Awareness of Agency : Three Levels of Analysis

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AWARENESS OF AGENCY : THREE LEVELS OF ANALYSIS

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Exploring the neural correlates of consciousness presents three kinds of challenges. The first one has to do with the difficult notion of a neural- or of a cerebral - realization of a function. Although everyone agrees that every mental function supervenes on the activity of some part of the brain, some indeterminacy may arise on the kind of supervenience basis that is to be looked for. A common view is that every mental function, even highly modular ones, only operates on the background of other mental functions, or cerebral systems. Therefore when one looks for neural correlates of any particular function, one has to differentiate those neural or brain properties that are identifiable as directly correlated to that function from those that are only indirectly correlated to it. In other words, there are two ways of understanding the neural correlation of a mental state to a cerebral state. In the stronger sense, such a correlation should be both necessary and sufficient. The causal entanglement of cerebral functions makes such a demand implausible. What can be looked for is at most a weaker kind of correlation : only on the background of a normally functioning brain, can some particular neural states be associated with particular mental properties. In the case of interest here, the effort at locating the supervenience basis of consciousness in one definite well-circumscribed center is at odds with the notion that conscious states are information-processing states, using widely distributed data analyses and retrieval.

The second challenge consists in specifying what the term "consciousness" is supposed to refer to. As Block (1995) shows convincinly, several different concepts are often confused under this word. *Phenomenal consciousness* refers to experiential states, like seeing green or feeling a pain. *Access-consciousness* has to do with the rational control of speech and behavior. While phenomenal states have a non-conceptual content, access-consciousness involves inference, and thus conceptual content.

This second challenge is made still more difficult when one realizes that conscious states of both categories (phenomenal and inferential) might be related to a specific function which itself depends both on implicit (unconscious) and on explicit learning, i.e. *attention*. Attention cannot itself be identified with some conscious state, because if it helps determine which kinds of contents will be made phenomenally salient and inferentially promiscuous, it cannot without circularity be itself triggered by phenomenally and inferentially salient features of incoming or stored data[1].

The third challenge consists in a well-known, venerable set of worries linked to the fact that

after all, there is nothing that we can tell about the *causal connection* between some neural activation - more generally, some physical structure - and a particular phenomenal quality. Shepard (1995) gives an interesting twist to the problem. Given that non-human animals cannot report on their internal states, how are we to establish in any principled way what kind of organism can enjoy conscious states ? Neither would the very ability to report subjective feelings and experiences, as displayed by humans, suffice to establish that consciousness emerges at the agent-level. Does then the ability to have conscious experiences depend on complexity in the underlying system ? Is this a holistic capacity, or is there an emergent qualitative property at the level, say, of the neuron or of the neuron assembly ?

However laden which conceptual difficulties, these problems cannot be articulated and solved without relying on scientific inquiry. Folk psychology is a dubious adviser in such a task, which consists in part in understanding the very possibility of folk psychology. One way to circumvent suggestions from folk psychology is to concentrate on the data of mental pathology. This domain, poorly described and understood by ordinary psychology, offers interesting correlations between functional alterations and perturbations of consciousness.

We will concentrate below on the subjective impression associated to the notion that one is the actor of one's own acts. Taking the subjective lead, we will try to look for a functional basis and for a neural correlate for this "feeling in charge". Although it is a platitude to say that one did something on the basis of one's own intention to act, it is not all that clear how an action is actually planned and executed, how a subject becomes conscious of intending, acting, and having completed the action, and how far prior or occurrent conscious states are necessary for the whole process to develop. Studying a pathological case, where a patient may either misattribute some action as being his own, or, on the contrary, disavow being the actor of a particular action - claiming that a foreign influence had him move-, should shed some light on the relationships between functional data, subjective reports of agency or loss thereof, and neural correlates. Schizophrenia offers such cases.

The clinical symptoms of schizophrenia include disturbances in visual experience, blocking phenomena, specific problems in speech production, speech understanding and thought control. The patients often have delusions of control (they see themselves as endowed with specific, more or less extensive powers over other people) or delusions of reference (other people in the street have something particular to communicate with the patients). A significant proportion of patients experience hallucinations, in general (verbal-) auditive, haptic, or olfactory. They also experience a number of difficulties related to action, also called "executive" difficulties. These perturbations are manifest both in the subjective reports issued by the patients, and in their results in executive tests such as the Tower of London, or the Wisconsin Card Sorting Test. Being requested to tell how it all started, a patient gives the following account : "I get shaky in the knees and my chest is like a mountain in front of me, and my body actions are different. The arms and legs are apart and away from me, and they go on their own. That's when I feel I am the other person and copy their movements, or else stop and stand like a statue. I have to stop to find out whether my hand is in my pocket or not... Sometimes the legs walk on by themselves or sometimes I let my arms roll to see where they will land." (Chapman, 1966).

From the mosaic of reported perturbations in the domain of action, emerge a sense of imposed

actions, of being subject to a foreign will, or conversely, of exerting influence on others; a disposition to copy others without preestablished intention of doing so, and a relative difficulty at resisting impulses triggered by contextual cues.

If we want to contrast the levels of analysis of the awareness of agency in these disorders, it is important to insist that this way of summarizing the clinical evidence is shaped by covert functional hypotheses, which will be made explicit below. A patient normally couches his own experience in qualitative, holistic terms, involving not only a change in his own mind, but a brutal change in the external world as well as in several of his bodily functions. Delusions can be seen as normal inferences from puzzling new experiences, on the background of an existing system of beliefs. Any systematic change in the quality of perception can receive a subjective explanation in epistemic and motivational terms with a considerable impact on the subject's apprehension of his world and of his own role in it.

The description I just gave of the schizophrenic syndrom is compatible with a functional hypothesis, according to which the disease would be in part constituted by a perturbed monitoring of action. By action monitoring, is understood a set of complementary operations such as instigating an action in the correct time and place, exerting a feedback control on the movement towards the goal or target event, stopping the movement when goal is reached, or when crucial preconditions fail to be met.

Before we examine various ways of articulating this hypothesis, we need to define an action. Following neuroscientists as well as philosophers sensitive to the issue of animal psychology[2], an action should be defined not on the basis of its source (in terms of relevant beliefs and desires) but as a process that develops from an internal model towards a goal with an appropriately monitored execution. In other words, feedback is the central notion for an action : a movement has to be guided in an internally controlled way up to goal attainment to be called an action. In this view on action, the source of the action, i.e. the actual cause that triggers it, may be external as well as internal. The fact that an action can be carried out consciously or not, in an automatic or in a deliberate way, is also an extrinsic property of action, that does not need to enter its definition. As a consequence, one can also, at least as a matter of conceptual distinctions, separate control of an action from conscious access to control mechanisms. On the other hand, an essential ingredient consists in a comparator, through which a system can modify the currents step towards the goal as a function of the difference between observed and predicted output.

According to an influent theory (Frith, 1992), many of the clinical data reported above, besides the openly executive symptoms, result indeed from difficulties in processes related to the monitoring of action. Within this general framework, Christopher Frith has an interesting strategy for explaining schizophrenic symptoms. The first step consists in widening the executive hypothesis in such a way that it encompasses action proper as well as the mental activity related to action. The second step consists in extending still further the hypothesis, by considering the previous perturbations as special cases of an overarching metarepresentational capacity. Let us examine these two steps in turn.

From Monitoring actions to monitoring intentions and self

In schizophrenia, both the monitoring of action and the monitoring of the intentions to act would be disturbed (Frith, 1992, p. 81). Positive symptoms, such as delusion of control or verbal-auditive hallucinations, would be explained by an inability to distinguish changes due to our own actions from changes due to external events. The patient who hallucinates is seen as failing to recognize an internal speech production as his own. Similarly, in thought insertion, a patient is taken to be unable to recognize a thought as his own.

Why would these failures occur ? Normally, any mental or physical activity is perceived as originating in self or in some external event thanks to the information carried by a dedicated signal, telling whether a movement was effected by the individual ; when absent, the system would interpret a movement as unwilled, as when the body is passively subjected to some external force. The relevant signal is supposed to help compare reafferent signals with the signals that are expected on the basis of the current willed action. It has been suggested that such a signal would be delivered by a mechanism underlying active perceptual activitities, named corollary discharge, (Sperry, 1950) or efferent copy (von Holst & Mittelstaedt, 1950). Although it is only hypothetical at this stage of our knowledge of brain functions, such a mechanism is required to explain, for example, how ocular saccades can be taken into account and neutralized in interpreting visual input. When no such efferent copy signal is produced (one is sitting in a train), it is much more difficult to say whether oneself is moving or whether the perceived scene is. In our conscious sense of agency, a major component would thus consist in the *sense of effort* which is the subjective correlate of the corollary discharge of any action.

Granted that a sense of effort is responsible for being aware that one acts, why not suppose that a similar subjective sense allows knowing that one thinks? To give his hypothesis a wider scope, Frith suggests that the very same "sense of effort" could be present when a thought is produced. A loss of such a (thought- or action-related) sense of effort would issue either in an experience of thought insertion or of externally controlled action. In the case of ordinary thoughts, it is plausible that thoughts that one does not identify as one's own are taken to be alien, inserted thoughts. Being a particular kind of thought, an intention to act could thus be misattributed as somebody else's intention to act.

These intriguing hypotheses have already received partial support from clinical and experimental data. In particular, the difficulty in monitoring one's own actions is experimentally testable, through standard executive tests such as WCST, or through specific tasks, such as the ability to correct videogame motor responses used by Frith & Done (1989)[3]. Schizophrenic patients with passivity experiences (delusions of control and thought insertion) are shown to be abnormally impaired in a motor correction task when they are not provided with visual feedback on their own actions. Using the theoretical apparatus summarized above, the idea is that, while normal subjects can use central "efference copy" signals to compare the actual with the expected output of their actions, schizophrenics seem not to be able to produce or at least to use these signals. Being unaware of their own intentions, they will experience their actions as having an external agent. This inference is based on an incorrect memory of the type of action

effected. The delusion of control thus expresses a defect in self-monitoring.

Problems of monitoring and metarepresentational deficits

Frith (1992, 1994) suggests that the disorders described above, affecting both self-monitoring and the monitoring of intentions, could after all express deeper-rooted problems, having to do with the very structure of conscious experience. His argument develops both on conceptual and empirical grounds. Conceptually, Frith relies on what philosophers call a "higher-order theory of conscious states"[4]. To be consciously looking at a tree, for example, you must form the thought representing the fact that you look at a tree, and hence, you must form a metarepresentation of your looking at a tree. If metarepresentation is crucial for self-awareness, then people having problems with metarepresenting states (their own or the others'states) should have problems with self-consciousness as well as with interpreting other people's mental states.

Empirically, Frith proposes that what is disturbed is not only some kind of low-level mechanism (such as the efferent copy mechanism evoked above), but the very ability to recognize that one is in a certain mental state (intention or belief). This ability could depend on a high-level, general-purpose mechanism responsible for a large part of metarepresentational performances. This system, first described by Shallice (1988), called *the Supervisory Attentional System*, (SAS) is the set of control functions involved in non-routine, willed operations. In this model, pursuing a goal may be a matter of a routine that is performed by "contention scheduling". But representing this goal, i.e. making it the content of a conscious intention, is the duty of SAS. Thus, in the reading that Frith offers for Shallice's SAS, operation of the will is indeed dependent on self-consciousness. In this reading, a state of affairs has to be represented *as* the content of an intention, to be efficacious in guiding behavior. All willed action has therefore a metarepresentational structure. Deliberate intentional action implies that a connection between two representations is established : one for a primary condition (like "do X") , and one for the function that is allocated to the primary representation : intending, believing, knowing. (Frith, 1992, 130)

To understand how metarepresentation could be instantiated in the brain, one should therefore, according to Frith, concentrate on the relationship between contention schedule and SAS : the first gives a primary information -- "do X" -- about a movement to be performed. Such an information can be understood as a first-order proposition, or as some representation activated in motor cortex. SAS then specifies what the function of the former proposition will be ; an additional brain representation interacting with the former will thus allow forming the metarepresentation "I intend to do X". This additional structure could be different according to the kind of connection between the metarepresentation and its primary content. Looking at the relevant brain areas, it is found that tasks that require inhibition of prepotent responses involve the orbito-frontal lobe, whereas tasks requiring delayed-reponses would activate dorsolateral frontal areas. Prefrontal cortex, SMA (Supplementary Motor Area) and the basal ganglia would be in charge of the proper control of the use to which the primary content (represented in the relevant part of motor or temporal cortex) should be put (Frith, 1992, 130).

Let us summarize. For Frith, monitoring one's actions presupposes a monitoring of one's own

intentions, which in turn presupposes being conscious of having those intentions. For example, the fact that rats can monitor their own actions *ipso facto* indicates that these animals "have some kind of self-awareness" (Frith, 1992, 131). In this metarepresentational framework, schizophrenic symptoms result from the underlying disorder in the ability to metarepresent mental states, both in the self and in other people. In auditory hallucination, a patient hears a voice and does not recognize it as his own for lack of a self-attribution ; in reference delusion the patient makes incorrect inferences about the intentions of other people. : he misattributes a mental state to someone who does not have it. A patient with a delusion of influence does not recognize his own intentions and takes them to be somebody else's.

Frith's model thus sees schizophrenia as lying on a continuum with a developmental disorder such as autism. Autistic children present a perturbation in understanding of mental states in themselves and others, as is shown by their specific difficulty in solving the false belief task. To succeed at such a task, one must take the point of view of someone else on a situation even though the corresponding belief is false (outdated). Let us suppose that an autistic child watches the following scene : a toy is removed from where child A has put it when A is out of the room. Now let us ask the following question to the autistic child : where will A look for his toy ? An autistic child - as well as a normal child under 3/4 - will attribute to A a piece of knowledge that he acquired himself , but that A fails to have. According to the "theory theory" of mind, favored by Frith, autistic children fail the false belief task because they are unable to metarepresent states, which in turn expresses the impairment of a specialized module, the theory of mind module. In contradistinction with autistic patients, schizophrenic patients, according to Frith, did have access to this module during their earlier life, but become unable to use it. Such a disorder would affect their present performance at representing various kinds of mental states : their own goals (grandiosity, unrealistic goal attribution), their own intentions (delusions of control, thought insertion) as well as the goals and intentions of others (persecution, verbal-auditory hallucination). (Frith, 1994, 156)

Discussion

There are several methodological objections that can be addressed to this type of theory, understood as a common explanation for autism and schizophrenia. Before such an innate theory of mind module is postulated, - or in general, before one tries to understand a symptom in terms of some higher-level functional hypothesis - one should first investigate which lower-level processes might jointly result in the ability to understand mental facts. In autism, it may be that affects fail to be perceived and recognized by the baby, which in turn would prevent him/her to extract the relevant information for categorising internal states[5]. Another possibility would be a specific deficit in memorizing motor imagery or in imitating[6], or in inhibiting prepotent stimuli[7]. In schizophrenia, disorders in metarepresentation may also be derivative on an executive disorder, linked to a deficit in working memory , or to an attentional disorder.

Another objection has to do with the very notion of explanation in psychiatry. When a pathological symptom is to be explained, it is not informative to invoke a hypothetical corresponding function whose alleged disorder causes the symptom. What is needed is an

independent proof of the existence of the "new" function, in particular of the information used and on the processor using it[8]. In all cases, it must be shown that the disturbances in the known functions cannot account for the symptom. It must also be demonstrated that the symptom as described forms a "natural class", i.e. that its defining properties help determining a common causal structure. In the particular case of Frith's theory, it is unclear why two different kinds of explanation are offered for the same class of symptoms. One is, as we saw, that a patient does not have a proper corollary discharge mechanism allowing him to know what action he has performed. He has therefore not a conceptual problem with his own intentions, but only a content-identification problem. The other is, according to the modular view, that a schizophrenic patient fails to master intentional concepts ; his module for a theory of mind is impaired. In this case the patient does not know what belief is, and commits mistakes on contents in a derivative way (i.e., because he has an inadequate understanding of what a belief, a desire, an intention should be). Each explanation - the lower-level theory of efference copy, and the higher-level modular theory of mentalization - seems to preempt the other.

Claiming that a particular module has the effect of performing some particular cognitive task clearly does not suffice establishing that this module does in fact exist independently from other functions, in particular that it uses specific inputs, and delivers specific outputs, in the fast, automatic, and informationally encapsulated way associated to the very concept of module[9]. Now how can the existence of a module be established ? Developmental data do suggest constraints on functional links, but do not by themselves speak in favor of a particular mental architecture. By contrast, neurological data may support modular claims, because they let the possibility of identifying cerebrally and functionally identified areas through the method of double-dissociation[10].

From a philosophical point of view, Frith's approach exemplifies a theory in which consciousness is taken to be a mental function alongside with other functions such as language, perception or action planning. Whether self-awareness is explained through the SAS model, or through a modular mechanism such as the theory of mind module, in both cases it is suggested that the brain has specialized mechanisms for becoming aware of mental facts allowing the subject to know not only *what* he believes, but also *that* he has beliefs. Mental pathology would thus reflect the fact that mental information failed to be processed.

Also, although this point is often left implicit, it is presupposed in this view that the mechanisms for self-awareness are also those responsible for self-identity. There are several arguments to be offered against such an assimilation. If consciousness about one's own states is distributed at many different levels - such as memory, perception, action -, it may be more questionable to identify the acquisition of a concept of a self with the various types of conscious states emerging from monitoring the various kinds of internal information. Data from animal psychology prevent an assimilation between elementary reflexive states such as these with the building blocks of the concept of a self. Research in the corollary discharge in the fruit fly never tackled the concept of an emergent fly-selfhood. To detect who did the action requests a restricted answer, in terms of a GO-NOGO type of switch. No decision on personal identity is involved in agency attribution,

although conversely there can be no personal identity without a capacity for anwering who-questions.

Self-awareness may therefore alternatively be understood as emerging from underlying functional processes that mediate in specific cases consciously accessible or reportable outputs. In this perspective, conscious states may occur in a variety of mental functions without having to be dealt with separately, in the sense that their being conscious makes them functionally special. As Rizzolatti (1994) emphasizes, "motor preparation is not a category of neural operations ("unconscious") opposed to another category of neural operations ("conscious"), but rather a term which describes the effect that some neural operations may have on motor responses regardless of whether or not they are conscious". This view on consciousness is of a radically different kind from the view described above, where self-awareness and awareness of others is entirely realized at the theory-of-mind level and seems to emerge at a very late stage in phylogeny.

It is worth exploring a theory that purports to explain the symptoms of schizophrenia listed above in a more parsimonious way , i.e. in terms of lower-level mechanisms that may indeed have far-reaching effects on the system of beliefs and of motivations of the disturbed patient. This theory, developed by Marc Jeannerod and his collaborators, tries as Frith's theory to understand the altered conscious states in deluded patients in terms of a monitoring of action deficit. Interestingly, this theory also has relevance to explain part of the autistic syndroms, without having to hypothesize a disturbed module for the theory of mind mechanism. I will present this theory in my own terms, hoping that, in its core, it is faithful to Jeannerod's general intentions.

Jeannerod's concept of action-awareness

Frith's theory paved the way for distinguishing various ways in which attributing a mental state may go wrong. Although he did make some of the crucial distinctions, he failed to provide a description of what the normal individual is able to perceive, and of what he has to infer. Let us then start by distinguishing at a conceptual level several types of attribution that may contribute to action-awareness. I will contrast agency awareness, goal awareness, and sensorimotor awareness. *Agency awareness* is typically a conscious realization that I -- or someone else -- did or did not perform an action. It is the state in which an organism finds itself when detecting his being active or passive in a particular situation. In particular, it is a state that is activated when interpreting input signals (afferences or reafferences) which in turn allow achieving a veridical perception of the environment. *Goal awareness* is the type of awareness that individuates the action through its intentional content. This dimension of action-awareness allows categorizing actions according to their adaptive meaning. It focusses on the motive that drives the execution of the corresponding action. *Sensorimotor awareness* is related to the motor content of an

action. It is the form of awareness that identifies an action through its dynamics, i.e. via the spatial and temporal properties of the bodily movement involved in the action.

Commonsense has it that in a normal subject, these three forms of action-awareness are present in most types of action. Here is the folk story : an agent forms the conscious intention to do X. He does X by way of moving in a Q way. He knows that he Qs to reach X (sensorimotor awareness). he knows that he wants to have X done (goal awareness). He knows that he and no one else did X (agency awareness).

Schizophrenic patients' difficulties with the monitoring of action may disturb this picture. For as we say earlier, a patient may do X without acknowledging that he was the agent of the action X ("someone else made me act"); he may also do X without having a particular conscious goal in doing X (this is a case of automatic or stimulus driven behavior, such as psychotic roaming or stripping clothes away in public; but this latter class of dissociations is problematic, for we saw earlier that a subject in such a case always finds a way to rationalize his action by *making up* a goal). Even folk psychologists have to admit that sensorimotor content offers a perplexing case. Although one usually believes to be conscious of one's own motor activity, there are many cases in which one is unable not only to explain verbally how one does X, but also to do it "in the abstract", in the absence of the relevant contextual cues and motivational pressures.

To provide a low-level theory of the schizophrenic symptoms listed above, it is necessary to explain how the three components of action-awareness can be dissociated. Whereas Frith offers an explanation in terms of a metarepresentational disorder (what goes wrong is that the patient cannot form a mental representation of his own states), Jeannerod (in press) suggests that the problem stems from the representational structure of action : the possibility of a pathological dissociation suggests that several subfunctions cooperate in a more or less independent way. In its broad lines, the hypothesis advanced by Jeannerod is that, in the normal subject, a *goal representation* is in itself agent-neutral and coded in allocentric coordinates. *Sensorimotor representations* are egocentrically coded, but short-lived; activated mainly at a non-conscious level, they are often not --or only poorly -- memorized when the action is completed. *Agency representation* is effected separately, through an inference based both on internal and on external cues.

In this perspective, the schizophrenic symptoms have nothing to do with a specific disorder in metarepresentation. The altered conscious states may appear at each functional level where signals are received and used to monitor action. If the signals used for controlling motor execution are not the same as those used for generating a conscious judgment on the action, then subjects engaged in an action may have a poor conscious model of what they do, at least at the sensorimotor level. If the signals used in identifying a goal representation are different from those used in attributing the action to oneself, then patients may have a conscious representation of the goal of an action while rejecting their role in executing it.

As Jeannerod's target article shows in detail[11], various sources of data indicate that the same representational format is used to imagine, plan, memorize, prepare the action and guide its execution. In the definition of action proposed earlier, to which Jeannerod subscribes, an action implies the existence of an *internal model* of the goal that guides the execution until completion. The internal, dynamical model for a particular action can be run beforehand to test the viability of

the action, in a simulatory way, or run on-line to guide the action. It can also be activated by the perception of some external performance of this very same action. This format can be called *semantic,* if one understands under this term that the conditions of satisfaction of the action are couched in external, allocentric terms : the target-event of an action includes normally both the object on which the action is exerted and the final state of the organism in relation to this object. Therefore the representation of the goal of an action must code as well the dynamics of the action as a function of the properties of the target-object. This aspect of goal representation should rather be called "pragmatic" (see Jeannerod 1994, 198) because it draws on the pragmatic information in visual cortex, devoted to the properties of objects relevant for action. The latter are represented in the dorsal stream as "affordances", not as cues for symbolic categorization (represented in the ventral stream)[12].

Consciousness of action is in this view intrinsically related to the representational format for action. The very awareness of an action being performed by the self, i.e. motor imagery, is the subjective, felt correlate of the representation on which the execution relies, and is "functionally equivalent" to the representation used in preparing the action. A number of studies indeed show that mental imagery shares with the corresponding real action several key physiological correlates. For example heart rate, respiration rate, and end-tidal PCO_2 are increased in imagery as they are in the corresponding preparations of actions (Decety & al., 1991). Deliberate mental simulation of an action also activates motor pathways (Bonnet, Decety & al., 1997) as well as the corresponding areas of the sensory motor cortex and Supplementary Motor Area (Roth, Decety & al., 1996). The wealth of data gathered about the neural correlates of action indicate that a common network of neurons is activated for all conditions involving action : intending, imitating, observing, preparing, observing : the inferior parietal lobule (area 40), the ventral preomotor area (ventral area 6) and part of SMA. This network could constitute a general vocabulary of actions for all kinds of use. In addition, an overlap in dedicated areas can be observed between performing and simulating, simulating and observing, and finally performing and observing a particular action, which suggests close functional links between these activities.

Goal-representations are agent-neutral

Of particular interest for our schizophrenic symptoms is that one and the same representation can normally be used to produce a goal-oriented behavior or to recognize a behavior in someone else as being goal-oriented. It has been known for some time that neural assemblies in the superior temporal sulcus are involved in the recognition of specific movements in other organisms (Perrett & al., 1989). More recently, it was shown that neurons in F5, called "mirror-neurons", are able to respond both to visual stimuli of an action and to the production of movement by the self. A series of neural cell recordings in the macaque show that groups of neurons in the premotor cortex are activated both by a particular movement effected by another individual - animal or human - and by the active performance of the same movement (Di Pellegrino & al., 1992, Rizzolatti & al., 1996, Gallese & al., 1996). These mirror- neurons respond only when the observed agent acts on an object; they do not fire when the agent mimes an action in the absence of an object, or when only the object is presented. Transcranial magnetic

stimulation of the motor cortex (Fadiga & al., 1995) and PET studies on normal human subjects observing someone grasping objects (Rizzolatti & al., 1996) suggest that the same kinds of neurons are present in homologous areas of the humain brain (Broca's area). The presence of mirror neurons in this cerebral area might give an additional plausibility to the motor theory of speech defended by Liberman (1996).

According to Jeannerod, the discovery of mirror-neurons suggests that goal-representations may be at some level agent-independent. Becoming conscious of an action such as grasping or walking does not involve first identifying an agent, then specifying its current activity. It relies on the activation of a representation that is neutral as to the agent. Before we get to the question of how to proceed from goal identification to agent identification , let us examine more closely the sensorimotor content of an action.

Recognizing the sensorimotor content of an action

How far is a normal subject conscious of the dynamics of his own actions ? One way of ascribing an action to oneself could consist in relying on the internal model activated in the course of the execution. A decisive argument for such a claim would be that subjects have access to an accurate *internal* information on what kind of movement they have done. By "internal" is meant here the central or proprioceptive dynamics of the action, also called "internal feedback", as contrasted with the external feedback provided by visual reafferences.

Recent work by Fourneret & Jeannerod (1998; in press) indicates that normal subjects as well as schizophrenic patients, have a poor access to the internal model of the movement they have effected. When they are deprived from accurate visual feedback, and are instead given spurious visual reafferences on the course of their actions, they are quite unable to identify the actual movement they have produced. Their conscious sense of their own movement in space seems to be overwhelmed by the visual cues that are provided, even though these cues grossly depart from the actual direction of the movement. This result is coherent with experimental evidence concerning the lack of awareness of subjects having to adjust their movements for grasping an object to a sudden jump of the target. (Goodale, Pélisson & Prablanc, 1986). Again, the signals used in generating or correcting an action seem to depart from the signals used in forming a conscious judgement on which sensorimotor sequence occurred. It seems that subjects have to use external cues to consciously identify the sensorimotor content of their own actions, whereas they can rely on internal cues to make the necessary adjustments in an unconscious and automatic way.

Let us pause to observe the contrast between rehearsing the sensorimotor content of a past action and planning to act according to a particular sensorimotor content. While a subject can memorize quite well, and produce mental imagery, for sensorimotor contents that he plans to execute, he is quite unable to reactivate the mental imagery of a sensorimotor content for a past action when the latter has been produced as a response to contextual cues. I do know how to cut a piece of cake, or how to press an orange. But how did I grasp this object while it was falling ? How did I manage not to slide on the icy pavement ? These constrasts suggest that conscious access to one's sensorimotor content of action requires two types of additional conditions relative

to simple use of that content in ordinary learning tasks. First, that there are public, allocentric features to ground the sensorimotor judgment. As we will see below, this could indicate that conscious experience of verbally reportable experiences are functionally dependent on coding public, shared features of the environment. Second, that the action features need to be controlled on line. Mental imagery does occur in cases of careful motor preparation or execution. It does not need to occur in routine tasks. Once an action is executed, its sensorimotor content is rapidly erased from consciously accessible memory.

Judging who

One of the misleading intuitions about agency attribution consists in taking mental imagery to provide a complete picture of an action, including the agent, the target event, and the instrumental behavior. According to this intuition, everyone would have a direct impression on *who does what* in the content of his own mental imagery. "This action feels like mine", in this view, means that "I have the current experience of moving this particular way, and I see it happening in my own sphere, so to speak, i.e. within my reach". "That action does not feel like mine" would conversely mean that "it happens outside my sphere, without my reach, and with no associated phenomenal awareness".

This intuition is challenged by the dissociations articulated above, between the three levels of action representation: the goal-content, the sensorimotor content, and the agency content are three different kinds of information, which need different procedures for being correctly extracted and used, and which provide different (if any) conscious experiences. Let us suppose that you are watching a soccer game on TV : you may well share a large part of the phenomenology of the active player. As you work at identifying particular goal-contents, you form various mental images of the smart moves to perform, and may even feel "I can make it". This empathy does not help locating the true agent; it makes the solution more difficult to find. Although there is obviously a difference in neuronal activation when one looks at one action and when one performs it (in the latter case only, your brain launches the action, and receives feedback of both the internal and the external varieties), there is no exact mapping, as we saw, between our representational states on the one hand, and our conscious phenomenology and agency attributions on the other hand.

One practical, although by no means infaillible way of finding out who the agent is, seems to be to identify *where* the action took place. If something happens within your reach in the right temporal sequence, then you may safely infer that you are the agent for the action you have individuated. You are at home sitting in your armchair and not on a soccer field, and there is no ball around. This is (partly) how you know that you did not score a goal.

If this is true, one way of testing the ability of a subject to determine whether or not he is the agent of a particular action consists in providing him an ambiguous visual feedback about the spatial and temporal properties of his actions, in a context where agency attributions cannot be easily inferred. This can be done using an experimental paradigm in which the subject looks at his own gloved hand behind a transparent screen. What he considers as his hand can also be

the video-image of a similar, but alien hand. He must carefully compare his own internal representation of the action with the available visual feedback in order to detect possible mismatches (Nielsen, 1963). This paradigm was used to investigate the performance of schizophrenic patients in attributing to themselves a token of action on the basis of a visual feedback that can be either veridical (what they see is their own hand) or spurious (they see a similar alien hand) (Daprati & al., 1997). This experiment included three conditions : the seen hand could be the subject's (condition I) or the experimenter's ; in the latter case, the movement of the alien hand could be identical to the subject's response (condition II) or not (condition III).

It was found that normal subjects misjudged the alien hand as theirs in condition II only, in roughly 30 % of the cases, and never misattributed their own hand movement to the experimenter. Schizophrenic patients had a performance similar to normal subjects in condition I and III , but their error rate increased to 77% (for patients with hallucinations) and 80% (for patients with delusions) in condition II.

These results raise a set of new questions. First, how can one explain the contrasting results in conditions I and II ? When a subject does a simple action such as raising one finger when hearing a tone, and watches a simultaneous action by the gloved hand, he must compare fine central or proprioceptive details of timing and kinematics in the internal model of the movement effected with the visual cues to detect who the agent is. Normal subjects fail occasionally, when the mismatch between cues lies below a certain threshold. This failure is consistent with the data gathered by Fourneret & Jeannerod reported above. Vision may win against proprioception and convince the subject that what he did was what he saw. Let us note however that the present task is explicitly one of detection, whereas the explicit task in Fourneret & Jeannerod was a motor performance with visual feedback (drawing a straight line). This difference in goal could account for the better performance of subjects engaged in detection. Not having to use the visual feedback for pursuing the task may help the subjects to focus on their own sensorimotor experience, however impoverished it may be.

It is interesting to note that failure in normal subjects always consists in *overattributing* to themselves visual tokens of movements of the alien hand, never in denying that a movement was theirs. This asymmetry in the pattern of failures may be explained by claiming that the subjects are indeed conscious of having done the same type of movement as the one observed, have learnt to identify their movement in their peripheral space, and therefore are driven to adapt (within limits) their visual experience to their motor experience by neglecting the possible mismatches. (Still subjects with delusion of control do have a slightly stronger tendency in this experiment to incorrectly identify a gesture of their's as the experimenter's.)

The degraded performance of schizophrenic patients relative to controls in condition II needs to be accounted for. Why would patients with hallucinations and delusions make respectively 77 % and 80 % of agency misattributions to self, while other patients have a 50% rate of errors ? Several hypotheses come to mind, some of them explored in Daprati et al. (1997). The simplest and most venerable is that the system fails to produce or to use a sufficiently strong copy of the efferent signal. In this view, the system fails to keep track of his own representation of the action as effected. For lack of such a signal, the organism fails to correctly anticipate the feedback that should occur as a consequence of the executed movement. What this hypothesis does not

explain, though, is the asymmetry between the patients'performances in conditions I and II. The learning bias postulated above could again account for it. Also, this hypothesis fails to account for the fact that schizophrenics do not present problems at automatically correcting their own intentional movements in simple tasks.

A second general type of hypothesis, compatible with the first, consists in examining the relationship between sensorimotor representation and agency representation. Granted that a corollary discharge regulates the execution of an action and the extraction of the relevant feedback, one sees that this mechanism is purely "private", in the sense that it has to use egocentric coding : only in this way can a comparison be made between efference copy and reafferences. On the other hand, determining who did an action is a perceptual judgment made on the basis of public cues, represented in allocentric coding. To know that I am the agent of my actions, I need to represent the goal, as well as the relevant visual features of a current action, and determine whether these correspond to any internal model. Although, as we saw, the sensorimotor representation of the action is not *consciously* driving every step of the action, still some salient parts of the sensorimotor control of the action may be represented explicitly, in terms of the physical changes that occur in the world. The main evidence that I am the agent in a particular action is that the relevant aspects of the environment and of my body are successively felt to be affected in the planned way. If for some reason the world around me was changing successively in exactly the way it would if I acted on it intentionally, while I am only forming intentions to act, I would have a hard time, in the absence of a plausible explanation, resisting the idea that I am acting on it. Thus it may not be so much internal as external cues - as predicted by an action plan - that have the main burden in agency judgments.

Thus it is plausible that the schizophrenic patients have a specific difficulty either in comparing egocentric with allocentric representations, or in using the sequence of environmental cues to produce a conscious and verbally reportable agency judgment. Let us briefly explore these two routes.

It is a well established fact that schizophrenics have a specific deficit in integrating multiple sources of information. In particular, they might have a specific difficulty at integrating proprioceptive and sensorimotor representations with visual inputs. Clinical reports on schizophrenics frequently describe an egocentric perception of the outside world : patients tend to see people as similar to themselves in their physical appearance ; in verbal hallucinations they hear voices directed to themselves. In delusion of reference, they have the impression that unknown passers-by wish to communicate with them. In a few cases, patients have distorted impressions concerning the boundaries of their own body (Cutting, 1994). This perturbation in the egocentric-allocentric representation of states of affair may express a dramatically reduced ability to utilize contextual information in a task-relevant way (Cohen & Servan Schreiber, 1992; Silverstein, Matteson and Knight, 1996)). In this hypothesis, whatever the present task is, reception of familiar or egocentric information is facilitated, while those features of the environment that are novel or foreign tend to be ignored. (Cohen and Servan-Schreiber suggest that variations of dopamine in the brain are responsible for these changes in gain). Such an explanation could account for the clinical cases in which patients with delusion misattribute to themselves actions of other people, as well as for Daprati & al.'s results. In this

view, agency attribution is taken to be a cognitive task that involves selecting relevant cues and balancing egocentric and allocentric sources of evidence. Now one difficulty is again to explain how these same patients may have normal performance in integrating proprioception and visual data in other tasks and in dayly routines. As we saw earlier, Malenka & al. had shown that patients do indeed use visual feedback to correct their errors in motor performance, and on the contrary seem unable to make the adequate corrections when *they lack* such visual feedback.

A way out of the difficulty , explored in Jeannerod (in press) consists in denying that the various agency tasks under consideration present the same cognitive demands. Some are *automatic* : the adequate responses are either innate or overlearnt. The common feature in these automatic tasks is that they do not involve any specific control. They are stimulus-driven, and do not require any attentional resources. Some are *controlled* : in other words, they are either new or still to be learnt ; they cannot be executed without exerting a deliberate selection of inputs; to succeed in these tasks, subjects have to keep in working memory the goal and subgoals of the action. Now it seems obvious that the agency attribution task in Daprati et al's experiment does belong to the latter category. Subjects cannot rely on familiar routines to respond correctly. They indeed have to find by themselves a strategy for detecting the agent.

An important finding in this perspective is that, in schizophrenics, automatic processes (such as the inhibition of a blink reflex through presentation of a weak prestimulus) resist better to interference, while voluntary processes (such as pressing a key as soon as a checkerboard seen on a screen disappears) are more subject to interference than in normal subjects (Callaway & Naghdi (1982). Dominey & Georgieff (1997) show that schizophrenics do better, in a sequence learning paradigm, in learning the surface structure of sequences than in learning the abstract structure, which again indicates that their implicit learning is spared while their controlled, explicit processing may be impaired. This contrast between automatic and controlled processing could account for the impaired agency attribution in situations demanding a high level of explicit processing. Agency judgments happen in a variety of contexts, the less natural being the experimental ones. Ordinarily, a subject does not have to ask himself explicitly whether he was the agent of an act. Still the information on who did what is critical for the success of any active perception, as well as for any action. This contrast between agency information and agency conscious attribution appears also in clinical data, where the schizophrenic patients seem to be considerably more disturbed in their conscious sense of agency than in their actual interaction with the world.

In this view, altered conscious states in patients would not result from a general consciousness-related deficit, but to local difficulties with processing cues relevant for identifying an action and retaining them in working memory. Thus they would not be primarily impaired in the processing of first-person information, but in what philosophers call aspectuality, i.e. the way in which the context is taken to be relevant and used for controlling one's action.

Self-consciousness,simulation and the theory of mind : concluding remarks

In the present state of research on conscious agency attribution, there are still many questions to be answered, concerning in particular the cerebral mechanisms for agency attribution that are impaired in the schizophrenic patients, and the difference between the impairments underlying respectively the delusion of influence (where the subject is not conscious of acting, but of being acted upon) and the delusion of control (where the subject believes that he can cause other people to act). One question raised earlier in this chapter needs to be explored again in light of the preceding discussion. Is there any uniform notion of self-consciousness ? Is such a notion a product of metarepresentational abilities ?

Let us note that, even in those cases where patients attribute their own acts to some external force, they experience agency-deprivation in a first-person way. Similarly, a depersonalized patient reports having a feeling of depersonalization, or a patient with Cotard syndrom reports that he does not exist anymore. It seems paradoxical that a subject could retain a first-person experience of episodes that seem associated to no feeling at all. One could submit that these states lie on a continuum with extreme cases where no first-person experience is present and for that very reason is not reported ("negative" symptoms such as catatonia could raise this kind of problem). But this line of response fails to acknowledge what has been the main theme in this chapter. If there is a functional disconnection between conscious representation and unconscious information processing, then it is perfectly possible for someone to report abnormal qualia while not being impaired in processing automatically the corresponding stimuli.

The preceding discussion leads us to resist the view that reflexive conscious states would depend on the operation of some central mechanism generally responsible for metarepresentation. Clearly, there are many different types of information that are used in the course of an action to know who did what (corollary discharge, parameters on movement velocity, body vs target orientation, etc.). Among these, few can be directly made the content of a conscious experience. You don't feel in charge in the same direct way as you see a certain shade of green or as you feel a prick in your finger. Generally speaking, an actor does not have access to his own central efferent signals. Agent-related conscious representations may be, in respect with their informational basis, distributed on several distinct functions, such as visual perception, proprioceptive and haptic processing, inferential capacities, and verbal representations. When he becomes conscious of acting, it must be, as we saw, on the basis of third-person accessible information.

A second important fact that emerged is that goal representation is self-other neutral. If goal representations are essentially sharable, then we do not understand other people by projecting a piece of internal knowledge on to them, as often assumed. The problem which our brain has to solve is the converse problem : determining who the agent is, once a goal is identified. This fact does not imply that we become conscious of "detached" goal representations. What it does imply, is that it is certainly possible to identify the goal of an action without specifying who the agent is. A corresponding intuition of this phenomenon is offered by a type of mental imagery in which a pattern of movement is both visualized and effected mentally. This kind of simulation does not seem to call for an explicit representation of the agent. Mentally simulating an action in

a first-person way, and looking at someone with the intention of imitating his movement share important cerebral as well as phenomenological properties[13]. Simulation would in both cases appeal to the memory of a goal-directed action, and possibly carry with it part of the sensorimotor representation typical of the action. Such an ability, which seems denied to non-human animals, is the basis for craftsmanship, artistic and sport practices.

This view has interesting consequences on the theory of mentalization, i.e. on the explanation of what makes a human being able to attribute to others and to himself mental states such as believing and desiring. Here too it must be decided whether this ability develops as a whole, as a module coming to maturity around 4 years of age, or whether it results from the interaction of other independent subcapacities. Whereas as we saw, Frith's theory of schizophrenia invokes the impairment of a metarepresentational module, a view that Jeannerod seems to have adopted in some of his writings, the discussion above is compatible with another picture of the conscious attribution of mental states. The concept of simulation has been used by philosophers[14] to show that a theory of mind is not needed to attribute intentional states to others. According to this view, one can predict and explain each other's behavior by simulating the decision processes in the others as well as in oneself. Mental concepts such as belief, desire, and agency, would in this analysis not precede, but result from actively simulating others entertain goals and motivational states. Autistic children would be accordingly deprived of a theory of mind because they would have a primary trouble at simulating in the appropriate way the situation in which another is involved. The preceding discussion brings important additions to the simulation theory of mind, with the notion of the shared character of goal representations. One can plausibly speculate that observed action, with the simulatory component of action memory, form a major building block for an understanding of other minds. Metarepresenting, in this perspective, would depend on additional executive capacities for maintaining distinct the inferences from diverse simulated contexts of action. Simulating aspects of action and perception could thus give us a key to aspectuality and its disorders, i.e. those that seem to be instrumental in schizophrenia and in autism.

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Footnotes

[1]See Proust (1998).
[2]Jeannerod (1995), Frankfurt (1988).
[3]See also Malenka et al. (1982).
[4]See Rosenthal, 1996.
[5] See Hobson (1993).
[6] See Meltzoff & Gopnik, (1993), Pacherie (1997).
[7] See Russell (1997).
[8]See David (1994), p. 295.
[9] See Fodor, (1983), Russell, (1997)
[10]See Shallice (1988).
[11] Jeannerod (1994).
[12]On the functional distribution of cortical pathways for vision, see Ungerleider & Mishkin's (1982), Jeannerod, (1997).
[13]Decety & al. (1994), (1997) ; See Jeannerod (in press) for a review.
[14]See Goldman, (1993), Heal (1986), Gordon (1996a), (1996b), Gallese & Goldman (in press).