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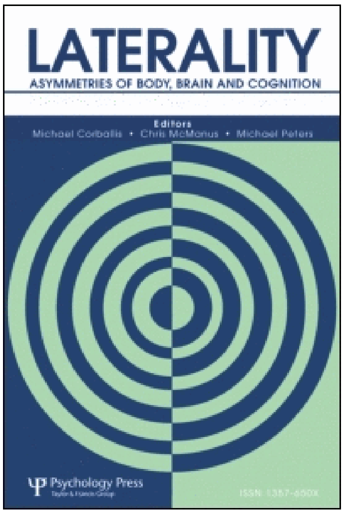

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Self-recognition, theory-of-mind, and self-awareness: What side are you on?

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Self-recognition, theory-of-mind, and self-awareness: What side are you on?

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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 centre of self-awareness because MSR and ToM tasks presumably increase activity in that hemisphere. These two claims are critically assessed here as follows: (1) MSR should not be equated with full-blown self-awareness, as it most probably only requires kinaesthetic self-knowledge and does not involve access to one's mental events; (2) ToM and self-awareness are fairly independent and should also not be taken as equivalent notions; (3) MSR and ToM tasks engage medial and *left* brain areas; (4) other self-awareness tasks besides MSR and ToM tasks (e.g., self-description, autobiography) mostly recruit medial and left brain areas; (5) and recent neuropsychological evidence implies that inner speech (produced by the left hemisphere) plays a significant role in self-referential activity. The main conclusions reached based on this analysis are that (a) organisms that display MSR most probably do not possess introspective self-awareness, and (b) self-related processes most likely engage a distributed network of brain regions situated in both hemispheres.

Keywords: Self-awareness; Self-recognition; Theory-of-mind; Right hemisphere; Inner speech.

In 1998, Gordon G. Gallup Jr. published an article whose title was "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 of the article). One of Julian Paul Keenan's papers (Feinberg & Keenan, 2005) is entitled "Where in the

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brain is the self?" According to the authors, "(. . .) the right hemisphere plays a special role in the creation of the self" (p. 15).

These two articles and their conclusions are representative of an increasingly popular view in comparative psychology and cognitive neuroscience.[1] 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-of-mind" or ToM); this view also holds that the right hemisphere represents the neurological seat of self-awareness because MSR and ToM tasks presumably increase activity in that hemisphere.

The goal of this paper is to question this dual assumption on several conceptual, behavioural, psychological, and neurological grounds (see Morin, 2002, 2003, 2007). The conclusions that will be submitted based on this analysis will cast doubts on the above target assumptions. It will be suggested that MSR need not be equated with "genuine" (i.e., private, as opposed to kinaesthetic) self-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 inner speech seems to play an important role in self-awareness.

MIRROR SELF-FACE RECOGNITION (MSR)

MSR and self-awareness

Most organisms that are confronted with a reflecting surface react as if they were seeing another conspecific creature: they engage in a variety of social responses such as bobbing, vocalising, and threatening. Only human primates, chimpanzees, orangutans, and some bonobos, elephants, dolphins, and most recently Australian magpies have been shown to exhibit spontaneous mirror-guided self-exploration—e.g., self-directed behaviours such as examining body parts only visible in the mirror (for reviews, see

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[1] 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. The reader can find below a list of their most important articles and book chapters.

Gordon G. Gallup Jr. and his team: Gallup, 1968, 1970, 1975, 1977, 1979, 1982, 1985, 1997; Gallup et al., 2002; Platek et al., 2003, 2004b; Stuss et al., 2001; Suarez & Gallup, 1981.

Julian Paul Keenan and his team: Barnacz et al., 2004; Guise et al., 2007; Keenan et al., 1999, 2000, 2001a, 2001b, 2003, 2005; Keenan & Gorman, 2007; Platek et al., 2004a; Rosa et al., 2008; Seger et al., 2004; Uddin et al., 2007.

Bard, Todd, Bernier, Love, & Leavens, 2006; Gallup, Anderson, & Shillito, 2002; see also Plotnik, de Waal, & Reiss, 2006; Prior, Schwartz, & Gunturkun, 2008; Reiss & Marino, 2001). The aforementioned animals also pass the more formal "mark test" and will touch a red dot that has been inconspicuously applied to their brow or forehead (or throat feathers in magpies' case). 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 also been studied 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). People are also competent at identifying their body, including limbs (e.g., hands) and shadows produced by the body (Cameron & Gallup, 1988), their odour (Platek, Thompson, & Gallup, 2004b), and their name (Kaplan, Aziz-Zadeh, Uddin, & Iacoboni, 2008).

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 (De Veer & van den Bos, 1999; Schilhab, 2004). The most extreme view, articulated by Gallup (e.g., 1982), can be summarised as follows. Emitting self-directed behaviours 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*-cognising 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 is beyond doubt; but what *type* or *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 comprises various self-domains (e.g., emotions, autobiographical retrieval, sense of agency, personality traits) 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, goals, sensations, attitudes; and visible characteristics (public self-aspects) like physical appearance, mannerisms, and behaviours (Fenigstein, 1986; Fenigstein, Scheier, & Buss, 1975).

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 probably the *only* prerequisite for MSR is a knowledge of one's *body* (e.g., Mitchell, 1993, 2002a, 2002b; Povinelli, 1995)—a strictly *public* self-aspect. More specifically, all an organism requires to self-recognise is a mental representation of its own physical self; the organism matches the kinaesthetic representation of the body with the image seen in the mirror and infers that "it's me". This interpretation implies that an awareness of *private* self-dimensions is not needed for MSR to take place: what is needed, however, is an awareness of the body. Keenan, Gallup, and Falk (2003), who insist that organisms that self-recognise are self-aware, define self-awareness as "the ability to reflect on one's own *mental state* (. . .)" (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.

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 psychiatric patients insisting that their reflection in the mirror was "someone else" (thus exhibiting some identity distortion), yet they passed the mark test. Sugiura and his colleagues (2006) report cases of demented patients combing or shaving in front of a mirror (the informal equivalent of the mark test), yet failing to recognise their own mirror images. Most autistic individuals are capable of MSR (Dawson & McKissick, 1984; Mitchell, 1997b) but are characterised by alexithymia—serious difficulties in reflecting on their inner experience and identifying their subjective feelings (Silani et al., 2008). So MSR can be exhibited in the presence of important self-awareness deficits, and MSR can be impaired despite intact self-knowledge: Klein, Gabriel, Gandi, and Robertson (2008) describe the case of a prosopagnosic patient incapable of self-face recognition who nonetheless showed perfect trait self-knowledge. If MSR were synonymous with self-awareness, one would not come across such peculiar observations.

Self-face recognition and the brain

Let us now focus on the claim that self-awareness is located in the right hemisphere because self-face recognition mostly activates areas within this hemisphere. This argument is fallacious for at least two reasons. The first one 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 evidence indicates that self-face recognition recruits a *bilateral* network of brain areas (Platek, Wathne, Tierney, & Thomson, 2008).

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

In a typical behavioural 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 buttons with the right or left hand. Such studies find a left-hand/right-hemisphere advantage (faster reaction times) when participants respond to self-faces, but not to other faces. Lesion studies report cases of patients with right hemisphere damage who fail to recognise themselves in the mirror (e.g., Keenan, Rubio, Racioppi, Johnson, & Barnacz, 2005). Note that only a handful of patients show such a condition (Rosa, Lassonde, Pinard, Keenan, & Belin, 2008).

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. All other published split-brain reports fail to replicate this clear-cut lateralised result. In Sperry, Zaidel, and Zaidel's experiment (1979), *both* hemispheres of two split-brain patients were capable of explicit self-recognition. 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 vice versa. Using slightly different procedures, Uddin, Rayman, and Zaidel (2005) obtained comparable results, and Turk et al. (2002) instead observed a *left* hemisphere bias for self-recognition.

It is worth noting here that the split-brain data actually present 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 specialised neural network for self-awareness in the right hemisphere. As Sperry et al. (1979) point out, it is relatively easy to objectify the conscious status of the left hemisphere by addressing verbal questions to it, in which case the left hemisphere will offer answers that visibly indicate that it has a complete sense of self—e.g., the name it 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 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, Keenan, Gallup, & Mohamed, 2004a). 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 obviously inconsistent with claims such as "neural substrates of the right hemisphere may selectively participate in processes linked to self-awareness" (Keenan, Nelson, O'Connor, & Pascual-Leone, 2001b, p. 305).

THEORY OF MIND (ToM)

ToM and self-awareness

An important aspect of the view being assessed here is the claim that because humans and primates possess self-awareness, they can make inferences about others' mental states (i.e., they can engage in ToM). ToM consists in attributing mental states such as goals, intentions, beliefs, desires, thoughts, and feelings to other social agents (Gallagher & Frith, 2003). The benefits of ToM are the ability to predict others' behaviour and, on that basis, to help, avoid, or deceive others as the situation dictates. Many variations of the "Sally-Ann" false-belief task are usually used to measure ToM abilities in children (see Birch & Bloom, 2004, Fig. 1a). Primitive forms of ToM emerge at around 18 months of age; an implicit understanding of mental states exists at 2 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). 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: "... 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, the "Simulation" (or "Projection) view, explicitly 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.

Although possibly linked, self-awareness and ToM are nonetheless relatively independent and should not be equated. One first difficulty (see Mitchell, 1997a) 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 4 years or more without spontaneously thinking about others' mental states? 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 is made up of two 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 leads to ToM (i.e., empathy); self-rumination actually *inhibits* TOM because the person is too self-absorbed to think about others' mental states (Joireman, 2004; Joireman, Parrott, & Hammaersla, 2002). And finally, brain areas correlated with self-awareness and ToM abilities differ (Dimaggio, Lysaker, Carcione, Nicolo, & Semerari, 2008). Overall, brain-imaging studies suggest that self-awareness tasks activate the ventral portion of the medial prefrontal cortex (mPFC), whereas ToM tasks engage a more dorsal subregion of the mPFC. Thus again, self-awareness and ToM are not interchangeable concepts.

ToM and the brain

Some lesion and brain-imaging studies of ToM tasks show a significant involvement of the right prefrontal cortex (e.g., Stuss, Gallup, & Alexander, 2001; Vogeley et al., 2001). An implied assumption made on that basis is that, since ToM skills seem to depend on right hemispheric activity, 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 most probably should not 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, although some studies do suggest a right hemisphere bias during mentalising tasks, a recent review of 40 fMRI studies of ToM (Carrington & Bailey, 2009) clearly reveals activation of medial and left brain areas. In a typical experiment (e.g., Calarge, Andreasen & O'Leary, 2003), healthy participants are asked to produce a fictive story about the mental state of a stranger whom they imagine meeting on a park bench. Brain activity during the ToM task is then compared to that of a control task consisting in reading a story requiring no mental state attribution. In their review Carrington and Bailey (2009) observed most activations occurring *bilaterally* in the medial prefrontal /orbitofrontal cortex, superior temporal sulcus, tempo-parietal gyrus, and anterior- and para-cingulate cortices. This is in sharp contradiction to statements such as "there is good evidence that tasks requiring Theory of Mind engage the right hemisphere" (Keenan et al., 2005, p. 701).

SELF-AWARENESS

Disorders of the self and the brain

One argument made in favour 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). Some patients may be incapable of recognising themselves in a mirror (the mirror sign syndrome), may experience dissociation, which includes derealisation (feeling outside of one's body), may suffer from asomatognosia (a failure to recognise specific body parts, e.g., one's left arm), or anosognosia (unawareness of hemiplegia, e.g., paralysis of one side of the body, most typically the left side). All these conditions follow right hemisphere damage. It is striking that all seem to involve a distortion or absence of a *body representation*—precisely the type of kinaesthetic information postulated to be required for MSR. It is tempting, then, to suggest that the mirror sign syndrome, asomatognosia, dissociation, and anosognosia 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 anosognosia are observed in response to traumatic brain injuries (TBI), where patients exhibit a lack of awareness into their own condition. Does anosognosia of that type result from damage specifically located in the right hemisphere? In a 20-year review of the literature, Prigatano (2005) concludes 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 anosognosia 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. Cocchini, Cameron, Beschin, and Fotopoulou (2009) note that left hemisphere damaged patients are often excluded from studies investigating anosognosia because of their language deficits, leading to an overestimation of the frequency of unawareness of impairment in the right hemisphere. Cocchini et al. (2009) used a non-verbal tool to assess their patients and found that 40% of those with left hemisphere injury exhibited anosognosia.

Other forms of self-referential activity and the brain

What kind of brain activation is observed when participants engage in more “introspective” forms of self-awareness? Does the postulated right hemisphere dominance also apply to autobiographical retrieval, assessment of one’s current emotional experience, or description of one’s personality traits? In their 2005 meta-analysis, Gillihan and Farah compiled activation maxima obtained across various imaging experiments using self-related tasks and neuropsychological case studies assessing self-awareness. In a standard “personality trait” experiment (e.g., Kelley et al., 2002), volunteers must decide if adjectives describe themselves (self condition) or a well-known person (other condition), or if adjectives are printed in capitals or lowercase letters (control 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-judgements of personality traits. In a typical brain-imaging study of autobiographical memory (e.g., Fink et al., 1996), participants 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. In contrast another meta-analysis of the functional neuroanatomy of autobiographical memory (Svoboda, McKinnon, & Levine, 2006) “. . . found a *left*-lateralised 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).

Northoff et al. (2006) reviewed 27 imaging studies of the self and observed that neural activity in the cortical midline structures is typical during self-related tasks across all domains, including personality traits judgements, autobiographical retrieval, and emotions assessment. 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 categorising the pictures into groups (e.g., animal/no-animal). Phan, Wager, Taylor, and Liberzon (2004) reviewed 55 functional-neuroimaging experiments of emotions: 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.

The REST (Random Episodic Silent Thinking) condition is now seen as an introspective state in which participants actively think about their current, past, or future goals, emotions, needs, behaviour, physiological sensations, etc. (Gusnard, Akbudak, Shulman, & Raichle, 2001): it recruits most brain regions that have also been shown to be active during self-awareness tasks. Wickera, Ruby, Royet, and Fonlupt (2003) reviewed 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. Schilbach, Eickhoff, Rotarska-Jagiela, Fink, and Vogeley (2008) looked at brain regions that are 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 and found differentially decreased neural activity in the *left* angular gyrus, *bilateral* medial frontal cortex, and the precuneus *bilaterally.*

Thus far, it can be concluded that various self-referential tasks such as thinking about one's personality traits, past, and emotions 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).

Self-awareness and inner speech

Evidence increasingly suggests that language, and more precisely inner speech, plays a fundamental role in self-awareness (Dimaggio, Vanheule, Lysaker, Carcione, & Nicolo, 2009; Morin, 1993, 2004, 2005; Morin & Everett, 1990). Since language is produced by Broca's area, located in the left hemisphere, this strongly implies that self-awareness is not uniquely located in the right hemisphere.

A correlation exists between the emergence of both language and self-focused thought. Archaeologists have identified a period called the Middle-Upper Palaeolithic transition (around 40,000 years ago) during which a cultural Big Bang occurred, characterised 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). Helen Keller, who spent a significant portion of her life blind and deaf, reports a lack of sense of self before she was taught a language (Salzen, 1998).

Inner speech represents the act of using language to talk to oneself internally (Langdon, Jones, Connaughton, & Fernyhough, 2009). Although we engage in self-talk for a variety of reasons, 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. Not surprisingly then, a significant positive correlation has repeatedly been 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).

Based on the observation that the left inferior frontal gyrus (LIFG) sustains inner speech use (e.g., McGuire 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, they hypothesised 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). To test these predictions, 59 studies measuring brain activity during self-referential tasks were reviewed; 56% 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%).

Inner speech loss following brain injury impedes self-awareness (Morin, 2009). Taylor (2006) 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.

CONCLUSION

The first view critically examined here was that human and non-human 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 kinaesthetic, 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, organisms 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 engaging 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 participate significantly 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. Current efforts aimed at identifying brain areas recruited during self-referential thinking in older persons (Gutchess, Kensinger, & Schacter, 2007), across cultures (Zhu, Zhang, Fan, & Shihui, 2007), and during mental time travel (D'Argembeau et al. 2008) further confirm this observation.

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