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Review

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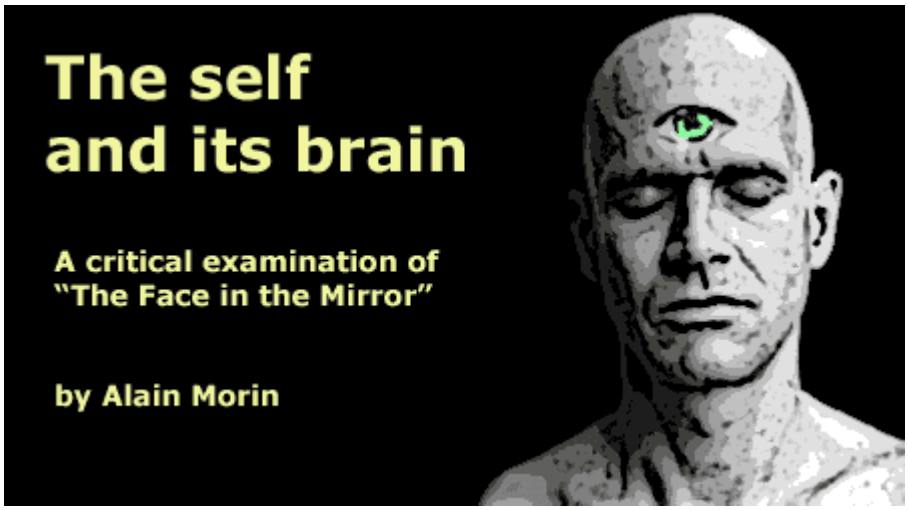


[SCR 2003, November, No. 1]

It is doubtful that full-blown, mature human self-awareness is primarily located in the right hemisphere, as Keenan claims…

Where is the self located in the brain? This is a question that has intrigued philosophers and scientists for quite some time. Four centuries ago, the French philosopher René Descartes thought that the self resided in the pineal gland, a small structure centrally positioned in the lower brain.

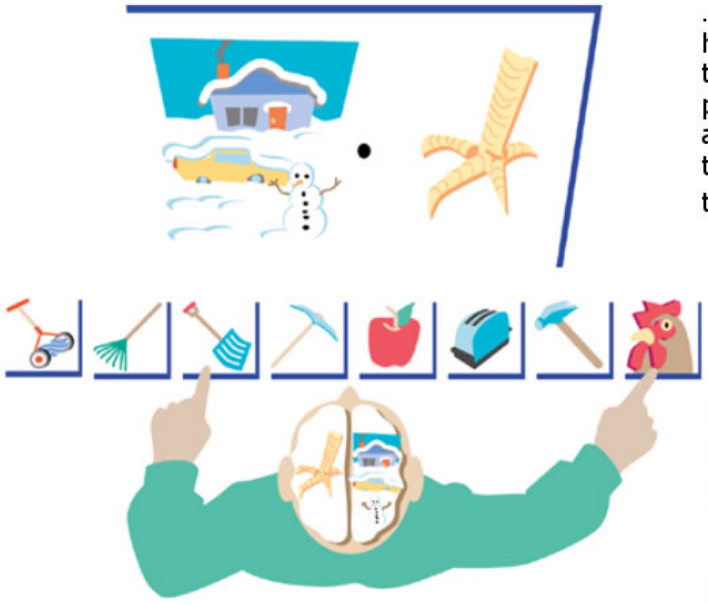
Two centuries later, the neurologist Paul Broca—another French—observed that people with damage to the left hemisphere consistently exhibited speech problems. Although Broca was not directly interested in the self, he suggested that the left hemisphere is specialized in language functions.

Other thinkers who believed that language is necessary for awareness of self (Michael Gazzaniga and John Eccles, for instance) later concluded that the same hemisphere sustains our sense of self. The study of split-brain patients in the early

sixties greatly stimulated speculations about the self and its brain. Some unfortunate people suffering from intractable epilepsy do not respond to drug treatments. The only available alternative consists in surgically eliminating the commissures linking their cerebral hemispheres (hence the term “commissurotomy”) so that the abnormal electrical activity generated within one hemisphere does not cross over to the other. This significantly reduces the severity of convulsions. Since split-brain patients have two independent and isolated cerebral hemispheres, it is possible to investigate their unique abilities by presenting lateralized information to each hemisphere and by asking it to perform given tasks (see Figure 1). This line of research (mainly instigated by Roger Sperry at the Pasadena Institute of Technology in California) showed that Broca was right… about the left hemisphere’s dominance for language. For example, if we flash an image of an apple in the left hemisphere, the patient will correctly name it (again, see Figure 1); the same image presented to the right hemisphere will elicit no verbal response—the patient will remain mute. But this hemisphere will nonetheless perceive the apple because the patient’s left hand (controlled by the right hemisphere) will choose the appropriate object among a array of available items. Split-brain studies also indicated that the right hemisphere, far from simply being a “minor” non-verbal hemisphere, is more emotional and specialized in visuospatial tasks such as mentally imagining objects or reading road maps.

The split-brain phenomenon gave rise to a host of conflicting propositions about the neuroanatomical localization of the self. Quite simply, the question is: Where is the self in the split brain? In the left hemisphere? In the right hemisphere? In both? And basically, three main interpretations have been proposed. (1) Despite remarkable performances by the right hemisphere on some perceptual and cognitive tasks, this hemisphere is unconscious; the self requires language to manifest itself, and thus it is located in the left hemisphere. (2) We actually all possess two selves, one in each hemisphere; the split-brain operation simply makes this fact more salient. (3) The self is located in both hemispheres; splitting the brain divides the self into two roughly equal parts.

By using a tachitoscope, which displays visual stimuli for very brief intervals of time on each half of the screen in front of the patient, information presented on the left is exclusively perceived by the right hemisphere, and vice versa. If we ask the patient to identify what is seen, the right hand (controlled by the left hemisphere) will point toward a chicken...



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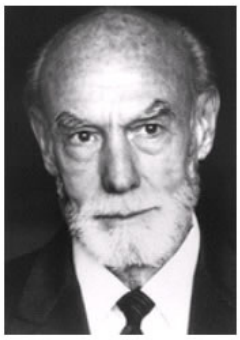
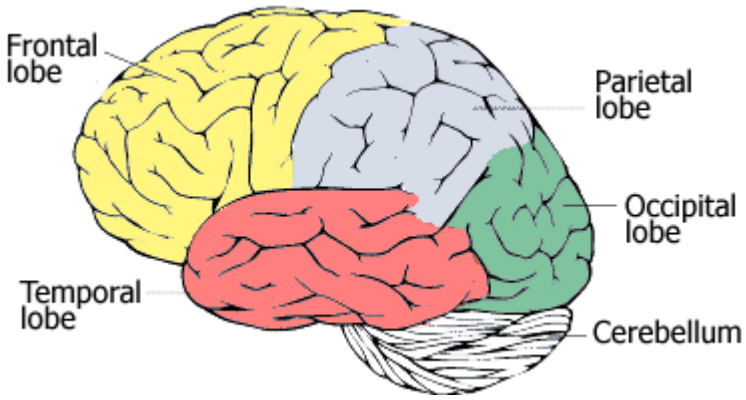
... whereas the left hand (operated by the right hemisphere) will choose a shovel (needed to remove snow in the scene).



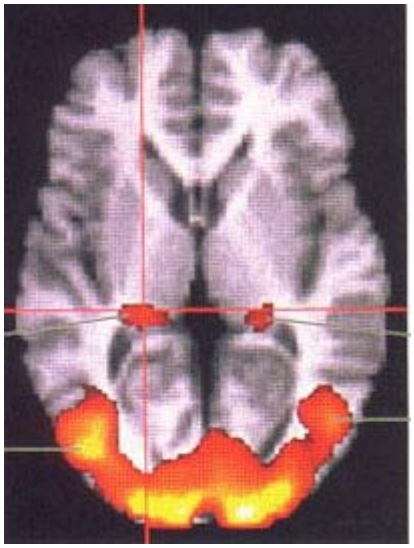
Researcher Roger Sperry

Figure 1. Lateralized presentation of information in a split-brain patient

With all this we are still left with mere conjectures because the evidence is too much open to interpretation. What does it mean exactly to have a self? What kind of "behavior" should a cerebral hemisphere emit to conclude that it is self-aware? But with the development of new and sophisticated brain-imaging techniques in the early 90's, such as Positron Emission Tomography (PET) scans and Functional Magnetic Resonance Imaging (fMRI) (see LINK), we can now distinguish what specific areas of the brain are active when people think, feel, imagine, perceive, and so on. For example—and I will deliberately avoid technical details here—, if your brain activity was being measured with a PET scan while looking at an object, your occipital lobes would show an increased use of oxygen and glucose. The scan would detect this bigger metabolically rate, indicating more activity in this specific brain structure. Or let's imagine that I ask you to mentally solve a problem or organize some information coherently while observing your



brain with fMRI. I would most likely identify a more important blood flow in your frontal lobes, signifying more activity in these regions.



Obviously, researchers are starting to apply this technology to find the self in the brain. Certainly the most crucial aspect of the self is *self-awareness*—the capacity the self possesses to reflect upon itself. This is important. If the self was unable to think about itself, it would not know that it exists. Without self-awareness there still would be a self but we would not know about it. We could not contemplate our existence and unpreventable death, describe who we are and develop an identity, have a sense of ownership ("*I* did this; *this* is part of who *I* am"), or recollect past personal experiences that at least partially explain why we are who we are. In light of this paramount significance of self-awareness, a more contemporary question is: What precise brain areas exhibit increased activity when people engage in self-reflection?

This leads me to the book under review, Julian Keenan's essay (written in collaboration with Gordon Gallup, Jr. and Dean Falk) The face in the mirror (see LINK). (Sorry for this long introduction, but I needed to put things into perspective…) Keenan is associate professor and director of the Cognitive Neuroimaging Laboratory at Montclair State University in New Jersey. He is precisely interested in locating self-awareness in the brain by using the newly available brain-imaging equipment. In his book, the author reports numerous neuroimaging experiments and case studies of patients suffering from brain injury. Keenan addresses various interesting questions about thinking abilities in lower animals, primates, and children. The last chapter on the evolution and functions of self-awareness is particularly fascinating. The book is clearly written, fun to read, and humorous at times. But the problem is Keenan's overall conclusion that self-awareness is dominantly associated with areas of the right hemisphere, more specifically the right prefrontal region.

I want to argue here that this conclusion is both inflated and premature for two main reasons. (1) Keenan bases his assumption on specific—and fairly primitive—forms of self-awareness. These are mirror self-recognition (MSR)—the emphasis of the book, hence the title—and Theory-of-Mind (TOM). The logic can be summarized as follows: since MSR and TOM seem to be associated with right hemispheric activity, then it means that self-awareness too is located in that same structure. As I will try to show, MSR does *not* involve full-blown, mature human self-awareness, and TOM is relatively independent of self-awareness. (2) Keenan neglects to report quite a few studies that show *bilateral* (i.e., in

both hemispheres) and *left* hemispheric activity during processing of self-relevant information. For instance, when we remember personal episodes of our life or describe who we are (two tasks requiring self-awareness), portions of the left hemisphere become especially active. In other words, Keenan has a tendency to focus on evidence that supports his view (self-awareness resides in the right hemisphere) and to ignore data that contradicts it (the left hemisphere also plays a role in self-awareness). These two limitations (1 and 2) seriously reduce the credibility of his overall thesis of right hemisphere superiority for self-awareness.

I start with self-recognition. MSR in human and non-human primates has been extensively studied by Gordon Gallup, Jr. at the University of Albany in New York (see LINK to Gallup's webpage). If you place a chimpanzee or human child in front of a mirror for the first time, their initial reaction will be to think they are looking at another chimp or child. Both the primate and the toddler will emit *social* behaviors toward their reflection, such as trying to touch the image, going behind the mirror to see who's there, or (in the chimp's case) attacking the reflection. Clearly, at this point, both organisms are not recognizing themselves in the mirror. But after a while they will stop behaving that way and will start producing what we call "*self*-directed behaviors", as opposed to "other-directed" responses. That is, the chimp and child will begin to use the mirror to actively examine themselves, touch their face, make grimaces, and (in chimpanzees) groom parts of the body that were not visually accessible before. Such self-directed behaviors indicate self-recognition—the organism knows that what it sees in the mirror is the self and not another comparable creature. (Note that there exists a more rigorous experiment for MSR, called the "mark test"; interested readers are invited to go to this LINK.)

There is no major debate about this. Problems arise with the *interpretation* of MSR. What does it mean exactly to be capable of recognizing oneself in a mirror, and by extension, on a photograph or on video? Gallup and Keenan both see MSR as a strong indicator of self-awareness. Their reasoning is that when you look at yourself in a mirror and actually *touch* your face (to remove some unwelcome thing on your skin or elsewhere, for instance), which represents a self-directed behavior, you become the object of your own attention. If you can focus attention on yourself as an "object", it means that you are self-

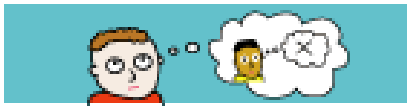
aware. At first glance this logic certainly seems convincing. Closer inspection however reveals a problem that has been identified by Robert Mitchell at the Eastern Kentucky University in Richmond. To adequately understand Mitchell's point we need to accept the fact that self-awareness represents a complex, multifaceted process. It consists in an introspective awareness of our own private mental states (our perceptions, sensations, attitudes, intentions, emotions, values, etc.) and a knowledge of our more public, visible, characteristics such as our body, behaviors, general physical appearance, and so on.

Now, the question becomes: What kind of awareness of self is required for MSR to take place? Mitchell's answer is that we just need an awareness of our *body*—not an access to our mental states. More specifically, in front of a mirror we "match" what we see with an internal image of our own body. This mental representation would develop fairly early in life through repeated "kinesthetic" (sensory, somatic) experiences with our body—touching ourselves and being touched by others, moving around in the world, observing our limbs, etc. The comparison between the image in the mirror and the image of our body in our mind would lead us to correctly infer the identify of the reflected image as being us. This interpretation of MSR is called the "kinesthetic-visual matching hypothesis." Mitchell's conclusion is that MSR does *not* require self-awareness of the introspective type (i.e., perceiving our mental experiences). Indeed, what would be the use of being aware that we feel happy, or that we entertain racist attitudes, for recognizing ourselves in a mirror?

So MSR most probably represents an ability only superficially related to authentic, fully developed human self-awareness. Interestingly, Keenan himself comes close to this conclusion when he writes that "while [MSR] indicates self-awareness, a full understanding of self is not yet complete" [p. 96]. Not surprisingly, research shows that chimpanzees, orangutans, and 18 to 24-months old babies are capable of MSR. To me, believing that self-awareness is present because an organism can engage in MSR is similar to thinking that someone who can utter "Je parle un peu Français" (I speak some French) can also write a 900-pages novel in that same language. I am exaggerating of course, but you get the picture. So my point is that self-awareness and MSR should not be equated.

Another mental ability examined by Keenan is Theory-of-Mind (TOM), "the ability to reflect on the thoughts of others" (p. 78). There exists a clear link between self-awareness and TOM. Once we become aware of our own private psychological events, we can then imagine how it is for others to experience similar states. Said differently: in order for me to

conceive of how it is for you to experience sadness, I first have to experience that state myself and to reflect on it, long enough at least to form an idea of the nature and "quality" of such an emotion. Empathy, for instance, would represent a by-product of TOM.



As he did with MSR, Keenan also uses TOM as an indicator of self-awareness. However, TOM and self-awareness, although related, represent two relatively independent activities. Think about it: when you are wondering about another person's feelings, that is, when you are actively engaged in TOM, you are not focusing your attention inside toward yourself but outward toward the person's potential mental events. Technically you are not "self-aware." I agree with Keenan that self-awareness most likely constitutes a prerequisite for the establishment of TOM. But I suggest that once fully developed, TOM stops directly involving self-awareness and takes a life of its own. In other words, we first need to be aware of our own mental processes in order to conceive that other persons might be experiencing comparable processes. Once we know that other people probably experience mental events like we do, there is no need anymore to constantly self-reflect in order to better understand these mental experiences. This view clearly implies that self-awareness and TOM should not be equated.

In his book Keenan presents a host of studies that suggest a right hemispheric participation to MSR and TOM. Some experiments indeed show increased activity of the right hemisphere when participants look at pictures of themselves (MSR) and think about what other people might be thinking (TOM). Clinical observations also indicate that patients with damage to the right hemisphere exhibit various MSR and TOM deficits. But as we have seen, MSR and TOM are fairly superficial and/or independent manifestations of self-awareness. Therefore, Keenan should not conclude, on the basis that these two processes seem to be taking place in the right hemisphere, that authentic self-awareness itself is also located in the same hemisphere. Another problem is the fact that other studies (not systematically presented in the book) suggest a *left* hemispheric participation in MSR, TOM, and other self-related processes. Actually, and to his credit, Keenan sporadically acknowledges the existence of studies that show "no clear evidence of laterality" in TOM (p. 218). Or: "there are a number of other regions, including those in the left hemisphere, that may be involved in self-face recognition" (p. 154). Todd Feinberg, a neurologist and psychiatrist at Beth Israel Medical Center in New York, recently published a book which, like Keenan's, deals with the neuroanatomy of the self. He states that "Many different areas of the brain contribute to the preservation of the self." (p. 149) Tilo Kircher, a brain scientist at the University of Tuebingen in Germany, asserts in a recent paper that "there is no unique center in the brain for self-relevant processing." (p. 690)

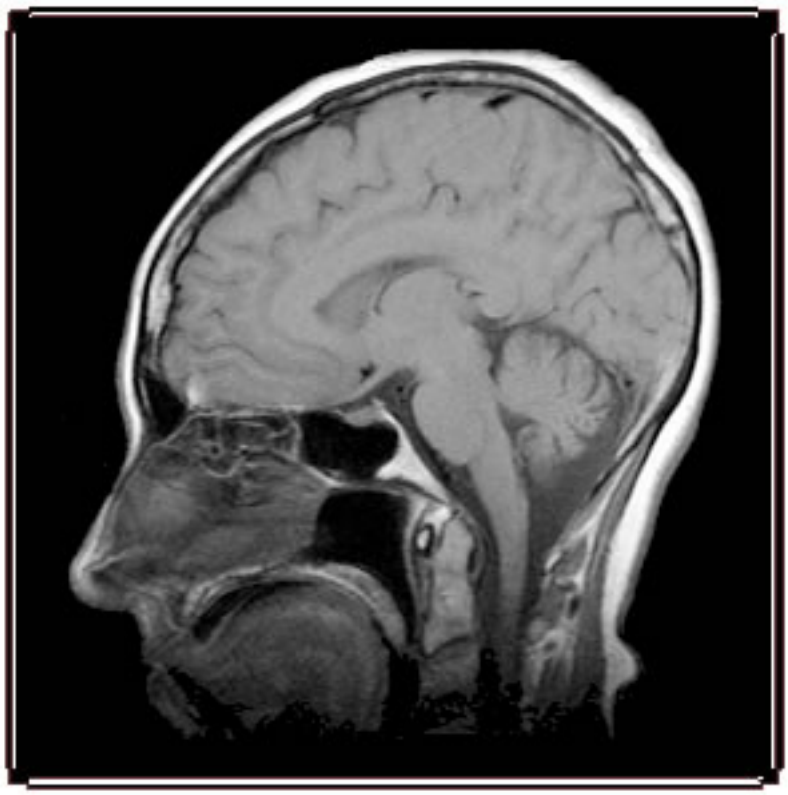


Table 1 (very crudely) summarizes some typical studies that identify the neural correlates of various self-referential activities. Overall, it shows that *both* hemispheres are involved in self-awareness. Take self-description for instance. Studies suggest that if I ask you to orally describe who you are (e.g., your personality traits, physical characteristics, abilities, and attitudes), both hemispheres of your brain will become more active. Another self-awareness process is autobiographical memory, our ability to remember significant events of our past. A growing number of experiments conducted by Martin Conway at the University of Durham in Great-Britain indicate that our left frontal lobe becomes particularly active when we recall specific past personal events. Obviously, self memories play a key role in self-awareness, because what happened to us in the past partially defines who we are today. The only way we can outline our present personal identity is by placing our current thoughts, emotions, goals, values, etc. in historical perspective. To do this, we need to be able to recall our past.

Why researchers obtain conflicting results about the localization of self processes in the brain is unclear. One possibility is the use of different neuroimaging techniques, participants (healthy people vs neurological patients), and tasks.

Since Keenan proposes that self-awareness is located in the non-verbal right hemisphere, it suggests that language is neither necessary nor sufficient for self-awareness to develop. Indeed, he claims that “The idea that the highest from of consciousness must exist in the left hemisphere because it possesses language is no longer tenable” (p. xxiii).” This statement itself is not defensible. An increasing number of researchers, including myself, remain convinced that self-awareness requires language, and more specifically, inner speech. (See my SCR paper: LINK.) Self-talk can reproduce and extend social mechanisms leading to self-awareness; furthermore, when we talk to ourselves we can verbally identify,

process and store information about our current physical and mental states as well as past or present behaviors. At this point I cannot offer direct neuroanatomical evidence linking inner speech to self-awareness. But recent correlational studies conducted by Johann Schneider at the University of the Saarland in Germany suggest that the more we focus on the self the more we talk to ourselves, and vice-versa.

Activity	Task	Tech-nique	LH	RH	Reference
Self-description	Judging how well personality traits describe participants (n=8).	PET	*	*	Craik et al. (1999)
	Judging how well personality traits, abilities & attitudes describe participants (n=11).	fMRI	*	*	Johnson et al. (2002)
	Orally describing one's personality traits and physical attributes (n=7).	PET	*	*	Kjaer, Nowak & Lou (2002)
	Judging how well personality traits & physical attributes describe participants (n=6).	fMRI	*	*	Kircher et al. (2002)
	Making self-referential judgments (n=24).	fMRI	*	*	Gusnard et al. (2001)
Self-description / recognition	Judging how well personality traits describe participants / Recognizing morphed facial stimuli of self & familiar other (n=6).	fMRI	*	*	Kircher et al. (2000)
TOM	Thinking about mental representations (n=23).	ERP	*		Sabbagh & Taylor (2000)
	(Review of various studies.)	--	*	*	Gallagher & Frith (2003)
Self-recognition	Recognizing morphed facial stimuli of self & familiar other.	Split-brain patient	*		Turk et al. (2002)
	Recognizing morphed facial stimuli of self, familiar & unfamiliar others (n=20).	fMRI	*		Kircher et al. (2001)
Autobio-graphical memory retrieval	Recalling specific personal events (n=24).	EEG	*	*	Conway et al. (2001)
	Recalling specific personal events (n=6).	PET	*		Conway & Turk (1999)

Table 1—Sample of recent studies looking at neurological substrates of self-awareness and related abilities

(Note—LH: left hemisphere; RH: right hemisphere; PET: Positron Emission Tomography scan; fMRI: Functional Magnetic Resonance Imaging; EEG: ElectroEncephaloGram; ERP: Event Related Potential.)

The ultimate proof that language and the left hemisphere *do* participate in self-awareness can be found in case studies of commissurotomized patients. It is obvious that the left hemisphere of split-brain patients is fully self-aware because this part of the patient's brain can verbally state the name it collectively shares with the right hemisphere, its current feelings, future goals, aspirations, etc. In other words, the left speaking hemisphere clearly possesses a comprehensive sense of self. By denying participation of both language and the left hemisphere to self-awareness, Keenan finds

himself in an awkward and impossible situation where he has to adhere to the view that the left speaking hemisphere is unconscious. All this could be avoided by presenting a less extreme version of the thesis: *both* hemispheres of the brain are involved in self-awareness.

This review is based on a more elaborate and technical paper published in Evolutionary Psychology (2003), 1, 161-171. LINK I shamelessly stole my title form Karl Popper and John Eccles' book The self and its brain: An argument for interactionism (1977; Berlin: Springer International).

Alain Morin, Behavioral Sciences, Mount Royal College,
4825 Richard Road S.W., Calgary (AB), Canada T3E 6K6
Email: amorin@mtroyal.ab.ca
Webpage: http://www2.mtroyal.ab.ca/~amorin/

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