Self-recognition, Theory-of-Mind, and self-awareness in primates and right hemispheres¹

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A fashionable view in comparative psychology states that primates possess self-awareness because they exhibit mirror self-recognition (MSR), which in turn makes it possible to infer mental states in others ("Theory-of-Mind"; ToM). In cognitive neuroscience, an increasingly popular position holds that the right hemisphere represents the center of self-awareness because MSR and ToM tasks presumably increase activity in that hemisphere. In this chapter I critically assess these two claims as follows. MSR should not be equated with full-blown self-awareness; for instance, evidence suggests that MSR only requires kinesthetic self-knowledge and does not involve access to one's mental events. ToM and self-awareness are fairly independent and should also not be taken as equivalent notions; to illustrate, ToM implies a focus of attention on others, not on the self, whereas self-awareness exclusively entails self-focus. MSR and ToM tasks engage medial and left brain areas—not sites solely located in the right hemisphere, as recent meta-analyses of brain-imaging studies clearly show. Other self-awareness tasks besides MSR and ToM tasks (e.g., self-description, autobiography) mostly recruit medial and left brain areas. And inner speech, produced by the left hemisphere and which primates lack, plays a significant role in self-referential activity; indeed, accidental loss of inner speech following brain injury leads to self-awareness deficits. The conclusions I will reach based on this analysis is that (1) primates that display MSR most probably do not possess introspective self-awareness, and (2) self-related processes most likely engage a distributed network of brain regions situated in both hemispheres.

1- Introduction

In 1998 Gordon G. Gallup Jr. published an article whose title read "Can animals empathize?" His answer to this question was a confident "yes": "Animals that pass the mirror test are self-aware and thus can infer the states of mind of another individual" (first paragraph). One of Julian Paul Keenan's papers (Feinberg & Keenan, 2005) is entitled "Where in the brain is the self?" According to the authors, "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" (p. 15).

These two articles and their conclusions are particularly representative of an increasingly popular view in comparative psychology and cognitive neuroscience.² In essence, this position states that primates possess self-awareness because they exhibit mirror self-recognition (MSR), which in turn makes it possible to infer mental states in others (i.e., to develop a theory about others' minds, called "Theory-of-Mind" or ToM); this view also holds that the right hemisphere of the brain represents the neurological seat of self-awareness because MSR and ToM tasks presumably increase activity in that hemisphere.

In this chapter I will question this dual assumption on several conceptual, behavioral, psychological, and neurological grounds (see Morin, 2002, 2003, 2007). It will be suggested that MSR should not be equated with "genuine" (i.e., private, as opposed to kinesthetic) self-

¹ I would like to thank Petra Kamstra and Cass Foursha-Stevenson for their helpful editorial comments on previous versions of this chapter.

² This view is based on Gallup's and Keenan's extensive research on self-recognition and self-awareness; in Gallup's case, it spans over more than 40 years. Providing the reader with an exhaustive list of their published work is unrealistic. Here I identify what seems to represent their most important articles and book chapters.

Gordon G. Gallup, Jr. and his team: Gallup, 1968, 1970, 1975, 1977, 1979, 1982, 1985, 1997; Gallup, Anderson & Shillito, 2002; Platek, Myers, Critton & Gallup, 2003; Platek, Thompson & Gallup, 2004; Stuss, Gallup & Alexander, 2001; Suarez, & Gallup, 1981.

Julian Paul Keenan and his team: Barnacz, Johnson, Constantino & Keenan, 2004; Guise, Kelly, Romanowski, Vogeley, Platek, Murray & Keenan, 2007; Keenan, McCutcheon, Freund, Gallup, Sanders, & Pascual-Leone, 1999; Keenan, Wheeler, Gallup & Pascual-Leone, 2000; Keenan, McCutcheon & Pascual-Leone, 2001; Keenan, Nelson, O'Connor & Pascual-Leone, 2001; Keenan, Gallup & Falk, 2003; Keenan, Rubio, Racioppi, Johnson & Barnacz, 2005; Keenan & Gorman, 2007; Platek, Keenan, Gallup & Mohamed, 2004; Rosa, Lassonde, Pinard, Keenan & Belin, 2008; Seger, Stone & Keenan, 2004; Uddin, Iacoboni, Lange & Keenan, 2007.

awareness; that ToM and self-awareness are relatively independent and thus should also not be taken as equivalent concepts; that MSR and ToM tasks recruit medial and left brain areas—not areas exclusively located in the right hemisphere; that other self-awareness tasks besides MSR and ToM tasks (e.g., self-description, autobiography) mostly involve medial and left brain sites; and that language (i.e., inner speech) seems to play an important role in self-awareness. The conclusions that I will submit based on this analysis will cast serious doubts on the above target assumptions: (1) primates that exhibit MSR, and by extension all other non-primate animals, most probably do not possess full-blown introspective self-awareness; (2) self-related processes most likely engage a distributed network of brain regions situated in both hemispheres. A broader implication directly relevant to the main theme of this book will be as follows. If one uses self-awareness as an indicator of the presence of a mind in a thinking organism, I will suggest that it is improbable that animals do possess one—at least not a fully mature mind.

2- Mirror self-face recognition

(a) MSR and self-awareness

Most organisms that get confronted to a reflecting surface react as if they were seeing another conspecific creature: they engage in a variety of social responses such as bobbing, vocalizing, and threatening. Only human primates, chimpanzees, orangutans, and some bonobos, elephants, and dolphins have been shown to exhibit spontaneous mirror-guided self-exploration—e.g., self-directed behaviors such as examining body parts only visible in the mirror (for reviews, see Bard, Todd, Bernier, Love & Leavens, 2006; Gallup *et al.*, 2002; also see Plotnik, de Waal & Reiss, 2006; Reiss & Marino, 2001). The aforementioned primates also pass the more formal “mark test” and will touch a red dot that has been inconspicuously applied to their brow or forehead. Emitting self-directed responses in front of a mirror and passing the mark test indicate MSR; in humans this developmental landmark is achieved between 18 and 24 months of age (Amsterdam, 1972). MSR has mostly been studied in animals and healthy humans, but also in individuals diagnosed with autism (Dawson & McKissick, 1984), Down syndrome (Cunningham & Glenn, 2004), Alzheimer’s disease (Biringer & Anderson, 1992), and schizophrenia (Lee, Kwon, Shin, Lee & Park, 2007), where deficits have been observed in these last three disorders. Video recordings of the self have been used to test time-delayed self-recognition (e.g., Povinelli, Laudau & Perilloux, 1996). Note that although most research has focused on self-face recognition, other forms of self-recognition have been investigated as well. People are competent at identifying the identity of their body, including limbs (e.g., hands) and shadows produced by the body (Cameron & Gallup, 1988), their odour (olfactory self-recognition—e.g., perspiration; Platek, Thompson & Gallup, 2004), and their name (visual name-recognition; Kaplan, Aziz-Zadeh, Uddin & Iacoboni, 2008). These different sensory modalities interact to generate cross-modal self-recognition—a more rapid self-face recognition following exposure to visual, auditory, or olfactory self-primers (Platek *et al.*, 2004).

While some have tried to discredit the validity of the mirror test on diverse methodological and conceptual grounds (e.g., Epstein, Lanza & Skinner, 1981; Heyes, 1998), there is no real controversy surrounding the evidence: displaying self-guided responses in front of a mirror and/or passing the mark test do indicate that an organism is capable of self-recognition. A debate emerges when one attempts to interpret what “self-recognition” actually signifies. Various interpretations have been put forward (for a review, see De Veer & van den Bos, 1999); here I purposefully focus on the most extreme view articulated by Gallup (e.g., 1982), which can be summarized as follows. Emitting self-directed behaviors in front of a mirror indicates that the organism can take itself as the object of its own attention; the ability to self-focus constitutes a well-established component of self-awareness (Duval & Wicklund, 1972; Mead, 1934). In addition, re-cognizing oneself in front of a mirror presupposes pre-existing “self-cognition” (i.e., self-knowledge, a self-concept) and thus self-awareness.

That MSR implies some form of self-awareness makes no doubt; rather, the question should be: what type, or what level, of self-awareness is involved? Self-awareness represents a state in which one actively identifies, processes, and stores information about the self (Morin, 2006). It constitutes a complex multidimensional phenomenon that comprises various self-domains (e.g., emotions, autobiographical retrieval, sense of agency, personality traits,

preferences) and corollaries (e.g., self-esteem, self-regulation, death awareness, self-conscious emotions). Importantly, self-awareness includes a knowledge of one's own mental states (private self-aspects) such as thoughts, opinions, goals, sensations, attitudes, etc., and visible characteristics (public self-aspects) such as physical appearance, mannerisms, and behaviors (Fenigstein, Scheier & Buss, 1975; Fenigstein, 1986). Self-awareness also entails knowing that one stays the same person across time and that one is separate from the environment (Kircher & David, 2003).

It is unlikely that MSR taps into all these rich aspects of self-awareness; indeed, as Mitchell and others have argued (e.g., Mitchell, 1993, 2002a, 2002b; Povinelli, 1995), probably the only prerequisite for MSR is a knowledge of one's body—a strictly public self-aspect. More specifically, according to the kinesthetic-visual matching hypothesis advocated by Mitchell, all an organism requires to self-recognize is a mental representation of its own physical self; the organism matches the kinesthetic representation of the body with the image seen in the mirror and infers that “it’s me”. This interpretation implies that an awareness of one's own thoughts (or any other more private dimensions of the self) is not needed for MSR to take place. In fact, one may ask with Mitchell (1997a, p. 27): in what way can knowing about one's own current emotions (or goals, values, sensations, etc.) may assist an organism in accurately identifying the reflection in a mirror as being itself? An awareness of private self-aspects does not seem relevant for MSR, whereas an awareness of the body is critical for self-identification in front of a mirror. This means that while MSR underlies kinesthetic self-knowledge, it most probably does not necessitate mental/cognitive self-knowledge. Keenan *et al.* (2003), who insist that animals that self-recognize are self-aware, explicitly define self-awareness as “the ability to reflect on one's own mental state and the capacity to regard the self as a different entity from others” (p. 5; italics added); in addition, as will be seen below, Gallup suggests that organisms that pass the mark test are self-aware and can engage in ToM because they have access to their own mental states. The present line of reasoning is clearly at odds with this view.

To summarize: MSR should not be equated with “genuine”, full-blown, introspective self-awareness. Emitting self-guided responses in front of a mirror and/or passing the mark test do(es) not signify that the organism can get access to its own mental states, evaluate, describe or regulate itself, define its identity, contemplate its own death, and so forth. Not surprisingly, in one study 96% of Down syndrome patients demonstrated MSR while only 57% showed awareness of their disability (Cunningham & Glenn, 2004)—a clear indication that self-recognition does not involve knowledge of fundamental self-aspects. Ramachandran (2007) observed some psychiatric patients³ insisting that their reflection in the mirror was “someone else” (thus obviously exhibiting some identity distortion) yet they passed the mark test. Sugiura and his colleagues (2006) report cases of demented patients who have been seen combing or shaving in front of a mirror (the informal equivalent of the mark test) and yet failed to recognize their own mirror images. Most autistic individuals are capable of MSR (Dawson & McKissick, 1984; Mitchell, 1997b) but are characterized by alexithymia—serious difficulties in reflecting on their inner experience and identifying their subjective feelings (Silani, Bird, Brindley, Singer, Frith, & Frith, 2008). So MSR can be exhibited in the presence of important self-awareness deficits. It can go the other way around: MSR can be impaired despite intact self-knowledge. Klein, Gabriel, Gandi, and Robertson (2008) describe the case of a prosopagnostic patient incapable of self-face recognition who nonetheless showed perfect trait self-knowledge. If MSR was synonymous with self-awareness (including private self-focus), one would not come across such peculiar observations.

(b) Self-face recognition and the brain

I now turn my attention to cognitive neuroscience and the claim that self-awareness is located in the right hemisphere because self-face recognition has been shown to mostly activate areas within this hemisphere. This argument is fallacious for at least two reasons. The first one

³ Ramachandran (2007) does not specify what is the exact nature of the patients' disorder.

has already been explored above: MSR and self-awareness cannot be equated; consequently, even if studies were able to demonstrate that the former is located in the right hemisphere, it would not imply that the latter be produced by the same hemisphere. The second reason is that current empirical evidence actually indicates that self-face recognition recruits a bilateral network of brain areas (Platek, Wathne, Tierney & Thomson, 2008).

Four main types of neurocognitive studies have been conducted to investigate the neural correlates of self-face recognition: behavioral, lesion, split-brain, and functional imaging. While behavioral and lesion data tends to support a right hemisphere dominance view of self-face processing, split-brain and functional imaging data does not.

In a typical behavioral study (e.g., Keenan et al., 1999), healthy participants are asked to determine if a visual stimulus represents their own face or that of either a familiar other or an unknown person by pressing on buttons with the right hand (controlled by the left hemisphere) or with the left hand (controlled by the right hemisphere). Such studies find a left-hand/right-hemisphere advantage (faster reaction times) when subjects respond to self-faces, but not to other faces. Lesion studies report cases of patients with right hemisphere damage who fail to recognize themselves in the mirror (e.g., Keenan et al., 2005). Note that only a handful of patients show such a condition (Rosa et al., 2008); the mirror sign syndrome will be further discussed in a subsequent section.

Although split-brain studies have been repeatedly used to support the right hemisphere view of self-recognition, closer inspection reveals a different picture. Preilowski (1977) presented various photographs of faces, including their own face, to the left and right hemispheres of two split-brain patients while recording galvanic skin response, an indicator of arousal. In both patients, the skin response was significantly greater when self-faces were projected to the right hemisphere than when they were presented to the left. The greater level of arousal was taken as evidence for implicit, as opposed to explicit, superior self-recognition in the right hemisphere. As such, this evidence seems hardly convincing, as arousal represents an emotional reaction to a stimulus that need not implicate a conscious understanding that the stimulus is "self". More importantly, all other published split-brain reports fail to replicate this clear-cut lateralized result. In Sperry, Zaidel, and Zaidel's experiment (1979), both hemispheres of two split-brain patients were capable of explicit self-recognition. That is, the patients successfully selected a picture of themselves (among an array of pictures of family members and acquaintances) with their right hand when the information was presented in the left hemisphere and with their left hand when the information was projected in the right hemisphere. Turk, Heatherton, Kelley, Funnell, Gazzaniga, and Macrae (2002) presented varying degrees of morphed images of self and familiar-other faces separately to the right and left hemispheres of one split-brain patient. The patient's task was to decide whether a given image displayed himself or a familiar other. They found that the left hemisphere was better at identifying the self and that the right hemisphere was superior at identifying the familiar other. Using a comparable procedure, Uddin, Rayman, and Zaidel (2005) observed that both left and right hemispheres of a split-brain patient were equally capable of self-recognition.

It is probably worth noting here that the split-brain data actually presents a major challenge not only to the idea of a right hemispheric superiority for self-face recognition, but also to the general notion of the existence of a specialized neural network for self-awareness in the right hemisphere. As Sperry et al. (1979, p. 153) point out, "... conscious function in the disconnected left, language dominant hemisphere is relatively easy to determine through direct verbal communication". That is, the experimenter can address verbal questions to the left hemisphere of the patient's brain and it will offer answers that visibly indicate that it has a complete sense of self—e.g., the name it collectively shares with the right hemisphere, its present feelings, future goals, fears, hopes, etc. How can the right hemisphere be dominant for self-reflecting activities if the left hemisphere is also fully self-aware (Morin, 2007)?

With functional imaging studies of self-face recognition, healthy participants are usually invited to make identity judgements about their own face, the face of an acquaintance, and the face of a stranger while brain activity is being recorded with positron emission tomography (PET) or functional magnetic resonance imaging (fMRI) (e.g., Platek et al., 2004). While initial reports tended to favour the right hemispheric model, a recent meta-analysis of nine functional

neuroimaging studies of self-face recognition (Platek *et al.*, 2008) identifies a larger distributed, bilateral, network that comprises the left fusiform gyrus, bilateral middle and inferior frontal gyri, and right precuneus. This is not to state that both hemispheres in the reviewed studies were equally recruited—indeed, “Left hemisphere... substrates were reported to be activated less than right hemisphere substrates...” (p. 177); nonetheless, in all nine studies reviewed, there were 31 activations reported in the left hemisphere vs. 50 in the right hemisphere. This is obviously inconsistent with claims such as “... self-recognition is mostly supported by right frontoparietal regions” (Uddin *et al.*, 2007, p. 154), or “neural substrates of the right hemisphere may selectively participate in processes linked to self-awareness” (Keenan *et al.*, 2001, p. 305). Platek, Loughhead, Gur, Busch *et al.* (2006) suggest that a potential source of contradictory findings is the variability in control conditions, especially on the dimension of familiarity of the acquaintance.

3- Theory-of-Mind

(a) ToM and self-awareness

An important aspect of the view being assessed here is the claim that because human and non-human primates possess self-awareness, they can make inferences about others’ mental states (i.e., they can engage in ToM)⁴. ToM (also called “mentalizing”, “mind-reading”, “intentional stance”, or “mental state attribution”) consists in attributing mental states such as goals, intentions, beliefs, desires, thoughts, and feelings to other social agents (Gallagher & Frith, 2003). The social cognitive and evolutionary benefits of ToM are the ability to predict others’ behavior, and on that basis, to help, avoid, or deceive others as the situation dictates. The developmental, psychological, neuroanatomical, and pathological dimensions of ToM have been comprehensively studied (for reviews, see Brune & Brune-Cohrs, 2006; Frith & Frith, 2003; Saxe, Carey & Kanwisher, 2004). Many variations of the “Sally-Ann” false-belief task are usually used to measure ToM abilities in children (see Birch & Bloom, 2004, Figure 1a). In these tasks, children are told that Sally put a ball in a basket and then went outside. While Sally was away, Ann took the ball out of the basket and put it in a box. The question asked to children is: When Sally returns and wants to find her ball, where will she look for it? The correct response, that Sally will look in the basket, requires generating a representation of Sally’s belief about the situation. Primitive forms of ToM emerge at around 18 months of age; an implicit understanding of mental states exists at two years of age (Frith & Frith, 2003). A full development of ToM occurs at around 6 years of age; this development seems to be related to language acquisition (e.g., Garfield, Peterson & Perry, 2001; Milligan, Astington & Dack, 2007) and triadic interactions (Carpendale & Lewis, 2004). The underlying psychological and neural mechanisms of corollaries of ToM such as altruism, empathy, and deception are the focus of intense research efforts (e.g., Decety & Jackson, 2006; Spence, Farrow, Herford, Wilkinson, Zheng & Woodruff, 2001; Tankersley, Stowe & Huettel, 2007). ToM deficits are well documented in autism (e.g., Baron-Cohen, 2001) and schizophrenia (e.g., Brune, 2005); these deficits are increasingly being associated with brain dysfunction, most likely located in the more anterior region of the dorsal medial prefrontal cortex (Amodio & Frith, 2006).

Both Gallup’s and Keenan’s groups suggest that self-awareness, as measured by MSR, paves the way to the understanding of others’ minds: “... making inferences about states of mind in others is a logical extension of your experience with your own mental states. Knowledge of self is an inductive springboard for an inferential knowledge of others” (Gallup *et al.*, 2002, p. 10). “If self-awareness is intimately tied to understanding one’s own thoughts, then we might assume, self-awareness may give rise to the ability to reflect on the thoughts of others. That is, if I can think about my thoughts, I should be able to think about your thoughts as well” (Keenan *et al.*, 2003, p. 78).

This intuitively attractive idea is called the “Simulation” (or “Projection”) view; it explicitly

⁴ Note here that I do not wish to address the slippery issue of ToM in primates as it is ultimately irrelevant to my point. Interested readers may see Call & Tomasello (2008), Heyes (1998), Povinelli & Vonk (2004), and Premack & Woodruff (1978).

assumes that (private) self-awareness comes first and is rapidly followed by a natural propensity to impute internal states to others through a form of mental simulation. A critical review of this idea is beyond the scope of the present chapter; it is currently being debated in the literature, with some providing evidence that introspection indeed precedes ToM (Dimaggio, Lysaker, Carcione, Nicolo & Semerari, 2008) and others suggesting that ToM rather comes first (Carruthers, in press). What I wish to show is that although possibly linked, self-awareness and ToM are nonetheless relatively independent and should not be equated.

One first difficulty (see Mitchell, 1997a, for a somewhat similar argument) is the immense time gap that exists between the emergence of MSR (between 18 and 24 months in human children) and the effective establishment of ToM skills (at around 6): if introspection (which according to Gallup should already be present when MRS occurs) naturally leads to TOM, how could self-aware individuals navigate in their social world for four years or more without spontaneously thinking about others' mental states? This just does not look right. A second point is that by definition, ToM implies a focus of attention on others—not on the self, whereas self-awareness exclusively entails self-focus (Morin, 2002). In addition, in humans, self-awareness does not represent a uniform construct and is made up of two different tendencies (Trapnell & Campbell, 1999): self-reflection, which constitutes an authentic curiosity about the self, and self-rumination, which represents anxious attention paid to the self. Only self-reflection has been shown to lead to ToM (i.e., empathy); self-rumination actually inhibits TOM because the person is too self-absorbed to think about others' mental states (Joireman, Parrott & Hammaersla, 2002; Joireman, 2004). And finally, brain areas correlated with self-awareness and ToM abilities differ (Dimaggio *et al.*, 2008). Overall, most brain-imaging studies suggest that self-awareness tasks activate (among other areas) the ventral portion of the medial prefrontal cortex (mPFC), whereas ToM tasks engage a more dorsal subregion of the mPFC, as seen before. Thus again, self-awareness and ToM are not interchangeable concepts.

(b) ToM and the brain

The importance of the above analysis can now be better appreciated. Some lesion and brain imaging studies of TOM tasks show a significant involvement of the right prefrontal cortex (e.g., Stuss *et al.*, 2001; Vogeley *et al.*, 2001). An implied assumption made on that basis is that since ToM skills seem to depend on right hemispheric activity, then self-awareness abilities too ought to be located in the same hemisphere (e.g., Guise *et al.*, 2007, p. 133). This argument is erroneous of course, because ToM and self-awareness cannot be equated; as a result, even if studies were able to establish that the former is located in the right hemisphere, it would not mean that the latter be produced by the same hemisphere. Additionally, if some isolated studies do suggest a right hemisphere bias during mentalizing tasks, a recent review of 40 fMRI studies of ToM (Carrington & Bailey, in press) clearly reveals activation of medial and left brain areas. Various domains within mental state attribution have been explored in relation to brain activity and localization: false belief, deception, pretence, intention, desire, and empathy. A host of tasks have been designed to measure these domains, which include the use of simple questions, stories, static images, comic strips, animations and videos, and interactive paradigms. In a typical experiment (e.g., Calarge, Andreasen & O'Leary, 2003), healthy participants may be asked to produce a fictive story about the mental state of a stranger whom they imagined meeting on a park bench. Brain activity during such a TOM task is then compared to that of a control task consisting in reading a story requiring no mental state attribution.

In summarizing their observations, Carrington and Bailey (in press) conclude that "In the reviewed studies, the mPFC/OFC region [medial prefrontal /orbitofrontal cortex] and the STS [superior temporal sulcus] emerge as "core" regions activated during ToM tasks... The TPJ [tempoparietal gyrus] and anterior- and para-cingulate cortices also appear to be "core" regions". Note that none of these brain areas are lateralized on the right side; indeed, Carrington and Bailey explicitly state that the aim of their review was to "determine whether paradigmatic differences, in terms of task-type and mental state(s), could account for the heterogeneous results of imaging studies of ToM, which implicate distinct brain regions in both hemispheres". This is in sharp contradiction with statements such as "there is good evidence that tasks requiring Theory of Mind engage the right hemisphere" (Keenan *et al.*, 2005, p. 701).

4- Self-awareness

(a) Disorders of the self and the brain

One argument made in favor of the right hemisphere model of self-awareness is that injury to that hemisphere consistently leads to disturbances of the self (e.g., Feinberg & Keenan, 2005; Keenan *et al.*, 2005). To illustrate, some patients may be incapable of recognizing themselves in a mirror (the mirror sign syndrome), may experience dissociation, which includes derealization (feeling outside of one's body), may suffer from asomatognosia (a failure to recognize specific body parts—e.g., one's left arm), or asognosia (unawareness of hemiplegia—e.g., paralysis of one side of the body, most typically the left side). All these conditions have been shown to follow right hemisphere damage. It is striking that all seem to involve a distortion or absence of a body representation—precisely the type of kinesthetic information postulated by Mitchell (e.g., 1993, 2002a, 2002b) to be required for MSR. It is tempting then to suggest that the mirror sign syndrome, asomatognosia, dissociation, and asognosia have nothing to do with access to one's mental events (private self-awareness), and instead are related to one's mental conception of one's body—or lack thereof (Morin, 2003).

More subtle forms of asognosia are observed in response to traumatic brain injuries (TBI), where compared to family members and rehabilitation staff, patients significantly underestimate their physical, cognitive, and emotional disturbances—thus exhibiting a lack of awareness into their own condition. Does asognosia of that type result from brain damage specifically located in the right hemisphere? In a 20-year review of the literature, Prigatano (2005) concludes that “Evidence suggests that persistent problems of impaired awareness after TBI may require bilateral diffuse cerebral dysfunction” (p. 24, *italics added*). Sherer, Hart, Whyte, Nick, and Yablon (2005) scanned the brain of 91 patients with asognosia caused by TBI and observed that the severity of the injury, but not its location in the right hemisphere, was predictive of degree of self-awareness deficits. That is, “ISA [impaired self-awareness] was significantly associated with the number, but not with location or volume of focal lesions early after TBI. Posttraumatic ISA may reflect disruption in the integrated operation of broadly distributed neural networks, with lesion burden in any specific region being less relevant than disruption across multiple regions” (p. 287).

(b) Conceptual forms of self-referential activity and the brain

As we have seen above, MSR and ToM abilities recruit right, medial, and left brain areas; MSR and ToM tasks certainly do not exclusively depend on right hemispheric activity. What kind of brain activation is observed when participants engage in more direct and private forms of self-awareness? By “direct” I imply thinking about the self, not about others (ToM), and by “private” I mean introspective, as opposed to bodily self-awareness (MSR). Does the postulated right hemisphere dominance also apply to more subtle types of processing of self-information such as autobiographical retrieval, assessment of one's current emotional experience, or description of one's personality traits?

In their 2005 review of the literature, Gillihan and Farah compiled activation maxima obtained across various imaging experiments using self-related tasks and neuropsychological case-studies assessing self-awareness in the following self-domains: face and body recognition, sense of agency, personality traits, autobiographical memory, and first-person perspective. Here I only discuss brain-imaging studies ($n = 13$) of personality traits and autobiographical memory, as (self-)face recognition has already been covered, and the other self-domains examined by Gillihan and Farah are of a more perceptual (concrete, bodily), as opposed to conceptual (abstract, private), nature (see Morin & Michaud, 2007, for a discussion of the distinction between “perceptual” and “conceptual” self-aspects).

In a standard “personality trait” experiment (e.g., Kelley, Macrae, Wyland, Caglar, Inati & Heatherton, 2002), volunteers must decide if adjectives describe themselves (self condition), a well-known person (other condition), or if adjectives are printed in capital or lower case letters (case condition). A variation (e.g., Kjaer, Nowak & Lou, 2002) consists in asking participants to reflect on their own personality and physical traits for a short period of time (self condition), as well as on the personality and physical traits of a well-known individual (other condition). Eight

out of the ten studies in Gillihan and Farah's review (2005) report activation of areas in the left and right hemispheres; only two experiments found uniquely right hemispheric activity during self-judgments of personality traits. In a typical brain-imaging study of autobiographical memory (e.g., Fink, Markowitsch, Reinkemeier, Bruckbauer, Kessler & Heiss, 1996), subjects are scanned while they listen to a narrative describing a memory of their own (self condition) and a narrative describing another person's memory (control condition). Gillihan and Farah reviewed three such studies; one reports uniquely left hemispheric activity, another one, a strictly right hemisphere bias, and the third study indicates activation of areas in both hemispheres. A more recent meta-analysis of the functional neuroanatomy of autobiographical memory (Svoboda, McKinnon & Levine, 2006) rather "... found a left-lateralized [autobiographical memory] network, including select regions in the frontal, temporal and posterior cortices, as well as the cerebellum and a number of subcortical structures" (p. 15; italics added).

In their own meta-analysis of imaging studies of the self, Northoff, Heinzel, de Greck, Bermpohl, Dobrowolny, and Panksepp (2006) reviewed 27 experiments in the following self-domains: personality traits, first-person perspective, autobiographical memory, emotions, self-face recognition, ToM, and sense of agency. Although Gillihan and Farah (2005) failed to find a specific network uniquely recruited during processing of any type of self-related information, Northoff et al. (2006) conclude that "Neural activity in the [cortical midline structures] was observed during self-related tasks across all domains" (p. 450), including the more conceptual domains of interest here: personality traits, autobiographical memory, and emotions. It is worth emphasizing that cortical midline structures implicate areas located in both hemispheres of the brain. In a representative brain-imaging study of emotions (e.g., Goldberg, Harel & Malach, 2006), participants view various images and are asked to reflect on the emotional response that these stimuli produce; the control task may consist in categorizing the pictures into groups (e.g., animal/no-animal). Phan, Wager, Taylor, and Liberzon (2004) reviewed 55 functional neuroimaging experiments of emotions; consistent with Northoff et al.'s observation they found reliable activation in the medial prefrontal cortex, as well as in the amygdala (more so on the left side), anterior cingulate cortex, and insula.

One additional self-domain, as well as a peculiar "control" condition, are worth mentioning at this point: evaluative judgments and the REST (Random Episodic Silent Thinking) condition. Some studies have measured brain activity while participants were asked to judge if they liked or disliked various items, e.g., colours (Johnson et al., 2005), drinks (Paulus & Frank, 2003), food (Seger et al., 2004), and people (Zysset, Huber, Fersti & Von Cramon, 2002). Such tasks tap into private self-awareness because they require that participants assess their own preference in order to produce a judgment. These studies consistently report bilateral brain activation; areas include the superior medial parietal cortex, the anterior medial prefrontal cortex, the bilateral ventromedial prefrontal cortex, the anterior frontomedian cortex, retrosplenial cortices, and caudate nucleus.

The resting state has traditionally been used as a control condition in neuroimaging studies. Between two experimental tasks, participants are simply asked to relax and do nothing; the assumption is that they will do nothing and that the resultant lack of brain activity will act as an ideal point of comparison to be contrasted with brain activity observed during the cognitive tasks being studied. In an influential article, Gusnard, Akbudak, Shulman, and Raichle (2001) questioned this assumption on the basis that participants' brain is hardly inactive during that "control" condition and shows activity in the medial prefrontal cortex. In other words, and not surprisingly, even when invited to "relax and do nothing", people actively think about their current, past, or future goals, emotions, needs, behavior, physiological sensations, etc. The REST condition actually consists of an introspective state that recruits most brain regions that have also been shown to be active during self-awareness tasks. Wickera, Ruby, Royet, and Fonlupt (2003) performed a meta-analysis on five studies where brain areas activated during the resting state were compared to those recruited during active tasks. "Two maxima were revealed bilaterally along the superior frontal sulcus. The first one is located ventrally in the anterior part of the superior frontal sulcus (BA 10) whereas the second focus is more dorsal (BA 8/9). Another rCBF increase is observed in the anterior cingulate gyrus" (p. 227, italics added). More recently, Schilbach, Eickhoff, Rotarska-Jagiela, Fink, and Vogeley (2008) used the opposite approach and

looked at brain regions that get reliably deactivated during experimental tasks; these areas should precisely be those that are recruited at rest but inhibited during cognitively effortful tasks. The team performed a deactivation analysis across 12 fMRI studies; "... our meta-analysis revealed differentially decreased neural activity in the left angular gyrus, bilateral medial frontal cortex and the precuneus bilaterally", which indicates that these sites were significantly more active during the REST condition than during the experimental condition.

Thus far one can conclude that like more perceptual forms of self-awareness (i.e., self-face recognition) and other-directed types of introspective thought (i.e., ToM), various manifestations of self-directed conceptual self-awareness such as thinking about one's personality traits, past, emotions, and preferences, engage a wide network of sites located in both hemispheres of the brain. This observation obviously clashes with claims such as "We therefore find that the data support the hypothesis that the right hemisphere is dominant for higher-order consciousness" (Keenan et al., 2005, p. 702).

(c) Self-awareness and inner speech

In this last section I will suggest that language, and more precisely inner speech, play a fundamental role in self-awareness. Since language is produced by Broca's area located in the left hemisphere and primates (and obviously, lower animals) do not engage in linguistic activity, this will strongly imply that self-awareness is not uniquely located in the right hemisphere and that animals most likely are not fully self-aware.

A correlation exists between the emergence of both language and self-focused thought. Archaeologists have identified a period named the Middle-Upper Palaeolithic transition (around 40,000 years ago) during which a cultural Big Bang occurred, characterized by the emergence of the first burials and body adornments, boat-making, more sophisticated tools, and more refined cultural practices. They correlate these changes with the development of self-awareness; interestingly, experts also date the appearance of human language at about this same period (Leary, 2004). The observations related by Helen Keller are also pertinent in that respect. Helen was blind and deaf but nevertheless managed to learn to use language. She states, of the time before she was taught a language, that "Before my teacher came to me, I did not know that I am. I lived in a world that was a no world... When I learned the meaning of 'I' and 'me' and found that I was something, I began to think. Then consciousness first existed for me" (Salzen, 1998, p. 307). This citation strongly suggests that the acquisition of language was followed by the development of a sense of self—self-awareness.

My contention is that it is not language per se that is associated with self-awareness, but rather inner speech (but see Schlinger, in press). I do not intend to review all the available evidence here, nor do I wish to present an in-depth analysis of inner speech⁵. Efforts will instead be concentrated on the presentation of two recent neurocognitive sets of data.

Inner speech represents the act of using language to talk to oneself internally (Langdon, Jones, Connaughton & Fernyhough, in press). Although we engage in self-talk for a variety of reasons (e.g., to self-regulate, for mnemonic purposes, or to rehearse in preparation for a social encounter), by definition, when we talk to ourselves about ourselves we become the object of our own attention and are in a state of self-awareness. To illustrate, one can say to oneself: "I feel very happy about this"—thus reflecting on one's current emotion of joy, or "I believe that abortion is wrong because..."—thus examining one's opinion on a specific topic. Not surprisingly then, a significant positive correlation has been repeatedly observed between diverse validated scales measuring the frequency of private self-focus and use of inner speech (e.g., Morin, Everett, Turcotte & Tardif, 1993; Schneider, Pospeschill & Ranger, 2005; Siegrist, 1995). In brain injured patients who eventually recover from their trauma, conscious experience often returns in parallel with inner speech (Ojemann, 1986); conversely, healthy individuals report inner speech inhibition when they shift from wakefulness to sleep (Rusalova, 2005).

⁵ Interested readers may see Morin, 2005, in press—a; also see Depare, Hakim-Larson, Voelker, Page, and Jackson (2006) for supporting evidence on Morin's hypothesis of a link between inner speech and self-awareness.

Based on the observation that the left inferior frontal gyrus (LIFG) sustains inner speech use (e.g., McGuire, Silbersweig, Murray *et al.*, 1996), Morin and Michaud (2007) reasoned that an activation of the LIFG should be found in a reasonable number of self-awareness studies. Furthermore, we hypothesized that inner speech use should be greater in conceptual-abstract self-domains (e.g., emotions, traits) than in perceptual-concrete self-domains (e.g., agency, self-recognition). That is, perceptual self-aspects such as self-face recognition, because of the visual and concrete nature of the information, can most certainly be perceived without words. More conceptual self-dimensions such as emotions and personality traits however, probably require that one talks to oneself about them (e.g., “I feel tired”, “I’m intelligent”) to be fully brought to awareness. To test these predictions we reviewed 59 studies measuring brain activity during self-referential tasks in the following self-domains: agency, self-recognition, emotions, personality traits, autobiography, preferences, and REST. Fifty-six percent of all studies identified LIFG activity across self-awareness tasks, and LIFG activation was more frequently observed during conceptual tasks (68%) than during perceptual tasks (20%). It seems reasonable to conclude that inner speech is substantially recruited during self-related activities and that it is differentially involved across self-domains.

If inner speech plays an active role in the identification and retrieval of information about the self, does accidentally losing it following brain injury impede self-awareness? Yes—this is what I propose in my analysis of Jill Taylor’s 2006 book (Morin, *in press—b*), in which she details her experience of suffering from a left hemispheric stroke produced by a congenital arteriovenous malformation that caused a loss of inner speech. Her phenomenological description convincingly suggests that this impairment created a general self-awareness deficit as well as more specific dysfunctions related to her sense of individuality, retrieval of autobiographical memories, and self-conscious emotions.

In her book *My Stroke of Insight* (2006), Jill indicates that in the space of a few hours after her stroke “... my brain chatter began to disintegrate...” (p. 41). Her sense of self started to collapse as well: “I retained only a vague idea of who I was and what I was trying to accomplish” (p. 52); “What a daunting task it was to simply sit there in the center of my silent mind ... and trying to remember, Who am I? What am I doing?” (p. 57); “I struggled to comprehend my existence” (p. 91). Her sense of individuality was also disturbed: “I no longer perceived myself as a whole object separate from everything” (p. 42); Jill’s ability to retrieve autobiographical information was severely impaired: “Those little voices, that brain chatter that customarily kept me abreast of myself in relation to the world outside of me, were delightfully silent. And in their absence, my memories of the past and my dreams of the future evaporated” (pp. 42–43); and she was not able to experience some self-conscious emotions which normally accompany a sense of self (Lewis, 1992): “Among the many circuits in my brain that had gone off-line, it was my good fortune that my circuitry for embarrassment had also gone awry” (p. 83).

These various quotes are intrinsically subjective and alternative interpretations of the data are possible (see Mitchell, *in press*). But combined with similar cases of self-awareness deficits following loss of inner speech (e.g., Moss, 1972), Taylor’s case study is compelling. Some might still want to argue that lower forms of self-awareness are achievable without inner speech; I agree. However I add that taken together, the evidence presented in this section suggests that a fully human self-awareness most likely requires inner speech.

5- Conclusion

The first view critically examined in this chapter was that primates possess self-awareness because they exhibit self-face recognition, which in turn makes it possible to engage in ToM. It was suggested that both MSR and ToM should not be equated with “genuine”, introspective self-awareness. In essence, MSR most likely underlies a kinesthetic, as opposed to mental, form of self-knowledge, and by definition ToM implies focusing one’s attention on others—not on the self. As a consequence I submit that primates (and by extension all other non-primate animals and right hemispheres) that exhibit MSR and/or ToM most probably do not possess mature self-awareness.

The second position assessed was that the right hemisphere constitutes the neurological seat of self-awareness because MSR and ToM tasks typically increase activity in that hemisphere. In short, current empirical evidence rather indicates that participants engaged in self-face recognition, ToM, and complex types of conceptual introspection recruit a bilateral network of brain areas. In addition, inner speech, which seems to significantly participate in self-awareness, is generated by the left hemisphere. The conclusion is patent: self-related processes engage a distributed set of brain regions situated in both hemispheres.

This book is dedicated to the question of minds in animals. Do animals possess a mind? Some courageous scholars have tackled this issue, but to me it is ultimately insoluble—equivalent to the hard problem of consciousness (Chalmers, 2007). There are just too many species to consider and too many possible definitions of “mind” to mull over. However, if one takes a more modest approach and limits the inquiry to primates, one could tentatively operationalize “mind” in terms of self-awareness: a primate that is capable of identifying, processing, and storing private and public information about itself, including emotions, memories, preferences, goals, sensations, behaviors, etc., could be said to possess a mind. In light of the analysis presented here, I would suggest that primates do not possess a mind, or if they do it is rudimentary at best.

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