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The Cognitive Animal

Empirical and Theoretical Perspectives on Animal Cognition

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OA Funding Provided By:

The open access edition of this book was made possible by generous funding from Arcadia—a charitable fund of Lisbet Rausing and Peter Baldwin.

The title-level DOI for this work is:

[doi:10.7551/mitpress/1885.001.0001](https://doi.org/10.7551/mitpress/1885.001.0001)

42 Kinesthetic-Visual Matching, Imitation, and Self-Recognition

Robert W. Mitchell

The chimpanzee Viki was raised in their home by Keith and Cathy Hayes (see C. Hayes 1951). Having been treated as a human child, Viki acted like one—she played with her human parents, ate at the table, had trouble with toilet training, loved going for rides in the car, understood spoken language, used sounds to communicate her desires, pretended with imaginary objects, deceived, enjoyed attending to the pages of picture books, and used household tools like her human parents. Her actions provided evidence for activities previously thought by many scientists to be largely if not exclusively human, most particularly her abilities for extensive bodily imitation and mirror self-recognition. Although there had been earlier indications that great apes could imitate bodily actions and recognize themselves in mirrors (see Mitchell 1999), Viki supplied the first experimental evidence that animals can imitate diverse actions, doing a good job of re-creating the Hayes' actions when asked to do the same thing. Viki also used mirrors to clean up her face, attempt to pull out her tooth, and play with putting on lipstick, and thus clearly recognized her image (K. J. Hayes and Hayes 1955; K. J. Hayes and Nissen 1971). How is one to explain Viki's abilities?

Little attempt at an explanation was made until several years later, when some primatologists came to believe that apes who recognized themselves in mirrors needed to have a remarkably well-developed self-concept to do so, including a complex knowledge of their internal states that was presumed to be useful in interpreting others' mental states. Although the basic idea that some sort of "self-concept" is required for self-recognition seems plausible (for how else can one recognize one's body?), the nature of the proposed self-concept was problematic—how exactly did this self-concept allow an animal to recognize itself in a mirror? For example, how does knowing that one is self-congratulatory or selfish, or that one experiences mental imagery,

or that others have mental states, lead one to recognize one's self in a mirror? Obviously one must have some knowledge of what one looks like—a very specific form of self-concept—but this raises a paradox: How can you know what you look like *before* you recognize yourself in the mirror? My answer to this question [or, more specifically, Guillaume's (1926/1971) answer], organized a whole field of research in a new way, tying self-recognition, bodily imitation and pretense, communication via simulation, recognition that one is being imitated, and mental planning together in one neat skill—kinesthetic-visual matching (Mitchell 1993a,b, 1994, 1997a,b, 2000, 2002).

Guillaume studied the development of imitation in children he knew well—his own—and came up with the idea that bodily imitation and self-recognition require matching between kinesthesia and vision. He argued that imitative development does not start with, but rather leads to, making matches between one's own and another's actions. According to Guillaume, initially children try to re-create the effects other people have on objects, and only gradually come to re-create other people's actions. By repeated attempts at re-creation, the child learns to match his or her own kinesthetic feelings to the visual actions of another, and also becomes aware of what he or she looks like to others and in a mirror. In this way, children develop a match between inner and outer experience—between their own subjective experiences and those of others.

Piaget (1941/1962) acknowledged Guillaume's idea that mature bodily imitation and mirror self-recognition derived from matching between kinesthesia and vision. However, he disagreed with Guillaume's depiction of the cause of development, arguing instead that the child imitates because he or she is interested in reproducing an action per se, not just its effects; imitation thereby indicates intelligent awareness of the similarity between his/her own and others' actions, based

on a match between kinesthetic and visual experiences. Whichever of these hypotheses is correct [and it is unclear whether they are really as different as Piaget believed—see Mitchell (1993b)], the essential idea that kinesthetic-visual matching is necessary for self-recognition and any robust generalized imitation seems well taken. After such lucid solutions to the problem, Guillaume’s and Piaget’s hypotheses were (as so often happens in science) largely ignored. Not surprisingly, numerous other individuals “independently” came up with kinesthetic-visual matching as the basis for imitation and self-recognition [see Mitchell 1997a for historical overview; strangely, Povinelli (2000) not only claims priority for this idea, but previously claimed it to be false (Gallup and Povinelli 1993)].

Kinesthetic-visual matching as I envision it is the recognition of similarity between the feeling of one’s own body’s extent and movement (variously called “kinesthesia,” “somesthesia,” or “proprioception”) and how it looks (vision). We (and other animals) know generally where our appendages and mouth are at any given time, even though we do not see them; we also feel where they are when we move. This kind of knowledge seems necessary to engage in actions. But we also have an intimate knowledge of the relationship between these nonvisual perceptual experiences of our body and its visual appearance, even though we do not usually see ourselves in action. We have an idea of what we look like when we act—a general (and imprecise) idea of the “outline” of our bodies, and the relative positions of each part. That is why animals such as apes can recognize their mirror image and learn to imitate—because they sense (or can learn) that the image in the mirror or of the other is like their own image. And this sense can lead them to test the similarity, as when the captive gorilla Muni used a mirror to examine himself: He “looked at the mirror with his head placed between his legs . . . Later he stood on his hands, resting his feet on the mirror. Returning to a sitting position, he lifted one leg and looked at his

reflection, inspecting the parts of him that he ordinarily could not see. He obviously recognized himself” (Riopelle et al. 1971, p. 88).

Kinesthetic-visual matching is remarkable and does not seem to exist in many species of animals. Here is an example. Several years ago Jim Anderson and I provided a long-tailed macaque (*Macaca fascicularis*) named Rodrique, a former pet of a primatologist, with a concave mirror and videotaped his activities. A concave mirror provides an image of whatever is in front of it, but the image is upside down and transposed. Rodrique engaged in some remarkable activities with this mirror. We observed him putting his hand into the mirror, moving his thumb and forefinger as if grooming; as well as putting his head into the mirror and sticking his tongue out, as if licking. Certainly these were odd behaviors, and suggested to us that Rodrique might have been playing with his image—sticking his tongue out, or moving his fingers, to see what happened. But because his actions seemed like grooming and licking, we looked into the mirror ourselves, and discovered that from the perspective of having your head somewhat into a concave mirror, an image of a three-dimensional upside-down head is visible inside. It appeared that what Rodrique was doing (or trying to do) was grooming and licking the upside-down head of a monkey! He never recognized, after many hours of experience with the concave mirror, that the upside-down monkey head was his own. [We also tested him by marking his head with a red mark, but he showed no interest in the mark after looking in a flat mirror, with which he had also had experience—see Mitchell and Anderson (1993).] Rodrique’s actions are intriguing. He seemed content to interact with the phantom monkey as if it were a real monkey, apparently never recognizing that this monkey did the same thing he did, not caring that he was grooming and licking nothing tangible. It would seem that Rodrique did not have the ability to connect what he knew and felt about his own body with what he saw the other monkey doing—i.e., kinesthetic-visual matching.

Kinesthetic-visual matching does not, of course, work in isolation from other matching abilities that are widespread throughout mammals. For example, most mammals can recognize matches between two visual stimuli (e.g., Rodrique knew it was a monkey in the mirror), perhaps including even parts of their own body and those of other species members (Mitchell 1993a). Kinesthetic-visual matching works in combination with, and is clearly dependent on, an organism's other matching skills (Mitchell 1994). It would be surprising if an animal with kinesthetic-visual matching did not have visual-visual matching or other within-modality matching skills, and more surprising still if an organism was only able to use one of these matching skills at a time. Thus, assuming that kinesthetic-visual matching is essential to a generalized ability for bodily imitation does not, as Whiten (2000, p. 499) states, "neglect the possible role of visual feedback [i.e.] visual-visual matching." (Surprisingly, the potential visual-visual matching available from actively grooming the phantom monkey with his fingers did not afford Rodrique any self-recognition, perhaps because the reflected image was upside down and reversed, and transformed as his fingers moved closer to the reflected image.) There are, of course, alternative means besides kinesthetic-visual matching by which organisms might match their own and others' bodies. Haptic-kinesthetic matching might be used, for example, by blind organisms (or sighted ones at that), and perhaps auditory-kinesthetic matching (for those organisms with echolocation). But kinesthetic-visual matching seems the most likely possibility for most mammals, especially primates; other matches to kinesthesia besides the visual seem to require more active exploration to be detected.

Imagine organisms (like Rodrique) without kinesthetic-visual matching. Presumably they have within-modality matching skills, so that visual-visual or haptic-haptic or auditory-auditory matching is relatively easy for them. They also presumably have internal mental images of these modalities, so that they might be

able to think or dream with these images; and they have kinesthesia, so they know where their body parts are and have a general notion of the outline of their body. They could reenact their own actions, for deceptive purposes or in play. They might even have cross-modal matching abilities, such as recognizing the analogical relation between a brighter light and a louder sound. But without connections between kinesthesia and vision, the organism would not be able to have a visual mental image of its own body and would not be able to connect the kinesthetic image it has of its own body with any visual image. Thus, such an organism could not translate from its bodily feelings to a visual mental image of itself (and thus could not have a visual mental image of itself). Such a creature might have dreams or thoughts in which it observed things, but it could never represent itself visually—it could only be an observer not visually represented. And without an ability to translate between its own bodily feelings and those of others, it could never recognize that others have bodily feelings and thoughts like its own. In fact, such a creature could not attribute its experiences to itself, for without an ability to attribute psychological states to others, one cannot attribute them to oneself (and vice versa).

This last idea is surprising, because many people think that we understand others because we analogously attribute our own experiences to them; that is, we judge from our knowledge of ourselves to knowledge of others. But this judging is problematic, as the philosopher P. F. Strawson pointed out, because it is unclear how one can attribute experiences *to* oneself without an ability to attribute experiences *per se*:

There is no sense in the idea of ascribing states of consciousness to oneself, or at all, unless the ascriber already knows how to ascribe at least some states of consciousness to others. So he cannot (or cannot generally) argue "from his own case" to conclusions about how to do this; for unless he already knows how to do this, he has no conception of *his own case*, or any *case* (i.e., any subject of experiences). Instead, he just has evidence that pain, etc., may be expected when a

certain body is affected in certain ways and not when others are. (Strawson 1958/1964, p. 393)

Such an organism would experience pain, of course, but would not have a notion of itself as the possessor of that or any other experience (see Mitchell 2000, for elaboration).

An organism with all of the capacities of an organism like Rodrique, but with the addition of kinesthetic-visual matching, would have a great variety of understandings available to it based on matching between bodies. Such organisms would know (or at least have a general idea of) what they look like when they act, and would recognize that others' actions are possible actions for their own body. Thus, not only could they recognize that the visual image of their body in the mirror looks like what their body movements feel like (and thus infer that the image in the mirror is an image of their body), but they could also do what they see others do; that is, imitate others' actions. Such organisms could also recognize when they are being imitated, or pretend to be another by acting like them. And they could have some awareness that others have psychological experiences, in that they can recognize the bidirectionality of kinesthetic-visual matching. Not only do they feel like what another looks like, but they look like what another feels like. In addition, these organisms can represent themselves visually in thought, and be able to translate from the visual image of themselves to their own kinesthetic movements in order to act in relation to the visual image; that is, they can plan to do things. (Of course language offers another means of planning, without visual images.)

This theoretical orientation has led me to examine the evidence of self-recognition, imitation, recognition of being imitated, pretense, and planning in humans and nonhumans. The most consistently examined evidence concerns self-recognition and bodily imitation, two activities that are of course common in humans and which become mature at about 18 months of age or

earlier. In fact, generalized imitation and self-recognition appear to develop at about the same time in human children (Asendorpf and Baudonnière 1993; Hart and Fegley 1994; Asendorpf et al. 1996), which supports my prediction that they develop from the common skill of kinesthetic-visual matching (Mitchell 1993a).¹ Unfortunately, access to the sorts of animals likely to show similar skills—apes and other large-brained animals—is difficult, so to test my prediction I have had to look to the literature to see what other scientists have discovered.

At first the evidence was pretty clear—apes showed self-recognition and imitation, but most other species did not (see Mitchell 1993a, 1997b). Experimental testing of chimpanzees showed that they can use a mirror to self-recognize when a mark has been applied to their face (Gallup 1970), and a redoing of the Hayes's work with Viki showed that chimpanzees and orangutans can engage in generalized bodily imitation (Custance et al. 1995; Miles et al. 1996). [Imitation on demand does not seem to be present in other species (Mitchell 1993a; Mitchell and Anderson 1993), although not many species have been tested.] Superficially, the evidence seemed clear—at least some members of each ape species can self-recognize (Swartz et al. 1999) and imitate diverse bodily actions, so that both are potentially species-wide skills. Add the evidence that dolphins (*Tursiops* species) can engage in generalized bodily imitation (Tayler and Saayman 1973; Bauer and Johnson 1994) and self-recognition (Marten and Psarakos 1994; Reiss and Marino 2001), and it would appear that the evidence supports the kinesthetic-visual matching hypothesis. Another point in its favor is evidence that cotton-top tamarins show self-recognition (Hauser et al. 1995) and marmosets, a closely related species, show some skill at bodily imitation (Bugnyar and Huber 1997; Voelkl and Huber 2000; although see later discussion).

The problem is that the evidence is not all that conclusive. Other than the chimpanzee Viki, the gorilla Koko, and the orangutan Chantek—

all human-reared apes—there is little evidence (except in human children, for whom it is robust) of the co-occurrence of generalized bodily imitation and self-recognition in the same individual (Mitchell 1997b). [Unfortunately, many scientists seem content to use evidence that theoretically codependent activities occur in different members of the same species to support their belief that the same ability is responsible for both activities; see discussion by Mitchell (1993b).] Also, there seems to be evidence against the hypothesis; some animals (gibbons) that are not known to imitate appear to show a skill for self-recognition (Ujhelyi et al. 2000), although new research may indicate some skill at imitation. And some animals that are not known to self-recognize (macaques) every once in a while act in ways that are suggestive of imitation via kinesthetic-visual matching (see Mitchell 2002).

In addition, evidence of kinesthetic-visual matching in marmosets and tamarins is not convincing. Although some researchers characterized two tamarins' actions toward a mirror as looking at body parts that are not visible without a mirror and five tamarins' actions as wiping off a mark near their face while looking in the mirror (Hauser et al. 1995), alternative interpretations are possible (Anderson and Gallup 1997; cf. Hauser and Kralik 1997). For example, the behavioral evidence is rare and/or ambiguous in its support of the claim that the tamarins were using the mirror to look at their normally visually inaccessible body parts or the mark on the hair above their face. Similarly, some potential evidence of bodily imitation in marmosets (Bugnyar and Huber 1997) may result from visual-visual matching and/or chance similarities in handedness between observer and demonstrator marmosets (see Mitchell 2002), but the evidence is still suggestive. More recent evidence of marmoset imitation (Voelkl and Huber 2000) is also suggestive. Observer marmosets tended to open a film canister to obtain food using the same body configuration (by hand or mouth) that the demonstrator marmoset had used. Specifically, after

observing another marmoset open film canisters using its mouth, 4 out of 6 observer marmosets opened at least one canister (actually, 2, 6, 11, and 13) out of 14–15 with their mouths (which is infrequent among marmosets). By contrast, after observing another marmoset open film canisters using its hands, all 5 observer marmosets opened 14–15 canisters out of 15 with their hands (none used its mouth).

While these data are suggestive, the actions the demonstrator marmosets used may have been perceived by the observer marmosets as indicating something distinctive about the canisters they later opened. Based on the pictures of both actions on p. 197 of Voelkl and Huber's article, the method of opening by mouth suggests that the marmoset is attacking the lid of the canister, whereas the method of opening by hand suggests that the marmoset is exploring what is inside the canister. Thus it may be that the marmosets did not imitate the specific action of opening used by the demonstrator marmoset, but rather responded in a similar attitude toward the objects. Similarly, chimpanzees tended to react aggressively or with exploration toward a hidden object when another chimpanzee who had seen the object acted aggressively or with exploration (Menzel 1973). Imitation at the level of intentionally re-creating the actions of others seems unlikely in these circumstances.

Given that access to and control over great apes and dolphins is particularly difficult, my own penchant is to explore more directly whether animals who have never shown self-recognition can learn generalized imitation. (That is, I am looking for potentially disconfirmatory evidence.) As noted earlier, one attempt to teach the long-tailed macaque Rodrique to imitate my bodily actions failed (Mitchell and Anderson 1993). Recently, collaborator Ellen Furlong has been unsuccessful in teaching a Syke's guenon (*Cercopithecus mitis albogularis*) at April Truitt's Primate Rescue Center in Nicholasville, Kentucky to imitate her actions using a method, similar to that used with Rodrique, of rewarding

the animal for scratching where she (the model) scratches. Of course if we can teach a monkey to engage in generalized bodily imitation, we can test it for self-recognition, thereby providing evidence for or against the kinesthetic-visual matching hypothesis. But given other researchers' interest in self-recognition and imitation, particularly those studying human children, we probably will not have to wait long for more information about the correlation between these two activities in the same individuals.

Note

1. Two more recent and well-thought-out empirical studies also show a developmental synchrony among self-recognition, generalized bodily imitation, and pretense based on body modeling (Nielsen 2001; Baudonnière et al. 2002) which supports the kinesthetic-visual matching hypothesis. Neither study acknowledges this, and Nielsen even argues that the occurrence of deferred imitation earlier than generalized bodily imitation and self-recognition provides evidence against the kinesthetic-visual matching hypothesis. It is important to clarify here that deferred imitation is not necessarily evidence of generalized bodily imitation. In my presentation of the kinesthetic-visual matching hypothesis, I explicitly acknowledged that deferred imitation occurred earlier than self-recognition (Mitchell 1993a, p. 303), and consequently suggested that a more generalized skill for bodily (including facial) matching is needed to indicate a kinesthetic-visual matching mature enough to support self-recognition (p. 303).

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