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Where in the brain is the self?

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Abstract

Localizing the self in the brain has been the goal of consciousness research for centuries. Recently, there has been an increase in attention to the localization of the self. Here we present data from patients suffering from a loss of self in an attempt to understand the neural correlates of consciousness. Focusing on delusional misidentification syndrome (DMS), we find that frontal regions, as well as the right hemisphere appear to play a significant role in DMS and DMS related disorders. These data are placed in the context of neuroimaging findings.

Keywords: Self; Brain; Self-awareness; Delusional misidentification syndrome; Asomatognosia; Capgras; Neuroimaging

1. Introduction

Along with the explosion of interest in the biological basis of consciousness, scientists have become increasingly interested in the neurobiology and neuroscience of the *self*. Indeed, it is difficult if not impossible to imagine consciousness without some form of self as a subject of that consciousness, and therefore, without selves, consciousness as we usually understand it cannot exist. As noted by John Searle:

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> We know furthermore that all such conscious states are subjective in the sense that they only exist as experienced by a human or animal subject. Conscious states require a subject for their very existence. They do not exist in a neutral or third-person fashion, they have an existence that depends on their first-person subjective qualities, and that is just another way of saying that a conscious state must always be someone's conscious state (Searle, in press).

But what is the "self"? Is it "real" in the sense that a brain is real? Kant was a firm believer in the existence of the self and he placed a primordial and unified ego at the center of his philosophy. William James on the other hand argued in his *The Principles of Psychology* that the "Ego" was nothing but "a 'cheap and nasty' edition of the soul." Although James conceded that selves exist, he denied that there is anything that could be called an "I" or "ego" at their center. He argues that all that really existed were passing states of consciousness, and our belief in ourselves as unified beings is due to the fact that we experience successive mental states in our stream of consciousness that are uniquely our own. Indeed, James asserted that if several independent minds shared a common experience and past, one could produce the same mental unity among several minds that we as single minds experience. "Metaphysics or theology may prove the Soul to exist; but for psychology the hypothesis of such a substantial principle of unity is superfluous." (James, 1892).

Dennett, in his book *Consciousness Explained*, sums up nicely why the belief in selves remains controversial and why great minds have come down on both sides of the issue:

> Since the dawn of modern science in the 17th century, there has been nearly unanimous agreement that the self, whatever it is, would be invisible under a microscope, and invisible to introspection, too. For some, this has suggested that the self was a nonphysical soul, a ghost in the machine. For others, it has suggested that the self was nothing at all, a figment of metaphysically fevered imaginations. And for still others, it has suggested only that a self was in one way or another a sort of abstraction, something whose existence was not in the slightest impugned by its invisibility. After all, one might say, a center of gravity is just as invisible—and just as real. Is that real enough?... The question of whether there really are selves can be made to look ridiculously easy to answer, in either direction... (Dennett, 1991).

There are at least three reasons why the self remains such an elusive concept, and all three are in many respects identical with questions regarding the nature of consciousness in general. The first reason the idea of the self is problematic is that while we subjectively experience ourselves as single and unified beings, the brain is actually composed of millions of individual neurons. The manner in which neuronal assemblies are synchronized to produce unification in perception and action is an active area of research in neuroscience, but even if we fully understood the mechanism or neural synchronization, there still appears to be a fundamental difference—an unbridgeable gap—between the unified self and the divisible brain. This is the problem of the *unification* of the self.

Another reason the notion of the self is problematic, as pointed out by Descartes over 300 years ago, and reiterated by Dennett in the above quote, is that unlike a brain or a body, and in common with consciousness itself, the self cannot be objectively observed, but only subjectively experienced. The subject that represents the "I" in the sentence"I exist" cannot be weighed or measured. We can refer to this as the problem of the *subjectivity* of the self.

Finally, even if we accept that there is a unified entity in the world that can appropriately be called a self, we do not know where in the brain or which brain structures are most important for its creation. This is the problem of the *location* of the self.

In prior publications, one of us (TEF) has offered solutions to these problems (Feinberg, 2000, 2001a, 2001b, in press). The proposed solution to the problem of *mental unification* is based upon the hierarchical organization of neural systems. For instance, the processing streams of all perceptual systems are hierarchical. This organization allows for neural assemblies at an early stage of perceptual processing to create higher order perceptual features subserved by specialized "hypercomplex" neurons that are located further "downstream." This process is known as *topical convergence* (Zeki, 1993). But the idea that the neural substrate of the unified self *converges* at a particular place in the brain (as proposed by Descartes) or alternatively that the mind or the self *emerges* at the pinnacle of the neural hierarchy (as proposed by Sperry, 1990) cannot be correct. In visual perception, for example, while it is true that cells of the brain project to levels in a hierarchical fashion to code for increasingly specific complex and abstract properties, the information coded by cells earlier in the process is not and cannot be lost to awareness. Both lower order and higher order neurons make a contribution to consciousness. By the same token, the analysis of action demonstrates that *intention* or *will* does not emanate solely from the highest most explicitly conscious levels of the neural hierarchy. Rather, the neural substrate of a voluntary action is actually distributed across multiple hierarchical levels.

The principal problem with prior accounts of the neural hierarchy with reference to mental unification is that these accounts view the mind as a *non-nested hierarchy*. A non-nested hierarchy has a pyramidal structure with a clear-cut top and bottom. A non-nested model of sensory awareness would posit that consciousness would emerge at the summit of the neural hierarchy at the peak of a processing stream. In a similar way, a non-nested hierarchical model of intentional action would propose that unified action emanates from a "ghost in the machine" at the summit of the motor hierarchy.

Feinberg (2000, 2001a, 2001b, in press) has proposed an alternative framework for viewing the mind/brain relationship. The model proposes that the mind operates—as do all living things—as a *compositional* or *nested hierarchy*. The important difference between non-nested and nested hierarchies is the relationship between lower and higher levels of the hierarchy. In a non-nested hierarchy, the lower and higher levels of the hierarchy are physically independent entities. The top of the hierarchy is not physically composed of the bottom of the hierarchy. In an organic nested hierarchy, in contrast, the elements comprising the lower levels of the hierarchy are physically combined or *nested* within higher levels to create increasingly complex wholes. In the nested hierarchy of a unified mind, lower order features combine in the mind as "part of"—or *nested* within—higher order features. Elements that are bound to other elements in awareness are represented *dependently* and are *nested* together. In this manner, neurons at both lower and higher levels of the hierarchy are able to contribute to sensory consciousness, and mental unification is possible. Similarly, intentional action does not emanate from a "ghost in the machine" at the pinnacle of the neural hierarchy. Rather, the unification of action is embodied within the entire hierarchical system across multiple hierarchical levels.

According to this account, mental unification occurs because the highest level of *meaning* provides the constraint required for the unification of sensory awareness while the highest level *of purpose* provides the constraint that underlies volitional action.

With these considerations in mind, we can turn to another obstacle to a neurological understanding of the self, the problem of *subjectivity*. The problem of subjectivity has several aspects, but one in particular can be elucidated by neural hierarchy theory considered above. This is the question of whether the self and the mind as subjectively experienced can be entirely reduced to the brain as objectively observed. Searle, among others, has argued that the mind cannot be reduced to the brain. He points out that traditionally a successful scientific reduction entirely removes subjective factors from the analysis. In this way, an observation that "appears" a certain way in non-reduced form is ultimately reduced to its scientific "reality." However, in the case of mental events, Searle suggests that "the ontology of the mental is an irreducibly first-person ontology" (Searle, 1992, p. 95).

>There are numerous and fairly basic reasons from the standpoint of neurology why the mind and self cannot be reduced to the brain, and that the mind and self are indeed ontologically subjective (Feinberg, 1997b, 2001b). While some of these reasons go beyond the purposes of this review, we have already laid the groundwork to consider one. We have explained how hierarchical sensory neural systems create higher order perceptual features by topical convergence. When a neural hierarchy is objectively analyzed, it indeed appears to have the structure and functional characteristics of a *non-nested hierarchy*, with lower order neurons successively converging upon higher order neurons to create higher order perceptual features. However, we have also seen how the same neural system, when subjectively experienced, functions and is experienced as a *nested hierarchy*. In a similar fashion, while the nested nature of the motor system provides the subjective experience of unified action, that unification also exists only from the subjective point of view, since the neurons that contribute to a voluntary action are actually distributed across multiple neurological levels. It should be fairly obvious and not terribly mysterious, based upon these facts alone, why the objective and subjective aspects of a complex and conscious neural system are mutually irreducible. It is not possible to ontologically reduce the self or mind to the brain because from the objective standpoint the system appears as a distributed non-nested hierarchy, while from the subjective standpoint *the same neural system* functions and is experienced as a unified nested hierarchy.

These considerations lead us to the third problem, the *location* of the self. If the unified self is distributed across multiple neurological levels, are there particular brain structures especially critical for its creation and maintenance? One approach to this problem is by studying patients who have disturbances of the self as a result of brain damage. For most of us, the relationship between the self and one's physical body, between the self and the outside world, or between one's personal boundaries and those of others are well defined. However, there are a number of clinical neurological conditions in which these boundaries become disturbed. As noted by Sigmund Freud:

> Pathology has made us acquainted with a great number of states in which the boundary lines between the ego and the external world become uncertain or in which they are actually drawn incorrectly. There are cases in which parts of a person's own body, even portions of his mental life—his perceptions, thoughts, and feelings—appear alien to him and as not belonging to his ego; there are other cases in which he ascribes to the external world things that clearly originate in his own ego and that ought to be acknowledged by it. Thus even the feeling of our own ego is subject to disturbances and the boundaries of the ego are not constant (Freud, 1930, p. 66).

Freud observed that, under certain pathological conditions, the margins between the ego and the world might be transformed. He further opined that the transformations or perturbations of the self might be of two complimentary types. In the first, entities that were once personally significant to the individual may become *alienated* from the self. Alternatively and conversely, entities that were normally related to the self become *externalized* into the world.

Neurology provides for us many conditions in which there is a disturbance of self–self or self–other relationships, and these disorders provides a unique insight into the self and its origins in the brain. By turning to these cases, we can gain a better understanding of the role the brain plays in creating the self.

2. Clinical disorders of the self

2.1. Delusional misidentification and reduplication

Among the many neurological conditions that affect the brain and behavior there is a subset of disorders that specifically affect the self. These are conditions that alter the relationship between the individual and their body as seen directly or in a mirror, or their personal relationship to significant persons, places, or objects in their environment. Some of best-defined and most common clinical disorders that fit this general description are the syndromes of *delusional misidentification* and *delusional reduplication*. The elucidation of the underlying neuropathology that creates these conditions holds great promise in the quest to understand the neurobiology of the self.

Delusional misidentification syndromes (DMS) are conditions in which a patient consistently and adamantly misidentifies persons, places, objects, or events. The first described and one of the most commonly occurring forms of DMS is known as the Capgras syndrome. First reported by Capgras and Reboul-Lachaux in 1923, the patient with the Capgras syndrome harbors the delusional belief that "doubles" or imposters have replaced a person or persons. The condition is delusional in nature and the patient cannot be convinced that the person who is misidentified is indeed who they claim to be. The condition can be distinguished from prosopognosia (the inability to identify persons from facial features alone) by the fact that other persons are correctly identified. Furthermore, prosopognosics are not delusional. They will use extra-facial visual features such as the appearance of the hair, clothes, and non-visual features such as the sound of the voice, to make correct person identifications, Further, unlike the patient with Capgras syndrome, when their errors are pointed out to them, they do not deny their mistake.

A related type of misidentification is the Frégoli syndrome (Courbon & Fail, 1927). This condition involves the belief that a person who is well known to the patient is really impersonating, and hence taking on the appearance of, a stranger. For example, the patient may think that a stranger is her father. Vié (1930) posited that hypothesized that while Capgras syndrome represents the illusion of *negative* doubles, Frégoli represents the illusion *of positive* doubles. Christodoulou (1976, 1977) elaborated on this idea when he noted that Capgras syndrome is a manifestation of "hypoidentification" while Frégoli syndrome represents a "hyperidentification." Feinberg (1997a, 1997b, 2001b), Feinberg and Shapiro (1989), Feinberg and

Roane (1997a, 1997b, 2003) suggested the various delusional misidentification syndromes cleave along the dimension *of personal relatedness* based upon the pattern of identification between the self and other persons, objects, events, or experiences. According to this viewpoint, Capgras syndrome represents *under-personalized* and Frégoli syndrome *over-personalized* misidentification.

A condition related to and to some extent overlapping with DMS is the *delusional reduplication syndrome (DRS)*. Some patients with DMS reduplicate or double the misidentified entities(s). For example, it is common in patients with the Capgras Syndrome that there are two versions of the same person, an ''actual'' or ''original'' as well as an ''imposter,'' ''facsimile,'' or ''duplicate.'' However, not every patient with DMS reduplicates the misidentified entity and the reduplication is a by-product or result of the misidentification. The patient with DRS, on the other hand, claims the existence of a fictitious person or place, often a double of an actual person or place, without the misidentification of the reduplicated entity(s).

3. Delusional misidentification/reduplication syndromes and focal Neuropathology

There are a minimum of six DMS/DRS that are reported as occurring in neurological patients with focal brain pathology.

3.1. Capgras syndrome (under-personalization) for persons, places, or body parts

There are several reports of Capgras syndrome for persons occurring in the setting of focal brain lesions. For example, one of the first and perhaps the best know reported case was described Alexander, Stuss, and Benson (1979) who described a 44-year-old man who sustained a traumatic brain injury resulting in right frontotemporal encephalomalacia. This patient insisted that his actual wife and his five children had been replaced by nearly identical substitutes. Staton, Brumback, and H (1982) described a 31-year-old man who 8 years after a traumatic brain injury and right frontotemporal and parietal injury claimed that his parents, siblings, and friends were not ''real'' but were ''look-alikes'' or ''doubles'' of the originals.

Patients with the Capgras pattern of misidentification may misidentify entities other than persons. Kapur, Turner, and King (1988) described a patient who claimed his actual home was not his ''real'' home, although he recognized that the facsimile home had the same ornaments and bedside items as the original. Moser, Cohen, Malloy, Stone, and Rogg (1998) reported an 81-year-old man who after an acute right frontal infarct believed that his real home was the ''twin'' of the original.

Finally, probably the most common misidentification syndrome of all is known as *asomatognosia* (Feinberg, 1997a, 1997b; Feinberg, Haber, & Leeds, 1990; Feinberg, Roane, & Ali, 2000; Meador, Loring, Feinberg, Lee, & Nichols, 2000) describes a condition in which the patient demonstrates delusional misidentification of a part of the body. Asomatognosia typically occurs in a patient with a right hemisphere lesion, left hemiplegia, severe sensory loss on the left side, and left hemispatial neglect. The patient with asomatognosia claims that the left arm, less commonly the left leg, does not belong to him or her. With great insight, Jacques Vié (1930, 1944a, 1944b, 1944c) was perhaps the first to note that the delusional misidentification syndromes such as Capgras syndrome were related to asomatognosia. Vié pointed out that in several neurological syndromes including asomatognosia, systematic and selective misidentifications occurred that could not be explained solely on the basis of factors such as generalized confusion. More recently, Feinberg and Roane (1997a, 1997b, 2003) have argued that asomatognosia should be viewed as a Capgras syndrome for the body part in which personal relatedness is lost. Just as in Capgras syndrome in which the physical appearance of the misidentified person is recognized but the psychological identity is denied, the patient with asomatognosia may recognize that the arm *should be* the patient's arm, but disavows ownership of the limb.

An interesting aspect of asomatognosia is the manner in which some patients *personify* the misidentified arm (Critchley, 1955) or produce names that can be interpreted as *metaphors* for the misidentified limb (Weinstein & Friedland, 1977; Weinstein, 1991). Terms for the arm such as ''a piece of rusty machinery,'' ''my dead husband's hand,'' or ''a bag of bones'' indicate the patient has an altered sense of themselves in relation to the arm. Personification and metaphor are evident in the following case (Feinberg, 2001b), a woman in her 50s who had a large right hemisphere infarct and described a feeling of alienation from her left arm:

Shirley: *It took a vacation without telling me it was going. It didn't ask, it just went.*
Feinberg: *What did?*
Shirley: *My pet rock. [She lifted her lifeless left arm with her right arm to indicate what she was talking about.]*
Feinberg: *You call that your pet rock?*
Shirley: *Yeah.*
Feinberg: *Why do you call it your pet rock?*
Shirley: *Because it doesn't do anything. It just sits there.*
Feinberg: *When did you come up with that name?*
Shirley: *Right after it went plop. I thought I'd give it a nice name even though it was something terrible.*
Feinberg: *Do you have any other names for it?*
Shirley: *Her. She belongs to me so she's a her. She's mine but I don't like her very well. She let me down.*
Feinberg: *In what way?*
Shirley: *Plop plop rock rock nothing. I was on my way home out the door and then she went and did this [pointing to her left arm]. She didn't ask if she could [shaking her head back and forth]. I have to be the boss not her, [she said pointing to her left arm.].*

During one interview, Shirley grasped her left hand with her right, shook it and began to sing:

Shirley: *Wake up! Time to go home. What are we gonna to tell your mama? What are gonna tell you papa? What are we gonna tell your friends when they say ooh la la wake up little Suzie, it's time to go home. Then she held her left hand to her cheek and hugged it and kissed it and fondled it and petted it. She said she's a good girl.*
Feinberg: *What was that?*

Shirley: *Wake up little Suzie, remember the Everly Brothers? [Pointing to her left arm] that's her, that's little Suzie. She been out all night long she has to go home. That's it she's done she's gotta go home or their gonna think she's the town whore [laughing].*
Feinberg: *Why would you say that?*
Shirley: *Because she's not behaving [she wiggled her arm again pulling on her fingers as if to rouse it] wake up little Suzie! [She later went to tell me why she had developed this idea about her left arm being little Suzie. It's a coping mechanism. It's like laughter is the best medicine. If you can't laugh what have you got? [She explained later on to me.] I thought I could bring her back with some loving kindness. So I sang it wake up little Suzie which is one of my favorite songs from the Everly Brothers.*
Feinberg: *What's the theme of that song?*
Shirley: *A girl and her boyfriend were out too late at night. And the entire town is gonna be talking about them, that she's being a slut. So it's a way of avoiding getting in trouble. And then he says what are you gonna tell you mama, what are you gonna tell you papa, what are you gonna tell your friends when then they say ooh la la wake up little Suzie it's time to go home. [Then she lifts her left arm] I wanna go home.*

3.2. Frégoli syndrome (over-personalization) for persons or places

Frégoli-like misidentifications are common in the setting of focal brain pathology. Ruff and Volpe (1981; case 4) reported a 60-year-old woman who underwent removal of a right frontal subdural hematoma and subsequently asserted that the patient in the next bed was her husband. She was actually pleased that her husband no longer snored! Feinberg, Eaton, Roane, and Giacino (1999) described a 61-year-old man who sustained a traumatic brain injury with right frontal and left temporoparietal contusions and developed Frégoli misidentifications for many staff members of his rehabilitation hospital. He claimed the nurses, doctors, and therapists were actually his sons, daughter-in-laws, co-workers. He even claimed an ice skater on TV was himself.

Frégoli syndrome can be manifested as a misidentification for place. In this circumstance the patient misidentifies their current and relatively *unfamiliar* environment, such as hospital room or rehabilitation hospital, for a place of *greater personal significance*, such as their home or work place. Some patients, in a manner similar to cases of the Capgras syndrome, maintain that there are two versions of the same place, or claim that they are in *both* a correct and incorrect location. When this latter situation occurs in association with memory impairment the disorder is called *reduplicative paramnesia*. But as many of these patients misidentify their environment without reduplicating it, the term Frégoli syndrome for environment is a better descriptor of the syndrome. Further, the term *Frégoli syndrome for environment* brings this condition into relationship to the other delusional misidentification syndromes. Furthermore, some patients demonstrate Frégoli syndrome for *both* persons and their environment, as was the case with patient L.A. a 41-year-old man with a right frontal intracranial hemorrhage and subarachnoid hemorrhage secondary to an arteriovenous malformation. The patient had confabulation, claimed he was at work, and misidentified multiple staff workers as people from his workplace. The examination was performed in a Rehabilitation facility in New Jersey:

Examiner:	*What are you doing here?*
Patient:	*I'm working.*
Examiner:	*OK. And what are you working at?*
Patient:	*I'm trying to learn from them.*
Examiner:	*OK. Is this part of your job?*
Patient:	*Yes.*
Examiner:	*And what's your job?*
Patient:	*I'm a computer person.*
Examiner:	*So that's what you're doing here? Computers?... And you're at work here?*
Patient:	*Yes.*
Examiner:	*Do you get paid your regular salary?*
Patient:	*Yes.*
Examiner:	*Where are we right now?*
Patient:	*We're at [name of his company] in New York...My office is right around the corner [pointing]. If they have problems with their computers I solve them.*
Examiner:	*[Pointing to a therapist of the facility that the patient had previously claimed he knew] And you know her from...?*
Patient:	*Yes. [names his company]...*
Examiner:	*Co-worker? What's her job?*
Patient:	*Her job is to do research on certain items and then bring them to [his company]... She works with somebody else... She comes to me for the type of information I need to connect for her...that's the time we have connection. Otherwise there isn't any connection...when she has problems with her computer she comes to me.*

3.3. Delusional reduplication (without misidentification) of self or other persons

Finally, there is an interesting group of patients who reduplicate persons or places *but who do not misidentify the reduplicated entities.* Weinstein, Kahn, and Morris (1956) provided the earliest descriptions of these patients. They described patients with brain injuries who claimed the existence of one or more fictitious children, a condition they termed the "phantom child syndrome." They reported that a unique feature of the delusion was that the patients with this condition often ascribed to the "phantom child" the same illness or physical problems that they had themselves. For example, a woman blindness from a brain tumor claimed she had a child who was "sick and blind," and a 21-year-old soldier with a head injury and weakness in both legs claimed he had a 3-year-old "daughter" who had leg paralysis from polio. Some patients ascribed to the "phantom child" problems other than physical illness. This was the case with a woman who felt abused by the nursing staff and claimed that she had a "baby" that the nurses had "harmed and even killed."

The following case (Feinberg, 1997a, 1997b, 2001b) illustrates this condition. A 63-year-old man sustained a ruptured anterior cerebral artery aneurysm and bilateral frontal infarctions. The biological father of three children, he never adopted any children, and although he was estranged from his wife since the time of his injury, he claimed the existence of a child that he was planning to adopt. He denied his own impairments but asserted the adopted child "has problems" and complained about the way the doctor's were treating "the child":

Sam: *I feel like I've got a little more ability than they give me credit for.*
Examiner: *So one last question: Has this aneurysm or the consequences of this aneurysm changed your life in any way at all?*
Sam: *No.*
Examiner: *So basically your life is the way it was before?*
Sam: *Yeah, like the way it was before. We have another baby... we've just adopted, and I have three children of my own. I've got my own house.*
Examiner: *When did you adopt a baby?*
Sam: *We haven't gotten the final result, but about a month ago.*
Examiner: *They said you could have the baby?*
Sam: *But the baby has problems now. They're trying to sort out the problems before, you know, somebody really adopts it... the baby. They want to make sure it's the right direction.*
Examiner: *Who's actually adopting the baby?*
Sam: *Me and my wife.*
Examiner: *Have you seen the baby at all?*
Sam: *Well, we've seen pictures. And I've seen the baby in person, too.*
Examiner: *And where does the baby live now?*
Sam: *The baby lives with the mother, and I think it's the mother of the boy that was dumped... and the mother would like to have the baby. I guess she lost her sons he might as well have the baby. That's a little problem there.*
Examiner: *You said before the baby has some problems.*
Sam: *That's what the psychologists are telling the guy who is in charge of the hospital. You know it's like they say certain things I go along with and certain things I don't go along with. I think there's too much pressure on the kid to really give an honest answer. I don't think a kid who is 6 or 7 years old is capable of giving you the right answer.*
Examiner: *What kind of problems does this child have?*
Sam: *I don't know...to tell you the honest truth, I don't know. I know this kid has been in the hospital off and on for a couple of years, and they kind of rate them as far as progress goes or things like that. [The patient was being rated during the interview.]*
Examiner: *How do they rate them?*
Sam: *I guess they must rate them when they don't hear the things they want to hear...like the kid is not accomplishing anything, which I think is very unfair to basically analyze a kid that way.*

4. The neuroanatomy of the self

4.1. Anatomical analysis of cases of delusional misidentification and reduplication

In a recent review (see Feinberg, Roane, & Solms, in press) we analyzed a series of previously published cases of these conditions (Table 1). The disorders were organized into six categories:

1. Capgras syndrome for person(s).
2. Capgras syndrome for environment.
3. Capgras syndrome for arm (asomatognosia).

Table 1
Patients used for the DMS/DRS analysis

Capgras		
For persons		
37	M	Hayman and Abrams (1977, case 1)
44	M	Alexander et al. (1979)
31	M	Staton et al. (1982)
67	M	Jocic and Staton (1993)
30	M	Hirstein and Ramachandran (1997)
51	M	Mattioli et al. (1999)
For environment		
71	M	Kapur et al. (1988)
81	M	Moser et al. (1998)
For arm (asomatognosia)		
79	F	Feinberg (1997)
55	F	Feinberg (2001b; Shirley p. 1 8)
62	M	Feinberg (2001b; Jack p. 21)
Frégoli		
For persons		
60	F	Ruff and Volpe (1981, case 4)
66	F	de Pauw et al. (1987)
27	M	Burgess et al. (1996)
61	M	Feinberg et al. (1999)
27	F	Box et al. (1999)
54	F	Feinberg (2001b; Fannie p. 43)
41	M	Patient L.A.(Feinberg, in press)
For environment		
49	M	Benson et al. (1976, case 1)
72	M	Vighetto et al. (1980)
64	F	
64	M	Ruff and Volpe (1981, case 2)
29	M	Ruff and Volpe (1981, case 3)
60	F	Ruff and Volpe (1981, case 4)
41	M	Patient L.A.(Feinberg, in press)
Delusional reduplication of self or other persons		
42	M	Baddeley and Wilson (1986; RJ).
63	M	Feinberg (1997a, 1997b, 2001b)
16	M	Bouvier-Perrou et al. (2000)
65	F	Feinberg (2001b; Linda p. 63)

The number indicates the age in years and the letter the gender.

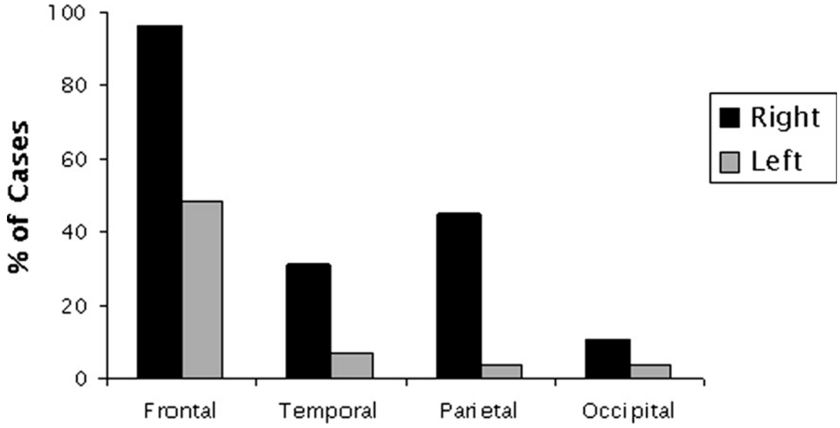

Fig. 1. Data from DMS/DRS patients reveals that the greatest number of cases are associated with right frontal damage. Regardless of region (all demonstrated a significant right hemisphere bias with the exception of the occipital lobes), there tends to be a right hemisphere dominance in terms of DMS/DRS.

4. Frégoli syndrome for person(s).
5. Frégoli syndrome for environment.
6. Delusional reduplication (without misidentification) for the self or other persons.

The data indicated a bias for the right frontal damage (Fig. 1). In fact, in over 96.6% of the cases ($N = 28$ of 29), there was fight frontal damage. Left frontal damage was present in 48.3% of the cases ($N = 14$). This difference was found to be significant ($X^2(1) = 4.67$, $p < .05$). These data indicated that there was a strong hemispheric bias in terms of the frontal lobes (see Fig. 1).

In the temporal lobes we found a similar patterns. Thirty-one percentage of the cases had right temporal damage, while 6.9% of the patients had left temporal damage. This difference was found to be significant ($X^2(1) = 4.45$, $p < .05$). The parietal lobes revealed an even more striking hemispheric difference. There were 13 patients (44.8%) with right parietal damage and only 1 patient with left parietal damage (3.4%). This difference was found to be significant ($X^2(1) = 10.29$, $p < .001$). There was no difference between the number of right occipital cases (10.3%) and left occipital cases (3.4%; $X^2(1) = 1.0$, $p > .05$). This may have been due to the fact that there were only a total of four patients that suffered from occipital damage (Fig. 1).

These data confirm a preliminary analysis indicating that right hemisphere occurs more often than chance in DMS/DRS patients (see Feinberg, in press). We also found in the right hemisphere a bias for frontal lobe incidents ($X^2(3) = 24.38$, $p < .001$). A similar pattern was found in the left hemisphere ($X^2(3) = 21.25$, $p < .001$). These data suggest that regardless of hemisphere, frontal damage is influential in DMS/DRS.

5. Imaging the self

How does the neuroimaging data support the findings in DMS/DRS patients? Is there a right hemisphere bias in self/other distinctions? The neuroimaging data appear to support the findings in patients. Before examining the data, however, it is wise to realize that 1:1 relationships are rare in terms of brain:behavior relationships. In localizing any cognitive or behavioral event in terms of brain function, one of us (J.P.K.) has suggested that the brain be visualized as a mobile (Keenan, 2001). With billions of connections, the brain lies in a balance. The brain, being composed of 'modules,' 'areas,' and 'regions,' is a highly integrated system. Like the mobile, distal events can influence elements spatially and temporally far removed. Disruption to any given area is rarely an isolated event, even if such disturbance lies below our ability to detect such effects. The brain exists in a balance based on interconnectivity.

Such an analogy is prudent when attempting to examine issues such as the self or DMS/DRS. In particular, when describing complex cognitive events, one must keep in mind that modules of the brain do not exist in isolation. Even when describing functions at the hemispheric level, it is acknowledged and encouraged to view the brain as an entire entity such that we consider both the distal and proximal occurrences of phenomena.

If one examines the brain in terms of hemispheric function, the right hemisphere is typically mute in terms of verbal responding. This often leads to a situation where the right hemisphere is unable to report on its own consciousness. Historically, this has lead to the idea that the right hemisphere is the 'minor' hemisphere. The left hemisphere, dominant for language, is also dominant for motor abilities. These two facts have lead to a left hemisphere 'bias' in the thinking of the brain and cognition that dates back to the third century BC and continues to today (Morin, 2002).

Thinking the right hemisphere was at least equal to the left in terms of self-awareness, Nobel Prize winner Roger Sperry turned to split-brain patients. In the split-brain patient, the fibers bundles connecting the two hemispheres are severed allowing for the testing of the functions of each hemisphere separately.

Taking advantage of this, Sperry, Zaidel, and Zaidel (1979) and Preilowski (1977) performed a number of studies to determine the 'self-awareness' of the hemispheres. In his study, Sperry and his colleagues presented faces, including the own-face to the right hemisphere. He found that the right hemisphere had a robust and emotional reaction to the self-face. Two years before this report, Preilowski found that there was almost no difference between the brain activity of the hemispheres when familiar faces were presented. When, however, self-faces were presented, a robust difference emerged between the hemispheres—the right hemisphere had more than twice the activity for the self-face compared to the familiar faces. While one recent report has found that there might be a left-hemisphere dominance for self-face recognition in split-brain patients (Turk et al., 2002), other reports have confirmed Sperry's and Preilowski's initial findings (Keenan, Gallup, & Falk, 2003).

We examined the cortical correlates of self-face recognition by use of fMRI. Employing a photograph of the self-face, which we contrasted with the face of a famous person (e.g., Bill Clinton), we presented these images in the scanner and found a right frontal activation (Keenan et al., 2003; Keenan, McCutcheon, & Pascual-Leone, 2001). Sugiura et al. (2000) employed PET in their investigations of self. Comparing passive self-faces (e.g., they were not attending to them) to control faces, the overall volume activated in the right hemisphere (right frontal and right cingulate) was 1.26 times greater than the volume activated in the left. In another fMRI experiment involving self-faces, it was found that self-faces compared to unfamiliar faces activate 1.8 times more volume in the right hemisphere. When self-faces are contrasted to familiar faces, the activity is still 1.3 times as great. Further, the activity in the left hemisphere is again dominated by the fusiform gyms (personal communication, Kircher et al., 2001). These data were recently replicated using fMRI by Platek, Keenan, Gallup, and Mohamed (2004). Interestingly, self-voices also appear to activate right frontal regions (Nakamura et al., 2001) as well as other self-related stimuli (for review, see Keenan et al., 2003). For example, morphed stimuli involving the self appear to be right hemisphere dominant (Keenan et al., 2001). Craik et al. (1999) found that self-attribution activated regions of the right frontal regions, while Kelley found activation in the medial prefrontal region (Kelley et al., 2002).

Being aware of another's mind (Theory of Mind; ToM) is related to awareness of one's own mental state (Keenan et al., 2003). That is, monitoring the thoughts of the self appear to be related to monitoring the thoughts of others, though there still exists controversy in this area as to which comes first or which animals possess both abilities. In terms of neuroimaging, early studies were

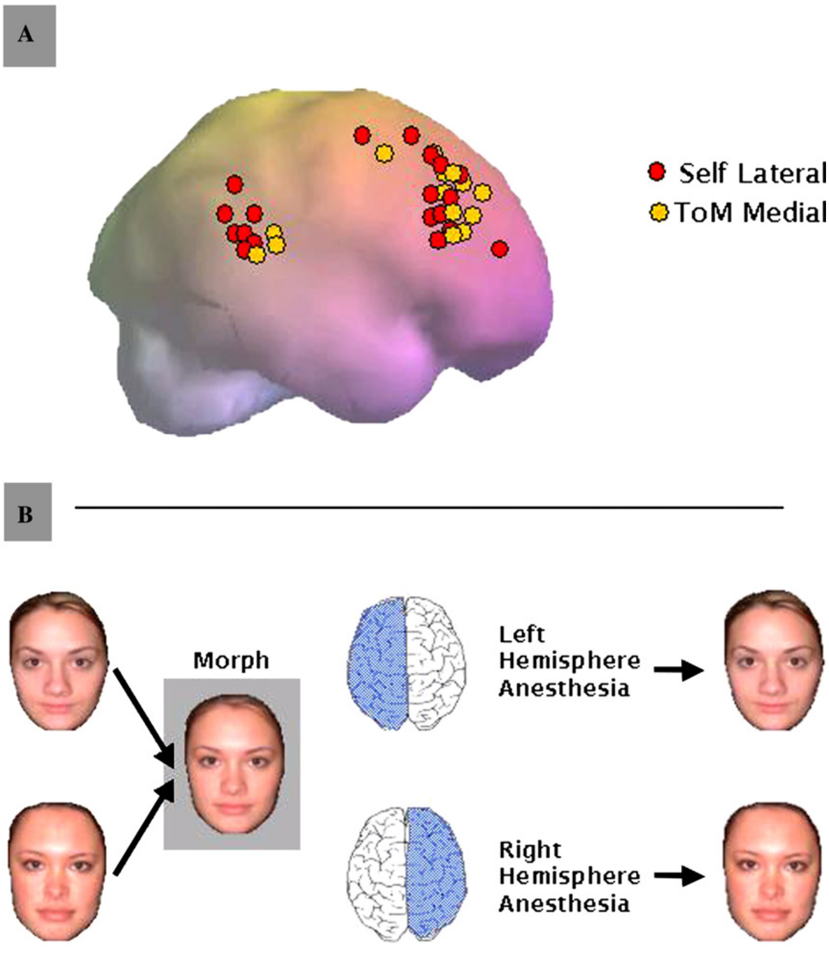

Fig. 2. Neuroimgaging studies indicate a possible right hemisphere bias in self and other processing (A). These data, adapted from Decety and Sommerville (2003), demonstrate that a number of studies indicate a relationship between the right hemisphere and the processing of self. One such study (B) revealed that anesthesia applied to the right hemisphere resulted in self-face recognition disruptions. The self-face (top left) was combined with a familiar face (bottom left). When asked to identify the morph, disruption of the right hemisphere lead patients to indicate the face did not contain self.

non-conclusive in terms of localizing of ToM (Fletcher et al., 1995; Gallagher et al., 2001; Goel, Grafman, Sadato, & Hallett, 1995). However, as neuroimaging techniques have improved, it is being revealed that the right hemisphere and the medial prefrontal cortex are key to monitoring self and other (McCabe, Houser, Ryan, Smith, & Trouard, 2001). For example, both Vogeley et al. (2001) and Platek et al. (2004) found that self and ToM tasks activated regions of the right prefrontal cortex. The right posterior parietal region has been found to be particularly key in ToM and it may serve as distinguishing cognitive thought and actions from first person perspective to third person (Decety, Chaminade, Grezes, & Meltzoff, 2002; Decety & Sommerville, 2003; Farrer et al., 2004, 2003; Ruby & Decety, 2004; Saxe, Xiao, Kovacs, Perrett, & Kanwisher, 2004). This region, along with medial prefrontal cortex areas (Seger, Stone, & Keenan, 2004) appear key in distinguishing self from other.

These data map on well to the findings in DMS/DRS patients Fig. 2. It is possible that a right hemisphere network exists that involves a cognitive mechanism that involves self/other distinctions. This theory has been put forth by Decety and Sommerville (2003) who hypothesized that right parietal and medial regions are key to identifying self and other cognitive states. In terms of DMS/DRS, damage to these regions may result in self/other confusions, or disruption in either self or other cognitive streams. At this point, it is uncertain how such a mechanism might function.

6. The brain, the right hemisphere, and the self

The findings regarding the clinical disorders of the self, as well as the experimental and imaging studies, strongly suggest that the right hemisphere plays a special role in the creation of the self. We do not wish to make the claim, however, that the self "resides" in the right hemisphere. Rather these findings suggest that the right hemisphere is dominant for these aspects of the self.

But an intriguing question remains: What special functions of the right hemisphere create its dominance for the self and self-related functions? In the patients we have described, under certain conditions of brain dysfunction and without the mediation of the right hemisphere, particularly the right frontal lobe, there are patients who display an inappropriate alienation from items of personal relevance, such as a spouse, an arm or a home. Conversely, some patients, like those who develop the phantom child syndrome, may *project* features of the self onto others in the environment. And in asomatognosia, when the right frontal regions fail to establishment the appropriate ego boundaries, we may see *both* an alienation from the arm ("Its not my arm") as well as the projection of the arm into the environment ("It belongs to my mother-in-law"). Therefore, pathology of the right frontal lobe can create both types of ego disorder described above in the quote from Freud.

These observations suggest that the right frontal damage that these patients have sustained creates a disturbance of *ego boundaries* and *ego functions* and that the right hemisphere, particularly the right frontal region, under normal circumstances plays a crucial role in establishing the appropriate relationship between the self and the world. In these conditions, the ego dysfunction results in a *two-way disturbance* of personal relatedness between the self and the environment that can lead to disorders of *both* under and over relatedness between the self and the world.

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