Self-awareness Part 2: Neuroanatomy and importance of inner speech

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The present review of literature surveys two main issues related to self-referential processes: (1) Where in the brain are these processes located, and do they correlate with brain areas uniquely specialized in self-processing? (2) What are the empirical and theoretical links between inner speech and self-awareness? Although initial neuroimaging attempts tended to favor a right hemispheric view of self-awareness, more recent work shows that the brain areas which support self-related processes are located in both hemispheres and are not uniquely activated during self-reflective tasks. Furthermore, self-awareness at least partially relies on internal speech. An activation of Broca's area (which is known to sustain inner speech) is observed in a significant number of brain-imaging studies of self-reflection. Loss of inner speech following brain damage produces self-awareness deficits. Inner speech most likely can internally reproduce social mechanisms leading to self-awareness. Also, the process of self-reflection can be seen as being a problem-solving task, and self-talk as being a cognitive tool the individual uses to effectively work on the task. It is noted that although a large body of knowledge already exists on self-awareness, little is known about individual differences in dispositional self-focus and types of self-attention (e.g., rumination vs. self-reflection).

Introduction

Self-awareness constitutes the capacity to become the object of one's own attention (Duval & Wicklund 1972). A self-aware organism is actively identifying, processing, and storing information about the self (Morin 2004). As Figure 1 below suggests, research on self-awareness and related notions (e.g., self-concept, self-regulation, self-recognition) has grown exponentially over the last few decades. The number of published papers with the words "self-awareness", "self-consciousness", and "self-perception" in their title basically doubled from the 70s to the 80s and in the past decade was ten times that of the 60s. (Of course a similar increment trend applies to many other psychological concepts.)

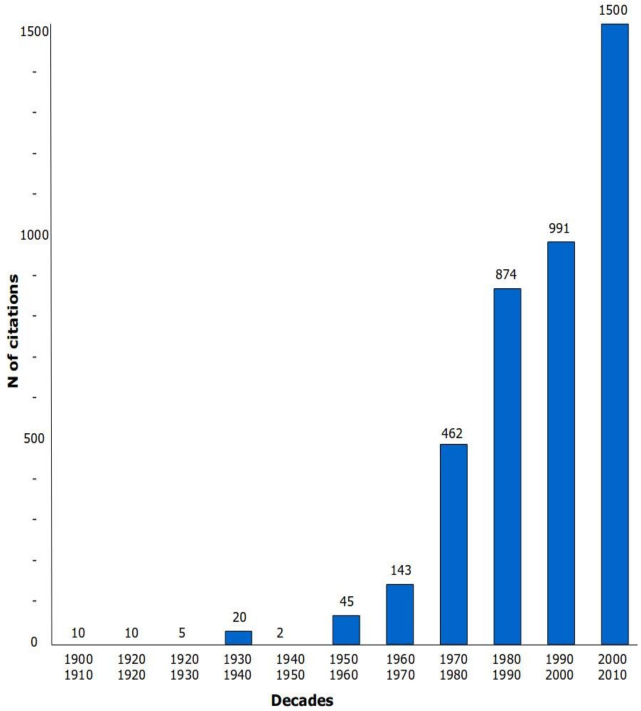

Figure 1. Citation frequencies obtained from PsycINFO, Medline and PsycARTICLES in peer-reviewed journal articles for "self-awareness", "self-consciousness", and "self-perception" from 1900 to 2010.

Some of this body of work was reviewed in a Part 1 article published in this journal (Morin 2011a). The review presented various definitions of self-related processes, existing measures, main effects and functions of self-attention, and antecedents of self-awareness. In doing so Part I addressed the "how", "why", and "when"of self-awareness—*how* do our brain, cognitive processes, and social environment generate self-awareness? *Why* are we self-aware—what functions does self-observation serve? And *when*, in what situations, are we most likely to engage in self-reflection? Here the "how" question will be further examined: *how* does language, and more specifically inner speech, help one to identify self-aspects? Additionally, the "where" question will be raised: *where* are self-reflective processes located in the brain? Actually, are there brain regions uniquely associated with self-reflection? Let us start with the localization issue.

Neuroanatomy

Early studies

Initial attempts at localizing self-related processes in the brain operationally defined self-awareness as the ability to recognize one's face in a mirror or on a photograph (Morin 2010). There are numerous problems with this approach, some of which will be addressed below (see Morin 2007). Spontaneous mirror-guided self-exploration has only been objectified in human primates, chimpanzees, orangutans, and some bonobos, elephants, dolphins, and Australian magpies (see Bard, Todd, Bernier, Love, & Leavens 2006; Plotnik, de Waal, & Reiss 2006; Prior, Schwartz, & Gunturkun 2008; Reiss & Marino 2001). These animals also pass the mark test (e.g., Gallup, Anderson & Shillito 2002): they successfully try to remove a red dot that has been applied to their brow or forehead (or throat feathers in magpies' case) while looking at themselves in a mirror. Gallup's contention (e.g., 1968, 1985, 1997) is that such self-directed behaviors indicate that the organism can become the object of its own attention. Furthermore, self-*re*cognition in front of a mirror presupposes *pre*-cognition of the self—self-awareness.

Premature conclusions favored a right prefrontal account of the neuroanatomy of self-awareness. Four types of studies have been used to investigate the neural correlates of self-face recognition: behavioral, lesion, split-brain, and functional imaging. Behavioral and lesion studies tend to support a right hemisphere dominance view of self-face processing; split-brain and functional imaging data do not. Behavioral studies (e.g., Keenan, McCutcheon, Freund, Gallup, Sanders & Pascual-Leone 1999) invite normal participants to decide if a visual stimulus represents their own face or that of either a familiar person or an unknown individual by pressing buttons with the right or left hand. A left-hand/right hemisphere advantage (i.e., faster reaction times) is observed when participants respond to self-faces, but not to other faces. Lesion studies present cases of patients with right hemisphere damage who fail to recognize themselves in the mirror (e.g., Keenan, Rubio, Racioppi, Johnson & Barnacz 2005). Note that very few patients actually exhibit this condition (Rosa, Lassonde, Pinard, Keenan & Belin 2008).

Self-face recognition was first studied in two split-brain patients by Preilowski (1977), who presented various photographs of faces, including their own face, to the left and right hemispheres of two patients; the dependent measure was galvanic skin response as an indicator of arousal. Both patients showed significantly greater skin response when self-faces were presented to the right hemisphere than when they were projected to the left. Note that using an arousal measure to infer self-recognition is ambiguous at best. Published reports of actual self-recognition tasks in split-brain patients do not replicate Preilowski's clear-cut lateralized result. To illustrate, in an experiment conducted by Sperry, Zaidel and Zaidel (1979), both hemispheres of two split-brain patients were capable of self-recognition. Both patients correctly chose a picture of themselves (among a series of pictures of family members and friends) with their right hand when the information was presented to the left hemisphere, and vice versa. Other studies found similar results (e.g., Uddin, Rayman & Zaidel 2005) or observed a *left* hemisphere superiority for self-recognition (Turk, Heatherton, Kelley, Funnell, Gazzaniga & Macrae 2002).

In a typical functional-imaging study of self-face recognition (e.g., Platek, Keenan, Gallup & Mohamed 2004), healthy volunteers are asked to make identity judgments about their own face, the face of a friend, and the face of a stranger while brain activity is being recorded with positron emission tomography (PET) or functional magnetic resonance imaging (fMRI). Although initial reports tended to support the right hemispheric view (all of which interestingly came out of Keenan's lab), a recent meta-analysis of nine functional neuroimaging studies of self-face recognition (Platek, Wathne, Tierney & Thomson 2008) describes a wider distributed, *bilateral*, network that involves the left fusiform gyrus, bilateral middle and inferior frontal gyri, and right precuneus. This is clearly at odds with proposals such as "neural substrates of the right hemisphere may selectively participate in processes linked to self-awareness" (Keenan, Nelson, O'Connor & Pascual-Leone 2001, p. 305).

One major problem when reducing self-awareness to self-recognition is that one most likely measures a rudimentary manifestation of self-awareness—not the full-blown version (Morin 2002). Self-recognition obviously implies some form of self-awareness, but the question is: what type or level of self awareness is involved? Mitchell (1993, 2002) and Povinelli (1995) both argue that the only prerequisite for self-recognition is a knowledge of one's body. All the organism needs to effectively self-recognize is a mental representation of its own physical self; the organism matches the kinesthetic representation of the body and face with the image seen in the mirror and concludes that "it's me". This view suggests that an awareness of one's mental states is not required for successful self-recognition. Perhaps more importantly, conceptually speaking, self-recognition and self-awareness cannot be equated; thus even if studies were able to show that the former is located in the right hemisphere (and they don't), it would not signify that the latter is produced by the same hemisphere.

Beyond self-recognition

Do other forms of more "mental" self-reflection produce reliably localized brain activation? Does the suggested right hemisphere superiority for self-recognition also apply to autobiographical retrieval, assessment of one's current emotional experience, or description of one's personality traits? Gillihan and Farah (2005) calculated activation maxima gathered across various imaging experiments using self-related tasks and neuropsychological case studies evaluating patients' self-awareness. In a classic personality trait study (e.g., Kelley, Macrae, Wyland, Caglar, Inati & Heatherton 2002), participants 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). Ten personality trait studies in Gillihan and Farah's meta-analysis (2005) reported activation in both the left and right hemispheres, including in the right middle temporal gyrus and inferior parietal lobe, and left inferior frontal gyrus and superior temporal gyrus. In a standard brain-imaging study of autobiographical memory (e.g., Fink, Markowitsch, Reinkemeier, Bruckbauer, Kessler & Heiss 1996), participants are scanned while they listen to a narrative recounting a memory of their own (self condition) and a narrative describing another person's memory (control condition). Gillihan and Farah examined three such studies and found activation in a left-lateralized network that included regions in the frontal, temporal and posterior cortices, as well as the cerebellum and a number of subcortical structures (also see Svoboda, McKinnon & Levine 2006).

Northoff and colleagues (2006) reviewed 27 imaging studies of the self and observed neural activity in the cortical midline structures during self-inferential tasks across many self-domains, including personality traits judgements, autobiographical retrieval, and emotions assessment. In a representative brain-imaging study of emotions (e.g., Goldberg, Harel & Malach 2006), volunteers view various images and are invited to reflect on the emotional response that these stimuli produce; the control task may consist in categorizing the pictures into groups (e.g., colour/black-and-white). Phan, Wager, Taylor and Liberzon (2004) reviewed 55 functional-neuroimaging experiments of emotions and found significant activation in the medial prefrontal cortex, amygdala, anterior cingulate cortex, and insula.

The REST (Random Episodic Silent Thinking) state represents an introspective condition in which participants actively reflect on their current, past, or future goals, emotions, needs, behaviour, physiological sensations, etc. (Gusnard, Akbudak, Shulman & Raichle 2001). In a typical REST experiment (e.g., Mazoyer et al. 2001), participants are simply asked to sit with their eyes closed. The REST condition recruits most brain regions that have also been shown to be active during self-awareness tasks (Wickera, Ruby, Royet & Fonlupt 2003). Schilbach and colleagues (2008) investigated brain areas that are reliably *deactivated* during active tasks: these areas should theoretically be those that are activated at rest but inhibited during cognitively challenging tasks. The team performed a deactivation analysis across 12 fMRI studies requesting cognitive work and observed *decreased* neural activity in the left angular gyrus, bilateral medial frontal cortex, and the precuneus bilaterally.

The quest for localizing self-processes in the brain has led researchers to perform a huge number of imaging studies in numerous self-domains, including self-recognition, traits, autobiography, emotions, REST, intentions, agency, preferences, and mental time travel (see Morin & Hamper 2011 for a review). As seen above, different self-referential tasks engage a wide network of sites located in both hemispheres of the brain. The consensus is that the following regions are recruited during self-related processing: cortical medial structures, which include ventromedial and dorsomedial prefrontal cortex, precuneus, insula, posterior cingulate cortex, left and right temporoparietal junction, and anterior cingulate cortex (Salmon et al. 2008). Figure 2 depicts these brain areas.

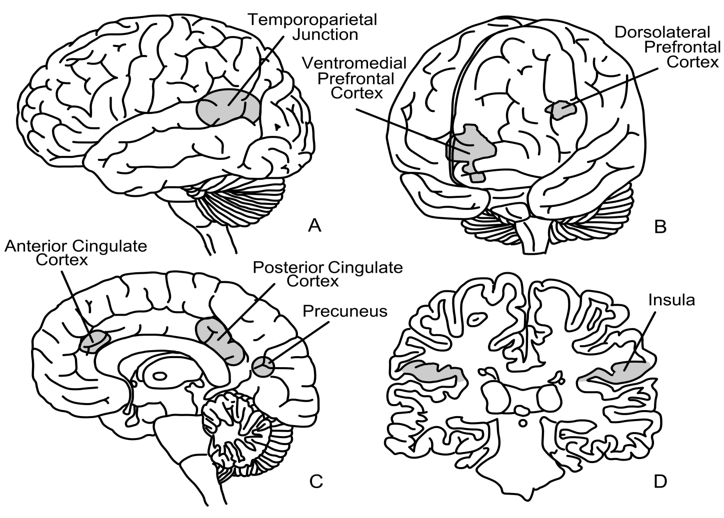

Figure 2. Brain areas known to be involved in self-reflection

The truth about the self-brain problem

The key question that needs to be raised now is: are the above-mentioned brain regions uniquely activated during self-processing? In other words, as Feinberg and Keenan (2005) have asked, “where in the brain is the self?” The answer to both questions seems to be: no(where). One of the very first brain-imaging study of self-awareness (Craik et al. 1999) reported that “every significant activation in the (self condition) was also found in either the (other person condition) or the (general semantic) condition, or both” (p. 30). This is the main point made by Gillihan and Farah (2005): humans’ representation of the self is not special—it is associated with brain areas that are physically and functionally similar to those recruited for general cognitive processing. A unitary system for the self does not seem to exist despite our subjective experience of a unified self. Thus, while early localization studies of the self took a rather phrenological stance, current evidence paints a more distributed and non-localized view of the neuroanatomy of self-awareness (Turk, Heatherton, Macrae, Kelley & Gazzaniga 2003).

Legrand and Ruby (2009) concur and further propose that two general cognitive processes utilized when one is engaged in self-referential processing are memory recall and inferential reasoning. Most self-reflection tasks employed in brain-imaging studies require one form or another of memory and evaluation involving a certain degree of uncertainty (e.g., does this personality trait apply to me?). Consistent with this hypothesis, most brain areas recruited during self-reflection are also activated during memory recall and inferential reasoning.

Inner speech

Background

Let us now address the “how” issue: how do we become self-aware? What are the specific mechanisms underlying self-reflection? Some such mechanisms have been discussed in Morin (2011a)—namely, proprioception, mental imagery, and the social and physical environments. Here the role of language, and more specifically inner speech, will be emphasized.

Inner speech is speech for self articulated silently (e.g., Langdon, Jones, Connaughton & Fernyhough 2009; Zivin 1979). Other related expressions are self-talk (which includes talking to oneself aloud), private speech (audible self-talk emitted by children), phonological loop, self-verbalizations, and internal dialogue (Morin 2011b). Inner speech serves various functions, among which self-control/regulation (e.g., Harris 1990; Tullett & Inzlicht 2010; Vygotsky 1943/1962; Winsler 2009), problem-solving (e.g., Roberts 1979), planning (Lidstone, Meins & Fenyhough 2010; Meacham 1979), memory (including autobiography) (Baddeley & Hitch 1974; Larsen, Schrauf, Fromholt & Rubin 2002), task switching performance (Karbach & Kray 2007), language in general (Levine, Calvanio & Popovics 1982; Verstichel, Bourak, Font & Crochet 1997), and reading (Abramson & Goldinger 1997; Sokolov 1972). Some psychological disorders such as anxiety and depression are mediated by dysfunctional self-talk (e.g., Beazley, Glass, Chambless & Arnkoff 2001). Inner speech represents a fundamental human cognitive activity as about one fourth of people's conscious waking life consists of inner speech (Heavey & Hurlburt 2008). Yet overall, and remarkably, inner speech has been under-studied when compared to other important psychological concepts. To illustrate, only seven out of 32 sampled Introductory Psychology textbooks (21.8%) mentioned inner speech and/or related terms in their subject indexes, and 84.5% of over 100 key psychological terms (e.g., cognitive dissonance, altruism) were cited more often than inner speech in PsycINFO from 1900 to 2009 (Morin 2009a).

One relatively overlooked role played by inner speech is self-reflection (see DeSouza, DaSilveira & Gomes 2008; Martínez-Manrique & Vicente 2010; Morin 2005; Neuman & Nave 2010; Werning 2010). The idea that inner speech is linked to consciousness and self-awareness is not new. Plato (cited in Blachowicz 1999), as well as some contemporary philosophers and psychologists (e.g., Carruthers 1996; Dennett 1991; Dewitt 1975; Flanagan 1992; Jaynes 1986; Mead 1934; Sokolov 1972; Stamenov 2003) have alluded to such a link. What *is* novel is empirical evidence establishing connections between self-reflection and the inner voice.

Empirical evidence

At a very fundamental level, the plain fact that we can talk to ourselves *about ourselves* suggests that inner speech plays a role in self-awareness. Indeed, people report talking to themselves mostly about the self, and more specifically (in decreasing order) when evaluating the self and reflecting on one's emotions, physical appearance, and relationships (Morin, Uttl & Hamper 2011). A significant positive correlation has repeatedly been observed between various validated measures of private self-focus frequency and use of inner speech (e.g., Morin, Everett, Turcotte & Tardif 1993; Schneider 2002; Schneider, Pospeschill & Ranger 2005; Siegrist 1995). This indicates that the more people reflect on the self the more they tend to engage in self-talk—and/or vice-versa. If inner speech plays a significant role in self-referential activities, then the later should be compromised when self-talk is lost following brain injury. This is exemplified by Jill Bolte Taylor's case study (2006), where 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 suggests that this impairment produced 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 (Morin 2009b; Moss 1972). Related to Taylor's case study is the observation by rehabilitated brain-injured patients that their conscious experience returned in parallel with inner speech (Ojemann 1986). Conversely, healthy individuals report inner speech inhibition when they shift from wakefulness to sleep (Rusalova 2005).

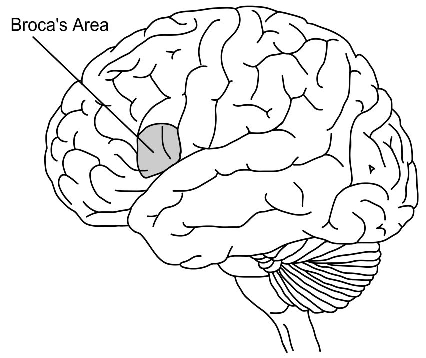

Figure 3. Broca's are, which sustains inner speech production

Both inner and outer speech are produced by Broca's area, also know as the left inferior frontal gyrus (LIFG) (e.g., McGuire et al. 1996). Figure 3 above depicts this location. Based on this observation, Morin and Hamper (2011; also see Morin & Michaud 2007) reasoned that an activation of the LIFG should be found in a significant number of brain-imaging studies of self-awareness. In addition, they predicted that inner speech use should be greater in conceptual-abstract self-domains (e.g., personality traits, autobiography) than in perceptual-concrete self-domains (e.g., agency, self-recognition). To test these ideas, 134 studies measuring brain activity during self-referential tasks were reviewed. Sixty percent of all studies identified LIFG activity across self-awareness tasks, and LIFG activation was more frequently noted during conceptual tasks (70%) than during perceptual tasks (25%). Figure 4 summarizes these results for five self-domains.

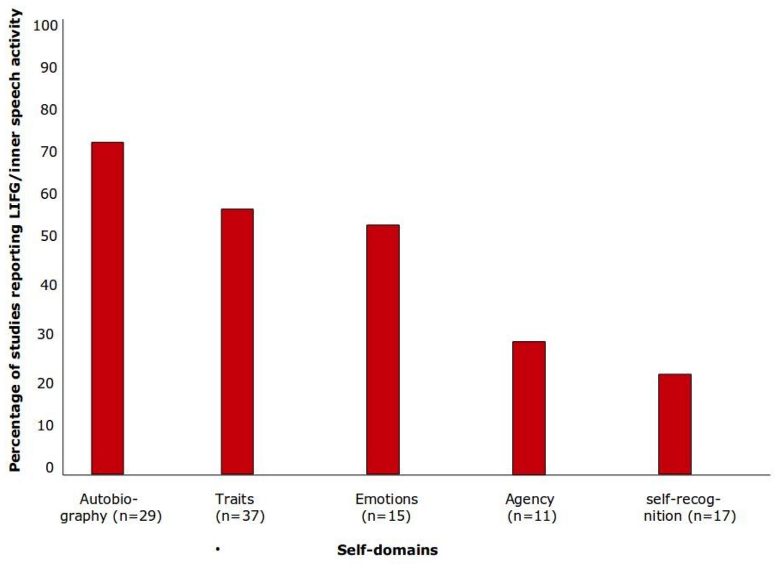

Figure 4. Percentage of studies reporting LIFG/inner speech activity.

One more indirect piece of evidence in favor of a link between inner speech and self-reflection stems from research on autism. One main deficit underlying autism is a poor ability to reflect on oneself, which in turn may be responsible for weak mentalizing abilities—that is, thinking about others' mental states (e.g., Baron-Cohen 2001; Birch & Bloom 2004; Frith & Frith 2003; Silani, Bird, Brindley, Singer, Frith & Frith 2008). A relation between Theory-of-Mind (ToM) abilities and language development has been proposed (Garfield, Peterson & Perry 2001; Milligan, Astington & Dack 2007), as well as between ToM and inner speech (Whitehouse, Maybery & Durkin 2006; Winsler, Abar, Feder, Rubio & Schunn 2007). More specifically, autistic children tend to under-use inner speech when working on various cognitive tasks (Holland & Low 2010) and normal adults perform poorly on a false-belief task under inner speech suppression conditions (Newton & de Villiers 2007). To the extent that ToM and self-awareness both rely on common underlying mechanisms, it is conceivable that deficits in the latter be caused by a failure to use inner speech in autistic individuals.

Theoretical considerations

Why would talking to oneself lead to the acquisition of self-information? Several possibilities exist (Morin 1993, 1995, 2005). One view of consciousness (e.g., Carruthers 1998, 2002) proposes that one becomes aware of a mental state when one generates a higher-order thought about that state. This stance is consistent with the current proposal: one becomes self-aware when one engages in self-talk (higher-order thought) about one's emotions, thoughts, personality traits, physical characteristics, etc.

Self-talk can also reproduce social mechanisms leading to self-awareness. Cooley (1902) noted that people regularly comment on our personal characteristics and behaviors. These reflected appraisals allow one to learn about oneself and can also induce self-awareness. With inner speech one can replicate to oneself appraisals one gets from others. Observations and inferences about one's thoughts, feelings, and behaviors made by others might imprint on one's own inner speech a propensity to address to oneself such remarks. Mead (1934) proposed that encounters with others motivate the individual to take others' perspectives in order to gain an objective point of view on himself or herself. Once in this position, the individual becomes self-aware and can acquire self-information. For example, a person could learn that he or she is patient after observing someone else being rude and impatient in a social setting. Talking to oneself can initiate a fictional dialogue where verbalizations of an objective, and thus different point of view about oneself is possible.

Yet another suggestion is that inner speech can "translate" self-information into a verbal representation; for example, an emotion (self-information) becomes "I feel happy" (verbal representation) once processed by inner speech. This creates a redundancy within the self-system because in addition to the experienced emotion there now is a verbal representation of it, which in turn creates a virtual distance between the self and self-information. This wedge makes it possible for the self to distance itself from what it is currently experiencing (e.g., an emotion), which facilitates self-observation. Figure 5 schematically illustrates this idea. Note here that the dialogical nature of inner speech, in which an individual asks a question and then answers it (see Blachowicz 1999), implies a duality of agency in the conversation that fits well with the present "distance" proposal.

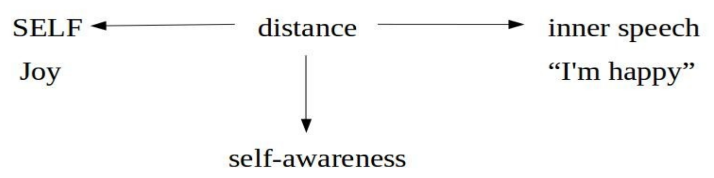

Figure 5. How inner speech is postulated to create a distance between the self and self-information.

Yet another way to look at the role played by inner speech in self-awareness is to conceive the process of self-reflection as being a problem-solving task, and self-talk as being a cognitive tool the individual uses to reach a "solution" to this "problem". The self is thus seen as a question to be solved (i.e., Who am I? What characterizes me? What behavior did I emit?), where the solution represents self-knowledge, and self-information, the data needed to work out the problem. Talking to oneself while engaged in problem solving tasks significantly facilitates the process (e.g., Fernyhough & Fradley 2005). Kendall and Hollon (1981) identified four categories of self-statements that assist the process of problem-solving; these can conceivably be applied to the self as follows. (1) Self-verbalizations permitting the formulation of a clear definition of the problem ("How did I react? [in a given situation]"); (2) self-verbalizations promoting an optimal approach to the problem ("I should try to remember exactly what happened and everything I did"); (3) evaluative self-statements to praise oneself when a solution is reached ("The first thing I did was Z. Then X happened, and I reacted by saying W. Good! I'm getting somewhere!") or when one needs to readjust one's strategy ("What did H [another person] say? No! That's not important—I need to take my time and think more"), and (4) self-verbalizations enhancing focus on the problem ("I don't need to take G [a given event] into consideration because it's not pertinent").

One last view of the nature of the relation between inner speech and self-awareness is that language allows to verbally label self-aspects (McCrone 1999; Zelazo 2004). This is postulated to greatly facilitate the identification of self-information, especially more abstract and conceptual material (Morin & Hamper 2011). To illustrate, one can obviously feel hungry without having to say to oneself "I am hungry", but one most likely will perceive hunger more acutely (and possibly more intensely) if one talks to oneself about this physiological sensation. Some self-aspects (e.g., opinions, values) probably require verbal labeling in order to fully become available to consciousness. Indeed, how could one realize that one is holding anti-semitic attitudes or hedonistic values without verbally labeling these?

Conclusion

In this review we examined the neuroanatomy of self-awareness as it relates to the laterality question, as well as empirical evidence and theoretical hypotheses pertaining to the importance of self-directed speech in self-reflection. Despite early claims to the contrary, it is pretty clear now that the brain areas which sustain self-inferential processes not only are located in both hemispheres of the brain (not just in the right hemisphere)—they are scattered throughout the brain and activated during other non self-reflective tasks. Any proposal that self-awareness is located in the right mute hemisphere entails that language is not involved in the development of a sense of self. This is inaccurate of course, as self-talk is reliably observed during self-reflection tasks and its loss following brain damage produces self-awareness deficits.

Part 1 of this review (Morin 2011a) dealt with issues related to definitions, measures, effects, functions, and antecedents of self-awareness. Combined with the current contribution, these two articles will hopefully provide the reader with a broad view of what we know about our ability to reflect on the self. Some outstanding research questions nonetheless remain unexplored. For instance, why do people differ in terms of frequency of self-focus? Some environmental variables are known to induce or reduce self-awareness (e.g., Carver & Scheier 1978; Diener 1979), but relatively little is known about the potential role of past experiences and psychological dynamics. Similarly, how can we explain individual differences in contents of self-attention? Why is it that some people most frequently engage in positive (self-reflective) self-focus while others more often ruminate about negatively perceived self-aspects (see Trapnell & Campbell 1999)? Another major unresolved issue is the connection between self-awareness and ToM (Dimaggio, Lysaker, Carcione, Nicolo & Semerari 2008; Williams 2010): both are linked but it is unclear which ability precedes the other—or perhaps they develop hand in hand?

Self-awareness arguably represents the crown acheivement of human evolution; but in many respects it still remains highly mysterious.

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