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Kinesthetic-visual matching, imitation, and self-recognition

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The chimpanzee Viki was raised in their home by Keith and Cathy Hayes (see Hayes, 1951). Having been treated as a human child, Viki acted like one, and her actions provided evidence for activities previously thought by scientists to be largely if not exclusively human--most particularly, extensive bodily imitation and self-recognition. Although there had been earlier indications that great apes could imitate bodily actions and recognize themselves in mirrors (see Mitchell, 1999a), Viki supplied the first experimental evidence that animals can imitate diverse actions, doing a good job of recreating the Hayes' actions when asked to do the same thing. Viki also used mirrors to pull out her teeth and otherwise manipulate her appearance, and thus clearly recognized her image (Hayes & Hayes, 1955). How is one to explain Viki's abilities?

Little attempt 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 which was presumed to be useful in interpreting others' mental states. Although the basic idea that some sort of "self-concept" is required to self-recognize seems descriptively true (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 greedy or angry, 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 another difficulty: How can you know what you look like before you see 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; 1993b; 1994; 1997a; 1997b; 1999b; 2000).

Guillaume studied the development of imitation in children he knew well--his own--

effects, thereby indicating 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 that 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.)

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 kinesthesis, somasthesis, or proprioception) and how it looks (vision). We know where our feet and hands and mouth are at any given time, even though we don't 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 non-visual perceptual experiences of our body and its visual appearance, even though we don't 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 out 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, Nos & Jonch, 1971, p. 88).

Kinesthetic-visual matching is remarkable, and does not seem to exist in many species of animals. Here's an example. Several years ago Jim Anderson and I provided a long-tailed macaque 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

Kinesthetic-visual matching does not, of course, work in isolation from other matching abilities which 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 in 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 active 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 in shape as his fingers moved closer to the reflected image.)

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. 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 kinesthesis 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--without an ability to attribute psychological states to others, one cannot attribute them to oneself.

This last idea is surprising, as most people think that we understand others

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.

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 should 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 which 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 & BaudonniÜre, 1993; Hart & Fegley, 1994; Asendorpf, Warkentin, & BaudonniÜre, 1996), which supports my prediction that they develop from the common skill of kinesthetic-visual matching (Mitchell, 1993a). 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' work with Viki

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) 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 co-dependent 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, evidence against the hypothesis seems present--some animals (gibbons) which are not known to imitate appear to show a skill for self-recognition (Ujhelyi, Buk, Merker, & Geissmann, 2000), although new research may indicate some skill at imitation. And some animals which are not known to self-recognize (macaques) every once in a while act in ways which are suggestive of imitation via kinesthetic-visual matching (see Mitchell, 2000).

In addition, evidence of bodily imitation and self-recognition in marmosets is problematic. Although some researchers characterized two marmosets' actions toward a mirror as looking at their body parts which are not visible without a mirror (Hauser et al., 1995), alternate interpretations are possible (Anderson & Gallup, 1997; cf. Hauser & Kralik, 1997). Similarly, some potential evidence of bodily imitation in marmosets (Bugnyar & Huber, 1997) may result from visual-visual matching and/or chance similarities in handedness between observer and observed marmosets (see Mitchell, 2000), but the evidence is still suggestive. More recent evidence of marmoset imitation (Voelkl & Huber, 2000) is also suggestive: observer marmosets tended to open a film canister to obtain food using the same body configuration (via hand vs. via mouth) that the observed 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 its mouth (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 suggestive, the actions the marmosets used may have been perceived by the observer marmosets as indicating something distinctive about the canisters they later opened: based on the depictions of both actions pictorially presented on p. 197 of Voelkl & 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's inside the canister. Thus, it may be that marmosets did not "imitate" the specific action of opening used by

she (the model) scratches. Of course if we can teach a monkey to engage in generalized bodily imitation, we can test him or her for self-recognition, thereby providing evidence for or against the kinesthetic-visual matching hypothesis. But given other researchers' interests in self-recognition and imitation, particularly those studying human children, we probably will not have long to wait for further support for the correlation between these two activities.

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