REL-AT: A relational-attentional account of consciousness

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Abstract

In this paper I will try to show that (i) consciousness makes a difference to human behaviour; (ii) the main difference it makes, is to provide us with the sense of self; (iii) this sense of self is produced because consciousness allows us to relate ourselves to other entities, and therefore to understand what kinds of relations exist between us and them; (iv) the basic mechanism that allows us to relate ourselves to other entities, place things in relation to each other, and more in general have conscious experiences, is represented by variations in the state of nervous energy elicited by the use of attention; by attentional acting, we produce conscious experiences in the form of either a constraint or a freedom (to act in general). Finally I will show that the principal means by which variations in the state of nervous energy are used to put things in relation, is that of serving as a basis for the construction of possible orders (such as space and time).

Keywords

Consciousness, sense of self, relations, attention, nervous energy, order

Introduction

A fundamental question characterizes the contemporary philosophical debate and scientific research on human consciousness: does consciousness make any difference to our behaviour? Does consciousness simply and epiphenomenally accompany our brain activity, without bearing any consequences on the course of our thoughts, actions, perceptions, etc. or rather does it play a role in our behaviour, by somehow determining or influencing what we think, do, feel, etc.?

If we just consider (a) the bulk of empirical evidence showing that human beings process much information unconsciously (see for example Merikle et al. 2001) - including the kind of information which implies the most complex and rational decision processes, as found by Dijksterhuis and Nordgren (2006) and Zhong et al. (2008), who showed that complex decisions are more rational when the thinking that led to them was not conscious -, and (b) the fact that very sophisticated information processing, such as recognizing faces, analyzing speech and chess playing, which have always been considered a characteristic aspect of intelligent beings, can be performed by modern computers, which few of us would be willing to qualify as conscious agents, we would certainly be led to accept the idea that consciousness has no significant function, and that it does not add any value to our lives. This conclusions, which has been reached by some scholars, like Rosenthal (2008), who – by also referring to Libet's (1985; Libet et al., 1983) and Haggard's (1999; Haggard & Eimer, 1999; Haggard et al. 1999) work, which seems to imply that intentional actions can result from volitions that are not conscious - argues that "the consciousness of thoughts, desires, and volitions adds little if any benefit for rational thinking, intentional action, executive function, or complex reasoning" (*ibid.*, p. 839).

However, if we have a closer look at the available data, we will realize that things are not so clear-cut. In this paper I will try to show (i) that consciousness does make a difference to human behaviour; (ii) what this difference is; (iii) what it is, in and through consciousness, that makes it possible to realize such a difference; (iv) what the basic mechanism is that realizes and underlies such a possibility, and more in general, conscious experience.

Most of the ideas I will present here were put forward in Marchetti (2010), where it is possible to find a more detailed discussion, as well as more extensive reference to supporting empirical evidence.

Consciousness plays a role in our behaviour

Does consciousness make any difference to human behaviour? Contrary to the opinion of those who maintain that consciousness is a mere epiphenomenon bearing no consequences on a person's behaviour, there is a great deal of evidence showing that consciousness *does* play a role.

(i) Firstly, there are studies providing evidence that conscious and unconscious processing can lead to qualitatively different consequences. For example, Merikle & Daneman (1998) describe five studies that demonstrate qualitative differences for consciously and unconsciously perceived stimuli: (1) Kunst-Wilson and Zajonc's (1980) work shows that our affective reactions to stimuli may be influenced to a much greater extent by unconsciously perceived information than by consciously perceived information; (2) Groeger (1984, 1988) shows that the way a stimulus is coded varies depending on whether it is unconsciously or consciously perceived: for example, when a word is unconsciously perceived, meaning or semantics is the predominant code, whereas when it is consciously perceived, structural or surface characteristics become more important; (3) Merikle and Joordens's (1997) study shows that unconsciously perceived information leads to automatic reactions that cannot be controlled by a perceiver, whereas, when information is consciously perceived, awareness of the perceived information allows individuals to use this information to guide their actions so that they are able to follow instructions; (4) in a series of experiments, Cheesman and Merikle (1986) and Merikle and Cheesman (1987) show that prediction based on stimulus redundancy only occurs when the predictive stimuli are consciously perceived: subjects who only unconsciously perceive stimuli do not capitalize on the predictive information provided by the stimuli; (5) Marcel's (1980) experiment shows that conscious perception of a stimulus is constrained by context but that unconscious perception of the same stimulus leads to automatic reactions that are relatively unconstrained by context (in fully evaluating the validity of the conclusions inferred from some of these experiments, one should however take into account the criticisms that have been raised because of the methodological problems implied by the use of masking procedures: for a recent review, see for example Kouider and Dehaene, 2007).

Other evidence about the different role of conscious and unconscious processing can be found in classical Pavlovian conditioning studies. The classical Pavlovian paradigm involves the presentation of a conditioned stimulus (CS), that is, a neutral stimulus which does not produces an overt behavioural response, along with an unconditioned stimulus (US), that is, a stimulus of some significance which evokes an innate, reflexive response (UR). By repeatedly pairing the CS and the US, the two stimuli become associated, so that the previous neutral conditioned stimulus comes to elicit a behavioural response (equal or similar to the UR), called the conditional response (CR). Conditioning may be induced by various procedures that differ in the temporal relationship between the CS and the US: for example, in *delay conditioning*, the CS and US overlap, whereas in *trace conditioning*, a temporal gap (the trace interval) separates CS termination and US onset. Clark and Squire (1998) showed that trace conditioning requires an awareness of the CS-US relationship for

CR acquisition, whereas awareness does not appear necessary for simple delay conditioning (as observed by Bekinschtein et al. (in press), there are at least three cases that seem to challenge this view: trace conditioning can be 1) learnt by almost every animal, even sea slugs; 2) elicited using subliminal stimuli; 3) learnt by clinically-defined unconscious patients. However, as Bekinschtein et al.'s analysis reveals, all the three cases do not contradict the possibility that consciousness is a prerequisite for trace conditioning).

Further evidence about the qualitative difference between conscious and unconscious processing comes from implicit learning studies. Fu et al. (2008) – consolidating the findings made by Destrebecqz and Cleeremans (2001) and confirming predictions by Cleeremans and Jiménez (2002) - show (Experiment 3) that unconscious versus conscious knowledge, arises early in training and is characterized by weak, poor-quality representations that are already capable of influencing a person's performance, and are too weak for the person to be able to exert control over them.

Additional evidence supporting the view that conscious processing leads to results that are qualitatively different from those produced by unconscious processing comes from Sackur and Dehaene (2009). In their Experiment 4, they show that while simple tasks - such as naming a target number, performing an arithmetic operation (adding a number to, or subtracting a number from, a target number) or comparing the target number to a reference number – can be performed even when the target number is masked and cannot be consciously perceived, a chained (or composite) task made of two simple tasks on one target number (performing an arithmetic operation - such as adding a number to, or subtracting a number from, the target number- and then compare the result to a referent number) cannot be performed in the absence of consciousness. Commenting on their finding that "piping" of information from one task to the successive one is fragile and dependent on consciousness, Sackur and Dehaene observe – among other things – that "consciousness may be essential to the control of information accumulation and decay throughout mental processes (...) One function of conscious access would be to control the accumulation of information in such a way that a discrete decision is reached at each stage, before it is dispatched to the next processor" (*ibid*. P. 209).

Finally, even those researchers who most contributed with their work to showing the supremacy of the unconscious, cannot fail to recognize the usefulness of consciousness, at least for some aspects of human information processing. For example, Dijksterhuis and Nordgren, while arguing that in many ways unconscious thought is superior to conscious thought, have to admit that "this superiority of unconscious processes does not pertain to the earlier stage of information acquisition. At that stage, conscious processes are superior" (Dijksterhuis and Nordgren, 2006, p. 106). They exemplify their conclusions in the following way: "In concrete terms, when one wants to buy a new house, one should consciously acquire as much information as possible. One may consciously engage in listing the information, so that it is processed very thoroughly. However, the next step, the weighting and integration of the information to arrive at a judgment, should then be left to the unconscious. In short, consciousness should be used to gather information, and the unconscious should be used to work on it" (ibid., p. 107).

(ii) Secondly, the interpretation of empirical data supporting the primacy of unconscious processing is not as straightforward as it may seem at first sight.

Let's consider Libet's (2004) findings, for example. Libet devised an experiment in which a subject, who was fixing his gaze on the centre of an oscilloscope's face arranged like a normal clock (its spot of light revolved near the outer edge of the face, which was marked in clock seconds), was asked to perform a freely voluntary act, a simple but sudden flexion of the wrist, whenever he felt like doing so. The subject was asked not to preplan the act: but rather, to let the act occur "on its own". The time of the act was measured by means of electrodes placed on the muscle to be activated. The subject was also asked to associate his first awareness of his intention to act with the position of the revolving spot of light on the clock. Throughout the experiment EEG potentials were recorded from the above the surface of the region of motor cortex involved in hand movement. He found that: (a) when a subject consciously decides to perform a simple action, the neural event (RP=readiness potential) that initiates the action occurs significantly prior (about 350-400 msec) to the awareness of his conscious will to perform a freely voluntary act; (b) a subject who has planned to perform an act can veto it during the last 100-200 msec before the expected time of the action. From these facts, Libet concludes that it is not the subject's conscious free will that initiates his freely voluntary act: the latter would be initiated instead by his brain's unconscious processes. The subject's conscious free will can only control the outcome or actual performance of the act: it could only permit the action to proceed, or it can veto it. In my opinion, this conclusion seems unjustified, or at least misleading. In fact, in Libet's experiments, subjects were asked to perform a freely voluntary act, a simple but sudden flexion of the wrist, whenever they felt like doing so. They were aware of the task they had to accomplish well before the time in which the freely voluntary act was to occur. The act had to occur "on its own" of course, and the subjects were asked not to preplan when to voluntarily act. But they were asked to preplan to voluntarily act anyway! Therefore, in the causal chain of the events, a conscious decision to perform a freely voluntary act indisputably precedes the act itself. In this sense, I think it seems wrong to say, as Libet does, that it is not the subject's free will that initiates his freely voluntary act. In this case, it would be more appropriate to say that while the subject's conscious free will does not specify when to initiate the freely voluntary act, it nonetheless specifies that, whenever he feels like doing so, he has to initiate a freely voluntary act. As I have tried to show (Marchetti, 2005) most of the problems with Libet's erroneous conclusion that conscious will does not initiate a voluntary act, originates from his misuse or misconception of the word "voluntary". Although Libet gives a clear and almost comprehensive definition of "voluntary", he seems to overlook it. According to Libet (1985, pp. 529-530), an act is voluntary when: a) it arises endogenously, not in direct response to an external stimulus or cue; b) there are no externally imposed restrictions or compulsions that directly or immediately control a subject's initiation and performance of the act; and c) most importantly, subjects feel introspectively that they are performing the act on their own initiative and that they are free to start or not to start the act as they wish. Indeed, Libet's investigation focuses primarily not so much on the fundamental and initial component of a voluntary act that causes the whole chain of events (that is, the conscious event in which the subject preplanned the voluntary act), as on the subsequent steps of the chain, that is: the subject's readiness potential preceding the act, the subject's awareness that he is going to perform the act, and the act itself (the flexion of the wrist). In so doing, he isolates the main components of a spontaneous act, but overlooks the main component of a voluntary act. A clear category mistake underlies Libet's erroneous conclusions about conscious will: he investigates and explains a phenomenon belonging to the volitional sphere by using methods and logics pertaining to the "spontaneity" or "accidental" spheres.

A somehow related observation in the research field of unconscious priming, has been raised by Kunde et al. (2003). Contrary to the hypothesis that unconscious priming originates from purely unconscious semantic processing of the prime, Kunde et al. showed that unconscious primes activate responses to the degree that they match pre-specified action-trigger conditions: that is, the impact of subliminal stimuli is crucially determined by the subject's pre-stimulus intentions.

In the research field of classical Pavlovian conditioning, some researchers are even very critical towards and skeptical about empirical evidence proving the possibility of conditioning in the full absence of awareness, mainly because of the methodological problems arising from measures of awareness that may have underestimated conscious knowledge: for example, Lovibond and Shanks (2002), after reviewing post-1990 scientific literature on Pavlovian conditioning, argue that the bulk of evidence is consistent with the position that awareness is necessary but not sufficient for conditioned performance, and conclude: "Although it is possible that conditioning without awareness occurs reliably within relatively specialized systems (e.g., the gustatory system), the idea that unconscious conditioning is commonplace is clearly contradicted by our review" (*ibid.*, p. 22).

A similar skeptical attitude is also expressed by some authors towards the possibility of dissociating learning from awareness, a possibility which is instead envisaged and supported by implicit learning studies (Destrebecqz and Cleeremans, 2001; Nisbett and Wilson, 1977; Reber, 1967). In reviewing the literature of implicit learning, Shanks (2005) finds that "it has yet to be proved beyond reasonable doubt that there exists a form of learning that proceeds both unintentionally and unconsciously" (*ibid.*, p. 216), and Perruchet (2008) argues: "there are quite limited supports to claim that while they perform the implicit test participants (1) have no conscious knowledge about the study material, (2) have the subjective experience of guessing, or (3) have no control over the expression of their knowledge" (*ibid.*, p. 615).

Finally, Rey et al.'s (2009) experiment was important in clarifying the claim made by Dijksterhuis et al (2006) about the supremacy of unconscious over conscious thought at solving complex decisions. Rey et al.'s (2009), by using a similar experimental design to Dijksterhuis et al. (2006) but with an additional control condition - the "immediate condition"- in which subjects gave their choice immediately without any period of thought (conscious or unconscious), showed that decisions made by subjects in the immediate condition were just as good as in the unconscious one, hence challenging Dijksterhuis et al.'s (2006) interpretation. According to Rey et al. (*ibid*., pp. 377-378): "The results obtained in the control immediate condition are clearly inconsistent with the idea that a period of unconscious thought is beneficial for complex decision making (...) It proposed that decision processes are modulated by the amount of conscious processing of the information. The more time allocated to conscious processing, the greater the number of attributes considered by participants". This finding was replicated by Waroquier et al. (2010), who showed that decisions made immediately, that is, withot any further thinking, conscious or otherwise, were just as good as decisions made after a period of distraction. But they also found that while too much conscious deliberation can actually deteriorate high-quality first impressions, conscious thought enhances the quality of decisions in the absence of such prior first impressions: which suggests that the purported advantages of unconscious thought result not from the superiority of unconscious information processing but rather from the fact that too much deliberation can actually deteriorate high-quality first impression.

(iii) Thirdly, studies such as those by Perruchet and Vinter (2002), show that conscious mental life, when considered within a dynamic perspective, is sufficient to account for (at least part of) human behaviour without the need to resort to the concepts of unconscious representations and knowledge, and the notion of unconscious inferences. The "mentalistic" framework put forward by Perruchet and Vinter, expressed by the concept of self-organizing consciousness (SOC), proves to be more parsimonious than the prevailing view of the mind being grounded on the postulate of an omnipotent cognitive unconscious. Their model, by adopting basic associative principles that operate on successive conscious contents, but at the same time respecting and taking advantage of the constraints inherent to the conscious system, such as limited capacity, seriality and relative slowness of processing and memory decay, appears to be capable of generating highly complex representations that are able to fulfil functions generally assigned to unconscious rule-governed thinking.

(iv) Fourthly, experiments that have directly compared the brain activation evoked by conscious versus nonconscious stimuli, have revealed that conscious processing involves neural processes that differ from those involved in nonconscious processing, thus supporting – even if in an indirect way - the idea of a distinct functional role for consciousness (incidentally, it must be noted, however, that there is no general consensus among researchers not only about what constitutes the neural basis or correlate of consciousness, but also about the investigation stance and methods, such as introspection, to be adopted in order to find the neural basis of consciousness: for a discussion, see Lamme, 2010).

For example, time-resolved experiments using ERPs aimed at following the processing of a visual stimulus in time as it crosses (or does not cross) the threshold for conscious perception, have showed that it is possible to coarsely distinguish two periods of stimulus processing: subliminal stimuli produce a transient, small and brief activation during the first 250 ms that progresses from the occipital pole toward both parietal and ventral temporal sites; conscious stimuli elicit a sudden onset of high-amplitude activity around 270 ms broadly distributed in inferior and anterior prefrontal cortex as well as in posterior parietal and ventral occipito-temporal cortices (Dehaene, 2009; Del Cul et al., 2007).

Lamme (2003, 2006, 2010) suggets a similar division of stimulus processing in different stages associated with different levels of conscious access, but based on different neural mechanisms. When an image hits the retina, information flows - in what is called the fast feedforward sweep (FFS) - from visual area V1 to the extrastriate and dorsal and ventral stream areas to the motor cortex and prefrontal regions involved in controlling and executing movement: within 100-150 ms, the FFS enables a very rapid extraction of the essential features of the image (orientation, shape, colour, movement), and its categorization. However, processing by the FFS is not accompanied by conscious experience of the visual image: in order to have conscious experience neurons in visual areas must engage in recurrent processing (RP), which allows for dynamic interactions between high- and low-level areas that can become more widespread as time after stimulus onset evolves. RP would enable the widespread exchange of information between the areas processing different attributes of the visual image, thus supporting perceptual grouping and coordinated and planned responses to selected visual information.

A possible reconciliation of these two extreme rival accounts of the neural correlates of visual awareness, is offered by Rees et al. (2002). Using event-related functional magnetic resonance imaging, Rees et al. (2002) identified brain areas activated by stimuli in the left visual field of a right parietal patient suffering from left visual extinction (right hemisphere patients with extinction typically fail to report a contralesional left-stimulus, which is extinguished from visual awareness by a competing ipsilesional stimulus. Visual extinction can partly improve over time, thus allowing researchers to compare brain activity for those bilateral trials where both stimuli are successfully detected – i.e., without extinction – against those trials with extinction: the possible neural correlates of conscious visual detection can therefore be assessed). Rees et al. (2002) found that left visual field stimuli that were extinguished from awareness activated the ventral visual cortex, including areas in the damaged right hemisphere, while left visual field stimuli that were consciously detected were supported by a greater activity in the right ventral visual cortex, plus left parietal and pre-frontal areas. Rees et al.'s findings seem to suggest that conscious detection is "associated both with higher activity in ventral visual areas, and also in parietal and frontal areas" (*ibid.*, p. 391).

Further evidence that conscious processing involves brain processes that differ from those involved in nonconscious processing comes from EEG studies. Fingelkurts et al.'s (2011) study on vegetative (VS) and minimally conscious (MCS) patients shows that the size and duration of local EEG fields are smallest in VS patients, intermediate in MCS patients and highest in healthy fully conscious subjects. At the same time, these fields are quite stable in healthy subjects, less stable in MCS patients and very unstable in VS patients. The number and strength of coupling of local EEG fields (supposed to be responsible for the integrated subjective experiences) are highest in healthy subjects, intermediate in MCS patients and smallest or even absent in VS patients.

In short, contrary to the opinion of those who maintain that consciousness is a mere epiphenomenon bearing no consequences on a person's behaviour, not only is there evidence that consciousness does play a role, that conscious processing does lead to behavioural consequences that are qualitatively different from those produced by unconscious processing, and that conscious processing is underpinned by neuronal processes that differ from those underpinning unconscious processes, but there are also strong arguments (a) against the validity of evidence that certain phenomena, such as implicit learning and classical conditioning, can occur in the absence of awareness, and (b) supporting the view that part of human behaviour can be explained through conscious processing only.

From an information-processing-approach to a person-approach to consciousness

I think that much of the misunderstanding - or rather, the lack of understanding - concerning the role played by consciousness in a person's behaviour originates from the level of analysis that is usually adopted by researchers when investigating it: namely, the information-processing conception of mind. The information-processing approach has certainly yielded results in psychological research on the mind, but it is not the most appropriate approach when studying consciousness. This is due to the fact that the primary concern of the information-processing approach is to analyze the *piece of information* processed by the person, rather than to analyze what it means for a *person* to consciously experience the piece of information that he/she is processing (not to speak of analyzing what it means for a person to self-consciously experience that he/she is processing a given piece of information).

The information-processing approach can tell how long it takes for information to become conscious (Cleeremans and Sarrazin, 2007; Libet, 2004), the different levels of processing information involved by conscious vs. unconscious processes (Dehaene, 2009, and Kouider and Dehaene, 2007), the different consequences that consciously vs. unconsciously processing information has on memory, learning, etc. For example, as Dehaene's (2009) analysis shows, a subliminal stimuli can be processed to the extent of being coded semantically, being categorized by applying arbitrary instructions, and eliciting a motor response; on the contrary, conscious processing, being characterized by a brain activation that reverberates for a long time period and propagates to many brain systems compared to unconscious processing, allows information (i) to be held on-line for a duration unrelated to the initial stimulus duration, and (ii) to be shared across a broad variety of processes. Therefore, compared to unconscious processing, conscious processing would allow for the performance of novel behaviours that require putting together evidence from multiple sources, and of deliberation processes supporting voluntary action with a sense of ownership.

However, the information-processing approach cannot tell what it means for a person to feel the information that he/she is processing. Being focused on how information is processed, the information-processing approach can at best account for the function of consciousness in *processing information*, but not for the function that consciousness has for the *person*.

The first, direct and almost unavoidable consequence of the information-processing approach of investigating consciousness is that it leads researchers to wrongly believe that the qualitative, phenomenal aspect of consciousness (the "what-it-is-like") is completely useless (for a similar, albeit based on a slightly different ground, critique, see Clément and Malerstein, 2003; see also Fingelkurts et al., in press). By reducing the working of consciousness to a purely information-processing activity, this approach makes one assimilate the human mind to a computer (as it is currently conceived, that is, as a machine that does not possess any form of phenomenal consciousness) and conclude that the phenomenal aspect of consciousness is unnecessary for the good functioning of the organism. The line of reasoning that led to such a conclusion is more or less as follows: let's suppose that consciousness processes information; we know however that non-conscious devices such as computers also process information; therefore, we can conclude that information does not need consciousness (or at least its phenomenal, qualitative aspect) in order to be processed. In short, consciousness is irrelevant to a person's behaviour because the information it can possibly process can also be processed by computers, which as everyone knows do not possess any form of consciousness.

Another consequence of the information-processing approach has more general epistemological implications: it leads researchers to completely overlook the importance of consciousness in the emergence and development of the person as such, and in the meaning and knowledge construction process. As highlighted by some authors (Cisek, 1999; Edelman, 1989; Freeman, 1999; Searle, 1980, 1984, 1992), the information-processing framework is characterized by the fact that it considers: (a) information as made up of ready-made symbols representing the external world, whose meanings derive not so much from the importance they have for the person processing them, but from the importance they have for the researcher's investigations; (b) the person's mind as a processor of representations that already have their own meaning, independently of the history of the person. Taking the existence of both information and the person processing it for granted, the information-processing approach misses the opportunity to investigate fundamental aspects such as why a person processes information, why and how something becomes "information" for a person, if and how the person changes and transforms by processing information, how something acquires a meaning for a person. As I have tried to show elsewhere (Marchetti, 2010), by trying to tackle these very questions, we can find that: (i) both the person and information are not ready-made entities, but rather the product of a continuous activity of differentiation carried out by an organism through the application of its nervous energy to itself: an activity which, in relating the organism to other entities (by "other entities" I mean not only the objects, beings, organisms and events of the environment, but also the products of the very organism's activities, such as its movements, thoughts, plans, etc.), allows the person and the other entities to co-emerge and come into existence; (ii) the main tool that an organism possesses to carry out this activity of differentiation from other entities and emerge as a person, is consciousness: by making the organism directly experience how other entities relate to it (and how other entities relate to each other), what effects other entities have on it, how they limit it, how the organism's activity modifies other entities, consciousness is the privileged means by which the organism determines what relations exist between it and other entities, acquires a knowledge of itself and other entities, assigns a meaning to itself and other entities, and defines its own boundaries and shape, thus emerging as a differentiated entity: a person.

In order to fully account for the role that consciousness plays in a person's behavior, emergence and development, it is necessary to move the scientific analysis from an investigation of the difference that it makes for *information* to be consciously (vs. unconsciously) processed, to an investigation of the difference that it makes for a *person* to consciously (vs. unconsciously) process information.

The sense of self

An appeal to change the direction of scientific investigation on consciousness, moving from the information-processing-approach to a person-approach has been made by Cleeremans (2008, 2011). Cleeremans answers the question about what the notion of conscious subjective experience or *quale* means, by rejecting proposals such as Tononi's (2007), which, in analyzing conscious experience as a rather abstract dimension or aspect of information, would seem to miss fundamental facts about experience. "Experience – *what it feels like*" observes Cleeremans "is anything but abstract. On the contrary, what we mean when we say that seeing a patch of red elicits an 'experience' is that the seeing *does something to us*" (Cleeremans, 2008, p. 20).

Cleereman's proposal about what conscious subjective experience does to us, includes three main elements: memory, emotion and the sense of being the subject of one's experiences. For the first two, Cleereman states: "a first point about the very notion of subjective experience I would like to make here is that it is difficult to see what experience could mean beyond (1) the emotional value associated with a state of affairs, and (2) the vast, complex, richly structured, experience-dependent network of associations that the system has learned to associate with that state of affairs. 'What it feels like' for me to see a patch of red at some point seems to be entirely exhausted by these two points" (*ibid.*, p. 21). I think that Cleereman's proposal that memory and emotion are the main characteristics qualifying the difference when a *person* consciously (vs. unconsciously) processes information, while certainly identifying some important aspects, does not fully address the question. On the one hand, I see no reason why some other equally important aspects or processes that usually characterize subjective experience should be ruled out: for example, perceptions and thought, as well as all those processes listed by Baars (1988), or Seth (2009). On the other hand, these two characteristics can also be elicited by unconscious processing: for example, emotional responses such as fear can occur without awareness of their triggering stimuli (for a review, see Tsuchiya and Adolphs, 2007). Finally, these two characteristics seem to describe byproducts or second-order, albeit important, effects of conscious subjective experience, rather than to capture the fundamental differences that conscious (vs. unconscious) experience makes to a person, and that characterize all conscious experiences: not all our conscious experiences are accompanied by emotion or memories, which, on the contrary and most of the times, are consequent upon and triggered by a given conscious experience.

On the contrary, the third element identified by Cleereman - the sense of being the subject of one's experiences - seems to be more plausible: "it does not make any sense to speak of experience without an *experiencer* who experiences the experiences" (*ibid.*, p. 21); a "thermostat fails to be conscious because, despite the fact that it can find itself in different internal states, it lacks the ability to remove itself from the causal chain in which it is embedded. In other words, it lacks knowledge *that* it can find itself in different states; (…) there is no one home to be the *subject* of these experiences" (*ibid.*, p. 21). Indeed, all of our conscious experiences are accompanied – either at the same time as we have them, or at a later time - by the feeling that they belong to us, in the sense that we feel that it is we, and not someone else, who are experiencing them.

For sake of simplicity, I will call such a feeling "the sense of self", meaning by this expression the sense of a minimal self - with its components of the sense of agency and the sense of ownership - and the sense of a narrative self (see Gallagher, [2000], Hohwy, [2007]), as well as self-consciousness and the other possible manifestations of the sense of owning or being the subject of one's own conscious experiences.

The sense of self is continuously brought about and reinforced (Fingelkurts and Fingelkurts, 2011) every time: (i) we (decide/are able to) recall our past conscious experiences and experience them again; (ii) we decide to stop having a given conscious experience and start having another one; (iii) we realize that a conscious experience modifies and changes as we modify and change (for example, our conscious experience of duration changes with our age, psychological state, the kind of activity we are performing, etc.: see Flaherty, 1999; Marchetti, 2009); (iv) we observe that the conscious experience we are having is a precise and specific one, which differs from other ones (as Cleeremans, 2008, p. 23, observes, "When I claim to be conscious of a stimulus, I assert my ability to discriminate cases where the stimulus is present from cases where it is not").

The sense of self is dynamic, not singular but multiple, emerging chronologically in development "like onions, layers after layers, in a cumulative consolidation" (Rochat, 2003, p. 730).

No doubt then, one of the main differences when a person consciously (vs. unconsciously) processes information, is that it provides him/her with the sense of self. How does the sense of self affect and characterize the person's conscious experiences?

Firstly, the person's conscious experiences are characterized by a sense that they primarily originate from, are made possible by, and refer to him/herself (what the person feels depends on him/her). This is quite patent when the person's actions and thoughts are involved. But this is also evident with the other kinds of conscious experiences: there is no perception which does not originate from or is related to the person's specific sense-organs, body, position in space, way of looking at and conceiving the world, etc.

Secondly, it makes the person feel that the conscious experiences he/she has, have a direct effect on him/her, in the sense that every conscious experience the person has, directly affects, changes, modifies or transforms the person (what the person feels has an effect on him/her). The most obvious examples of these effects are extreme and acute sensations such as pain, effort, exhaustion, pleasure, gratification, relief, thirst, hunger, etc., but there are also countless examples in the various sensory domains represented by sensations having intermediate or minor effects.

Thirdly, it provides the person with the sense of being a persistent, coherent entity, self or agent. Even if the person undergoes changes, modifications and various and different experiences, he/she continues to exist as a unified and coherent whole, on and from which all his/her actions and experiences center and evolve (what the person feels makes him/her experience to be a consistent, persistent, unique agent).

Fourthly, it makes the person understand that he/she can directly control and guide the course of his/her own actions by means of his/her conscious activity. The person, once he/she has understood this – or, paraphrasing Cleeremans (2008), once he/she has “learnt to be conscious” -, equips him/herself with the capacity to self-regulate him/herself: that is, to set his/her own aims and objectives, take decisions, evaluate events and situations, learn new strategies, adapt to changes, etc., in a word to be self-conscious. From that moment on, the person’s actions are primarily and directly governed not so much by innate instincts as by what happens in the person’s consciousness, even though the latter can be occasioned by the former (for a detailed discussion, see Marchetti, 2010).

(With respect to the possible ways in which the sense of self affects a person’s conscious experiences, it is interesting to refer in passing to the various clinical and experimental dissociations that have been observed: for example, Zahn et al., 2008, report a case of a patient with a selective loss of the sense of self-ownership in the perception of objects, but with an intact sense of self-ownership in the proprioceptive domain and an intact sense of self-agency: the patient could see an object normally, but did not immediately recognize that he was the one who perceives the object; in contrast, he was aware of being the one who acts and perceives his body. For other interesting examples see Frith, [2005]).

According to Vogeley et al. (2004) and Schilbach et al. (2008), the neurophysiological basis of self-consciousness or the sense of “being a self” is provided by the default-mode network (DMN). Fingelkurts and Fingelkurts’ work (2011) brings further support to this hypothesis. By showing that the integrity of DMN persists unchanged across a variety of different cognitive tasks - and therefore is task-unrelated -, they can account for the fact that a subject that experiences phenomenal self-consciousness *always* feels directly present in the centre of a multimodal perceptual reality.

The main activity that consciousness allows a person to do

But what are the conditions necessary for the sense of self to emerge and take shape? I think that an indication pointing to a very plausible answer comes from developmental psychology, when it describes how the subject forms and develops. As suggested for example by Piaget (1974, pp. 281-282), the subject (in my terminology, the person) only learns to know himself when acting on the object (in my terminology, other entities), and the latter can become known only as a result of progress of the actions carried out on it. In other words, by continuously acting, the subject *differentiates* from the object and emerges as a cognizing agent: this process allows the subject to define itself and its own boundaries while also defining the limits and boundaries of the object. It should be noted here that “object” refers not only to inanimate entities but also to animate ones: in fact, as noted by various researchers, in order to emerge, a person’s higher-order cognitive processes, such as those involving meta-representational self-consciousness (Newen and Vogeley, 2003), require a person to interact with other persons, so that the person can compare and distinguish his/her own cognitive states with those of others (Decety and Chaminade, 2003; Newen and Vogeley, 2003; Schilbach et al., 2008).

The process of differentiation which allows the subject to emerge implies, and is based on, a very general activity: that is, the possibility for the subject *to relate* to other entities. This activity includes not only very basic and simple ways of relating - such as the same/different distinction or symmetry, repetition, alternation and relationships along some perceptual dimensions (smaller-than or brighter-than) - but also more complex and abstract ones. In the differentiation process, the person comes to learn and understand: how, when, where and why he/she relates with other entities (for example: how the perceived shape of an object changes depending on the angle the person views it from; in how many various and different ways he/she can handle an object; for how many different purposes he/she can use the same object); the value, importance and functions that other entities have for him/her (for example, a given object may imply danger for the person while some other object may imply survival; a given object may help the person achieve a certain goal while some other object may hinder him/her from achieving it, or may even be neutral); how the person can affect or change other entities; how other entities affect him/her and make him/her change or not change (for example, meeting a certain person or coming to know a certain idea or opinion can bring a dramatic change in the person's life; performing a certain activity may leave him/her completely indifferent; etc.). Some of these relations, once experienced, do not change but remain constant (we know that fire burns); others, on the contrary, can vary and change with time (the person can become intolerant to a certain food). Subsequently, and on the basis of this first-level knowledge of the relations between him/her and other entities, the person can build a second-level knowledge of the relations existing between other entities (for example, the person can understand how he/she can relate one object to the others, or how one object modifies the others).

In my view, this is precisely the main activity that consciousness allows the person to perform: that is, *it allows the person to relate him-herself to other entities*, and therefore to understand what kinds of relations exist between him/her and other entities. Consciousness, making the person experience directly what he/she is doing, the results of his/her activity, how he/she can affect other entities (and vice versa), how other entities limit him/her, etc., is the privileged way a person has of recognizing the relation between him-herself and objects, and concurrently of defining him-herself and other entities (I think that this aspect is well captured by Cleeremans' [2011, p. 10] observation that consciousness – by means of the independent meta-representations, which are constitutive of the sense of agenthood - enriches and augments the original representations (that is, what one sees, hears, feels) "with knowledge about (1) how similar the manner in which the stimulus' representation is with respect to that associated with other stimuli, (2) how similar the stimulus' representation is now with respect to what it was before, (3) how consistent is a stimulus' representation with what it typically is, (4) what other regions of my brain are active at the same time that the stimulus' representation is, etc."). It is through consciousness that a person understands how an object relates to him-herself, learns how to use it, and gets to know it.

Some could argue that because animals are also able to successfully perform tasks involving elementary forms of relational learning (for instance, as reported by Perruchet and Vinter, 2002, p. 317, rats that are trained with two stimuli differing in brightness in such a way that the choice of the brighter is rewarded and the choice of the darker not rewarded, subsequently choose the brighter of two new stimuli even though the absolute brightness of the new rewarded stimulus may be identical to that of the old unrewarded stimuli), and because it is questionable (at least) whether animals have any form of consciousness, consciousness is not necessary in order to (learn how to) place entities in relation to each other.

Apart from the plausibility of the claim that animals do not possess any form of consciousness (see Northoff and Panksepp, 2008; Panksepp, 2005), the argument that consciousness is not necessary to learn and place entities in relation to each other can be refuted on the ground that there is abundant evidence showing the opposite, at least as far as more complex forms of relations are involved. For example, Sackur and Dehaene (2009), as we have seen, have shown that it is not possible to perform a composite task made of two simple tasks on one target number (performing an arithmetic operation and then comparing the result to a referent number) without consciousness. Studies on classical conditioning show that "awareness is a prerequisite for successful trace conditioning" (Clark and Squire, 1998, p. 79), in which a short interval is interposed between the presentation of the conditioned stimulus (CS) and the unconditioned stimulus (US or UCS). According to Clark and Squire, the trace interval between the CS and the US makes it difficult to process the CS-US relationship in an automatic, reflexive way: therefore - versus a simpler form of conditioning such as delay conditioning – the more complex condition involved by trace conditioning would require consciousness to represent and remember the temporal CS-US relationship. In the field of fear conditioning, a similar view on the role of consciousness has been expressed by Knight et al. (2006, p. 160), who found that awareness is necessary for conditional responding during trace, but not delay, fear conditioning: "the differential roles that awareness plays in delay and trace conditioning may be related to temporal differences in the CS–UCS relationship. During delay conditioning, the CS and UCS overlap. Consequently, the neuronal representation of the CS is active during UCS presentation. In contrast, the CS terminates prior to UCS onset during trace conditioning. As a result, the CS representation within the basic fear circuit may decay prior to UCS presentation, and higher level cognitive processes may be needed to maintain this representation and bridge the temporal gap between stimuli. (...) declarative and working memory processes may be necessary for the synaptic plasticity that mediates CR [*conditional response*] acquisition during trace conditioning" (see also Carter et al., 2003, who showed how subjects tested for their ability to associate auditory cues with shocks under a variety of conditions - single-cue versus differential; delay versus trace; no task versus distracting 0-, 1-, and 2-back task -, could acquire reliable trace conditioning under a 0-back task only when they were briefed ahead of time about the nature of the experiment). Núñez and de Vincente (2004) have showed that whereas 50% of the participants who remained working at a non-conscious level acquired conditioned response (CR) during a *detection* task (in which they had to differentiate whether a flash of light corresponded to a blank screen or to a screen with a word), only 10% of the participants who remained working at an unconscious level reached the CR acquisition criterion during an *identification* task (in which they had to distinguish whether word 1, word 2, or a non-word was presented). Clearly, the identification task, forcing participants to remain alert as they see something in order to identify what is presented to them, involves more complex conditions than the detection task (such as the intervention of working memory, semantic memory, a comparison system, etc.), which can explain the need for consciousness to perform the former task. Moreover, Núñez and de Vincente's results indicate that when conditioning is conscious, it tends to be acquired more quickly and more regularly than when it is unconscious.

The influence of consciousness on the formation of relations is also evidenced by findings on the psychology of perception, which shows, for example, that the order of perceived events is highly dependent on whether their duration falls or does not fall inside what Stern (1897) has called *Präsenzzeit*, or "phenomenal present", that is, the interval of physical time that, despite being composed of non-contemporaneous parts, is perceived as a unitary and unique act of consciousness (see also Fingelkurts et al., 2010 for a discussion). As Vicario (2005) extensively shows, when all the single phases of a sequence fall into the phenomenal present, the sequence can undergo some kind of restructuring (according to some Gestalt principles of organization) irrespective of the physical temporal contiguity of the stimuli. On the contrary, if the single phases of a sequence occupy a whole phenomenal present, the sequence of stimuli cannot undergo any kind of restructuring, and the sequence of the perceived stimuli will be the same as the sequence of physical stimuli. Consider for example the phenomenon of "temporal displacement" in the experiment devised by Vicario (1963) in the in the auditory field. Triplets of stimuli such as a_1-b-a_2 were used, where a_1 and a_2 are high tones of 1760 and 1568 Hz respectively, and b is a low tone very different from the other two (82,4 Hz). For tones each lasting 100msec, subjects perceived a succession of high notes followed by a low note (a_1-a_2-b): as Vicario observes, it is as if the succession of similar, high notes "expelled" the different, low note, relegating it to a position where it cannot disturb the succession. The displacement of the central note takes place only when stimuli are shorter than150msec, while for stimuli longer than 150msec, the sequence of notes perceived by subjects tends to be the same as the sequence of the physical stimuli. What the phenomenon of temporal displacement as well as the other phenomena quoted by Vicario - such as the "continuous displacement", the "tunnel effect", the "Renard effect", the "window effect", the "phi phenomenon" - show, is that how relations between objects and events appear to us is strongly determined by the very features of the conscious working (such as, the duration of the phenomenal present), to the extent that the order of perceived events does not correspond to, and is sometimes in contradiction with, the order of physical events: for example, "before" in phenomenal, subjective time can come "after" in physical time, and vice versa; what is perceived as contemporaneous or simultaneous in phenomenal time, can be a sequence of events in physical time.

In my opinion, however, the clearest evidence that a person must be conscious in order to create and place entities in relation to each other, is represented by the extensive creation, use and exploitation of natural and formal language which is done exclusively by human beings, as compared to other species. Artificial and natural languages provide a wide and specialized variety of ways of connecting and correlating real and abstract objects and events, as exemplified by logical connectives, mathematical operators and "grammatical" words and morphemes, such as prepositions, conjunctions, negation, pronouns and adjective of quantities, interrogative-indefinite-relative pronouns and adjectives, etc. (Benedetti, 2009, 2010, Ceccato and Zonta, 1980). The fact that language represents a unique and specialized tool in connecting objects and events is further exemplified by the evidence reported by Conway and Christiansen (2001) of the strong connection between language and the ability to encode and represent the order of discrete elements occurring in a sequence (sequential learning): agrammatic aphasics (typically with damage to Broca's area) who have severe problems with the hierarchical structure of sentences also have problems with sequential learning. Furthermore, training aphasic patients on non-linguistic hierarchical processing improves complex linguistic constructions. Animals do not develop, use and exploit languages as extensively and frequently as humans do: this fact alone should suffice in demostrating the fundamental role played by consciousness in the creation of relations against the opinion of those who – believing that even unconscious beings such as animals can create relations – maintain that consciousness is not necessary to place entities in relation to each other.

The hypothesis that the main feature of consciousness is to allow a person to (learn how to) place entities in relation to each other (and by mean of these relations, to define him-herself and other entities), can also be criticized by saying that it is too restrictive and does not account for all that consciousness allows a person to do. Undeniably, such a criticism would seem more than reasonable if one considers, for instance, the eighteen functions listed by Baars (1988): definition, context-setting, adaptation, learning, editing, flagging, debugging, recruiting, controlling, prioritizing, access-control, decision-making, executive, analogy-forming, metacognitive, self-monitoring, autoprogramming and self-maintenance. As he argues: "it is doubtful whether any shorter list can do justice to the great and varied uses of conscious experience" (ibid., p. 347). I believe, however, that the variety of functions he lists can be reduced to the one I propose inasmuch as they let the person relate him-herself to the objects and events of the world, thus making the person understand both him/herself, the objects and the relations between him-herself and the objects. Indeed, all the activities a person can consciously perform - reducing and resolving ambiguity of interpretation (definition, context-setting, editing, flagging, debugging, and analogy-forming function), learning and adapting to new events (adaptation and learning function), setting goals, organizing, carrying out and controlling his/her mental and physical actions (flagging, recruiting, control, decision-making, and executive function), assigning priorities to the information to be processed (prioritizing and access-control function), and controlling and acting upon his/her own conscious states (metacognitive, self-monitoring, autoprogramming and self-maintenance function) - allow the person to understand how events, objects and other beings of the world relate to him/her (and to each other).

Summarizing, then, what makes the sense of self possible is the fact that a person can, by means of his/her consciousness, place entities in relation to each other, and that, by means of placing entities in relation, he/she can differentiate him-herself from other entities. But how does this activity of placing things in relations with each other through consciousness occur? What mechanism allows consciousness to place entities in relation with each other? More in general, what is the mechanism underlying consciousness?

The mechanism underlying consciousness

My main hypothesis is that consciousness is the result of a person's attentional activity - that is, the continuous use and application of his/her attention -, and that by means of his/her attentional activity, a person understands what relations exist between him/her and other entities, what his/her own boundaries and limits are, and concurrently the limits and boundaries of other entities. The hypothesis is based on some fundamental tenets, part of which I will describe here briefly: the reader can find a detailed presentation and a detailed discussion of supporting empirical evidence in Marchetti (2010).

(i) (Focal) attention is the core element necessary, even if not sufficient, for consciousness: without attentional activity, there cannot be consciousness. The position about whether attention is necessary for consciousness ranges from those who maintain that attention and consciousness are distinct phenomena that need not occur together (for example, Koch and Tsuchiya 2006, Lamme, 2003) to those who maintain that the two are inextricably entangled (for example, De Brigard and Prinz, 2010, Mack and Rock, 1998, Posner, 1994). As I have tried to show (Marchetti, 2010), the view that in general there can be consciousness without attention originates primarily from a failure to notice the varieties of forms that attention and consciousness can assume. There are various forms of attention and consciousness. Attention can, up to a certain extent, be split between different perceptual and processing modalities (Pashler 1998); it can be either exogenously or endogenously elicited; it can be both widely distributed for relatively long time periods in a certain location (preparatory attention) and narrowly distributed in another location for shorter periods (selective attention) at the same time (La Berge 1995); it varies according to the perceptual load (Lavie 1995); it has one transient component and one sustained component (Nakayama& Mackeben 1989); etc. Likewise, a general awareness of our environment (ambient awareness) can be distinguished from a more detailed focal awareness of a scene (focal awareness) (Iwasaki, 1993); a form of primary consciousness, including an awareness of the world and mental images, but not a concept of self, can be distinguished from a form of higher-order consciousness, including self-awareness, a sense of time, and language (Edelman 1989); forms of spatial awareness can be distinguished from more reflective forms of consciousness based on intellectual acknowledgment (Bartolomeo 2008). Not all forms of attention produce the same kind of consciousness, and conversely not all forms of consciousness are produced by the same kind of attention. In order to understand the relationship between attention and consciousness properly, it is essential to take due account of the varieties and complexity of forms of attention and consciousness: overlooking this factor may lead to the wrong view that there can be consciousness without focal attention (for a similar criticism, see Kouider et al., 2010, Srinivasan, 2008).

(ii) Attentional activity can be performed thanks to the nervous energy supplied by the organ of attention. The concept of "nervous energy" implies the ideas that nervous energy is a pool that allows us to do a certain kind of work, is limited, runs out, is replenished, and can be used in a flexible way. The concept of nervous energy – for which alternative terms, such as "psychic energy", "limited capacity processor", "resource", "effort", "pool of limited capacity", have also been used – has been analyzed in various ways in relation to attention by many researchers and authors (for example: Csikszentmihalyi 1992, Kahneman 1973, Mach 1890, Wickens1984). The notion of energy is currently used and investigated more in general in relation to brain activity (Laughlin, 2001, Laughlin and Sejnoiwski, 2003, Shulman et al., 2009a, 2009b). The notion of "organ of attention" can prove to be problematic for some. In physiology, for example, an "organ" usually denotes something that is anatomically delimited, while in the case of attention it could turn out that many structures are involved at various levels. Therefore, it could be better to use some other term, such as for example "nervous structures". At present, however, I think organ is the preferable term because it requires and conveys the complementary idea of function, which is fundamental at this initial stage of research on the brain structures underpinning consciousness.

Notwithstanding the problems that the term of "organ of attention" could raise, it must be noted that many scientists have started investigating its physical substrate. For example, Crick and Koch maintain that the thalamus is the organ of attention (Crick 1994, Crick and Koch 2003). Mesulam (1990) proposes a network model of attention in which several distinct cortical regions interact: the posterior parietal cortex (which provides an internal perceptual map of the external world), the cingulated cortex (which regulates the spatial distribution of motivational valence), and the frontal cortex (which coordinates the motor programs for exploring, scanning, reaching, and fixating), all of which are influenced by the reticular activating system (which provides the underlying level of arousal). La Berge's (1995) neural model of visual attention involves the thalamus, the oculomotor regions of the superior colliculus, and the posterior parietal cortex. Posner and colleagues (Posner 1990, 1995; Posner and Petersen 1990) present a model of attention consisting of three interconnected networks: a posterior attention network involving the parietal cortex, the pulvinar, and the superior colliculus; an anterior attention network involving the anterior cingulated cortex and supplementary motor areas in the frontal cortex; and a vigilance network involving the locus coeruleus noradrenergic input to the cortex. Knudsen (2007) proposes that attention reflects the combined contributions of four distinct processes supported by different, but partly overlapping cortical and subcortical structures and areas: working memory (supported by the prefrontal cortex and the posterior parietal cortex), competitive selection (supported by the lateral intraparietal area, the superior colliculus and the frontal eye fields), top-down sensitivity control (supported the posterior parietal cortex and the frontal eye fields) and automatic filtering for salient stimuli.

(iii) Attentional activity consists in the continuous application of attention to the other organs (sense organs, the proprioceptive system, the interoceptive, system, the musculoskeletal system, and working memory) or to attention itself. This "continuous" working of attention can best be conceived as cyclical, that is, a repetition of successive acts of focalizations each of which has a certain minimal and maximal duration. The hypothesis of the cyclical dynamics of attention, which has been put forward and tested by several researchers (see for example, Buschman and Miller, 2010, Large and Jones, 1999, VanRullen et al., 2007, or Ward 2003, who states that attention seems closely associated with alpha and gamma rhythms), can also be inferred from the observation that no one can possibly attend continuously to an object that does not change (James, 1890), or from the close correlation between the perception of apparent simultaneity and the alpha phase at which stimuli are presented (Varela et al. 1981);

(iv) Attentional activity allows a person to perform actions that can directly vary his/her own state of nervous energy. It is this variation that constitutes the phenomenal aspect of consciousness, or qualia. My the idea that conscious experience is the result of a change in the state of nervous energy (induced by the use of the nervous energy itself) derives in part from Valéry's (1973) observation that sensation is a variation of the state of energy of a closed system: "Sensation is not an introduction of something from the outside, but rather an intervention, that is, an inner transformation (of energy) made possible by an external modification, a variation in a state of a closed system (…) sensation is due to some kind of disequilibrium (…) sensation is what occurs between two states of equilibrium" (I have translated this from the Italian version, 1988, pp. 411-412). Other suggestions indicating that consciousness results from a variation of the organism's internal state, can also be found in Damasio's (1999) work: "we become conscious when the organism's representation devices exhibit a specific kind of wordless knowledge - the knowledge that the organism's own state has been changed by an object" (*ibid*., p 25).

(v) By acting attentionally, a variation in the state of nervous energy is induced, which produces a conscious experience in the form of either a certain level of constraint or of non-constraints (to act in general). The constraints and non-constraints that the person experiences when acting attentionally are determined by the level of attention applied, the specific structure of his/her body and the relations resulting from the interaction between his/her body and other entities (this aspect was conveyed very well by Piaget [1937], who – in describing how the idea, or concept, of an

object is built up during the first stages of intellectual development - observed that the subject recognizes his own reaction before he recognizes the object as such);
(vi) These constraints and non-constraints – which are the basic elements of conscious perception - consist precisely of the interruption, hindrance, slowing down, facilitation, stimulation, acceleration, and so on, of attentional activity. Whenever a person finds an obstacle or cannot extend his/her limbs beyond a certain length or cannot make a movement, his/her attentional activity, and all his/her being along with it, is slowed down or even temporarily stopped, so much so that the person must either apply his/her nervous energy in a new way or redirect it to something else, if he/she wants to unblock the situation.

A very interesting, albeit partial, exemplification of the mechanism by means of which attentional activity induces a variation in the state of nervous energy, is represented by Cabanac and Russek's (2000) model of regulated biological systems. Cabanac and Russek start by correctly pointing out that describing regulation in biological systems using the classical terms of control theory has the disadvantage of not distinguishing signals from energy: control theory is more concerned with signal processing than with energy flow, which, on the contrary, is the main problem of any living being: "A computer, or a T.V. set, are plugged into an infinite energy supply, and energy counts for little in the problem engineers face in building or using them. On the other hand, energy and matter supply is a major problem for animals. It is therefore necessary to revise the concepts of regulation in order to face this specific problem in living beings" (*ibid.* 2000, pp. 141-142). According to Cabanac and Russek, living beings are open systems that accumulate free energy and reduce their entropy at the expense of the energy input: they reach a steady state, so that a constant amount of free energy available for use is maintained, and the input and output flows of energy are equal and constant. Their capacity of reducing their local entropy and of organizing themselves at the expense of the energy flow through them, may represent the thermodynamic basis of life and evolution. Cabanac and Russek's model of regulation in physiological systems (Figure 1), which is essentially a homeostatic one, is based on a *set point* that indicates the normal level of function. Perturbations of the steady state require the system to compensate for deviations from the set point. The compensation is achieved by regulating the input and output flows, which are anatomically distinct (body outflow - urine, heat loss, etc. - is not the same loop as inflow – water intake, heat production, food intake, etc.). The inflow regulation is a negative feedback loop, in which an input subsystem responds to a perturbation of the steady state by increasing the flow when energy is drained and decreasing it when energy levels rise above the set point. The outflow is a positive feedforward loop in which changes in the state relative to the set point induces changes in the same direction in the output subsystem.

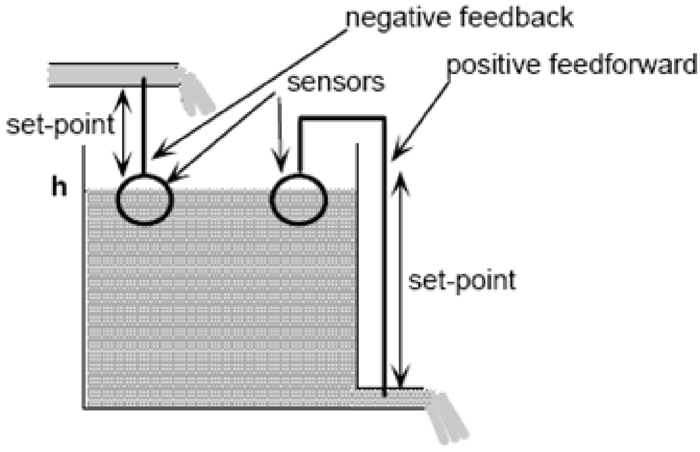

Figure 1. Cabanac and Russek's (2000) model of regulated biological systems.

Cabanac (2000) observes that sensations of pleasure and displeasure are strongly dependent on the actual internal state of the system, that is, how much the level of free energy available for the system deviates from the set point: for example, while hypothermic subjects feel cold stimuli as unpleasant and warm stimuli as pleasant, hyperthermic subjects feel the opposite in response to the same stimuli: as soon as subjects return to normothermia, all stimuli lose their strong pleasure or displeasure component and tend to become indifferent. Cabanac uses the word "alliesthesia" to indicate that the hedonic dimension of sensation is contingent upon the internal state of the stimulated subject. Therefore, sensory pleasure can be characterized by its physiological usefulness in correcting a physiological problem or deficit.

If we apply Cabanac and Russek's model to my attentional model, the energy flow becomes the nervous energy which is continuously used by the organism in the form of attention. The application of attention induces perturbations of the energy level of the system, which can generate either pleasant, unpleasant or indifferent sensations. The hedonic dimension of the sensation - that is, its pleasantness, unpleasantness or indifference - depends substantially on whether the energy level of the system is moving away from, or toward the set point (as we have seen, pleasant sensations occur when perturbations are corrected, bringing the energy level toward the set point, while unpleasant sensations occur when perturbations are introduced, which brings the energy level away from the set point), the distance between the actual energy level and the set point (indifferent sensations occur when the energy level is near the set point; painful sensations occur when the energy level reaches a certain distance from the set point), and most probably the speed at which the energy level moves.

Let's try to imagine how the internal state modifies when a person, touching a surface, feels a soemthing "soft". The initial application of attention – through the organ of touch - to the surface produces a slight expenditure of nervous energy, which induces a temporary decrease of the energy level of the system. This in turn entails – through the regulatory negative feedback – the opening of the faucet at the input so as to let the energy level rise in order to restore the set point. Subsequently, with the surface of the object not offering any resistance to the fingers, less nervous energy is required at the output. The sudden increased input flow not counterbalanced by an equal output flow makes the energy level return to the set point, with the accompanying sensation of pleasure.

On the contrary, a sensation of "hard" implies, after the initial application of attention, a subsequent increase of output flow, which, not being duly counterbalanced by the input flow, leads to a further decrease of the energy level, with the accompanying sensation of effort and sometimes also displeasure.

By offering a model of representation that is common to both human consciousness and the other main physiological functions (such as pulmonary ventilation, blood circulation, etc.), Cabanac and Russek's model also gives biological plausibility, from an evolutionary point of view, to my model of consciousness as being the evolution of more primitive systems. The continuity between old and new systems, however, does not necessarily imply that there are no differences between them or that they perform comparable functions. Indeed, while the old systems have the main function of keeping energy flow and oscillations under control, thus maintaining the amount of free energy available for use as constant as possible, human consciousness allows a person to control the other organs and systems through the use of the energy flow. That is, human consciousness offers the privilege of controlling the other organs and systems by means of a unique and common kind of energy: nervous energy.

This latter aspect of my model of consciousness is also well conveyed in Cabanac's (1996, 2003) idea of the affective dimension of human consciousness as being the "common currency" for the trade-offs that take place in the mind to achieve a ranking of priorities and ensure that the most urgent motivation wins access to the behavioral final common path: which, in Cabanac's view, is what makes human consciousness useful for a person (this aspect is also reminiscent of Ukhtomsky's [1966] principle of "dominanta": for a discussion of Ukhtomsky's principle, see Fingelkurts et al. [2010]).

The constraints and non-constraints a person experiences every time he/she acts attentionally, represent the basic elements that allow the person to come to know and define him-herself, other entities, and the relations between him-herself and other entities. For instance, the activity a person performs when trying to reach something unsuccessfully has a direct effect on him-herself, in the sense of modulating his/her own pool of nervous energy by either blocking the nervous energy flow, re-directing its course, or further stimulating it in the same direction. This effect, which constitutes the "feeling" a person has, immediately gives this person the dimension of his/her effort, and helps define the boundaries of both his/her body and the entity he/she tries to reach, and the relations between him-herself and the entity. The information so acquired constantly updates what I have defined the "schema of self" in my model of consciousness (Marchetti, 2001, 2010), that is, the system that incorporates and coordinates all the (innate or learned) values (at the top of which is what I define the algorithm of life or being: "operate in order to continue to operate") and schemata that are necessary to keep the organism alive, and provides all the rules which make our organism perceive, move, act in general and interact with other organisms.

On the basis of the initial experiences of his/her own boundaries and limits and those of other entities, a person can subsequently and progressively refine and develop the definition of the relations existing between him/her and other entities (and consequently the relations existing between other entities). As demonstrated by Piaget's (1936, 1937) influential work on developmental psychology, a person's relations are defined through and by means of a gradual and continuous process of differentiation and systematization, made of different stages that progressively generate and consolidate, among other things, the notions of independent entities (such as "object", "agent", "space", and "time").

The process by means of which a person defines his/her relations with other entities and concurrently defines him-herself, requires some a-priori, inborn behaviors by means of which the process can be started and facilitated. Examples of these inborn behaviors are the various fundamental reactions inherent in the hereditary equipment of the newborn child - such as sucking and grasping reflexes, crying and vocalization, movements and positions of the arms, head or trunk – which, as observed by Piaget (1936), give rise to a systematization which exceeds their automatization, and prepare him to adapt himself to his external environment and to acquire subsequent behavior. Such inborn behaviors are most probably supported by cognitive mechanisms based on generative models and predictions such as those described by Gallagher (2000) and Hohwy (2007). However, it is important to note that while these cognitive mechanisms can explain the subject's capacity to assign the cause of a certain experience of constraint to an external agent rather than to him-herself, or the subject's capacity to judge whether a certain experience of constraint reflects a real object of the world rather than a hallucination, they cannot explain the experience of constraint itself, that is, how conscious phenomena and experiences generate. As correctly observed by Hohwy (*ibid.*), the explanation provided by mechanisms such as generative models and predictive coding is not aimed "at consciousness itself, but at why specific aspects of *conscious contents* are the way they are, rather than another way"(Hohwy, *ibid.*, p. 16, italics are mine).

Consciousness creates orders

In my view, the principal way (because of the important consequences and developments it implies and brings forth) in which the variations in the state of nervous energy (induced by attentional activity, and which elicit experiences of constraints and non-constraints) are used to place entities in relation to each other, is by serving as a basis for the construction of possible orders (by "order" I refer to all kinds of series, successions, arrangements, sequences, schemas and organizations in general). Typical examples of orders are space and time. Once an order is created, it is possible to build various kinds of relations on this: relations of comparisons ("X is nearer to us than Y" or "X is brighter than Y”), spatial relations (“X was in front of Y”), temporal relations (“A arrived before Y”), causal relations (“It is X that moves Y”), logical relations, physical relations, etc.

According to my analysis, an order can be created from variations in the state of nervous energy by exploiting some characteristics of the organ of attention and working memory, that is, respectively, the possibility of: (i) applying attention to something in a continuous, incremental and cumulative way (at least, up to a certain extent); (ii) keeping track of the results of the work of attention.

Let’s consider first how temporal order can be obtained by using the work of attention. As I have aimed to show (Marchetti, 2009), time-sensation is determined by the quantity of labor performed by the portion of our attention (A_t) that is focused in a continuous and incremental way (up to a certain extent) on the conscious product of the activity performed by means of another portion of one’s attention (A_e). The activity performed by A_t represents the “temporal activity” (for instance, estimating duration); the activity performed by A_e represents the “non-temporal activity” (for instance, perceiving the shape of an object). The amount of nervous energy - supplied by the organ of attention - expended to support the activity of A_t constitutes the basis on which the conscious experience of duration and more in general time-sensation are based.

If we consider that a given event X can be associated with a certain level of expenditure of the nervous energy supplied by the organ of attention for the temporal task, an event Y that is associated with more expenditure of attention (and consequently with high sensations of constraint and effort) appears to us to happen “after” X, whereas an event Z that is associated with less expenditure of attention (and consequently with low sensations of constraint and effort) appears to happen “before” X. A “succession” or “sequence” of events, actions, etc., as well as their “duration”, can then be built out of the levels of nervous energy associated with them. Since the level can only increase, this makes it possible to arrange or order events, actions, etc. in a univocal and exact way: precisely, in a temporal way (Eagleman, 2008, p. 134, puts forward a similar explanation: “duration is a signature of the amount of energy expended by neurons”, even though he [Eagleman and Pariyadath, 2009] does not seem to directly link the notion of neural energy expenditure to attention).

In spatial order, the possibility of using working memory to keep track of the various conscious sensations produced by (applying attention to) a moving sense-organ, is fundamental in my opinion. Let’s suppose that you are perceiving a surface by moving your index finger on it. By keeping present in consciousness, in an incremental way, the single sensations produced by the index finger while it moves, you will shape a sequence or succession of sensations, which is the basis for the formation of two-dimensional constructs, such as “path”, “line” and “distance”. On this basis, by exploiting the various features of attention – primarily, that attention is cyclical in nature and that each attentional cycle has a certain minimal duration, which allows for the realization and execution of mental cognitive operations (Benedetti et al., 2010) and their combinations in constructs of increasing complexity (Fingelkurts and Fingelkurts, 2001, 2005, 2006, Fingelkurts et al., 2010. On the advantages offered by discrete neural computations over a continuously evolving system, see also Buschman and Miller, 2010) -, it is possible to experience and develop more complex spatial constructions.

Other researchers base their explanation of the origin of spatial experience on the operations of attention. For example, according to Mandler (2008, 2010), during the first year of life, preverbal infants are able to reduce and redescribe perceptual information into a spatial image-schematic form thanks to the work done by what she calls Perceptual Meaning Analysis (PMA): an innate attentional mechanism that records selected aspects of incoming spatial information into an accessible conceptual format. PMA is activated by attention and in early infancy this is largely determined by the movements of objects in space rather than by the details of what objects look like, or what the infant is doing (for the first 5 to 6 months, infants cannot physically act on objects in any effective way, because of lack of hand control). PMA produces a set of spatial primitives, such as PATH, LOCATION, MOTION TRANSFER, which is sufficient to account for the early conceptualizations that preverbal infants use to interpret objects and events (and which enable them to recall the past, think about absent objects and events, imagine the future, make plans, and solve problems mentally). These early conceptualizations are important because they represent the core ontogenetic foundations on which later concepts are built and play a major role in determining the organization of the adult conceptual system. Carstensen (2007, 2011) shows that selective attention plays a central role in the characterization of spatial relations, and that the representation of attentional aspects leads to the possibility of defining an ontological upper structure which covers both the spatial and temporal domain. For Scheider and Kuhn (submitted), the human being experiences the geometrical and topological structures of the environment by performing and comparing attentional steps. An attentional step is the actual movement of attention from focus *x* to *y*. Scheider and Kuhn put forward an operational model of constructive geometry grounded on primitives of the human attentional apparatus, which allows for referencing and predication of geometrically relevant Gestalt phenomena in vista environment. In particular, it allows for detecting whether one focus of attention precedes another one (primitive perception of time), whether attention focuses on the same point-like feature, whether a given pair of foci is congruent to another pair, and whether a focus points between two others.

However, the fact that consciousness allows us to build orders does not exclude the possibility that non-conscious systems can also build some kind of order. As discussed by Cleeremans (2011), there are artificial neural networks that can learn rich structured representations that capture abstract dimensions of a given task domain, as a result of merely being required to process exemplars of the domain. The difference between conscious and non-conscious systems is that: (1) while the latter produce kinds of orders that can be successfully used only in the context of performing the particular task for which they were trained, the former produces kinds of orders that can be applied without restriction to any domains; (2) while non-conscious systems produce kinds of orders that cannot be easily modified, consciousness produces kinds of orders that can even be completely inverted (for example, we can conceive of time as being reversible).

The experiences of constraints and non-constraints supplies the firm ground on which the person can build orders that allow him/her to create various kinds of relations: spatial, temporal, etc. Consciousness makes it possible to create orders, and to create relations based on these orders. Without consciousness, neither orders nor the relations that can be built on them, would exist. A person's knowledge assumes the form that his/her consciousness allows it to assume. Everything a person knows is known in and through his/her consciousness. A person comes to know the world as it is thanks to his/her conscious experience. Conscious experience is the only level of reality that a person can directly access: all the other levels can be accessed only indirectly via the privileged medium of consciousness. Consequently, the world appears to the person as his/her consciousness lets him/her experience it: it unavoidably bears the hallmark of his/her consciousness. Its qualities and characteristics are the qualities and characteristics of his/her consciousness. The world is ordered according to the principles established by and through a person's consciousness, and has the form that such principles let it assume.

Conclusion

In this paper we have seen that: (i) consciousness makes a difference to human behaviour, determining and influencing what a person thinks, does, feels, etc.; (ii) the main difference that it makes, is to provide the person with the sense of owning or being the subject of his/her conscious experience, what I termed "the sense of self"; (iii) what, in and through consciousness, makes it possible for the person to have such a sense of self, is that a person can relate him-herself to other entities, and therefore understand what kinds of relations exist between him/her and other entities; (iv) the basic elements that allow a person to relate him-herself to other entities, and more in general to place entities in relation to each other, are the variations of his/her own state of nervous energy induced by the application of his/her attention; these variations, which constitute the phenomenal aspect of consciousness, or qualia, produce a conscious experience in the form of either a constraint or non-constraints (to act in general). We have also seen that the principal way in which variations in the state of nervous energy are used to place things in relation with each other, is byserving as a basis for the construction of possible orders (such as space and time).

Most of the ideas I have put forward here, and more in general my theory of consciousness should be treated as unproven until they are verified. I believe however that they are supported by a bulk of evidence, that they are congruent with many of the current theories and views of consciousness, and that their explicative power can account for many unresolved dilemmas.

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