model/rival training for some labels and other training techniques are used for other labels, the birds practice only the model/rival trained labels when alone! Pepperberg suggests that observing a model responding to a trainer may enable the parrot to represent the required response separately from the "do-as-I-do" command. As she notes, promising work is under way using the model/rival technique to facilitate learning for some autistic children.[17]

17. See also Jones's comments on Whiten et al. in volume 1, chapter 12.6 for a different angle on imitation and therapy for autism.

The dependence of Alex's learning on exposure to a very specific training regimen recalls Heyes's view that imitative learning can depend on particular cultural environments. More generally, observations of nonhuman animals in different environments or using different, apparently reasonable, testing methods may lead to very different estimates of their cognitive abilities. Because of the way environmental structure and input can affect the manifestation of cognitive capacities, great care is needed in determining what capacities are present and how they compare with human capacities.

This point is underscored by the way skepticism about chimp imitation has been overcome, as explained by the psychologists Andrew Whiten, Victoria Horner, and Sarah Marshall-Pescini, as well as by Bennett Galef, a former skeptic. Imitation was regarded through most of the nineteenth century as a low-level ability, characteristic of the mentally weak or childish, and as less rationally demanding than individual trial-and-error learning. But at the end of the nineteenth century Edward Thorndike showed that many animals who could learn through trial and error could not imitate, and argued that imitation is in fact the rarer and more cognitively demanding ability. This view is now generally accepted. While early fieldwork with chimps appeared to provide evidence of their imitative abilities, critics such as Galef, Heyes, and Michael Tomasello challenged this interpretation effectively. Many subsequent experimental studies reported a lack of chimp imitation. Only recently has evidence of chimp imitation won over most critics; the relevant questions now are what, how, and why they imitate, rather than whether they can do so at all.

Whiten and colleagues have played a prominent role in demonstrating chimp imitation and comparing it with imitation in children. Their innovative experiments using ingenious "artificial fruits" extend the two-action method, revealing that chimps sometimes emulate and sometimes imitate. For example, Whiten's pin-apple is a box containing food that can be opened in two ways: by poking or pulling its bolts, and then pulling or twisting a handle. One way of opening it is modeled for one group of chimps, the other way for another group. The chimps imitate the specific means modeled to remove the bolts, but merely emulate using the handle to achieve the goal of reaching the food. Children, by contrast, imitate the specific means modeled for both parts of the task, even when this is less efficient. Using a more complex pin-apple, the two-action method shows that chimps imitate sequential structure but not details of component techniques, suggesting program-level imitation. Yet another artificial fruit, the key-way, is used with the two-action method to contrast imitation of the hierarchical structure of a task with imitation of left-right versus

right-left sequence. Here, young chimps, like children, ignore the modeled sequence direction but do imitate hierarchical structure. They organize the multiple moves needed to open the key-way by rows or by columns, according to what they have seen modeled.

Why do chimps sometimes imitate and sometimes emulate? Do they imitate selectively, or do they have only a limited ability to imitate? Whiten and colleagues argue that chimps imitate selectively, selecting aspects of a modeled task to be imitated or not according to their appraisal of the significance of these aspects for achieving their goal. For example, a hierarchical task structure is not transparently irrelevant to success, while left-right sequence direction is. Using a variant of a task used by Paul Harris and Stephen Want to demonstrate selective imitation in children, Whiten and colleagues show that chimps imitate more selectively than 3-year-old children.[18] A model shows chimps how to obtain food in a box by using a tool to stab the food though tunnels in the box. The model first stabs down a tunnel and hits a barrier, which blocks the food from reach, but then stabs through a different tunnel and reaches the food. This "mistake" is modeled using both a transparent box, in which it is obvious that the initial downward stab will not reach the food, and an opaque box, in which it is not obvious. As predicted, chimps imitate the futile first downward stab less when the transparent box is used. Three-year-old children, by contrast, imitate the futile downward stab in both versions of the task, even if they are left alone to remove social pressure to conform.

Even if chimps *can* imitate, children are "imitation machines," as Michael Tomasello (1999, p. 159) has put it and as Andrew Meltzoff also argues (in vol. 2, ch. 1). Children have a stronger tendency than chimps to imitate rather than emulate, even when doing so is transparently inefficient. For example, after seeing a demonstrator use a rake inefficiently, prongs down, to pull in bait, chimps tend to turn the rake over and use it more efficiently, edge down, to pull in the bait. Two-year-old children in a parallel experiment almost never do so; they go right on imitating the inefficient means of obtaining the bait they have seen demonstrated, with prongs down (Nagell et al., 1993; cf. Gergely et al., 2002). Human imitation is flexible, ubiquitous, effortless, and intrinsically rewarding (see Jones, vol. 1, 12.6, p. 298). Chimps may appear to be better off in this comparison, at least in the short run. Why might it be beneficial to humans in the long run to imitate with such determination? Tomasello (1999) explains this in

18. See and cf. Harris and Want in volume 2, chapter 6.

terms of the *ratchet effect*. Imitation preserves rare one-off insights about how to achieve goals, which would not be rediscovered readily by independent trial-and-error learning, and so would be lost without imitation. Imitation spreads these discoveries around, makes them available to all as a platform for further development. Through the ratchet effect, imitation is the mechanism that drives cultural and technological transmission, accumulation, and evolution.[19]

We have discussed the mechanisms that may underlie and enable the strong imitative tendencies that are so characteristically human, and we will go on to consider their possible functions and effects in relation to human culture. But first we turn to the role of imitation in human development, and in particular in the development of another distinctive human capacity, the ability to understand other minds.

Volume 2, Part I Imitation and Human Development

Human beings are distinctive among animals in their capacities for language and for understanding other minds, or *mind reading*. Whether these are innate as *capacities*, the skilled behavioral expression of these capacities develops over years of interaction between infants and their environments, in well-studied stages during which much learning occurs. The same could be said about a third distinctive human capacity, the ability to imitate. This, however, begins to be manifested very early—indeed, at birth, according to highly influential work by the developmental psychologist Andrew Meltzoff and others on imitation in human infants, including newborns.

The relationships among this trio of capacities—for language, mind reading, and imitation—are of fundamental importance for understanding the transition of human infants into adult persons. Does the development of either language or mind reading depend on imitation? If so, at what levels of description and in what senses of "depend"? Or does dependence run the other way or both ways, dynamically? The answers are controversial, and may of course differ for language and mind reading. Several of the chapters in vol. 2, part I focus on the question of how imitation is related to the understanding of other minds and in particular other *agents*. This question brings into play the further controversy about whether mind reading is best understood as theorizing about other minds or as

19. See and cf. Harris (vol. 2, ch. 6), Sugden (vol. 2, ch. 15), Gil-White (vol. 2, ch. 16), Greenberg (vol. 2, ch. 17), Chater (vol. 2, ch. 18) and Blackmore (vol. 2, ch. 19).

simulating them. How does the theory–simulation controversy concerning the mechanism by which we understand other minds bear on the relationships between imitation and mind reading, or vice versa?

Meltzoff surveys his work on early imitation and draws on it to argue that early imitation and its enabling mechanisms beget the understanding of other agents, not the other way around.[20] In a series of famous experiments, Meltzoff and Moore studied imitation in newborns and infants under 1 month, including facial and manual imitation. Since infants can see others' facial acts but not their own, newborn facial imitation suggests an innate, supramodal correspondence between observed acts and an observer's similar acts.[21] Moreover, very young infants defer imitation across a delay of 24 hours and correct their imitative responses, homing in on a match without external feedback. The *active intermodal mapping* (AIM) hypothesis interprets this evidence in terms of the comparison and matching of proprioceptive feedback from an observer's own acts to an observed target act, where these are coded in common, supramodal terms. Elsewhere, Meltzoff and Moore (1997) explicate this common code as initially coding for relations among bodily organs such as lips and tongue, and developing through experience of body babbling toward more dynamic, complex, and abstract coding.

Meltzoff emphasizes that various further imitative and related behaviors are not present from birth, but are acquired at stages throughout infancy. Infants from 6 weeks to 14 months recognize that they are being imitated,[22] but only older infants act in ways that apparently purposively test whether they are being imitated. Since only people can imitate systematically, an ability to recognize being imitated provides a means of recognizing that an entity is a person. By 14 months, infants imitate a modeled novel act after a week's delay; they turn on a light by touching a touch-sensitive light panel with their foreheads instead of their hands, differentially copying the novel means modeled as well as the result (see Meltzoff, vol. 2, ch. 13, p. 59, and Tomasello and Carpenter, vol. 2, ch. 17, p. 138.) Note that in a follow-up to the Meltzoff's light-pad experiment,

20. In contrast to Rizzolatti (vol. 1, ch. 1) and Tomasello (1999), who argue in their different ways that understanding an action precedes imitation.

21. See Nicholas Humphrey (vol. 2, ch. 8.2) for some intriguing speculations on possible pathological phenomenological manifestations in adulthood of such supramodal mappings.

22. With differential activation of the right inferior parietal lobe; see Decety and Chaminade (vol. 1, ch. 4).

children do use their hands to touch the light-pad when they see a demonstrator whose hands are occupied by doing something else touch it with her head (Gergely et al., 2002). Children *can* emulate as well as imitate. Nevertheless, their tendency to imitate rather than emulate appears to be considerably greater than that of chimps when direct comparisons have been made, as in Nagell et al., 1993. By 15 or 18 months, infants recognize the underlying goal of an unsuccessful act they see modeled and produce it using various means. For example, after seeing an adult try but fail to pull a dumbbell apart in her hands, they succeed in pulling it apart using their knees as well as their hands. However, they do not recognize and attempt to bring about the goals of failed "attempts" from similar movements by inanimate devices.

Thus, in Meltzoff's view, the ability to understand other minds has innate foundations but develops in stages. Imitation plays a critical role in his arguments for a middle ground between Fodorian nativism and Piagetian theory. Infants have a primitive ability to recognize being imitated and to imitate, and hence to recognize people as different from other things and to recognize equivalences between the acts of self and other. The initial bridge between self and other provides a basis for access to people that we do not have to things, which is developed in an early three-stage process.

First, an infant's own acts are linked to others' similar acts supramodally, as evidenced by newborns' imitation of others' facial acts. Second, own acts of certain kinds are linked bidirectionally to own experiences of certain kinds through learning. Third, others' similar acts are linked to others' similar experiences. This process gets mind reading started on understanding agency and the mental states most directly associated with it: desires, intentions, perceptions, and emotions. The ability to understand other minds is not all or nothing, as Meltzoff emphasizes.[23] An understanding of mental states that are further from action, such as false beliefs, comes later in development.

Meltzoff claims here that the early three-stage process he describes is not a matter of formal reasoning, but rather one of processing the other as "like me." Meltzoff is often interpreted as viewing mind reading in terms of theoretical inferences from first-person mind-behavior links to similar third-person links, in an updating of classical arguments from analogy. There are clear elements of first-to-third-person inference in his view of

23. The same point can be made for other animals; see Tomasello (1999) on levels of mind-reading ability.

how mind reading develops. As he states in vol. 2, ch. 1, "the crux of the 'like-me' hypothesis is that infants may use their own intentional actions as a framework for interpreting the intentional actions of others" (p. 75). For example, 12-month-old infants follow the "gaze" of a model significantly less often when the model's eyes are closed than when they are open, but do not similarly refrain from following the "gaze" of blindfolded models until they are given first-person experience with blindfolds. Similarly, as Paul Harris comments, giving 3-month-old infants Velcro mittens to enhance their grasping abilities also enhances their ability to recognize others' goals in grasping. Nevertheless, the initial self–other linkage that Meltzoff postulates, expressed in imitation by newborns, is via a supramodal common code for observed acts and the observer's acts, which is direct and noninferential (see Meltzoff & Moore, 1997). In a graded view of mind reading such as Meltzoff's, the role of theoretical inference from the first to the third person in mind reading can enter at later stages and increase significantly with development.

Philosopher Alvin Goldman also considers the relationship between imitation and mind reading, first from the perspective that understands mind reading in terms of theorizing, which he attributes to Meltzoff, and then from his preferred view of mind reading in terms of simulation. The "*theory theory*" approach to mind reading regards commonsense psychology as a kind of protoscientific theory in which knowledge is represented in the form of laws about mental states and behavior; to the degree that these are not innate, they are discovered by testing hypotheses against evidence. People's specific mental states and behaviors are inferred from other mental states and behaviors by means of such laws. No copying is involved. By contrast, *simulation theories* understand mind reading to start with the mind reader taking someone else's perspective and generating pretend mental or behavioral states that match the other person's. These are not made the object of theoretical inference, but rather are used as inputs to the simulator's own psychological processes, including decision-making processes, while these are held offline, producing simulated mental states and behavior as output. The simulated outputs are then assigned to the other person; these may be predicted behaviors by the other, or mental states of the other that explain the observed behaviors. This is an extension of practical abilities rather than a theoretical exercise. The simulator copies the states of the other and uses the copies as inputs to her own psychological equipment, instead of formulating laws and making inferences from them about the other. Within this broad theory versus simulation contrast,

many finer distinctions have rightly been drawn among various versions, levels of description, and aims within each category.[24]

Consider the role of imitation in Meltzoff's version of a theory-theory approach to mind reading. One could restate Meltzoff's three-stage process, described earlier, in explicitly theory-theory terms, as follows. At stage one, the innate equivalence between my own acts and others' acts (exploited by early imitation and the recognition of being imitated) makes it possible to recognize that some acts (by myself) are similar to other acts (by another). At stage two, first-person experience provides laws that link one's own acts and mental states. At stage three, it is inferred that another's act that is similar to mine is lawfully linked to the other's mental states in the same way that my act is lawfully linked to my mental states. As Meltzoff points out (personal communication), there is no inference from the first person to the third person at stage one of this account; the initial bridge between the self and other expressed in imitation and recognition of being imitated is bidirectional. However, an inference from the first person to the third person does enter as we proceed through stages two and three of this account. It resembles traditional arguments from analogy in inferring laws linking third-person acts and mental states from laws linking first-person acts and mental states.

Goldman does not object here to the first-to-third-person inference per se. He notes that psychologists could be correct to attribute such an analogical inference to mind readers, even if, as philosophers have often argued, it is epistemologically unsound. Nor does he object to making understanding of other minds depend on direct first-person knowledge of one's own mental states; his own simulationist account does this. However, he regards such dependence as internally incompatible with a theory-theory approach to self-knowledge, according to which knowledge of first-person mental states relies on theoretical inference in the same way that knowledge of third-person mental states does. Thus, he argues that the argument from analogy makes knowledge of one's own mind asymmetrically prior to knowledge of other minds, while a theory-theory of self-knowledge treats them symmetrically, as equally dependent on theoretical inference. Thus, the argument from analogy and the theory-theory of self-knowledge are incompatible.

24. For some of these, and challenges to the distinction, see Davies and Stone (1995a,b), and Carruthers and Smith (1996). See also Millikan (vol. 2, ch. 8.4), who distinguishes ontological, ontogenetic, and epistemological questions about thoughts of other minds, on which theory-theory and simulation theory may differ.

Meltzoff might respond by rejecting this kind of theory-theory for self-knowledge while retaining his account of how mind reading builds on imitation, with its first-to-third-person inference. Philosopher Ruth Millikan argues, referring to Wilfrid Sellars, that theory theorists have other resources to draw on in characterizing self-knowledge, and that a critique of theory-theory needs to go deeper than Goldman's. She traces the theory-theory of mind reading back to a more general philosophical view of Willard Van Orman Quine and Sellars about the nature of thoughts, which was then applied to thoughts about other minds in particular, or mind reading. Undermining the theory-theory of mind reading, she argues, requires showing either that the more general view of thoughts is mistaken, or that thoughts about other minds are peculiar in some way, so that the more general view does not apply straightforwardly to them.

Quine and Sellars held that thoughts acquired their content in the same general way as theoretical terms in a scientific theory: in virtue of their inferential relations to one another, as well as to inputs and outputs. Millikan's own view is that this general view of thought is wrong (Millikan, 2000). But even if we assume that this general view is correct and that thoughts are in general identified by their inferential or functional roles, what should we say about the specific case of thoughts about another's thoughts, that is, mind reading? Surely, Millikan urges, thought about inferential roles and their relations rests on our own inferential dispositions, not on entirely independent beliefs about laws that govern inferential roles. Millikan's suggestion is that thinking about a thought requires me to be able to entertain that thought, which can be regarded as a kind of offline processing, or simulation. However, other mental processes in addition to mind reading, such as imagining and hypothetical thinking, also require offline simulation. She is skeptical that such simulative processes in general, or mind reading in particular, are directly linked to imitation.

Goldman finds a simulationist approach to the links between imitation and mind reading more promising than a theory-theory approach. He considers two compatible proposals: first, that simulationist mechanisms guide some imitation as well as mind reading, and second, that imitation plays a pivotal role in the development of advanced mind reading via simulationist mechanisms.[25]

To motivate the first proposal, Goldman notes that autists tend to be deficient in imitative skills, especially those requiring perspective switching, as well as in mind-reading skills. The two deficits may have a common

25. Compare the links described by Hurley (vol. 1, ch. 7).

cause: dysfunction in simulation mechanisms that normally enable perspective taking and thus underlie both abilities. He regards mirror neurons as a plausible neural substrate of such simulation mechanisms, since by means of them the observation of an action activates a similar goal-related plan (although that activity may be inhibited elsewhere). Thus, dysfunction of the mirror system may be at the root of a cascade of related problems in autism—problems with perspective-taking, imitation, and mind reading (see J. Williams et al., 2001).

Goldman's second proposal is that imitation contributes to advanced mind reading through role-play. Role-play is simulation that can be understood as a kind of extended imitation, in which an action type rather than an action token is copied creatively, with novel embellishments and including the mental states or processes appropriate to the action type. Children who engage in more role-play early on are better at advanced mind-reading tasks later, such as understanding that others may have false beliefs. Goldman sketches a progression in which action imitation extends to role-play, including mental simulation, which in turn contributes to mastery of advanced mind-reading skills.

Unlike Goldman, Wolfgang Prinz objects to the idea that we have direct, privileged access to our own minds, which we use to infer or simulate other minds. Organisms, Prinz argues, are designed to know the world at the expense of knowing themselves; perceptual mechanisms cancel out information deriving from the self in order to distill information about the world from the total information available. While we must, of course, use our own minds to know the world, our privileged access is to the world, not to our own minds. We come to understand ourselves as like others in part as a result of our experience as infants of being imitated by adults; the infant needs such a "mirror" to get to know herself.[26] Being imitated enables the infant to overcome the tendency to cancel out self-information in order to know the world; it allows an infant to perceive her own actions through the other. But, as Prinz admits, this view of self-knowledge does not address the question of how being imitated is recognized (see Decety and Chaminade, vol. 1, ch. 4), or indeed of how other minds are understood in the first place.

Philosopher Robert Gordon's radical version of simulation theory, which is quite different from Goldman's, explicitly rejects the first-to-third-person direction of explanation in understanding other minds. Note that it is a

26. Compare the role of being imitated in addressing the correspondence problem, in Heyes's account of imitation (vol. 1, ch. 6).

mistake to associate simulation theories too closely with the first-to-third-person arguments from analogy (Gordon's view is a counterexample) or theory theories with rejection of this type of argument (Meltzoff's view is a counterexample). The theory versus simulation distinction cuts across acceptance or rejection of the first-to-third-person direction of explanation.

Gordon here examines the links between imitation and mind reading from his own simulationist perspective on mind reading. Goldman finds no link between imitation and what he calls the "rationality" or "charity" approach to understanding other minds, versions of which are associated especially with Donald Davidson (1982, 1984) and Daniel Dennett (1987). However, Gordon's version of simulation theory is at the same time a variant of the rationality approach.[27] The role of rationality in Gordon's view of mind reading as simulation turns out to be important for understanding both how he connects imitation with mind reading and how he aims to avoid the first-to-third-person move in his account of mind reading.

In the course of comparing Meltzoff's and Gallese's views, Gordon distinguishes two kinds of mirroring response. In constitutive mirroring, a copied motor pattern is part of the very perception of the other person's action, although the motor pattern may be inhibited and thus not produce overt movement. By contrast, in imitative mirroring, a motor pattern that was active when the other person's action was observed is reactivated without inhibition. The same mirror neurons may be active in both.

Gordon finds constitutive mirroring in Gallese's account of the primitive intersubjective "we" space or shared manifold, which is the basis of empathy and which implicitly expresses the similarity of self and other (but not, as Gallese points out, their distinctness). Gallese understands empathy to involve, not the recognition of others as bodies endowed with minds, but rather the assumption of a common scheme of reasons by reference to which persons, self and others alike, are intelligible (vol. 1, ch. 3; see and cf. Strawson, 1959). Gordon proposes, in more detail, that when constitutive mirroring imposes first-person phenomena, a process of analysis by synthesis occurs in which the other's observed behavior and the self's matching response—part of the very perception of the other's behavior—become intelligible together in the same process. For example, when I see you reach to pick up a ringing phone, your act and my matching response are made sense of together, within a scheme of reasons that is part of the fundamental commonality of persons. I don't infer from the first to the third person, but rather multiply the first person.

27. See also Gallese (vol. 1, ch. 3), for implied links among imitation, a simulationist approach to mind reading, and rationality assumptions.

Gordon finds the first-to-third-person inference in Meltzoff's account problematic, not because it attributes *similarity* to one's own and others' acts or experiences, but because it requires that they be *identified* and *distinguished*. In the first stage of Meltzoff's account, the similarity between acts of self and other is supposed to be established by their innate equivalence, which is exploited by early imitation; this stage may involve constitutive mirroring, as in Gallese's primitive shared manifold. But the second and third stages of Meltzoff's account, where the analogical inference occurs, requires that self and other also be distinguished. If this kind of act *of mine* is linked to *my* experiences of a certain kind, then a similar (as established in stage one) kind of act *by another person* is also linked to that person's experiences of a similar kind. As Gordon says, if I cannot distinguish *a* and *b*, I cannot make an analogical inference from *a* to *b*. While such an inference may sometimes be a feature of mature imitative mirroring, Gordon regards it as beyond the capacities of infants.

However, a standard charge against pure simulation theories of mind reading has been that they lack the resources to explain how mature mind readers distinguish and identify different people and keep track of which actions and mental states belong to which people. Gordon suggests that multiple first persons are distinguished and tracked in the process of making them intelligible as persons, to avoid incoherence and disunity under the common scheme of reasons (see and cf. Hurley, 1998, part I). Mental states that do not make sense together are assigned to different persons. But can this be done in pure simulation mode, with no overlay of theory and inference? Simulation is supposed to be offline use of practical abilities, in contrast to theorizing about the actions and thoughts of others. But what exactly is the difference between making sense of an action and theorizing about it? When I use practical reason offline in mind reading, I don't formulate normative laws from which I make inferences; rather, I activate my own normative and deliberative dispositions. As Millikan might say, my thought about another's action is not wholly separate from my entertaining that action.

A suggestion worth considering here is this: The fundamental *similarity between self and other* may best be understood, not in terms of theorizing, but rather in terms of simulation (as in Gordon's constitutive mirroring, Gallese's shared manifold, Hurley's level three, or the innate self–other equivalence exploited by early imitation, in Meltzoff's view; a question that

needs further attention is whether this fundamental intersubjectivity should be understood to hold at the subpersonal level, at the personal level, or both). Such primitive intersubjectivity may persist into adulthood and remain an essential aspect of mature empathy and mind reading, as Gallese suggests. But as mind reading develops, it also employs a *self–other distinction*, as when an older child attributes to the other false beliefs, different from her own, or distinguishes imitating from being imitated (see Decety and Chaminade in vol. 1, ch. 4 and Hurley's stage 4 in vol. 1, ch. 7). More generally, mature mind reading requires the ability to distinguish, identify, and track different persons and to assign acts and mental states to them. The full range of distinctions and identifications that mature mind reading requires may indeed draw on theoretical and inferential resources, even while the simulative foundation remains essential.

Developmental psychologist Moshe Anisfeld represents a minority (including Celia Heyes and Susan Jones) who remain skeptical about evidence for very early and newborn imitation. He defends here a more extended, Piagetian timetable for representationally mediated imitation (as opposed to mere contagion effects, such as contagious crying by very young infants). Piaget regarded facial imitation as representational, since the imitator cannot see his own act and so must infer its correspondence to the observed act. Anisfeld finds evidence of facial imitation persuasive only for infants more than 6 months old. Work claiming to show earlier facial imitation, he argues, is subject to various methodological criticisms; in his view, there is convincing evidence only for tongue protrusion effects, but these are better understood as arousal effects than as imitation. Piaget regarded deferred imitation as representational when a novel activity is copied after a delay and without any immediate practice having occurred. Anisfeld finds evidence of deferred imitation persuasive only for infants that are more than 11 months old. He argues that work purporting to show earlier deferred imitation suffers from inappropriate controls, or fails to meet the novelty requirement. Moreover, Anisfeld finds support for Piaget's views about the development of representational abilities in work showing how children acquire the ability to generalize deferred imitation in stages: first across different test environments, and then later across different types or colors of stimuli.

The contribution of imitation to understanding other agents is examined in earlier chapters by Gallese, Hurley, Meltzoff, Goldman, and Gordon. By contrast, psychologists Michael Tomasello and Malinda Carpenter, like Rizzolatti, emphasize the contribution of action understanding to imitation. Here Tomasello and Carpenter review work in the past decade on the ways that imitative learning depends on intention reading.

In 1993, Tomasello, Kruger, and Ratner found no convincing evidence of imitative learning in nonhuman animals, and proposed that the understanding of behavior as goal directed or intentional distinguishes human social learning from social learning in other species. In this view, while human beings can either imitate observed means or choose other means to emulate observed goals, other animals do not distinguish means and goals in this way. Animals can copy movements without understanding their relevance to goals, or can learn about the affordances of objects by observing action on them. In neither case, the claim was, do other animals learn about the intentional, means-end structure of the observed action.

Subsequently, Whiten and colleagues obtained results with apes, using artificial fruit in a two-action paradigm, which were described earlier as widely influential in overcoming skepticism about imitation by apes. Tomasello and Carpenter comment here that such results can be interpreted in more than one way. Does a differential tendency to push or pull a rod to open the artificial fruit, in accordance with the model shown, reveal imitative learning with intentional structure or only emulation and affordance learning? They argue that other paradigms developed with children, which they review here, have made a clearer distinction between imitative learning and other forms of social learning (see also Meltzoff, vol. 2, ch. 1.5). It remains to be seen what results these methods will yield with other animals.

In these paradigms, the modeled action is unsuccessful or accidental. If the observer copies what was intended even though it was not shown, as opposed to only the observed movements or the observed though unintended result, that suggests the observer understands the intentional structure of the observed action. For example, an action modeled with an "Oops" indicating it was accidental is copied by 14- to 18-month-olds less than the same action without the "Oops." Eighteen-month-old infants (but not 12-month-olds) copy modeled actions equally whether they are successful or unsuccessful; they read the intended result into the model and produce the successful action even if they have only seen the unsuccessful model. While 14-month-olds copy an unusual means, such as touching the light box described earlier with their heads, they do so more often when the model's hands are free than when she is holding a blanket (Gergely et al., 2002). This suggests that the children infer that the model whose hands are free must have some purpose in adopting this unusual means, even if the purpose is obscure. Moreover, children learn more from an

otherwise identical demonstration if they already have information about the model's prior intentions when they watch the demonstration.

Tomasello and Carpenter argue that in recent demonstrations of imitative learning in which the modeled behavior is the same and only the modeled intention varies across conditions, the ability to read intentions is needed to explain what is copied. Given the results from the various imitation paradigms, they regard it as most parsimonious to assume that children use their understanding of intentions to imitate. Further progress in understanding social learning in children and other animals can be made, they suggest, by paradigms that systematically factor the information at the social learner's disposal into information about the demonstrated behavior, its results, its context, and the demonstrator's intention.[28]

How then should we view the relationship between imitation and mind reading? On the one hand, Tomasello and Carpenter emphasize the dependence of full-fledged imitative learning, with an intentional, means-ends structure, on intention reading, and Rizzolatti similarly argues that action understanding precedes imitation. On the other hand, chapters by Hurley, Meltzoff, Goldman, and Gordon argue in various ways that imitation underlies early mind-reading abilities. Are these views in conflict?

Not necessarily, in our view. In order to appreciate their potential compatibility, however, it is important to distinguish various stages or levels in both imitation and mind reading and the ways these could build on one another dynamically in evolutionary and developmental processes. Recall the way Rizzolatti argues that action understanding precedes imitation in evolution: he distinguishes the mirroring of movements (in response priming) from the mirroring of goals (in emulation) and from genuine imitative learning with a flexible intentional structure relating observed means to observed results. He suggests that the capacity to copy observed results via mirror systems may underlie a phylogenetically early understanding of action in terms of goals and intentions, which in turn is needed for phylogenetically later imitative learning with intentional structure, in which the mirroring of means and of ends are linked flexibly in the larger mirror circuit that is characteristic of human beings. Recall also earlier suggestions that recognition of a fundamental self–other similarity via simulation (as in Gallese's primitive shared manifold, Hurley's layer three, Meltzoff's innate self–other equivalence, Gordon's constitutive mirroring) may developmentally precede the registration of a self–other distinction, and more generally precede the inferential abilities, on which more advanced mind reading

28. Recall Harris's suggested experiment with monkeys, described earlier.

depends, to identify and distinguish persons and to keep track of which mental states go with which persons. Very early imitation may express a fundamental self–other similarity, while the distinctive human capacity for imitative learning with its flexible means-ends structure in turn contributes to the development of the self–other distinction and of more advanced mind-reading skills.

Developmental psychologists Paul Harris and Stephen Want focus on the ability to imitate selectively, which they suggest may require a certain level of mind-reading ability. They compare the capacities of 2-year-old and 3-year-old children to learn from observing others correct their own errors in using tools. One series of experiments employs a transparent tube containing a toy that can be pushed out of the tube with a stick; however, if the stick is pushed through the tube in the wrong direction, the toy will be trapped inside.[29] Few 2-year-olds find the solution without demonstration. Some of them are then given a demonstration in which the model extracts the toy correctly, while others observe a model who first makes an incorrect attempt, says "Oops" to register his own mistake, and then goes on to extract the toy correctly. Children in both groups of 2-year-olds learn from the demonstration to use the stick to try to extract the toy, but in neither group do they learn how to do so correctly. They apply the stick in the two directions at random, and extract the toy about half the time. Similarly, 3-year-olds who observe the model are only able to extract the toy about half the time. However, a significantly higher level of success is achieved by 3-year-olds who observe the model correct his own error. (Just observing the incorrect demonstration without subsequent correction does not lead to success at either age.[30])

Harris and Want interpret these results in terms of different capacities for selective imitation. The 2-year-olds learn nonselectively from whatever demonstration they are given: correct, incorrect, or both. But the 3-year-old children have a capacity for selective imitation, which is revealed when they observe both the correct and incorrect variants and differentially select the correct variant. It is interesting that the older children learn more efficiently by observing a model's mistake and immediate self-correction than they do from their own string of trial-and-error attempts. The 3-year-old's greater capacity for selective imitation here may turn on the development of either sufficient intention-reading skills to understand the model's deliberate self-correction after a first unsuccessful attempt, or sufficient

29. Similar results are obtained using a different apparatus.

30. Note the parallels with Pepperberg's training of Alex.

understanding of the causal mechanics of the task. Harris and Want favor the former explanation and suggest a further experiment to address this issue.

They also sketch an intriguing possible connection between the development of selective imitation and the course of cultural evolution. In the upper Paleolithic period, an explosive development of complex tool forms began, after a very long period during which a standardized form of hand axe persisted more or less unchanged. What accounts for this relatively sudden change after such a long period of stasis? If imitation is the mechanism that gives rise to the ratchet effect described earlier, thus enabling culture to accumulate and evolve, could this advance in the development of human tool use be explained by the advent of human imitative learning? Perhaps the neural mirror systems for movements and for goals became linked at around this point into a larger mirror system, enabling characteristically human imitation with its flexible means-ends structure. However, Harris and Want doubt that the advent of imitation per se provides the needed explanation; the standard hand axes that persisted for so long already required a complex and challenging production process that was itself probably guided by imitative learning. Moreover, they argue that nonhuman primates display a capacity for imitative tool use and yet no ratchet effect occurs in their tool culture. Rather, Harris and Want suggest, the spark that set off cumulative progress in human tool use may have been a distinctively human shift from nonselective to selective imitation, not found in other primates, which speeded up the selective transmission of more effective tool variants from one generation to the next. On the other hand, recall that Whiten and colleagues report that chimps imitated selectively, while 3-year-old children did not, in a variant of Harris and Want's task! The jury is still out on how to explain these different results concerning selective imitation in children (see Whiten, vol. 1, ch. 11).

Neurologist Marcel Kinsbourne's hymn to imitation sounds themes from both preceding and following chapters in describing the ways in which human beings can find social entrainment more compelling than reason. The enactive encoding of objects in terms of their affordances for action is a pervasive general phenomenon that underlies imitation in particular: observed action affords imitation. But chasing predators is inadvisable; it is adaptive to inhibit overt imitation in many circumstances. Even infants imitate selectively; recall that they do not copy mechanical devices in the same way as they do people.

Yet the fact that patients with damage to frontal inhibitory areas imitate too widely suggests that overt imitation is just the disinhibited tip of the iceberg of continual covert imitation, which is itself just one aspect of enactive encoding. While covert imitation may function to assist the analysis of speech input through simulative synthesis,[31] Kinsbourne also suggests that it reflects a fundamental motivation of human beings, adults as well as children, to interact synchronously or entrain with one another, which is a mechanism of affiliation as well as of social perception and learning. He regards imitative entrainment as having potent persuasive effects, emotional as much as cognitive, on human beings.

Philosopher Susan Brison comments that Kinsbourne's view of the compelling social influence of imitative entrainment contrasts strikingly with the overrationalist dismissal of imitative influences that is often expressed when freedom of speech is invoked to argue against regulation of violent entertainment. She raises two important questions about what is in effect the ecology of responsibility. First, if a cultural environment entrains imitative violence, are the perpetrators of such violent acts nevertheless responsible for their acts? Second, should citizens take responsibility for doing something about the resulting violence? We can, she argues, answer *both* questions positively. Later chapters by Eldridge and by Huesmann take up related issues. Educationist Guy Claxton is struck by the importance for education of the pervasive although selective tendency to entrain; of the way the intentional stance arises out of the intentional dance, as he puts it. More generally, Kinsbourne's view of the powerful human tendency to entrain through imitation prompts questions about the broader social and cultural effects and functions of imitation. These are the focus of vol. 2, part II.

Volume 2, Part II Imitation and Culture

Social psychologist Ap Dijksterhuis agrees with Kinsbourne that imitation has important affiliative functions and is the default social behavior for human beings. The results he presents indicate that imitative behavior in human social interactions may be much more common than is generally recognized.

Dijksterhuis distinguishes two imitative pathways. First, he describes a "low road" to the imitation of specific observed behaviors, arguing that we are wired for such imitation by shared representations of our own acts and observed acts, such as those discussed in vol. 1, part I in connection with mirror neurons and ideomotor theory, and in vol. 2, part I in connection

31. See also Gordon (vol. 2, ch. 3), on simulative analysis by synthesis.

with innate self–other equivalences expressed in early imitation. However, his main focus here is on the less direct "high road" to the imitation of complex patterns of behavior. On the high road, imitation is mediated unconsciously by the activation of personality traits and social stereotypes, which lead observers automatically to assimilate their behavior to general patterns of observed behavior. Such imitation, he argues, acts as "social glue," with many beneficial social consequences; in many (though importantly, not all) cases it leads people to coordinate actions, to interact more smoothly, and to like each other.

Dijksterhuis describes an extensive series of experiments that provide striking evidence of heavy travel on the high road to imitation in everyday social life. In these experiments, normal adult participants are primed by exposure to stimuli associated with traits (such as hostility, rudeness, politeness) or with stereotypes (such as elderly persons, college professors, soccer hooligans). Hostility-primed participants deliver more intense "shocks" than control participants in subsequent, ostensibly unrelated experiments based on Milgram's (1963) classic experiments. Rudeness-primed participants spontaneously behave more rudely, and politeness-primed participants more politely, than control participants in subsequent, ostensibly unrelated interactions with experimenters. Youthful participants who are subliminally primed with words associated with the elderly, such as "gray," "bingo," or "sentimental," subsequently walk more slowly, perform worse on memory tasks, and express more conservative attitudes than age-matched control participants. College professor-primed participants perform better and soccer hooligan-primed participants perform worse than control participants on a subsequent, ostensibly unrelated general knowledge quiz. Such priming results are very robust. They hold across a wide range of verbal and visual primes and induced behavior, and when the primes are presented subliminally as well as when participants are conscious of them.[32] Either way, participants are unaware of any influence or correlation between the primes and their behavior.

As Dijksterhuis explains, these results show imitation in a broader sense than we have been considering up to now; traits and stereotypes elicit general patterns of behavior and attitudes, and influence the ways in which behavior is carried out, rather than eliciting specific novel behaviors. These broad imitative influences have been referred to as the *chameleon effect*

32. See also Bargh et al. (1996), Bargh (in press), Bargh and Chartrand (1999), Chartrand and Bargh (1996, 1999, 2002), Carver et al. (1983), Chen and Bargh (1997), Dijksterhuis and Bargh (2001), and Dijksterhuis and van Knippenberg (1998).

(Chartrand & Bargh, 1999). They are rapid, automatic, and unconscious, and do not depend on any conscious goal of the participant, making imitation the default social behavior for normal human adults. Just thinking about or perceiving a certain kind of action automatically increases, in ways participants are not aware of, the likelihood of engaging in that general type of behavior oneself. Nevertheless, these influences are often inhibited, for example, by goals that make conflicting demands; elderly-primed participants don't walk more slowly if they have an independent need to hurry. These influences are also inhibited when participants are focused on themselves. Again, overt imitation is the tip of the iceberg of underlying covert imitation.

Another leading researcher in this area, social psychologist John Bargh, has emphasized elsewhere how very hard it is for people to accept that these broad imitative tendencies apply to themselves, both because they are unconscious and automatic, so that people are not aware of them, and because such external influences threaten their conception of themselves as being in conscious control of their own behavior (Bargh, 1999). Participants are surprised by, and even tend to resist, the experimental findings. We might expect resistance to be especially strong where the high road to imitation would make antisocial behavior more likely, as in exposure to aggressive traits and stereotypes in violent entertainment, discussed by Eldridge, vol. 2, ch. 11 and Huesmann, vol. 2, ch. 12. Nevertheless, it seems plausible to suppose that the power of broad imitative influences on behavior is recognized and exploited by advertising campaigns that expose viewers to traits and stereotypes. As Bargh suggests, recognizing that we are subject to such automatic and unconscious imitative influences may help us to gain control of them and to assimilate behavior patterns more selectively.

In addition to being subject to automatic imitative influences, human beings often deliberately select a pattern of behavior to imitate because it is associated with certain traits and stereotypes, even if they do not actually partake of these traits or stereotypes. This can be benign; perhaps I can become virtuous, as Aristotle suggested, by behaving like a virtuous person. But like automatic imitation, deliberate selective imitation does not always operate benignly. For example, a group of cooperators may develop shared behaviors by means of which members identify one another as cooperators and exclude noncooperators from free riding. Noncooperators may then selectively imitate such behaviors in order to induce cooperative behavior from group members, and then fail to return cooperative behavior, thus deceptively obtaining the benefits of cooperation without paying the costs.

So-called *"greenbeard genes"* could produce genetically determined analogues of such imitative free riding (see Dawkins, 1982, p. 149). However, the evolution of a general capacity for selective imitation would make it possible to obtain the advantages of free riding without the need to evolve genes for specific behaviors (see Hurley, in press).

Sociologist Diego Gambetta examines the deceptive uses of selective imitation to impersonate members of a group or category to which the mimic does not belong. Adopting the term used in biology, he refers to such deceptive impersonation as *mimicry*, which he analyzes in terms of the relations among three roles: the mimic, the model, and the dupe. (Compare the quite different sense of "mimicry" in Call & Carpenter, 2002, p. 214, and Tomasello et al., 1993: copying modeled behavior without understanding its goals.) In models, an unobservable property is correlated with observable signature behaviors. The mimic imitates[33] the model's observable signature behaviors in order to mimic the model's unobservable property; that is, in order to deceive the dupe into treating the mimic as if he possessed the model's unobservable property as well as its observable behavior. The model or dupe in turn may develop defenses against mimicry. Gambetta provides a rich and often amusing set of examples of the relentless semiotic warfare among mimic, model, and dupe as they search for new ways to "outwit" one another, whether via genetic signs or intentional signals. The conditions under which mimicry is possible can be analyzed by means of signaling theory, which specifies equilibrium conditions under which truth is transmitted even when the signalers have an interest in deception, but Gambetta enriches this abstract analysis in two ways. First, he provides a set of illustrated semiotic distinctions: *cues* are costless to display and often mimic-proof; *marks* are lifestyle by-products that are often costly to mimic; *symbolic signs* are often cheap to display, of low evidential value, and vulnerable to mimicry. Second, he distinguishes various triangular relationships among mimic, model, and dupe. For example, is mimic pitted against dupe, via model, or pitted against model, via dupe? Gambetta calls for a systematic interdisciplinary extension of the study of mimicry.

Lawyer Harry Litman provides an example of Gambetta's concerns in the contemporary crime of identity theft. Commenting also on the research surveyed by Dijksterhuis, Litman notes that its potential public policy implications are immense, most obviously concerning the protection of media violence on freedom of speech grounds. However, in his view further work is needed on the magnitude, selectivity, evolutionary role, and neural basis of high-road imitative effects, especially when the implications for policy about media violence are in question.

33. Although mimicry does not always rely on imitation; for example, it can rely on lying instead.

Sociologist John Eldridge takes up the question of why disagreement persists about the imitative influences of media violence. The issue has been highly politicized by libertarian, moral right, and feminist agendas and distorted by misleading reporting; some have questioned whether media violence can be identified and its effects researched objectively. Eldridge acknowledges the many studies showing a correlation of exposure to media violence and actual violence, as well as longitudinal studies concluding that causation runs from media violence to actual violence, such as those by Rowell Huesmann, described in vol. 2, ch. 12.

But Eldridge presses the point that causal claims rest on decisions about how the causal relata are identified, and he raises general issues about how images of violence are contextualized and given meaning so as to lead to one response rather than another. Eldridge finds it less fruitful to focus on the imitation of particular episodes of media violence than on the powerful role of the media today, including media violence, in the processes of socialization and transmission of values. For example, he describes a study in which 10-year-olds express a view of killing in the film *Pulp Fiction* as "cool." Yet he also emphasizes the different interpretations given to images of violence, taking images of war as an example. Are they viewed as news, expressions of patriotism, manipulative propaganda, spectacle, history, fictional entertainment, art? The influence of such images can depend significantly on the way they are interpreted. In his view, media violence contributes, along with other influences and subject to many contextual variables, to the vocabulary of motives by which we understand, excuse, and justify conduct.

George Comstock, co-author of a major meta-analysis linking media violence with actual violence (Paik and Comstock, 1994), agrees with many of Eldridge's points about interpretation and context, but is concerned that they may obscure important empirical issues about the imitation and emulation of violence. These issues arise even if, with Eldridge, we focus on broad patterns of behavior mediated by assimilation of stereotypes or values from the media (as in Dijksterhuis' high road to imitation) instead of on the copying of specific behaviors. Comstock argues that the combined weight of many studies makes it "irrefutably clear" that young people exposed to more media violence are more likely to behave aggressively; that there is a strong case for causation, not merely correlation; that the "reverse hypothesis" that aggressiveness leads to viewing of media violence is not

supported by the evidence; that effect sizes are significant and comparable to those found in major public health risks; and that the influence of media violence extends to illegal and seriously harmful behavior.

Psychologist Rowell Huesmann concurs that the evidence is compelling that exposure to media violence increases the probability that children will behave aggressively. Huesmann usefully distinguishes short-term processes, which include priming, excitation transfer, and immediate imitation, from long-term influences that operate through observational learning (of schemas for attributing hostile intentions, of scripts linking situations to aggressive responses, and of norms for evaluating such scripts) and desensitization. While the long-term influences are cognitively mediated and lead to broad patterns of behavior, repeated short-term effects contribute to establishing long-term patterns of aggression. Huesmann presents an integrated view of empirical support for the causal influence of media violence on actual aggression from various mutually supporting paradigms. These include well-controlled experiments, robustly replicable correlational studies from various countries, and longitudinal studies and regression analyses showing that exposure to media violence during childhood predicts actual aggression years later, but not vice versa (when other possible explanations are controlled for, including initial aggressiveness, class, education, and so on).

Since 80% of those doing research on media violence conclude from the evidence that this form of violence is causing aggression, why, Huesmann asks, do a minority deny this causal link, and why does public understanding lag so far behind the evidence? Powerful vested interests are at stake; we dislike any suggestion of censorship; and, as social psychologists have emphasized, our conception of ourselves as autonomous is threatened by evidence of imitative influences in general, let alone when they are influences to aggression. But Huesmann suggests that the most powerful explanation is that the general importance of imitation in socialization and the molding of human behavior patterns has not yet been widely appreciated. In particular, he suggests, recent scientific work on the mechanisms and functions of imitation, such as the work reported in these two volumes, has not yet been digested, either by relevant disciplines or by the public. As Hurley comments, the risks associated with media violence may be better and more widely understood when what is being learned about imitation in general has been more widely assimilated and has been applied to the imitation of violence in particular.

Philosopher Jesse Prinz examines the failure of moral emotions to develop in psychopaths and the role of imitation in the normal development

of moral motivations. Normally, he argues, moral judgments are intrinsically bound to moral emotions, and hence are intrinsically motivating. This link results from a process of moral development in which emotional mirroring and imitation play critical roles. But in psychopathy, emotional and hence moral development fails.

Psychopaths are often intelligent and can recognize that certain behaviors are conventionally regarded as wrong, but they fail to distinguish actions that would be wrong even if there were no rule against them (such as hitting other students) from actions that are merely against the rules (such as not wearing the correct uniform to school). They show deficits in nonmoral emotions, such as fear and sadness in nonmoral contexts, as well as deficits in moral emotions, such as empathy with others in distress. They are impulsive and find it difficult to inhibit an initial response or default plan of action. Prinz understands this constellation of features in terms of a deficit in the behavioral inhibition system (see Gray, 1987) that underlies many aspects of emotion and motivation. Psychopathic deficits in inhibitory emotions such as sadness and fear, Prinz suggests, may be symptoms of this underlying deficit. A sadness deficit may in turn contribute to lack of empathy with others' sadness, and remove one of the components of more complex emotions such as guilt and shame.

Prinz goes on to argue for the importance of broadly imitative processes in four stages of normal moral development. Moral responsiveness begins with emotional contagion and vicarious distress; young children "catch" emotions from others by imitating observed facial expressions and in other ways.[34] Imitative learning contributes in turn to the development of more active prosocial responses to other's distress, such as consoling; the acquisition of sensitivity to normative rules; and finally the acquisition of moral emotions and the distinguishing of moral from other norms. Moral development can be impaired by bad role models in these imitative processes, as well as by emotional deficits such as those found in psychopaths.

Prinz's account of moral development resembles Adam Smith's eighteenth-century theory of sympathy at certain points, especially with respect to emotional contagion. Smith hypothesizes that when I observe another in a situation that would induce a certain feeling in me, I automatically experience a weaker version of that feeling. Robert Sugden observes the way current work on emotional mirroring, its neural basis and

34. See the discussion of emotional mirroring and its neural basis in Rizzolatti (vol. 1, ch. 1), Iacoboni (vol. 1, ch. 2), Gallese (vol. 1, ch. 3), and Decety and Chaminade (vol. 1, ch. 4).

its developmental role, supports Smith's theory. Smith also postulates that human beings are fundamentally motivated to bring their feelings and responses into correspondence with those of others—thus in effect agreeing with Kinsbourne that people love to entrain. Commenting on Prinz's chapter, Huesmann concurs on the importance of emotional contagion in moral development, but also emphasizes the imitative aspect of the cognitive processes by which we learn to evaluate morally the scripts available to govern behavior (which may themselves have been imitatively generated, in his view), and to reject scripts that are morally unacceptable.

Psychologist Merlin Donald views human imitative skills as part of the broader human capacity for *mimesis*: purposeful analog motoric communication that reenacts and creatively modifies complex episodes and behaviors as continuous wholes, without parsing into chunks represented by discrete symbols.[35] He argues that basic mimetic capacities evolved as primarily motoric adaptations in hominids about two million years ago and remain just out of reach for most primates. Mimesis enabled not just imitation but also the rehearsal and refinement of skills, the public motoric display of perceived or remembered episodes, social coordination and ritual, nonlinguistic gesture and pantomime, and reciprocal emotional display or mirroring.

Human mimetic communication preceded symbolic language and provided the fundamental support for the cultural interactions and conformity to norms that eventually led to language. Symbolic language was scaffolded on mimesis, Donald claims; it emerged from stabilized networks in which human beings with mimetic skills and analog brains interacted. Moreover, despite the immense historical overlay of linguistic culture, the human mind and its cultures are still fundamentally mimetic. Mimetic, analog styles of representation operate below the cognitive surface, affecting the way we use linguistically structured symbols and providing the foundation of our mental communities.

Morten Christiansen stresses that even if Donald is right about mimetic culture preceding and scaffolding language, more needs to be said to explain the commonalities of structure across the world's languages. While the usual question is, Why is the human brain so well suited for learning language?, we need to ask, Why is language so well suited to being learned by the human brain? Christiansen argues that natural language has itself adapted to strong selectional pressures provided by specific constraints on

35. Compare Byrne (vol. 1, ch. 9) on behavior parsing by gorillas and Arbib (vol. 1, ch. 8.2) on the decompositional structure of imitation and its relationship to syntactic structure.

human learning and processing capacities, in particular, the capacities for processing sequential and hierarchical structures. That is, linguistic universals are not themselves genetically specified, but rather reflect the cultural evolution of language to fit universal but language-independent features of human cognition, and thus to be learnable. Moreover, the pressures operating on language to adapt to human learning capacities are significantly stronger than those operating on humans to be able to use language. Despite the differences among them, Donald, Christiansen, Byrne, Iacoboni, and Arbib agree in suggesting that social learning of the structure of complex actions may provide an essential evolutionary foundation for linguistic capacities.

As Susan Blackmore explains, "mimetic" in Donald's sense should not be confused with "memetic" in the sense of meme theory, as first proposed by Richard Dawkins and developed by herself (Blackmore, 1999), Daniel Dennett (1995), and others. According to meme theory, memes are analogous to genes in that both are replicators that evolve through a process of imperfect copying under selective pressure. Memes are understood to be whatever is copied by imitation, the mechanism that makes memetic evolution possible. So while imitation is just one aspect of mimesis in Donald's sense, it is fundamental to meme theory. While memes need not be representational, mimesis requires intentional, representational action. Donald views imitation as a relatively uncreative aspect of mimesis, while Blackmore argues that copying errors, recombination, and selection among variants makes memetic evolution creative in the same way that genetic evolution is. And while genetic adaptations may explain the emergence of basic mimetic capacities, including the capacity for imitation itself, meme theory explains culture in terms of the comparative reproductive success of memes themselves rather than the comparative reproductive success of genes.

What is the relationship between imitation and rationality? Modern human cultures tend to assume, as well as aspire to, rationality, despite experimental evidence of systematic human irrationality. The assumption that human beings make rationally consistent choices, as if they were maximizing along some single dimension of expected utility, is especially prevalent in economics. Biologists have also modeled animal behavior resulting from blind processes of natural selection as if it were the rational solution to maximizing problems. The gene-meme analogy thus leads to the question, Can a supposed tendency for human beings to act as if they were rational be shown to result from processes of memetic selection? Economist Robert Sugden answers "no." He argues, against an argument made by Ken Binmore (1994), that there is no reason to suppose that the

memes that are most successful at being imitated will yield behavior conforming to rational choice theory.

Sugden's central point is that as-if rational behavior by replicators does not necessarily entail as-if rational behavior by the actors who carry those replicators. To make this point, he provides three related models of replicator population dynamics. Replicator types, whether genetic or memetic, replicate at a certain rate and have effects, via the choices made by the actors who carry them, on their own replication rates. For a replicator (as opposed to the actor who carries it) to behave as if it were rational means that it "acts" in such a way that it survives in a stable equilibrium. The three models make different assumptions about the causal loop by which replicators determine choices by the actor who carries them, and such choices in turn determinate rates of replication by replicators. The question then is, Will the as-if rationality of replicators lead the *actors* who carry the replicators to act as if they were rational?

Under unrealistically simplifying assumptions about the causal loop, it will do so: where each replicator type is the cause of one and only one action type, and where replicators reproduce asexually by producing exact copies of themselves. In this first model, decision probabilities exactly reflect the dynamics of the replicator population, and the actors as well as the replicators behave as if they were rational. But under more realistic assumptions, this does not hold. Sugden's second model shows that as-if rationality by genetic replicators does not induce as-if rationality by actors where reproduction is sexual, where each actor has genes from two parents and passes on at random only one of its pair of genes to its offspring, so that actions are determined by a combination of genes and decision probabilities no longer mirror the population of genes.

Nor do actors inherit as-if rationality from memetic replicators that reproduce asexually, but through selective imitation of other agents. In Sugden's third model, when actors meet, one actor compares the consequences of her own meme and the other actor's meme for a particular decision problem and decides accordingly whether to adopt the other actor's meme: whether to imitate. But these pairwise comparisons do not guarantee that the decision probabilities across the population of actors will respect transitivity; the decision probabilities may cycle in a way that is irrational at the level of actors, although they may be explicable at the level of memetic replicators.[36]

36. Many readers will no doubt be reminded here of the rational individual preferences and irrationally cycling collective preferences of social choice theory; see Arrow (1963).

As economist Paul Seabright and philosopher Mark Greenberg both emphasize, Sugden shows that rational behavior is not *guaranteed* to develop by genetic or memetic evolution, but leaves quite open whether it may *in fact* have developed by such means, which is a further, empirical question. Sugden's concern is to show that purely a priori approaches to this question are misguided. Just as the theory of biological evolution depends on an empirical understanding of actual genetic mechanisms, so we need to know "messy" facts about the causal loops governing memes and about their human transmitters, in order to know the consequences of memetic selection for the rationality of behavior.

Anthropologist Francisco Gil-White also calls for more empirical study of influences on the transmission of memes. He considers the common characterization of memes as selfish replicators to be mistaken. Nevertheless, he defends the usefulness of understanding cultural change in terms of Darwinian processes operating on memes, which are understood as elements of culture transmitted nongenetically that show inheritance, mutation, and selection. He explains that strict replication is not required by a Darwinian account of memetic evolution and cumulative adaptation, and responds to the objections that memes lack well-defined boundaries and that they change too rapidly for selection to determine cultural evolution. Nor does a Darwinian account of memetic evolution depend only on exact imitation as a copying mechanism; it can countenance other complex cognitive mechanisms of transmission, such as the emulation of a model's inferred goal based on observing a statistical cloud of the model's performances, even if these are unsuccessful. Gil-White emphasizes that the transmission of memes can depend, not just on the information content of the meme, but also on a range of noncontent-related influences described in classic work by Robert Boyd and Peter Richerson (1985), such as the meme's frequency in relation to other memes (*conformity bias*) and its association with high-status persons (*prestige bias*). While Harris and Want suggest in vol. 2, ch. 6 that selective imitation may explain cultural progress, Gil-White stresses the way noncontent biases on meme transmission can explain cultural differences. He sees memetic accounts of cultural change in terms of noncontent biases as rivals to "selfish-meme" accounts inspired by Richard Dawkins's selfish-gene theory. Finally, he criticizes Susan Blackmore's arguments that memetic evolution can drive genetic evolution. Blackmore in response defends her conceptions of memes as "selfish" and of memetic drive. She argues that Gil-White misrepresents meme theory's conception of replication and that meme theory can accommodate noncontent biases.

Mark Greenberg objects that Gil-White's defense of memetic evolution against the rapid-change objection assumes perfect selection: that everyone selects the most attractive variant of a particular type of behavior to copy, thus agreeing in their evaluations of such behavior. But in fact people may differ widely in their goals and hence their evaluations of others' behavior, and so select quite different examples to imitate. Moreover, human goal-seeking can result in radical departures from existing models rather than cumulative change.

Greenberg argues that the selfish-meme theory has the potential to challenge the commonsense goal-based account, but that its success will depend on its doing more explanatory work than competing goal-based accounts. For example, the development and spread of a technological innovation might naturally be understood as a result of deliberate, goal-directed thought and action: research, development, production, marketing, and rational consumer choice. The proliferation of an innovation may indeed reflect the differential imitation and survival of a meme for that innovation, yet human goals appear to explain *why* that meme is selectively imitated and hence spreads. (Greenberg's point here again recalls the suggestion by Harris and Want that *selective* imitation drove progress in tool use.) More generally, even when cultural changes do reflect the accumulation of variation under selective pressure, human goals may explain the selecting and hence the changes. Meme theory needs to show when and why the prima facie plausible goal-based account is inadequate and the deeper or more comprehensive explanation is that some memes are more conducive to their own replication than others are.

Greenberg draws an illuminating threefold distinction among ways in which memes might be selected. First, memes can be deliberately selected because of the relationship of their content to human goals: the commonsense account. Second, memes can be good at getting themselves copied by virtue of their content-related effects but regardless of whether they serve deliberate human goals (say, by exploiting other features of human psychology or society): the selfish-meme theory. Third, memes can be selected by mechanisms that are indifferent to their content, as in conformity or prestige biases: the noncontent bias theory. Noncontent bias accounts, in Greenberg's view, do not undermine content-based selfish-meme accounts. The fundamental issue is not between content-based and noncontent-based accounts of selection. Rather, it is whether either content-based selfish-meme theory or noncontent bias theory, or both in alliance, can do more explanatory work than the content-based, goal-directed, commonsense account.

Psychologist Nick Chater highlights another aspect of the explanatory competition between Darwinian memetics and commonsense, goal-based accounts of cultural change: speed. He distinguishes a Mendelian view of memetics, which he finds promising, from a Darwinian view, about which he is more skeptical than Greenberg. While Mendelian memetics explains cultural change in terms of the differential spread of memes, Darwinian memetics is more ambitious; it aims to explain cultural complexity as the result of blind selection among memes. As a result, he argues, Darwinian memetics faces a serious problem: Blind selection is slow and will be overtaken by fast intentional selection in the production of cultural complexity. Darwinian accounts of the emergence of biological complexity assume that variation is random, not directed, and that selectional forces operate by means of the reproductive success of whole organisms, not directly at the level of individual genes. But neither assumption holds for cultural transmission. We often create deliberate variation and imitate creatively, guided by our goals; we intentionally select particular aspects of models to imitate and decide not to imitate other aspects. Cultural complexity, unlike biological complexity, is largely produced by design; by sighted, not blind, watchmakers.

In response to the related challenges that Greenberg and Chater pose for meme theory, Blackmore agrees that goals are indeed relevant to memetic evolution, but they are just one of many factors contributing to selection processes. Selfish-meme accounts of religious practices do more explanatory work than goal-based accounts, she suggests, since the relevant goals were exploited and redesigned by religious memes.

Viewed in the overall context of these volumes, these last chapters come full circle by emphasizing the role of human goals in guiding deliberate selective imitation and hence cultural evolution. By what cognitive processes, deliberate or otherwise, do human beings acquire and pursue their goals? Other intelligent social animals can acquire goals by emulation, but few if any can learn imitatively novel means by which to achieve their goals. Other social animals do not engage, at least in the way that humans do, in mind reading—which arguably depends on the capacity for imitation and which certainly serves many human goals, along with other forms of simulative thought. However, human beings have a default tendency to imitate, automatically and unconsciously, in ways that their deliberate pursuit of goals can override but not explain. Do the distinctive human capacity and tendency to imitate at some level enable the effective, flexible pursuit of goals, or do goals guide selective human imitation—or both—in a dynamic process? To understand how culture emerges from biology, we

should put the cultural roles of imitation into biological and psychological context. The cognitive neuroscience and the evolutionary and developmental psychology of imitation should inform our views of the roles and functions of imitation in human culture.

Why Imitation Matters

In light of the contributions from a variety of disciplinary perspectives that we have surveyed, the importance of imitation can be described in both substantive and methodological terms. Here we briefly sketch how the study of imitation illuminates substantive issues about the links between perception and action and between self and other; the modularity of mind; the relationships among various levels of description of minds in society; the relationship between genetic endowment and social environment in forming human minds; the relationships between cultural evolution, in which imitation is arguably the primary copying mechanism, and biological evolution, which gave rise to the capacity for imitation in the first place. We conclude by suggesting that the study of imitation illustrates promising methodologies for interactive collaboration among the cognitive and social sciences and philosophy.

The study of imitation sheds light on two relationships that are central to understanding minds in general and human minds in particular: the relationship between perception and action and the relationship between self and other. The following paragraph sketches our view of how it does so, drawing on suggestions in various chapters. While there is plenty of room for disagreement about the details, it is hard to doubt the relevance of imitation to these issues.

Hypotheses about the control, imitative, and simulative functions of the mirror system, and evidence from imitation studies for ideomotor and common coding theories, suggest that perception and action share a fundamental information space that is preserved as higher cognitive capacities and that distinctions are built on it (see Gallese, vol. 1, ch. 3; Decety and Chaminade, vol. 1, ch. 4; Prinz, vol. 1, ch. 5; Hurley, vol. 1, ch. 7; and Meltzoff, vol. 2, ch. 1). The distinction between results and the means to those results, on which goal-directed, perceptually guided intentional action as well as imitative learning depend, emerges as a flexible articulation of this shared processing (see Rizzolatti, vol. 1, ch. 1). However, perception remains fundamentally enactive, in a way that challenges orthodox views of perception and action as separate and of perception as motivationally inert (see Kinsbourne, vol. 2, ch. 7; see also and cf. Noë, in press). The intersubjectivity characteristic of human beings, the basis for their innate capacity to understand and empathize with one another, is enabled as a specialization of such enactive perception. Perceiving your action enactively, in a way that immediately engages my own potential similar action, thus enables me to understand, or to imitate, your action. Shared processing of the actions of other and self is a special aspect of the shared processing of perception and action. The problem of "knowledge" of other minds looks quite different from this perspective. It is not so much that intersubjective information bridges an informational gap between self and other as that the self–other distinction is imposed on the fundamental information space that self and other share. As Gordon puts it, the first person is multiplied—though care is needed over whether this multiplication is understood at the level of subpersonal information, at the personal level, or both (see and cf. Gallese, vol. 1, ch. 3; W. Prinz, vol. 1, ch. 5; Hurley, vol. 1, ch. 7; Meltzoff, vol. 2, ch. 1; and Gordon, vol. 2, ch. 3). Simulation theories of mind reading can be right about shared processing for self and other with respect to this fundamental intersubjectivity, even if more advanced aspects of mind reading require theorizing in ways enabled by language.

Imitation is also prime territory in which to investigate issues about the modularity of mind and the relationships among different levels of description: neural, functional, personal, social, and cultural. Does the study of imitation support views of cognition as emerging from layers of dynamic perceptual-motor skills scaffolded by social and cultural environments (horizontal modularity), rather than as embodied in a central module that interfaces between perception and action (vertical modularity; see Hurley, 1998, 2001; Brooks, 1999)? What does the common coding of perception and action in imitation imply about the modularity of mind? How do different levels of description of imitation constrain one another? How, for example, would shared subpersonal processing for self and other be reflected in personal-level understanding of others? What do neural mirror systems imply about imitation and mind reading? Why do some creatures have neural mirror systems but not imitative capacities, and what more is needed for imitation? What do hypotheses about the functional subpersonal architecture that enables imitation imply about neural structures and function (or vice versa)? About the development and nature of our capacities as persons to understand other persons? Do empathy and mind reading at the personal level depend on simulation? Is simulation, in effect, offline imitation? Is simulation a personal-level rival to theorizing, or a subpersonal mechanism, or both? Does cultural evolution

depend primarily on blind, automatic mirroring mechanisms or on deliberative, goal-driven, selective imitation?

The study of imitation can contribute to our understanding of broad theoretical issues, such as those between nativists and empiricists about the relative contributions of genetic and environmental influences to psychology and language. These issues arise at various levels in the study of imitation. Why does a special capacity to learn imitatively from social environments evolve genetically—and why so rarely? What does imitation reveal about the relationship between human nature and other animals? Is the correspondence between perception and action that imitation exploits innate, as Meltzoff suggests, or is it acquired in cultural environments, as Heyes suggests? Does the location of mirror neurons in Broca's area suggest that imitative learning plays more of a role in language acquisition than nativists about language acquisition allow? Does imitation structure linguistic competence in some way as well as prompting performance (assuming that a competence/performance distinction is viable)? Do the recombinant ends-means and sequential-hierarchical structures and the self–other parity found in imitative action provide a basis for syntactic structure and shared meanings in linguistic action? If so, should we understand this foundation in evolutionary or developmental terms, or both? If not, what is the relationship between language and imitation? (See Iacoboni, Arbib, Byrne, Pepperberg, Pickering, Donald, Christiansen.)

More generally, imitation is a critical locus for understanding the ecology of human cognition and norms: the dynamic interactions between cognitive processes and sociocultural processes. Once the capacity for imitation has evolved, does it give rise to a new medium of evolution—culture—that can drive genetic evolution, or does genetic evolution remain in the driver's seat? Or do life and culture, brain and language, coevolve? Is automatic or selective imitation the primary engine of cultural evolution? (See Donald, Christiansen, Sugden, Gil-White, Greenberg, and Chater.) Are innate or cultural deficits primarily responsible for autism; for psychopathy; for violent aggression? Can individual responsibility itself be understood, compatibly with an innate human tendency to imitate, in partly ecological terms? (See Donald, Jesse Prinz, Eldridge, Huesmann, and Brison.) As we have seen, the study of imitation connects with practical issues; for example, it may have clinical applications in the treatment of autism (see Pepperberg, Jones), and policy implications in relation to media violence (see Huesmann, Comstock, Litman, and Hurley) and education (see Claxton). How should we respond to the irony of imitation: that the capacity for imitation appears to be a distinctive feature of human nature and may well

be part of the basis for other distinctive features of human nature, such as mind reading and language, which together set us apart from other animals? Yet at the same time our innate, automatic tendencies to imitate can also threaten our conception of ourselves as autonomous and deliberative in ways that no other animals are.

Finally, the study of imitation illustrates a promising topic-based, interdisciplinary methodology. We have seen that imitation has important roles in human cognition and society. To seek a fundamental understanding of these, we do best to bring together the discoveries and theories of the various disciplines that study imitation, so that they can constrain, inform, and cross-fertilize one another—though of course we must remain aware of how specific aims and contexts differ across disciplines (see, e.g., Rizzolatti, vol. 1, ch. 1 and Byrne, vol. 1, ch. 9). In particular, these two volumes illustrate the fruitful interaction of techniques across disciplines: the interaction of single-cell brain recording; brain imaging work[37]; behavioral experiments; fieldwork; clinical work; and formal, conceptual, and theoretical arguments. Many new experiments as well as theoretical developments are suggested in these volumes as a result of interdisciplinary thinking.

These volumes also illustrate that there is work for philosophy to do that is often overlooked within a prevalent conception of philosophy as a strictly a priori discipline that addresses conceptual issues and is sharply separated from scientific inquiry about empirical matters. We do not subscribe to that division, but rather to the view that important conceptual and empirical issues are often densely and seamlessly intermingled, as they are in the study of imitation. As many scientists are aware, philosophical questions often grow organically out of scientific work, as again they do from work on imitation: questions that are at once philosophical and empirical and that can be addressed fruitfully by philosophy as well as by the sciences. We do not suggest that such questions should displace philosophy's historically derived traditional questions, but rather that they provide additional areas to which philosophical argument can contribute. Indeed, "natural philosophy" was long understood to include physics as well as metaphysics, logic, and ethics. We propose to revive and revise the term "natural philosophy" to describe the kind of empirically embedded philosophical work illustrated in these volumes.

Progress on some topics of fundamental and broad importance may demand topic-based research that cuts across disciplines, which, unfortu-

37. See the discussion by Iacoboni (vol. 1, ch. 2), Decety (vol. 1, ch. 4), and Kinsbourne (vol. 1, ch. 8.5) on the interaction of brain imaging and other techniques.

nately, contemporary institutional and disciplinary constraints often fail to facilitate. We hope that these volumes will encourage institutions to build opportunities for topic-based interdisciplinary research into their normal infrastructure and operating assumptions.

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