

## Beyond Consciousness of External Reality: A “Who” System for Consciousness of Action and Self-Consciousness

Nicolas Georgieff<sup>1</sup> and Marc Jeannerod

*Institut des Sciences Cognitives, 67 Boulevard Pinel, 69675 Bron, France*

This paper offers a framework for consciousness of internal reality. Recent PET experiments are reviewed, showing partial overlap of cortical activation during self-produced actions and actions observed from other people. This overlap suggests that representations for actions may be shared by several individuals, a situation which creates a potential problem for correctly attributing an action to its agent. The neural conditions for correct agency judgments are thus assigned a key role in self/other distinction and self-consciousness. A series of behavioral experiments that demonstrate, in normal subjects, the poor monitoring of action-related signals and the difficulty in recognizing self-produced actions are described. In patients presenting delusions, this difficulty dramatically increases and actions become systematically misattributed. These results point to schizophrenia and related disorders as a paradigmatic alteration of a “Who?” system for self-consciousness.

© 1998 Academic Press

### INTRODUCTION

The most commonly studied aspects of consciousness relate to awareness of external reality: they deal with perceptual questions such as “What is it?” and “Where is it?”, that the self has to resolve about objects in its environment. At variance with these studies, the present paper deals with a rather poorly explored aspect, consciousness of action. This is an important problem, however: action is an internally generated event, it relates to the productions of the self, and, for this reason, may be more closely related to self-consciousness.

Action will not only be considered here with respect to its overt appearance—a set of muscular contractions producing observable movements. Its description will also include the covert aspect which corresponds to the internal representation of its goal and of the means to achieve that goal (see Jeannerod, 1994). It will be postulated that the two aspects, covert and overt, of an action bear a close relationship to each other, such that they are parts of a single phenomenon (the representation–execution continuum). Although it is becoming commonplace in current cognitive research, this postulate bears important logical consequences, namely, that an overt action necessarily involves a covert counterpart, and that a covert action does not necessarily involve an overt counterpart. This asymmetry raises a methodological issue that can only be solved, in classical psychology, by inferring the properties of the covert part from its behavioral counterpart (e.g., by measuring reaction times). More recently, however, the introduction of objective methods for measuring brain activity provides

<sup>1</sup> Address reprint requests to Nicolas Georgieff, Institut des Sciences Cognitives, 67 Boulevard Pinel, 69675 Bron, France.

a direct access to purely internal states, even in the absence of any behavioral manifestation (see Jeannerod, 1999).

The above distinction between covert and overt aspects of an action overlaps with another one, that between "automatic" and "voluntary" actions. This dichotomy has often been used as an argument for the existence of two routes to action: automatic actions would be directly triggered by external events, as opposed to purposively generated actions which would originate from within (see Shallice, 1988). Although it seems highly relevant to the problem of consciousness of action, this distinction may not be valid conceptually for opposing modes of action generation. Indeed, even an action triggered by an external event or situation should not be considered as devoid of an internal counterpart (a representation, as crude as it may be). The fact that such actions can be corrected during execution (i.e., within delays too short to rely on sensory cues; Paulignan, McKenzie, Marteniuk, & Jeannerod, 1991) implies that they are based on an internal model to which erroneous execution can be compared. The absence of conscious representation of the goal in certain actions (a prerequisite for automaticity) therefore does not mean that a representation of the goal does not exist. Searle's distinction between an "intention in action" (the implicit step that precedes an overtly executed action) and a "prior intention" (the conscious desire to do something) (Searle, 1983) might represent a framework for discussing differences between what is commonly understood by "automatic" and "voluntary," respectively.

There are several interrelated aspects of consciousness of action to be considered. The first deals with the question of whether a subject is aware of his/her own actions, and whether he or she may or may not be able to make conscious judgments about them. This question will be discussed together with that of action-related signals, i.e., those signals generated by the various stages of the representation-execution continuum. The second aspect to be considered relates to how an action is attributed to its proper origin or, in other words, how a subject can make a conscious judgment about who is the agent of that action (an agency judgment). This question is central to the problem of self-consciousness: action is one of the main channels used for communication between individuals, so that determining the agent of an action contributes to differentiating the self from other selves.

The contribution of pathology to these issues will be examined in the last section of the paper. Arguments will be presented showing that some of the symptoms met in schizophrenia can be considered a specific disorder of agency. This pathological condition offers a striking illustration of a dissociation between different aspects of consciousness of action, such that a self-produced action can be correctly perceived and described, whereas, at the same time, it can be systematically misattributed.

## TYPES OF MOTOR REPRESENTATIONS. THE CONTRIBUTION OF NEUROIMAGING

Motor representations can be of different types, according to the context in which an action is generated. Studying the pattern of brain activity during the process of generating an action, either limited to its covert part, as in intending or mentally

simulating, for example, or also including overt motor performance, reveals that activated areas partly overlap during different types of representation. During mental simulation of movement of the right hand, activity increases in several areas directly concerned with motor behavior. At the cortical level, the primary motor areas, area 6 in the inferior part of the frontal gyrus and area 40 in the inferior parietal lobule, are activated on the left side. Subcortically, the caudate nucleus is activated on both sides and the cerebellum on the left side only. Another focus of activity is observed in left prefrontal areas, extending to the dorsolateral frontal cortex (areas 9 and 46) (Decety, Perani, Jeannerod, Bettinardi, Tadary, Woods, Mazziotta, & Fazio, 1994). Finally, the anterior cingulate cortex (areas 24 and 32) is bilaterally activated, as is the SMA (Stephan, Fink, Passingham, Silbersweig, Ceballos-Baumann, Frith, & Frackowiak, 1995).

Besides mental simulation, there are other modalities of consciously represented action, such as intentionally selecting a motor pattern among several possible alternatives. Brain activation in this condition involves the left dorsolateral prefrontal cortex, and the anterior cingulate region (Frith, Friston, Liddle, & Frackowiak, 1991), as well as the premotor and parietal cortices (Spence, Brooks, Hirsch, Liddle, Meehan, & Grasby, 1997). It is interesting to compare these results with those of another series of PET experiments exploring brain activity during observation of actions performed by others. Observing actions and their effects is a clue to understanding their meaning and to attributing them to their agent: it is thus directly relevant to the problem of agency. In the study performed by Decety, Grèzes, Costes, Perani, Jeannerod, Procyk, Grassi, & Fazio (1997), actions were displayed in front of normal subjects lying in a PET scanner. The subjects received different types of instructions, which were aimed at orienting their cognitive strategy during observation. When they were instructed to observe and memorize the actions with the purpose of later imitation, the SMA and the ventral premotor cortex were activated. Bilateral involvement of the dorsolateral prefrontal cortex was also found in this condition, in agreement with the above studies concerning the planning of voluntary actions and the mental simulation of actions. By contrast, when the instruction was to observe the actions with the purpose of later identification, only the parahippocampal gyrus in the left temporal lobe was activated.

The pattern of activation also differed according to whether the observed actions were meaningful actions which referred to a recognizable goal or meaningless sequences of movements. Observing a meaningful action activated areas which were mainly confined to the left hemisphere. The main structures involved were the middle temporal (area 21) and the parahippocampal regions, as well as the inferior frontal region (area 45). The involvement of area 45 is an interesting finding, as it is also found during mental simulation of hand actions (Decety et al., 1994; Grafton, Arbib, Fadiga & Rizzolatti, 1996) and during the recognition of man-made tools (Perani, Cappa, Bettinardi, Bressi, Gorno-Tempini, Matarrese, & Fazio, 1995). In contrast to observation of meaningful actions, observation of meaningless sequences primarily engaged the right hemisphere. Areas in the occipito-parietal region, including the cuneus and the precuneus, the middle occipital gyrus, and the inferior parietal lobule were involved. This pattern of activation fits the role of the occipitoparietal visual

pathway for processing the spatial properties of visual scenes (Haxby, Horwitz, Ungerleider, Maisog, Pietrini, & Grady, 1994) and for generating visuomotor transformation (see Faillenot, Toni, Decety, Gregoire, & Jeannerod, 1997).

The main point revealed by this comparison of brain activation during several modalities of action representation is the existence of a network common to all conditions, to which the inferior parietal lobule (area 40), part of the SMA, and the ventral premotor area contribute. This region corresponds to a crossroads between the ventral part of area 6 and areas 44 and 45, a cortical zone which bears some homology with the monkey ventral area 6 where a specific category of neurons is recorded. Besides the "classical" premotor neurons, which are selective for execution of a given type of goal-directed hand movement (e.g., a grasping movement), other neurons are activated, not only in relation to motor performance, but also when the immobile monkey watches the same movement performed by a conspecific ("mirror neurons"; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). Hence, Rizzolatti's hypothesis that monkeys recognize a motor action by matching it with a similar action motorically coded in the same neuronal population (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996; Rizzolatti, Fadiga, Mattelli, Bettinardi, Paulesu, Perani, & Fazio, 1996). In humans, a similar mechanism might operate for action recognition, including recognizing speech gestures (Rizzolatti & Arbib, 1998). This hypothesis would represent a rationale for common representations for simulating, recognizing, and perhaps executing various sorts of actions, including those related to verbal communication.

The fact that the cortical areas activated while representing one's own action partly overlap with those activated during observation of an action performed by someone else implies that the same representation may be shared by two (or more) persons. This notion of *shared representations* is directly related to the problems raised in this paper: how does one become aware of one's own actions, and how can one be able to distinguish one's actions from those of other people? In the next two sections, we examine the idea that understanding actions implies representations which are common to several persons and that the attribution of these actions to their real agent requires the processing of specific signals at the level of these representations.

## CONSCIOUSNESS OF ACTION

The first question to be discussed relates to conscious awareness of a self generated action. It is known from the literature that normal subjects are poorly aware of the determinants of their own actions. For example, if a target briskly changes its location during the ocular saccade that precedes a pointing movement toward that target, subjects may remain unaware of the displacement (they see only one, stationary, target); yet they correctly point at the final target location (e.g., Bridgeman, Kirch, & Sperling, 1981). Goodale, Péllisson, and Prablanc (1986) reported a pointing experiment where the target occasionally made jumps of several degrees, unnoticed by the subjects. They found that the subjects were nonetheless able to adjust the trajectory of their moving hand to the target position. Interestingly, no additional time was needed for producing the correction, and no secondary movement was observed, suggesting that the visual signals related to the target shift were used without delay for adjusting the trajectory. Generating a motor response to a stimulus and building a perceptual

experience of that same stimulus, thus, do not rely on the same mechanisms. Indeed, the two processes can be temporally dissociated: In an experiment where subjects were tracking by hand an unexpectedly moving target, the change in their hand trajectory occurred as early as 100 ms following the target jump, whereas the vocal signal by which they reported their awareness of the jump was not observed until more than 300 ms later (Castiello, Paulignan, & Jeannerod, 1991).

These results represent a paradox: a subject may accurately attribute the origin of an action to himself or herself and yet ignore many aspects of his or her motor performance. This suggests that there are dissociable levels in actions for what regards access to consciousness. This hypothesis seems to be consistent with the findings of Libet and his coworkers suggesting that intentions for carrying out voluntary action are generated unconsciously and retrospectively referred to the action when the latter has been executed (Libet, Gleason, Wright, & Perl, 1983). These authors instructed subjects to perform simple hand movements *ad libitum* and to report the instant at which they became aware of "wanting to move." In addition, readiness potentials were recorded from the subjects' skulls. The time to awareness was found to lag the onset of readiness potentials by about 350 ms. In Libet's terms, "The brain 'decides' to initiate or, at least, to prepare to initiate the act before there is any reportable subjective awareness that such a decision has taken place" (Libet, 1985, p. 536).

An experiment was specifically designed to investigate further the degree of accuracy of subjective reports about one's own movements and to determine which signals can possibly be used for monitoring voluntary actions. Subjects were instructed to draw lines in the sagittal direction on a digital tablet using a handheld stylus. The output of the stylus was shown to them on a computer screen seen in a mirror, itself placed to mask the subject's hand. On some trials, a bias was introduced in the output of the digital tablet, such that the line seen in the mirror appeared to deviate from the sagittal direction (to the right or to the left) and by a given angle. The subject, therefore, had to deviate his tracing in the opposite direction and by the same angle in order to fulfill the instruction of drawing in the sagittal direction. At the end of each trial, the subject indicated verbally (by selecting a line on a test card) in which direction he thought his hand had actually moved. The results were twofold: first, the subjects were consistently able to trace lines that appeared sagittal, that is, they accurately corrected for the bias. Second, they gave verbal responses indicating that they thought their hand had moved sagittally, hence ignoring the actual movements they had performed (Fournieret & Jeannerod, 1998).

The main conclusion to be drawn from this study is that normal subjects appear to be unable to consciously monitor the signals generated by their own movements (see also Jakobson & Goodale, 1989, for a similar result). Several categories of signals were, in principle, available to the subjects. A first category was represented by sensory signals, including visual signals related to the apparent direction of the line and kinesthetic signals related to the actual direction of the arm. A second category was represented by putative "endogenous" signals, possibly arising from the motor commands generated by the subject. During the unperturbed trials (when no bias was introduced), all signals provided the same information: the visually perceived and the kinesthetically felt directions of the movement were superimposed, and this information was congruent with the subject's intention. During the perturbed trials, by

contrast, the visual signals were in conflict with the others. In order for the line to appear straight ahead, the subjects had to deviate their hand path by the same amount as the amount of the bias and in the opposite direction. Thus, while the visual signals indicated the straight-ahead direction, the kinesthetic signals indicated a different direction. Similarly, the signals derived from the motor command sent to the arm to trace a line straight ahead were in disharmony with the kinesthetic signals generated by this same movement.

Several explanations can be put forward to account for the fact that subjects tended to grossly underestimate the deviation of their hand trajectory with respect to the sagittal axis. First, it can be conjectured that, because the visual effect on the screen was compatible with the desired action, the subjects tended to largely ignore the other, discrepant action-related signals. This explanation refers to the well-known dominance of visual information over information from other modalities (see Harris, 1963). Another possibility is that the verbal responses reflected the weakness of the action-related signals themselves. This seems an unlikely explanation, however: proprioceptive signals are essential for improving movement control, as can be inferred from the devastating effects of somesthetic deafferentation. In addition, the fact that due corrections were produced by the subjects in order to draw sagittal lines in spite of the bias shows that the relevant signals were indeed monitored by the visuomotor apparatus. A third possible explanation for the inaccuracy of the responses is that, although proprioceptive and internally generated action-related signals operated correctly at an automatic and unconscious level, they were not available for conscious monitoring. One could tentatively infer from this result that the role of action-related signals is limited to movement execution and that they are stored in a working memory which is rapidly erased after movement completion. It is known that conscious position sense, to which kinesthesia greatly contributes, rapidly degrades after a new position has been assumed (Wann & Ibrahim, 1992). A second experiment by Fournier and Jeannerod (1998), using the same technique as described above, confirms this point. The subjects were asked, after each trial, to replicate the trajectory along which they thought their hand had moved during the trial. The results showed an almost complete lack of deviation of the hand trajectory from the sagittal direction, including after trials where a large bias had been introduced. This reinforces the idea that the signals generated by a previous movement are indeed poorly accessible to conscious monitoring.

The results reported in this section suggest the existence of a double coding of action-related information. Signals used for controlling motor execution would be different from those used for generating conscious judgments on an action. In other words, consciousness of an action does not depend on those informations which come into play during automatic control of movements. This distinction would conform with Frith's (1995) proposal that the level of processing which relates to the "public" aspects of an action may be conscious, whereas the "private" aspects, such as the sensory signals generated by movement execution, are not shareable with other individuals and, therefore, remain unconscious.

#### AN EXPERIMENTAL INVESTIGATION OF AGENCY

The other problem to be discussed deals with the origin and the content of subjective experience of action. Being aware of, or having access to, the mechanisms of

generating our actions seems essential for recognizing them and differentiating them from those of other people. Barresi and Moore (1996) have attempted to specify the difference between conditions where an action appears. When the action is observed, the information available to the subject carries a "third person" knowledge, based on visual analysis of the movements of the agent toward objects, his gaze orientation, his facial expression, etc. When an action is self-generated, by contrast, the available information is of the "first person" type, that is, mainly based on self-produced signals, such as proprioceptive signals, for example. It is therefore likely that the distinction between self-caused and world-caused effects on external objects will rely on the presence or the absence of the latter signals. This distinction, however, will not be derived from a conscious monitoring of the endogenous signals, as we know from the previous section that they are poorly, if at all, accessible to consciousness.

Barresi and Moore also suggest that, whenever an action is taking place, it activates an intentional schema, a structure internal to every person involved in that action. This schema would have the capacity of coordinating first and third person information: according to the input signals available, the action will be attributed to the self or to the other person. This theory has the advantage of explaining that, because the schema pertains to the subject, the action (self-generated or not) which is currently monitored can be readily understood. This mechanism may become critical in situations where the two types of information about the action are available at the same time, i.e., when two agents are involved in situations like joint attention, matched actions, mutual imitation, etc. In the present section, we will directly address this problem of agency; i.e., we will explore the degree of accuracy of subjects when they have to consciously determine the origin of an action.

There are very few studies dealing with the conscious determination of agency. In one of these studies (Nielsen, 1963), a situation was created where subjects were presented with movements of an uncertain origin: they were shown the image of an alien hand visually superimposed on (and undistinguishable from) their own hand. Movements performed by the alien hand could be either in concordance or in discordance with the subjects' own movements. Even in the latter case, subjects experienced the alien hand as theirs, without regard for obvious discrepancies between the self-generated and the seen movements: they simply reported feelings of strangeness or, on some occasions, the impression of having their hand pushed by some external force or having lost control of their movements. These observations thus confirm that normal subjects are poorly aware of their own movements. When placed in an ambiguous situation, they tend to experience movements of an alien hand as theirs. In addition, when required to make an agency judgment, they tend to privilege movement-related visual information over kinesthetic information.

This problem was systematically reexamined in a new experiment (Daprati, Franck, Georgieff, Proust, Pacherie, Dalery, & Jeannerod, 1997). The Subject's hand and the Experimenter's hand were filmed by two different cameras. By changing the position of a switch, one or the other hand could be briefly displayed on the video screen seen by the subject. The two hands looked alike as they were covered with a similar glove. In each trial, both the Experimenter and the Subject had to perform a given hand movement on command (e.g., stretch thumb, stretch fingers 1 and 2, etc.): on some trials, however, the Experimenter's movement departed from the instruction. As a result of this experimental arrangement, the subject was randomly

shown either his own hand, or the Experimenter's hand performing the same movement as his, or a different movement. At the end of each trial, a verbal agency judgment was recorded: the subject had to say whether the hand he had seen was his hand or another hand. Normal subjects were able to unambiguously determine whether the moving hand seen on the screen was theirs or not in the two "easy" conditions: First, when they saw their own hand, they correctly attributed the movement to themselves; second, when they saw the experimenter's hand performing a movement which departed from the instruction they had received, they correctly denied seeing their own hand. By contrast, their performance degraded in the "difficult" trials, where they saw the Experimenter's hand performing the same movement as required by the instruction: in this condition, they misjudged the alien hand as theirs in about 30% of cases.

The specific increase in error rate observed in the "difficult" trials can be explained within the framework of the classical "comparator" model, postulated by physiologists to account for how the central nervous system can distinguish between internally generated and externally generated changes of the external world. According to this popular theory (the corollary discharge model, Sperry, 1950; the efference copy model, von Holst, 1950), the comparator is a specialized structure which receives action-related signals from internal and external (sensory) sources. During a self-generated action, internal signals, which are a copy of the commands sent to the effectors (and which, therefore, reflect the desired action), are sent to the comparator. These internal signals create therein an anticipation for the consequences of the action. When the action is effectively executed, sensory signals related to changes in the external world also reach the comparator. If these sensory signals match the anticipation of the comparator, the desired action is registered by the system; if they do not, a mismatch is registered between the desired action and the action that has been produced; finally, if sensory signals arrive in the absence of internal signals, a change in the external world independent of the agent is registered. The pattern of responses that Daprati et al. (1997) recorded in their "difficult" condition can be better understood if one assumes that agency judgments made by the subjects are based on the state of the comparator. In the "difficult" condition, no obvious mismatch was likely to occur between the anticipated and the perceived final hand postures, because the Subject's (invisible) hand and the Experimenter's (visible) hand both executed very similar movements. Only slight differences in timing and kinematic pattern between the internal signals and the sensory signals arising from the visual and kinesthetic receptors were available for the comparator to give the correct agency response.

Although these signals are not directly monitorable, they contribute to the state of the comparator, which itself can be read as a pattern of cortical activity specific for each modality of representation of action. Monitoring this pattern of activity would be the substrate for conscious distinction between representations corresponding to self-produced actions or actions produced by others. Indeed, the cortical activation patterns during these two situations overlap only partially. What is known from the monkey premotor neurons (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) also predicts a difference in cortical activity between performing and observing: whereas in the former case, all the premotor neurons coding for the self-produced movement will



be activated, in the latter, activation will be limited to the particular class of mirror neurons.

### SCHIZOPHRENIA: A PARADIGMATIC PATHOLOGY OF AGENCY

One class of symptoms displayed by schizophrenic patients seems to be closely related to a dysfunction of the above mechanisms subserving consciousness of action and agency. These so-called "positive symptoms" include insertion of thought, auditory-verbal hallucinations, delusion of reference, and delusion of alien control. These false beliefs lead to a feeling of depersonalization by impairing the distinction between the self and the external world (e.g., Schneider, 1959).

Although these positive symptoms have sometimes been attributed to perceptual problems, such as misperception by the patient of his own mental activity (e.g., Seglas, 1892) or difficulties in distinguishing between relevant and irrelevant stimuli (Gray, Feldon, Rawlins, Hemsley, & Smith, 1991), the fact that they pertain to the realm of action is supported by strong arguments. The first set of arguments arises from studies related to auditory hallucinations. It had been suggested that hallucinations in schizophrenics involving a verbal content are related to the production of speech by the patient. In some cases, verbal hallucinations correspond to the content of the patient's subvocal speech (Grenn & Preston, 1981; Bick & Kinsbourne, 1987), as if they were, in fact, producing speech and misinterpreted their own inner speech (e.g., David, 1994). This hypothesis is supported by recent PET studies. Brain activity recorded during verbal hallucinations is similar to that observed during production of inner language and auditory verbal imagery in normal subjects (Cleghorn, Franco, & Szechtman, 1992; Silbersweig, Stern, Frith, Cahill, Holmes, Grootoonek, Seeward, McKenna, Chua, Schnoor, Jones, & Frackowiak, 1995). In addition, in normal subjects, while inner speech activates Broca's area, imagining hearing the voice of someone else activates additional areas in the frontal and temporal lobes (McGuire, Shah, & Murray, 1993; McGuire, Silbersweig, & Frith, 1996). These data clearly support the idea that auditory hallucinations are, in fact, related to inner language, and that the impairment bears on consciousness of the action of speech. Verbal and other "sensory" hallucinations, once considered as a perception without an object, should be reevaluated as an action without an agent. Other types of hallucinations (such as thought insertion) and delusions of alien control might also correspond to an impairment of consciousness of action. Spence et al. (1997) examined cortical activity in schizophrenic patients with experience of delusional control. During the scan, the patients were required to voluntarily move a joystick and to freely select the direction of the movement. Most of them reported vivid experiences of alien control when performing the motor task. Brain activation was found to be increased in a cortical network including the left premotor cortex and the right inferior parietal lobule and angular gyrus, at the level of areas 40 and 39. This right parietal hyperactivity in deluded subjects is particularly interesting: it is noteworthy that lesions at this level frequently result in altered awareness (neglect) for the contralateral limbs and space and denial of the disease (anosognosia); conversely, transient hyperactivity (during epileptic fits, for example) may produce impressions of an alien phantom limb (see Spence et al., 1997).

The pattern of misattributions due to agency disturbances in schizophrenic patients is twofold. First, hallucinating schizophrenic patients may show a tendency to incorporate external events into their own experience or to interpret environmental cues as specifically directed to themselves. Accordingly, they may misattribute their own intentions or actions to external agents. During auditory hallucinations, the patient will hear voices that are typically experienced as coming from a powerful entity trying to monitor and control his own behavior. The voices are often comments where the patient is addressed in the third person and which include commands and directions for action (Chadwick & Birchwood, 1994). In cases of delusion of alien control, the patient may declare that he or she is being acted upon by an alien force, as if his/her thoughts or acts were controlled by an external agent. A change in the cortical pattern of activation in relation to observed actions might represent a mechanism for these pathological interpretations. Indeed, as stressed in Types of Motor Representations (above), the idea of shared representations includes the possibility that actions performed by others can influence the action system of the perceiver (in fact, the co-agent). Such an influence could represent the basis for several cognitive phenomena, either normal (like, for example, empathy) or pathological (for example, hallucinations and delusion of alien control in schizophrenic patients).

The reverse pattern of misattribution can also be observed. In this case, patients are convinced that their intentions or actions can affect external events, for example, that they can influence the thoughts and the actions of other people. As a consequence, they tend to misattribute the occurrence of external events to themselves. Daprati et al. (1997), using the same paradigm as above in groups of schizophrenic patients, found a dramatic increase in the rate of incorrect responses in the "difficult" trials. The error rate was 80% in a group of schizophrenics with delusional experiences, whereas, in a nonhallucinating group, it was only 50%. The fact that all patients gave nearly correct responses in the other two conditions (the error rate remained within 1–7%) excludes the possibility that the effect observed in the "difficult" trials could be due to factors unrelated to the task, such as lack of attention. In this experiment, schizophrenic patients thus tended to overattribute to themselves actions produced by others. This behavior might correspond to a dysfunction of the comparison process, such that the effects of actions of others would be interpreted through the intentions of the self. The consequence of this misinterpretation would be that external events are seen as the result expected from one's own actions. This type of errors by overattribution is an exaggeration of what is observed in normal subjects who, according to Nielsen (1963) and Daprati et al. (1997), also attribute to themselves actions performed by others when they are presented in ambiguous conditions.

### CONCLUSION: A "WHO" SYSTEM FOR SELF-CONSCIOUSNESS

The advantage of the above hypothesis is that the two aspects of the pathological experience of action are explained within the same framework, that of a dysfunctional representation of action. This implies that self-consciousness does not rely on discriminating between central signals and sensory reafferences (an explanation put forward by Frith, 1992), but on discriminating between central representations activated from within and those activated by external agents. Delusion of alien control and

hallucinations are better explained as a dysfunction of the mechanism of interaction between the self and the other, itself based on a proper monitoring of the shared representations. A mechanism for this discrimination has been proposed, based on partial overlap between cortical networks for different modalities of action representation. Activation of those areas which overlap during a self-produced and an observed action (and, therefore, which is common to several individuals) would be interpreted as an observed action; by contrast, activation of nonoverlapping areas would be interpreted as a self-produced action.

This interpretation offers a framework for studying cognitive mechanisms underlying agency judgments. It may represent a useful contribution for understanding self-consciousness and consciousness of other people and, ultimately, for understanding communication between individuals and social interactions. By analogy with the well-known pathological dissociations in the perceptual domain between the mechanisms for answering the questions of “Where?” or “What?” we are therefore submitting a framework for studying dysfunctions of the mechanisms for answering the question of “Who?” This mechanism is to our relationships with other individuals the exact counterpart of what the mechanism for “What?” and “Where?” is for our relationships to objects. How can the self become aware of its own productions, how does it distinguish itself from other selves, in other words, how can the “Who?” of an action be determined? Those are critical questions inherent in the social nature of human beings.

## REFERENCES

- Barresi, J., & Moore, C. (1996). Intentional relations and social understanding. *Behavioral and Brain Sciences*, **19**, 107–154.
- Bick, P. A., & Kinsbourne, M. (1987). Auditory hallucinations and subvocal speech in schizophrenic patients. *American Journal of Psychiatry*, **144**, 222–225.
- Bridgeman, B., Kirch, M., & Sperling, A. (1981). Segregation of cognitive and motor aspects of visual function using induced motion. *Perception and Psychophysics*, **29**, 336–342.
- Castiello, U., Paulignan, Y., & Jeannerod, M. (1991). Temporal dissociation of motor responses and subjective awareness. A study in normal subjects. *Brain*, **114**, 2639–2655.
- Chadwick, P., & Birchwood, M. (1994). The omnipotence of voices. A cognitive approach to auditory hallucinations. *British Journal of Psychiatry*, **164**, 190–201.
- Cleghorn, J. M., Franco, S., & Szechtman, B. (1992). Towards a brain map of auditory hallucinations. *American Journal of Psychiatry*, **149**, 1062–1069.
- Daprati, E., Franck, N., Georgieff, N., Proust, J., Pacherie, E., Dalery, J., & Jeannerod, M. (1997). Looking for the agent: An investigation into consciousness of action and self-consciousness in schizophrenic patients. *Cognition*, **65**, 71–86.
- David, A. S. (1994). The neuropsychological origin of auditory hallucinations. In A. S. David & J. C. Cutting (Eds.), *The neuropsychology of schizophrenia* (pp. 269–313). Hove, UK: Erlbaum.
- Decety, J., Perani, D., Jeannerod, M., Bettinardi, V., Tadary, B., Woods, R., Mazziotta, J. C., & Fazio, F. (1994). Mapping motor representations with PET. *Nature*, **371**, 600–602.
- Decety, J., Grèzes, J., Costes, N., Perani, D., Jeannerod, M., Procyk, E., Grassi, F., & Fazio, F. (1997). Brain activity during observation of actions. Influence of action content and subject's strategy. *Brain*, **120**, 1763–1777.
- Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: A neurophysiological study. *Experimental Brain Research*, **91**, 176–180.

- Faillenot, I., Toni, I., Decety, J., Gregoire, M. C., & Jeannerod, M. (1997). Visual pathways for object-oriented action and object recognition: Functional anatomy with PET. *Cerebral Cortex*, **7**, 77–85.
- Fourneret, P., & Jeannerod, M. (1998). Limited conscious monitoring of motor performance in normal subjects. *Neuropsychologia*, **36** (in press).
- Frith, C. D. (1992). *The neuropsychology of schizophrenia*. Hove, UK: Erlbaum.
- Frith, C. D. (1995). Consciousness is for other people. *Behavioral and Brain Sciences*, **18**, 682–683.
- Frith, C. D., Friston, K. J., Liddle, P. F., & Frackowiak, R. S. J. (1991). Willed action and the prefrontal cortex in man: A study with P.E.T. *Proceedings of the Royal Society of London, B*, **244**, 241–246.
- Frith, C. D., Friston, K. J., Herold, S., Silbersweig, D., Fletcher, P., Cahill, C., Dolan, R. J., Frackowiak, R. S. J., & Liddle, P. F. (1995). Regional brain activity in chronic schizophrenic patients during the performance of a verbal fluency task. *British Journal of Psychiatry*, **167**, 343–349.
- Goodale, M. A., Péliisson, D., & Prablanc, C. (1986). Large adjustments in visually guided reaching do not depend on vision of the hand or perception of target displacement. *Nature*, **320**, 748–750.
- Grafton, S. T., Arbib, M. A., Fadiga, L., & Rizzolatti, G. (1996). Localization of grasp representations in humans by positron emission tomography. 2. Observation compared with imagination. *Experimental Brain Research*, **112**, 103–111.
- Gray J. A., Feldon J., Rawlins, J. N. P., Hemsley, D. R., & Smith, A. D. (1991). The neuropsychology of schizophrenia. *Behavioral and Brain Sciences*, **14**, 1–84.
- Greyn, M. F., & Preston, M. (1981). Reinforcement of vocal correlates of auditory feedback: A case study. *British Journal of Psychiatry*, **139**, 204–208.
- Harris, C. S. (1963). Adaptation to displaced vision: Visual, motor or proprioceptive change? *Science*, **140**, 812–813.
- Haxby, J. V., Horwitz, B., Ungerleider, L. G., Maisog, J. M., Pietrini, P., & Grady, C. L. (1994). The functional organization of human extrastriate cortex. A PET-rCBF study of selective attention to faces and locations. *Journal of Neurosciences*, **14**, 6336–6353.
- Holst, E. von (1954). Relations between the central nervous system and the peripheral organs. *British Journal of Animal Behavior*, **2**, 89–94.
- Jakobson, L. S., & Goodale, M. A. (1989). Trajectory of reaches to prismatically displaced objects. Evidence for “automatic” visuomotor recalibration. *Experimental Brain Research*, **78**, 575–587.
- Jeannerod, M. (1994). The representing brain: Neural correlates of motor intention and imagery. *Behavioral and Brain Sciences*, **17**, 187–245.
- Jeannerod, M. (1997). *The cognitive neuroscience of action*. Oxford, UK: Blackwell.
- Jeannerod, M. (1999). To act or not to act. Perspectives on the representation of actions. *Quarterly Journal of Experimental Psychology* (in press).
- Libet, B., Gleason, C. A., Wright, E. W., & Perl, D. K. (1983). Time of conscious intention to act in relation to cerebral activities (readiness potential). The unconscious initiation of a freely voluntary act. *Brain*, **102**, 193–224.
- Libet, B. (1985). Unconscious cerebral initiative and the role of conscious will in voluntary action. *Behavioral and Brain Sciences*, **6**, 529–566.
- McGuire, P. K., Shah, G. M. S., & Murray, R. M. (1993). Increased blood flow in Broca’s area during auditory hallucinations in schizophrenia. *Lancet*, **342**, 703–706.
- McGuire, P. K., Silbersweig, D. A., & Frith, C. D. (1996). Functional neuroanatomy of verbal self-monitoring. *Brain*, **119**, 907–917.
- Nielsen, T. I. (1963). Volition: A new experimental approach. *Scandinavian Journal of Psychology*, **4**, 225–230.
- Paulignan, Y., McKenzie, C., Marteniuk, R., & Jeannerod, M. (1991). Selective perturbation of visual input during prehension movements. I. The effect of changing object position. *Experimental Brain Research*, **83**, 502–512.
- Perani, D., Cappa, S. F., Bettinardi, V., Bressi, S., Gorno-Tempini, M., Matarrese, M., & Fazio, F.

- (1995). Different neural systems for the recognition of animals and man-made tools. *Neuro-Report*, **6**, 1637–1641.
- Rizzolatti, G., & Arbib, M. A. (1998). Language within our grasp. *Trends in Neurosciences*, **21**, 188–194.
- Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research*, **3**, 131–141.
- Rizzolatti, G., Fadiga, L., Matelli, M., Bettinardi, V., Paulesu, E., Perani, D., & Fazio, F. (1996). Localization of grasp representations in humans with PET. 1. Observation versus execution. *Experimental Brain Research*, **111**, 246–252.
- Schneider, K. (1959). *Clinical psychopathology*. New York: Grunne and Stratton.
- Searle, J. R. (1983). *Intentionality: An essay in the philosophy of mind*. Cambridge, UK: Cambridge Univ. Press.
- Seglas, R. (1892). *Les troubles du langage chez les aliénés*. Paris, France: Rueff.
- Shallice, T. (1988). *From neuropsychology to mental structure*. Cambridge, UK: Cambridge Univ. Press.
- Silbersweig, D. A., Stern, E., Frith, C. D., Cahill, C., Holmes, A., Grootoonk, S., Seeward, J., McKenna, P., Chua, S. E., Schnoor, L., Jones, T., & Frackowiak, R. S. J. (1995). A functional neuroanatomy of hallucinations in schizophrenia. *Nature*, **378**, 176–179.
- Spence, S. A., Brooks, D. J., Hirsch, S. R., Liddle, P. F., Meehan, J., & Grasby, P. M. (1997). A PET study of voluntary movement in schizophrenic patients experiencing passivity phenomena (delusions of alien control). *Brain*, **120**, 1997–2011.
- Sperry, R. W. (1950). Neural basis of the spontaneous optokinetic response produced by visual inversion. *Journal of Comparative and Physiological Psychology*, **43**, 482–489.
- Stephan, K. M., Fink, G. R., Passingham, R. E., Silbersweig, D., Ceballos-Baumann, A. O., Frith, C. D., & Frackowiak, R. S. J. (1995). Functional anatomy of the mental representation of upper extremity movements in healthy subjects. *Journal of Neurophysiology*, **73**, 373–386.
- Wann, J. P., & Ibrahim, S. F. (1992). Does limb proprioception drift? *Experimental Brain Research*, **91**, 162–166.

Received May 14, 1998