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THE RIGHT HEMISPHERE AND THE DARK SIDE OF CONSCIOUSNESS

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Abstract

Self-awareness and Theory of Mind comprise the main elements of higher-order consciousness. In attempting to localize these abilities, it appears that regions of the right hemisphere including fronto-temporal regions are capable of sustaining a sense of self-awareness. The right hemisphere appears dominant for tasks involving Theory of Mind as well as deception, which may be important for understanding the brain and laterality in terms of evolution. These findings are critical for our understanding of hemispheric differences in terms of higher-order consciousness.

Key words: self-awareness, consciousness, right hemisphere, deception, evolutionary, cognitive neuroscience

In localizing any cognitive or behavioral event in terms of brain function, we have suggested that the brain be visualized as a mobile (Keenan, 2001). With millions of neurons and billions of connections, the brain lies in a precarious balance. The brain, often perceived as being composed of ‘modules’, ‘areas’, and ‘regions’, is a highly dynamic and integrated system. Like the mobile, distal activity can affect discrete elements. Disruption to a module is rarely an isolated event, even if such disturbance lies below our ability to detect such effects. The brain exists in a balance based on interconnectivity.

Such an analogy is prudent when attempting to exact any given phenomena to its brain underpinnings. In particular, when describing complex cognitive events, one must keep in mind that modules of the brain do not exist in isolation. Even when describing events on the level of hemispheric differences, which we will do, it is acknowledged and encouraged to view the brain as an entire entity such that we consider both the distal and proximal occurrences of phenomena. In terms of consciousness, this view is a necessity.

Researchers who are interested in localizing consciousness must relate two complex phenomena. The brain, certainly one of the least understood ‘phenomena’ in our universe, defies even more than a basic description. In terms of consciousness, the second of the elusive phenomena, we are also faced with a difficult task involving description. There are seemingly as many definitions of consciousness as there are ‘consciousness researchers’. Therefore, precision in our definitions and measurements is critical to any researcher attempting to investigate the brain correlates of consciousness.

If one examines the definition of consciousness in the *Oxford Dictionary* (3rd ed.), three basic concepts emerge. The first concept relates to what can be viewed as a ‘medical definition’. Here an individual is considered conscious if he or she is aware of any stimuli, internal or external. Conversely, an individual who is unconscious under this category would not be aware of events such as flashing lights or the sound of a voice. He or she would likely be unaware of his or her own thoughts, and such ‘consciousness’ is typically graded on scales that are used to assess basic autonomic functions. Further, we imagine that all animals, at some level, have this ‘medical’ consciousness.

The two other definitions of consciousness can be ascribed the term ‘higher-order consciousness’. The first involves a knowledge or awareness of one’s inner thoughts or knowing that the self, is a separate, individual, entity. Related to this is the final definition which involves a co-knowing, or a shared, mutual knowledge. These definitions of higher-order consciousness relate to two common constructs in psychology: Self-awareness and Theory of Mind.

Self-awareness involves being aware of one’s own thoughts, or mental state. It includes having the ability to reflect on one’s own cognitions. Further, self-awareness includes the ability to think about oneself as an entity in the third person, allowing for imagining oneself in the future or in the past. Theory of Mind can be referred to as mental state attribution or mindreading. Theory of Mind involves the recognition that other minds are possible, and the individual may be privy to thoughts of another.

Self-recognition and Self-awareness

In 1970, Gallup published one of the most important findings in consciousness research. Shaving in his bathroom, Gallup wondered if other animals have the ability to recognize their own face. To test this possibility, Gallup first placed a group of chimpanzees in front of a mirror for 10 days. After 10 days of exposure, the chimpanzees were placed under anesthesia and a mark was applied above the eye ridge. Upon awakening, all of the animals immediately directed touches towards the marks placed on their foreheads, indicating that the animals were capable of recognizing themselves in the mirror. The touches occurred while the animals were in front of the mirror (indicating the animals were employing the mirror to self-investigate).

Gallup also tested a group of monkeys and he found that they did not make mark-directed responses to the mirror. Gallup concluded that it was only the chimpanzees that had the ability to recognize themselves in a mirror. Following his initial publication, the results of his study have been replicated numerous times. The findings indicate that chimpanzees and orangutans are capable of self-recognition, while monkeys are not (Kitchen et al., 1996; Lin et al., 1992; Lethmate and Ducker, 1973; Gallup et al., 1980; Povinelli et al., 1993). The gorilla is found to be non-self-recognizing under rigorous testing, though there are indications that this species may have some form of self-recognition (for discussion, see Keenan et al., 2003). In non-primates, the only other animal that may possess self-recognition is the dolphin, though testing must be modified from the original Gallup test (Gallup, 1995; Marino et al., 1994; Reiss and Marino, 2001). These data remain disputed (see Keenan et al., 2003).

It is noted that Gallup was not the first researcher to turn to a mirror to investigate self-awareness. To our knowledge, the first published report appeared in 1828 (Grant, 1828). In this report, an orangutan was presented with a mirror, and the animal's response was compared to the reaction of monkeys. Grant reported no positive signs of self-recognition, though he noted the orangutan's response differed from the responses observed in monkeys. A number of other researchers, including Charles Darwin (1877, 1898) and Wolfgang Kohler (1925, 2000), employed a mirror to test for signs of self-awareness in primates and humans prior to Gallup (e.g., Schmidt, 1878; Preyer, 1889; Yerkes and Yerkes, 1929).

The question, however, is as follows: Does self-recognition equal self-awareness? That is, does the fact that the chimpanzee can pass the mark test indicate that it is capable of 'monitoring its inner thoughts' or 'thinking of its own thinking'? This answer is difficult to arrive at, as most primates do not report on their own thoughts. Yet, in one orangutan, it was found that passing the mirror test correlated with the use of the sign 'I' and 'Chantek' (the animal's name; Miles, 1994). To answer the question, researchers have tested infants and applied a similar correlational method.

Infants generally pass the mirror-recognition test around the age of 18 months, and self-recognition almost never appears before 14 months in the normal child (Amsterdam, 1972; Anderson, 1984). Before this age, infants react to the mirror as if the image in the mirror is another individual, much like the reactions of the non-human primates that are not capable of recognizing themselves in a mirror. By examining infants, researchers have a better opportunity to examine the relation between recognizing the self and self-awareness.

Lewis has provided strong evidence that self-face recognition is a definite indicator of self-awareness (Lewis et al., 1989, 1990; Lewis, 1990, 1993, 1992). Lewis has correlated indicators of self-awareness with passing the mirror test. For example, he has found that only children that pass the mirror test exhibit self-conscious emotions (i.e., emotions that require a sense of self) such as shame, guilt, and pride. In children that do not pass the test, such emotions are not exhibited.

This is not to say that prior to 18 months, infants do not exhibit emotions. However, emotions that require a sense of self (such as shame) do not appear until the infant makes a mark-directed response in the mirror. Lewis, in these studies, has also found that insecurely attached infants pass the mirror test earlier than securely attached infants. Lewis reasoned that infants that are insecurely attached, gain a sense of self earlier, and thus pass the mirror test earlier. It has also been found that personal pronouns such as 'I' and 'me' are correlated with the timeline of self-recognition (Imbens-Bailey and Pan, 1998).

Theory of Mind (Premack and Woodruff, 1978), or mental state attribution, appears related to self-recognition and self-awareness (Gallup, 1982). It appears that understanding one's own mind is a pre-requisite for understanding the mind of another person. For example, the primates that demonstrate self-recognition (i.e., chimpanzees and orangutans) appear to pass Theory of Mind tasks whereas animals that fail Gallup's test do not exhibit Theory of Mind (de Waal, 1996, 1998; Povinelli et al., 1990, 1992a, 1992b). These tests involve taking the perspective of another in experimental settings or in the field. For example, a chimp may be placed in a setting where two humans see food placed under a cup. One of the humans is blindfolded, the other is not. The chimp then has to trust the judgment of one of the humans. The correct choice, obviously, would be trusting the judgment of the person that is not blindfolded. Though chimps do not pass all Theory of Mind tests, they certainly demonstrated evidence for it, and they definitely outperform monkeys. These data also remain controversial (for discussion, see Keenan et al., 2003).

In direct tests in humans, there also appears to be a relation between understanding one's own thoughts and the thoughts of another. Gopnik has performed research correlating the understanding of self and other (Gopnik and Meltzoff, 1994). She has found that around the age of four is when children pass complex Theory of Mind tasks. Further, passing these tests appears to be correlated to understanding one's own mind. Signs of Theory of Mind do appear earlier, in fact, close to the age where self-recognition appears. True deception, which requires thinking about another person's thoughts, emerges by the age of two, with children becoming expert deceivers by the age of five (Ritblatt, 2000).

Therefore, most researchers agree that there is a relationship between self-recognition, self-awareness, and Theory of Mind. Recognition of one's own face appears to be related to an inner state of self, and self-awareness is related to a Theory of Mind. This very brief review of the literature indicates that the self-face may be an ideal stimulus to begin the investigations of higher-order consciousness and the brain.

The Right Hemisphere and the Self

If one examines the brain in terms of hemispheric function, the right hemisphere is typically mute. The ability to make a verbal response to a presented stimulus is typically only possible when the left hemisphere is engaged. Classic speech areas are located within the left hemisphere, thus making the testing of the right hemisphere difficult. Therefore, the right hemisphere is unable to report on its own consciousness. Historically, this has lead to the idea that the right hemisphere is the 'minor' hemisphere. The left hemisphere, dominant for language, is also dominant for motor abilities. These two facts have lead to a left hemisphere 'bias' in the thinking of the brain and cognition that dates back to the 3rd century BC (Finger, 2000).

This idea did not go unnoticed by Sperry, noted for his examinations of split-brain patients. In the split-brain patient, the fibers connecting the two hemispheres are severed. The cutting of theses fibers (the corpus callosum) separates, at some level, communication between the two hemispheres. This allows for the testing of the functions of each hemisphere separately.

Taking advantage of this, Sperry et al. (1979) and Preilowski (1977) performed a number of studies to determine the 'consciousness' of the hemispheres. Sperry, along with colleagues introduced their article as follows:

"Contentions that the minor hemisphere is wholly lacking in conscious awareness have largely given way in recent years to a modified position which concedes that the right hemisphere may possess elemental forms of subjective awareness but denies the presence in the minor hemisphere of the higher reflective self-conscious type of mental awareness that characterizes the human brain and which is needed, so it is said, to qualify a system as a person" (DeWitt, 1975). Self-consciousness appears to be almost strictly a human attribute, according to present evidence drawn mainly from mirror self-recognition tests (Gallup, 1977). It seems not to be found in animals below the primates, and only to a limited extent in the great apes. In human childhood self-consciousness makes its appearance relatively late in development, appearing first at around 18 months of age (Amsterdam, 1972). Thus, ontogenetically as well as phylogenetically self-consciousness can be rated as a relatively advanced stage of conscious awareness (pp. 153-154).

This description aptly summarizes the application of Gallup's test and the need to test the right hemisphere for consciousness.

In their study, Sperry et al. (1979) presented faces, including the own-face, to the right hemisphere (he cited a previous presentation where the left hemisphere was found to recognize the self-face). He found that the right hemisphere had a robust and emotional reaction to the self-face. Certainly, the right hemisphere was capable of self-recognition. He concluded that the right hemisphere was at least equal to the left in terms of consciousness.

However, two years before this report, Preilowski measured skin resistance in split-brain patients. By monitoring activity in each of the hands, it was possible to find the degree of physiological response evoked by the self-face. Preilowski tested two split-brain patients. It was found that in the patients, there was almost no difference between the brain activity of the hemispheres when familiar faces were presented. When, however, self-faces were presented, a robust difference emerged between the hemispheres. In the first patient, the right hemisphere had more than twice the activity of the left hemisphere when the self-face was presented. In the second patient, when the self-face was presented, the right hemisphere was about one and a half times more active than the left hemisphere. Further, looking within each hemisphere, a right/left difference emerged. The left hemisphere made a small distinction between the self and familiar faces. However, in both patients, the right hemisphere had more than twice the activity for the self-face compared to the familiar faces.

These data strongly indicated that the right hemisphere was not only as capable as the left in terms of self-recognition, but was in fact dominant in terms of response. There was surprisingly little follow up to either of these papers. In fact, these papers remain somewhat obscure, perhaps because the findings are counter to the 'left is consciousness' idea.

In 1995, we began investigating the neural correlates of self-face recognition using a variety of techniques. In our first study, we examined the cortical correlates of self-face recognition by use of fMRI. Employing a photograph of the self-face, which we contrasted with the face of a famous person (Bill Clinton), we presented these images in the scanner (Keenan et al., 2001). Under each of the images, we also placed descriptors (e.g., 'I think' or 'He thinks') to help the subjects pay attention. Contrasting the self-face with the famous face, we found that the right prefrontal cortex was active for the self-condition. These data appeared to support the findings of Preilowski, and the right hemisphere as being dominant for the self (Keenan et al., 2000).

In a similar experiment, subjects were presented with their own faces contrasted again with a famous face. However, we also presented the own-voice to the subjects as well. As with the first experiment, we found that the right prefrontal cortex was activated. Activation occurred in both the self-face and self-voice conditions (Keenan et al., 1999).

Other groups have examined both self-faces and self-voices. These researchers employed PET in their investigations of self (Sugiura et al., 2000). The first of their experiments involved both 'passive' and 'active' self-face recognition. The step of the experiment involved taking a series of pictures of the subjects. After taking the pictures, the researchers manipulated the images by tilting the photographs at different angles. The researchers also included a series of non-self-faces that were tilted as well. These faces were used for a series of different conditions. The basic premise was that the subjects were asked to evaluate the 'angle' of each of the faces.

In the 'control' phase of the experiment, the subjects viewed non-familiar faces during PET scanning. In the 'passive' condition, the subjects were not told they would be seeing their own face but they were simply asked to determine the angle of the face. However, the faces included self-images, allowing the researchers to determine the areas of activity related to self-face recognition, even when the task was not to find the self-face. The last condition was the 'active' condition. In the active condition, the subjects were informed that they would be presented with their own face. They were instructed to specifically look for their own-face, thus the recognition was 'active'.

The data were analyzed in a number of ways. First, comparing the passive self-faces (e.g., they were not attending to them) to control faces, the overall area activated in the right hemisphere was 1.26 times greater than the area activated in the left. There were no laterality differences when the active and control conditions were compared. A large difference was found favoring the right hemisphere when active and passive viewings were compared. In this contrast, the researchers found that number of regions active in the right hemisphere was 2.18 greater than in the left hemisphere.

The regions activated within the right hemisphere included the right frontal and right cingulate areas. The left hemisphere activity was localized in the fusiform gyrus, which is involved in general face recognition (this indicates that the left activity was indicating face recognition rather than self-awareness). These data are similar to those found by Tanaka and Porterfield (2002). Tanaka also examined both the active and passive recognition of self-faces using ERPs. What Tanaka and Porterfield (2002) found was that the self-face, during both active and passive recognition preferentially activated regions of the anterior right hemisphere. The differentiation of the self-face from other faces occurs at about 170 msec from face presentation. Incredibly, such differentiation in the right hemisphere occurs whether the subject is attending to his or her own-face or not. Just the presentation of the self-face is enough to activate the right hemisphere. In another fMRI experiment involving self-faces, it was found that self-faces compared to unfamiliar faces activate 1.8 times more area in the right hemisphere. When self-faces are contrasted to familiar faces, the activity is still 1.3 times as great. Further, the activity in the left hemisphere is again dominated by the fusiform gyrus (Kircher et al., 2001).

As indicated, Sugiura et al. (2000) also performed self-voice recognition experiments. Employing PET again, the researchers contrasted listening to the self-voice with listening to non-self-voices (Nakamura et al., 2001). The researchers also included a control condition, which included a basic grammar task. It was found that the familiar voice activated a number of regions in both hemispheres. When the self-condition (hearing one's own voice) was compared with the grammar condition, the main area of activation was within the right hemisphere, with most activity in the frontal cortex. There was a lesser degree of left frontal involvement as well. However, once the role of the familiar voice was taken out, leaving only self, it was only the right hemisphere that was activated, specifically within the right frontal cortex.

To further investigate the role of self-faces, we developed a series of morphing tasks. The morphing tasks involved the combining of the self-face with other faces. The benefit of such morphing is that it allows the self-face to become a quantitative, dependent variable. That is, no longer is a face either self or not self, but one can construct a face that is, for example, 40% self, and 60% not-self. This allowed for the measurement of self along a continuum.

In the first of the morphing experiments, it was discovered that there were hand differences in identification rates. Previously, it was found that

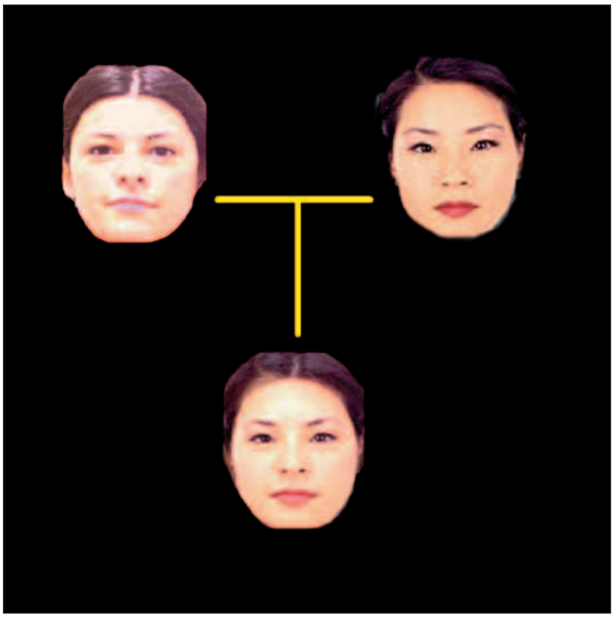

Fig. 1 – *A sample morph used in a variety of experiments. Here Lucy Liu is being morphed to a subject and a 50% has been created. The right hemisphere appears to 'see' the morph as self whereas the left hemisphere 'sees' the morph as being famous.*

self-faces (non-morphed) were more rapidly identified when the subjects were using their left hand (indicating a right hemisphere advantage). In this study, the reaction time for the self-face, with the left hand was significantly quicker than reaction times to the self-face with the right hand (Keenan et al., 1999). Further, the left-hand, self-advantage existed for both upright and inverted faces. It has been suggested that inverted faces are processed in the brain not like faces, but rather like objects. Therefore, finding such an advantage for inverted faces indicated that the left hand advantage was not unique to self-faces, but rather self-stimuli.

These findings were extended using morphs. Subjects were presented with their own-faces in a series of 'morphs'. For example, a male subject was morphed into Bill Clinton in steps of 5%. The subjects were then asked to identify their face in these morphs. When using the left hand (engaging the right hemisphere), subjects tended to see themselves more often in the morphs (Keenan et al., 2000). These data were replicated and extended by Platek and Gallupp (2002) who found a similar left hand advantage. However, they also found that the laterality effect varied in terms of schizotypal personality traits that may be a measure of self-awareness. Using a survey measure of schizotypal traits, Platek found that subjects that were less schizotypal (and possibly more self-aware) exhibited a greater left hand advantage. Those subjects that were classified as more schizotypal (possibly less self-aware) did not have any right or left hand differences in response.

To determine the hemispheric processing of the morphs, we employed the WADA test. The WADA test is used to identify hemispheric dominance in pre-surgical patients. Briefly, each hemisphere is given anesthesia, which temporarily inactivates each hemisphere. This technique is typically used to determine which hemisphere is critical for memory or language, which assists in deciding which areas to remove during surgery. Using the morphs, we examined a series of patients undergoing the WADA procedure.

During anesthesia, the patients were presented with a 50/50 morph, with half of the face being their own image and half being the face of a famous person. The patients were simply asked to remember the face during the anesthetization of each of the hemispheres. Once they recovered from the anesthesia (approximately 5 to 10 min), the patients were asked which face they were presented with: their own-face, or the face of the famous person. Note that neither face was presented, rather it was a combination of the two. When the right hemisphere was inactive, patients tended to think that the presented face was the face of a famous person. However, when the right hemisphere was intact, the patients thought that the face presented was their own (Keenan et al., 2001). These data were followed up with normal subjects where it was found that presenting self-morphs increased right, but not left, hemispheric activity.

Patient data also indicate that there is a right hemisphere dominance in the self. Specifically, the data on 'mirror sign', indicate the right hemisphere is critical to self-recognition. Mirror sign is the inability to recognize the own-face even though general face recognition is normal (i.e., there is no prosopagnosia). In all of the cases of mirror sign reported, there is direct evidence that the right hemisphere is disrupted (Feinberg et al., 1990; Feinberg, 2000; Breen et al., 2001; Spangenberg et al., 1998; Breen, 1999). TMS delivered to the right prefrontal cortex can both inhibit and facilitate self-face recognition, confirming these data (see Figure 2, p. 700).

It has been argued that emotional valiance may explain the self-face/right hemisphere effect. Preilowski (1977) recognized this in the initial self-face experiment. To control for emotionality, he presented other highly emotional stimuli and found that it was the self-face (and not other emotional stimuli) that resulted in a significant right hemisphere increase in activity. We have found the same in a split-brain patient (data under preparation). Regardless of emotion, it was the self-face that resulted in a right hemisphere dominance.

Other self-recognition deficits also occur following right hemisphere damage. Asomatognosia is a disorder that involves misidentifying parts of one's own body (usually limbs), and it usually involves thinking that one's arm or leg belongs to another person or is an inanimate object. Feinberg (2000) has described quite a number of these cases. He notes that a patient will think that his arm

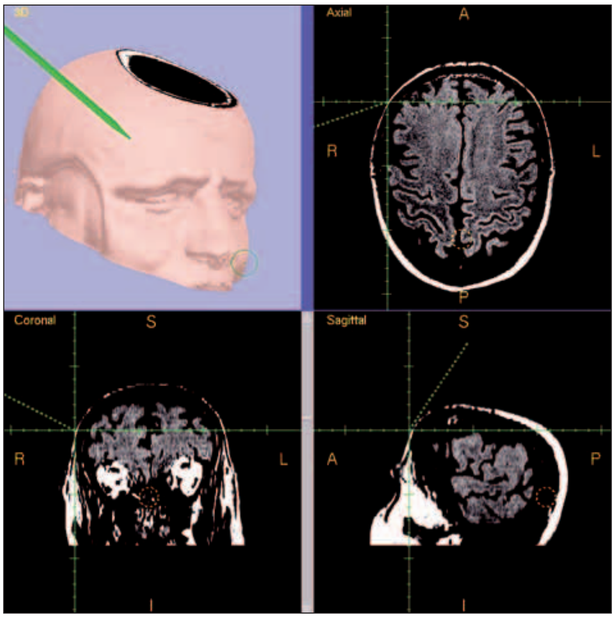

Fig. 2 – *A stereotaxic map of TMS delivered to the right frontal cortex. TMS applied to the right prefrontal cortex both inhibits and facilitates self-recognition depending on the parameters employed. TMS (and rTMS) delivered to the left prefrontal cortex has no effect.*

belongs to a doctor or a dead relative. These claims by the patient are made without a general dementia, that is, the patient is lucid in all other aspects of cognition. Feinberg notes that of the hundred or so cases that he knows of, never has there been a case of asomatognosia following left hemisphere damage.

Anosognosia involves a denial that there is damage or paralysis to a person's body. Typically a patient has suffered damage to a brain region that results in paralysis. The patient believes, however, that the damaged limb is fully functioning. Anosognosia, like asomatognosia is also associated with right hemisphere damage (Bisiach et al., 1986; Feinberg et al., 1994; Starkstein et al., 1992). Using the WADA test, researcher are able to induce both asomatognosia and anosognosia (Meador et al., 2000). It has been found that following right hemisphere anesthesia, both occur in patients at high rates (over 80%).

Patients suffering from right hemisphere damage, particularly fronto-temporal, can experience a disruption of autobiographical memory (Levine et al., 1998). Hans Markowitsch has described a number of cases where damage to the right fronto-temporal cortex leads to a selective loss of autobiographical memories (Markowitsch et al., 1993, 1997, 1999; Markowitsch, 1995), leading to the hypothesis that episodic, personally recalled memories are right hemispheric dominant, while semantic memories are left hemisphere dominant.

Stuss has long argued that the right prefrontal region is critical for the maintenance of self-awareness (Stuss and Alexander, 2000; Stuss et al., 1992; Stuss, 1991; Stuss and Benson, 1986). Noting that patients have an altered, often dramatic change in self following right hemisphere damage, he has argued that our sense of self is critically intermingled with the right prefrontal regions. Citing William James's idea that the self can be construed as a consistent entity across time, Stuss has found that patients with right prefrontal damage lose such continuation. These data were recently confirmed by Miller et al. (2001) who found that patients that exhibit dramatic shifts in self are almost always suffering from damage to the fronto-temporal region.

Therefore, along numerous dimensions, the right hemisphere appears dominant for self-awareness.

The Dark Side of Consciousness

The evidence that there is a right hemisphere bias in terms of self-awareness is overwhelming. Yet, to explain the existence of self-awareness, one might turn to an evolutionary analysis. Put simply, for any brain function to exist, its benefits should outweigh the costs. The cost of developing and maintaining brain tissue is inherently expensive, and the addition of any brain function must result in benefit.

While this is an extreme over-simplification of the evolutionarily approach (e.g., it disregards the possibility of pleiotropic explanations), the idea is intuitively practical for examining brain/behavior relationships. It can be assumed that the processes of self-awareness and theory of mind require a great deal of energy to maintain. While no specifics are available in terms of the degree of energy these abilities consume, researchers are currently examining this question (Raichle, personal communication). It is assumed that these processes are expensive, and an evolutionary approach would examine what benefit these abilities would provide to 'offset' such a cost.

We have known that the right hemisphere is dominant for quite a number of processes, such as spatial awareness and many emotional processes (Joseph, 1988). Certainly self-awareness is not the only function of the right hemisphere. However, it is quite definite that the amount of brain tissue and function dedicated to self-awareness is great. To outweigh the cost, self-awareness must provide substantial benefits. Therefore, we must look to the advantages that a self-aware individual would have compared to his or her non-self-aware colleague.

One can imagine on the African plain that those individuals that were self-aware would secure a slight advantage by being able to groom themselves and thus increase reproductive opportunities. The self-recognizer would also not waste resources attacking an 'enemy' which was merely a reflection, perhaps in a pool of water. These benefits are obviously minimal and would not justify the cost of maintaining the surplus brain tissue. A larger advantage would be derived from what we have termed 'cognitive goldilocks' (Keenan et al., 2003; this term is identical to 'chronesthesia', in Tulving, personal communication). Just like the tale, cognitive goldilocks allows one to test out a variety of scenarios. Having a concrete sense of self allows an individual to cast him or herself into the past and future. We are able to imagine our selves in a variety of situations. This casting would have a certain benefit, as one would be able to judge beforehand the possible advantages and disadvantages of different actions in different situations. Certainly this would provide a tremendous evolutionary advantage.

However, most researchers turn to Theory of Mind to explain the benefits of self-awareness. Theory of Mind, as indicated, is the ability to model the mental state of another individual. It has been found that there is a relationship between self-awareness and Theory of Mind in both humans (Gallup, 1998a; Gopnik and Meltzoff, 1994) and non-human primates (Gallup, 1998b) such that self-awareness appears to be a necessary condition for Theory of Mind. Further, there is good evidence that tasks requiring Theory of Mind engage the right hemisphere.

Early neuroimaging studies were non-conclusive in terms of localizing Theory of Mind (Fletcher et al., 1995; Goel et al., 1995; Gallagher et al., 2001). However, as neuroimaging techniques have improved, it is being revealed that the right frontal region is dominant for Theory of Mind (McCabe et al., 2001). Kai Vogeley, a German researcher, has performed the critical experiment, which examined both self-awareness and Theory of Mind employing fMRI (Vogeley et al., 2001). In his research, he found that the right frontal cortex is critical for tasks that involve thinking about one's own thinking (self-awareness) and thinking about another person's thinking (Theory of Mind). In both conditions, the right prefrontal and right cingulated regions were involved.

Other evidence suggests a relationship between the right hemisphere and Theory of Mind. For example, persons with both Autism and Asperger's disease have Theory of Mind deficits that are quite similar to right hemisphere damage (Ellis and Gunter, 1999). Finally, right hemisphere damage leads directly to difficulties in Theory of Mind (Happe et al., 1999; Stone et al., 1998; Shammi and Stuss, 1999).

With the right hemisphere so involved in both self-awareness and Theory of Mind, the benefits can be fully elucidated. In fact, it has been indicated that the true benefit of self-awareness relates to Theory of Mind. By having the ability to 'enter the mind of another', one has the capability to benefit from a myriad of complex, rich, social interactions. For example, empathy, which involves the perspective taking of another individual, is critical to the formation of advanced societies. The benefit of having empathy is certain as it allows for elaborate relationships.

While this is the typical thinking in terms of the benefits of self-awareness and Theory of Mind, we assume that an equally powerful benefit is derived from being able to deceive.

Deception, or the dark side of consciousness, may provide one of the greatest advantages when considering the costs and benefits of self-awareness and Theory of Mind. Simply, a tremendous advantage would be bestowed upon the individual that could deceive as compared to the individual that could not deceive. Such an advantage would justify the 'cost' associated with maintaining extra brain matter. Therefore, it is postulated that one of the advantages of higher-order consciousness is the ability to deceive, as well as detect deception.

To be an effective deceiver, one improves his or her chances of success if he or she is able to understand the mental state of another person. For example, my friend once forgot to pick up the dry cleaning. Knowing his wife would be mad, he tried to deceive her. Knowing that she was going to walk by the dry cleaners the next day, he knew not to tell the lie "The dry cleaners burned down". That would be evidence of a poor understanding of her mental state. Instead, the lie "I was actually going to stop by, but I had to rush home so that I could take you out to dinner", was much more effective.

This simple example suggests that individuals that are able to monitor others' mental states are more effective deceivers. While this is an over simplification of a complex subject, the idea remains. If one can deceive, and deceive successfully, a certain advantage is generally secured.

Children deceive at an extremely high rate, with deception beginning around the age that self-awareness appears (Chandler et al., 1989; Lewis et al., 1989; Ritblatt, 2000). These studies have revealed that deception correlates with abilities on other Theory of Mind tasks, such that the better a child is at modeling mental state, the more likely he or she is to deceive. Further, animals that are self-aware (such as the chimpanzee) engage in deception, while monkeys are not seen as deceivers (de Waal, 1988).

Both deception and deception detection are correlated with the right hemisphere (Modell et al., 1992; Porter et al., 2002; Sellal et al., 1993; Spence et al., 2001; Stuss et al., 2001; see also Langleben et al., 2002). These studies, both neuroimaging and patient reports, support the hypothesis that deception may be one of the adaptive roles of the right hemisphere. Ganis et al. (2003) have in fact recently confirmed these findings employing high-resolution fMRI. He found that multiple types of deceptions are correlated most significantly with activity in the right prefrontal cortex.

Recently, we have begun to examine the relationship between self-awareness, Theory of Mind, and the right hemisphere. We found that survey measures of self-awareness correlated with deception detection ability (Malcolm and Keenan, 2003). Specifically, it was found that as self-awareness increased, deception detection ability also increased. We also found that it was the right hemisphere (and not the left) that had a true relationship in terms of self-awareness and deception detection. Similar findings are being reported by Barnacz et al. (2004). They also found a correlation between right hemisphere performance and deception detection such that greater right hemisphere involvement lead to better deception detection.

Interestingly, it appears that the left hemisphere often fills in information that it is unaware of. This has led some to the idea that the left hemisphere is the interpreter (Gazzaniga, 1998). However, the filling in of left hemisphere does not require insight, self-awareness, or any higher-order state. The left hemisphere appears to do so in a rather blind manner. Thus, the idea that consciousness is a left hemisphere phenomenon (in terms of interpretation) is not supported. The right hemisphere, in fact, truly interprets the mental state not only of its own brain, but the brains (and minds) of others.

We therefore find that the data support the hypothesis that the right hemisphere is dominant for higher-order consciousness. Further, it is possible that the right hemisphere may have sustained such higher-order consciousness by providing deception, which would gain a significant advantage in terms of primate evolution.

The dark side of consciousness, namely deception, may be an effective way of understanding the sustaining of such complex and 'expensive' phenomena as self-awareness and Theory of Mind.

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