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Chapter 2

CONSCIOUSNESS EXTENDED: BRIDGING INFORMATIONAL BROADCAST AND PERCEPTUAL AWARENESS WITHIN A COMPREHENSIVE CONCEPTUALIZATION OF CONSCIOUSNESS*

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ABSTRACT

There is no consensus yet regarding a conceptualization of consciousness able to accommodate all the features of such complex phenomenon. Different theoretical and empirical models lend strength to either the occurrence of a non-accessible informational broadcast, or to the mobilization of specific brain areas responsible for the emergence of the individual´s explicit and variable access to given segments of such broadcast. Rather than advocating one model over others, this chapter proposes to broaden the conceptualization of consciousness by letting it embrace both mechanisms. Within such extended framework, it is proposed the conceptual and functional distinction between consciousness (global broadcast of information), awareness (individual´s ability to access the content of such broadcast) and unconsciousness (focally isolated neural activations). The hypothesis is that a demarcation in terms of neural thresholds distinguishes the unfolding of the informational broadcast from the emergence of subjective awareness. In this light, consciousness is conceptualized as a phenomenon unfolding along a continuum ranging from complete inaccessibility to full awareness. The proposal presented in this chapter grants both quantitative and qualitative parameters to consciousness, it accounts for its different phenomenological expressions, and it affords hypotheses aimed at explaining specific neurological disorders.

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1. INTRODUCTION

Although both at theoretical and empirical levels the study of consciousness is steadily enriched by the unrelenting work of scientists and philosophers, the core issue concerning the conceptualization of the phenomenon has yet to yield agreement. While consciousness may be explained by some as the awareness of our own actions, thoughts and feelings, the phenomenon may be addressed by others as the state opposite to sleep and coma. Nevertheless, an individual who is not in a coma nor asleep is not necessarily aware of his or her own behavioral responses, nor of his or her own feelings. Explanatory divergences exist also with respect to the mechanisms that may determine the emergence of consciousness. The phenomenon can in fact be understood as the emergent result of the neural computations taking place within specific brain structures. However, consciousness can also be assumed to derive from the totality of specific computations taking place anywhere in the brain (see Atkinsons *et al*. 2000, for a more exhaustive account of the different approaches to the study of consciousness).

It could then seem that the path towards consensus might imply the adherence to one specific theoretical framework rather than to another one. An alternative approach could however be to consider to what extents the existing theoretical models, and the bulk of data so far collected, could be interpreted in relation to different mechanisms involved in consciousness. A conceptual and functional distinction between such processes could then advance our understanding of consciousness as a whole. To such intent, this chapter dares the role of moderator in the debates concerning both the conceptualization and the emergence of consciousness. Rather than arguing for one model above others, it is here proposed to expand the conceptualization of the phenomenon by letting it embrace both the mental faculty to broadcast and effectively deploy implicit information, and the ability to intentionally and explicitly access such knowledge. Within the frames of the proposed conceptualization, these distinct (albeit closely interacting) mechanisms are respectively referred to as *consciousness*[1] (i.e. the faculty of broadcasting knowledge), and awareness (i.e. the accessible content of such knowledge)[2.] Accordingly, *unconsciousness* is taken to describe only focally isolated neural activations since they effectively lay outside the margins of the broadcast, that is, outside consciousness.

In sum, the aim of this chapter is threefold. Firstly, it will probe the possibility that divergences between different theoretical approaches might, at least partially, depend on the relatively narrow perspective traditionally applied to the phenomenon, i.e. its conceptualization in terms of subjective experience.

I will therefore discuss the extent to which the localist and the globalist models of consciousness appear to address the distinct mechanisms that are respectively involved in the broadcast of implicit information and in the modulation of perceptual awareness[3]. The final

[1] In order to distinguish the proposed broad conceptualization of consciousness from its current understanding, the former will be indicated in italics throughout the paper.

[2] This choice leans on the intransitive application of the expression "to be conscious." (i.e. to be in a state opposite to coma), and on the transitive function implicit in the expression "to be aware *of something/someone*...." (i.e. to acknowledge explicitly a perceptual object).

[3] The edges between localist and globalist approaches are in fact relatively blunt and – at least for what concerns specific theories – often overlapping. It is indeed their theoretical compatibility that guides the intuition to outline their respective strengths, and to let them merge into a comprehensive framework.

suggestion will therefore be to broaden the conceptualization of consciousness by letting it include both mechanisms.

Secondly, this chapter will consider the different methods currently employed to assess consciousness. Rather than highlighting the intrinsic validity of the different measures, the discussion will concern the extent to which subjective (e.g. confidence ratings, verbal reports) and objective (e.g. physiological recordings and brain imaging data) methods can account for distinct correlates of consciousness. I will therefore argue that, although the mechanisms responsible for the informational broadcast and for the modulation of perceptual awareness are distinct one from another, they nonetheless interact closely.

The final hypothesis will suggest that quantitative parameters characterize the unfolding of stimuli broadcast from their eventual emergence into awareness.

Lastly, this paper will propose that specific neuronal thresholds distinguish the informational broadcast from the individual´s subjective awareness of its contents. This proposal will reason in favour of the gradual emergence of consciousness, and it will rest on the theoretical and empirical evidence that confutes the dichotomous nature of the phenomenon. Furthermore, the proposed distinction between the informational broadcast and perceptual awareness will lead to the hypothesis that, following focal damage, specific neurological conditions might reflect an inability to reach the amplification necessary for the stimulus to emerge into awareness.

2. LOCALIST AND GLOBALIST MODELS: TWO SIDES OF THE SAME COIN

It is beyond my intentions to carry out a comprehensive review of the theories of consciousness that respectively subscribe to the localist or to the globalist stances, and therefore only few proposals will be mentioned in this section (these proposals are succinctly outlined in table 1).

In fact, my present goal is to advance the suggestion that, as different models appear to address distinct neural mechanisms, a broader conceptualization of consciousness can reconcile such different stances and strengthen our grasp on the phenomenon.

2.1. Localist Approach: Explaining the Informational Broadcast

Broadly speaking, the localist approach argues for the emergence of multiple consciousness-units widely distributed across the brain. The mechanism described by Zeki (2003, 2008) and by Tononi (2004) appears therefore suitable to account for a network responsible for the broadcast of the processual output of specialized units, and for the integration of such continuous flow of information into implicitly meaningful percepts. Such a distributed mechanism presents a number of valuable elements.

Firstly, it bears adaptive value since it can prevent the complete inability of the organism to process stimuli, even if focal cortical damage may have affected the processing of some specific perceptual features.

Table 1. The table outlines some of the main tenets of the localist and globalist theories mentioned in section 2

Localist models of consciousness
The theory of multiple consciousness (Zeki, 2003, 2008) By introducing the concepts of micro- and macro-consciousnesses, Zeki´s theory of multiple consciousness emphasizes the composite nature of the phenomenon. While *micro-consciousnesses* encode the discrete features of a stimulus (e.g. its colour), *macro-consciousnesses* bear the bound cluster of such distinct percepts (e.g. its colour and its smell). Micro- and macro-consciousnesses are then the necessary elements compounding the emergent phenomenon that occupies the top of such computational hierarchy: the *unified consciousness* of the stimulus (e.g. an apple bearing its specific colour, smell and taste). As we constantly acquire a continuous flow of micro- and macro-experiences, it is therefore Zeki´s proposal that consciousness is only *illusorily* an unitary phenomenon. The interesting conclusion is that "*subjects become conscious of the bound percept after they become conscious of the attributes that are bound, again suggesting a temporal hierarchy in perception.*" (Zeki, 2003, p.216). It is worth underlining that, since the specific features of a stimulus can be experienced independently of one another**,** the emergence of consciousness appears to be independent from perceptual binding.
The information integration theory (Tononi, 2004) The information integration theory proposed by Tononi (2004) is a significant attempt to shape operational frames for the dimensions of consciousness, i.e. its quality and its quantity. While the former addresses the features defining the kind of consciousness generated by a system, the latter defines the extents to which a system is conscious. In such cases, Tononi proposes the quantitative evaluation of consciousness by means of the value Φ, that is the amount of causal information integrated at any one time in a specific complex of elements. Complexes, which are the nuclei that integrate information, represent the distributed loci of consciousness and their computations are strictly dependent on the interactive links formed within their boundaries. It has to be noted however that elements external to the specific complex may still be connected to it and exchange data, but they do not become part of the given conscious experience. With respect to the quality of consciousness, Tononi has proposed that it depends upon learning and consequently upon the brain´s organization of such learning. More precisely, Tononi has argued that perceptual subjective variations emerge from the 'fine-tuning' of informational relationships within and between the cortical areas shaping the main complex.
Globalist models of consciousness
The Global Neuronal Network (Dehaene and Naccache, 2001) Drawing on the Global Workspace Theory (Baars 1988; 2005), Dehaene and Naccache argue that, although constantly processed in parallel modular brain assemblies, percepts acquire a conscious state only upon entering the global neuronal workspace. By means of attentional amplification, the mobilization of the computational units participating to a specific processual assembly will determine a global state of neural activity, and consequently lead to the emergence of consciousness. Such a global network is characterized by long-distance connections which allow the flow of information between specialized brain areas. However, it is argued that only perceptual-, motor-, memory-, evaluation- and attentional circuits are able to bind together, and therefore only data processed within these modules are potentially enabled to emerge into consciousness. Nevertheless, specific responses may still unfold unconsciously as long as they conform to specific criteria, i.e. they must reflect routine action-sequences, and the computations compounding them must not draw on interconnected modular systems already deployed in parallel operations. Although the neuronal workspace is conceptualized as a dynamic network that involves the participation of different neuronal assemblies, particular relevance has been assigned to some specific brain structures. Specifically, Dehaene and Naccache have argued that prefrontal cortex (PFC), anterior cingulate (AC) and the areas connecting these two structures – given their supposedly high concentration of workspace neurons – are crucial structures in the shaping of subjective experience.

Conditions such as object agnosia[4] can support the occurrence of an informational broadcast which, although lacking input from a specialized processing area, it is still able to modulate stimulus´ recognition on the basis of different perceptual modalities (see Morady and Humphreys, 2009). Despite not being able to recognize and to explicitly name visual stimuli, patients´ability to process different features of stimuli (e.g. its smell, texture, shape, sound) can in fact lead to semantical recognition (Konen et al. 2011).

A different kind of focal damage, specifically to the ventromedial occipital cortex, can lead to cerebral achromatopsia, where the patient is no longer able to distinguish colours, nor to perform tasks involving color discrimination. However, research conducted by Heywood, Kentridge, and Cowey (1998) has shown that these patients are able to distinguish between two targets (such as a square and its background) if these are equiluminantly colored (i.e. respectively, red and green). The patients' knowledge can nevertheless not be accessed: they actually cannot explain what is different about the square and its background even though they know that they differ somehow.

A further advantage of a distributed mechanism able to broadcast a flow of information prior to the attainment of a full-featured representation, is that it might rapidly enable the organism to respond on the basis of proto-representations, and therefore to modulate the emergence of phenomenal and monitoring consciousness[5]. In fact, although the processing of stimuli might initially lack perceptual accuracy, their proto-representation may be sufficient to determine their summary assessment. On the basis of such gross appraisal, percepts could then be either 1) ignored, 2) determine an automatic response and/or a feeling of perception, or 3) be granted attentional resources (see Augustenborg, 2010). The distributed process illustrated by Tononi's (2004) computational model demonstrates how such system, which is able to integrate and broadcast remarkable degrees of informational complexity, can indeed maximize its computations by granting functional speed to its processes.

2.2. Globalist Approach: Explaining Perceptual Awareness

The globalist model proposes consciousness as a phenomenon involving dedicated brain structures. As noted with respect to the localist model, also the globalist approach presents elements of indisputable value. In the first place, it is difficult – if not utterly impossible – to deny the occurrence of topographically consistent activations congruent with the emergence of subjective experience (see Quin et al. 2010; Del Cul et al. 2009; Vogeley et al. 1999). It would not seem sensible either, in the light of the remarkable evidence from brain imaging studies, to oppose the argument in favour of a dynamic network of activations involving specialized areas in accordance with the nature of specific stimuli or tasks (Loeb and Poggio, 2002). More so, the functional value of the globalist workspace is highlighted by its capacity to temporally and conceptually isolate specific data-units from a flow of background information. Such resource-demanding faculty allows the selected data to be a) accurately assessed, 2) subjectively evaluated in the context of the organisms´ current goals and

[4] Object agnosia refers to the inability to recognize familiar objects, and it is determined by unilateral lesion in the lateral fusiform gyrus in the right hemisphere.

[5] Monitoring consciousness (Block,1995) supervises the ability to carry on familiar action patterns without the need to invest attentional resources in the task. Phenomenal consciousness defines instead the pure experience of a percept, that is, a representation deprived of its physical descriptive features such as colour, smell, form, etc..

priorities, and 3) within such comprehensive cognitive frames, to be strategically and intentionally deployed. In sum, by entering the workspace, the outcome of the organism´s perceptual processes is conveyed into a more fine-grained processual cycle where information acquires accessible subjective values. In such contexts, the involvement of PFC and AC is highly compatible with the emergence of subjective experience since both areas have been consistently associated with attentional processes, and with the emergence of the sense of self (Longe et al. 2010; van der Meer et al., 2010; Bishop et al. 2004).

2.3. Mutual Compatibility between Globalist and Localist Models

Both the localist and the globalist approaches appear to offer remarkably plausible accounts of different processes and, at the same time, to compensate for their respective explanatory weakness. In fact, while the globalist approach seemingly offers a convincing account of the emergence of subjective experience, and of our ability to intentionally access it and verbally report it, it lacks a convincing hypothesis concerning the integration and deployment of the parallel informational flow. Global workspace theories argue that, while consciously learned instructions may be followed unconsciously, unconsciously acquired (masked) information cannot be strategically deployed. This assumption, which appears to greatly limit our faculty to profit from the perceptual richness we seem otherwise able to process (Tononi and Edelman, 1998; Tononi 2004, but see Kouider et al. 2010), has also been confuted by recent studies (van Gaal et al., 2008, 2010)[6]. Conversely, the power of the localist proposal is indeed to account for a mechanism able to broadcast and to integrate a significant amount of information. This goal is pursued by conceiving a network that plastically builds upon the interactive connections emerging among its own distributed complexes. In sum, the mechanism of informational integration and broadcast proposed by localist theories can plausibly be assumed to mediate the non-accessible flow of information, i.e. implicit knowledge.

The emergence of perceptual awareness, plausibly explained by the globalist model, assumes instead a relatively less central role in the localist model. In fact, Tononi had explicitly reasoned that a conscious percept can be present in the system even when it is not experienced by the organism. This premise leads to an empirical impasse: if nor verbal neither emotional response can be taken as proof for the emergence of consciousness, the criteria to define the phenomenon clearly cannot include neither one of the two faculties.

3. A BROAD CONCEPTUALIZATION OF CONSCIOUSNESS

Since informational broadcast and perceptual awareness appear to emerge as two distinct, but strictly interacting mechanisms, the suggestion advanced in this chapter is to broaden the conceptualization of consciousness by letting it embrace both processes. It is also maintained that the unfolding of the informational broadcast is the necessary – but not sufficient -

[6] Recent evidence has also challenged the globalist suggestion that only familiar responses can be carried on unconsciously (Patsenko and Altmann, 2010).

condition preceding the eventual emergence of its contents into a state of increased neural activity that significantly invests frontal and parietal regions leading to perceptual awareness.

The broadening of the conceptualization of consciousness entails therefore that the term should also apply to those instances in which the subject is actually not able to access own perception, i.e. during the informational broadcast. However, in order to avoid the semantic conundrum "unconscious of being conscious", a terminological distinction between consciousness and awareness is suggested in this chapter. Specifically, it is adopted the term consciousness when addressing the non-accessible informational broadcast, while awareness is taken to identify the state of enhanced activity leading to an individual´s explicit experience of the percept[7]. Admittedly, the use of the term consciousness also in instances in which the individual is not aware of his/her own percepts might appear confusing. However, the existing taxonomy of consciousness (e.g. Block, 1995; Dehaene et al. 2006) has already highlighted the variegated range of experiential nuances encompassed by the phenomenon. In agreement with the gradual nature of consciousness, it is therefore suggested to broaden its conceptualization by letting it embrace the perceptual continuum spacing from the informational broadcast (null-access) to full reportability.

One of the initial objections to the suggested distinction between consciousness and awareness could be that it appears to retrace the more familiar discrimination between unconscious and conscious mechanisms. It could therefore be argued that, whether we call "unconscious" (traditional sense) those percepts that we cannot directly access and/or report, or we label them "conscious, but not aware" (proposed definition), might not change significantly our scientific landscape. However, the existing distinction between consciousness and unconsciousness largely rests on the empirical grounds of subjective measures, where the occurrence of explicit and intentional responses to stimuli distinguishes conscious from unconscious perception. Remarkable evidence – some of which will be considered in the next section – shows nevertheless the vulnerability of such reasoning, bringing to mind the words of Johnjoe McFadden: "Any theory that fails to account for the difference between conscious and unconscious brain activity is clearly incomplete" (in Tuszynsky, 2006, p.387). According to the conceptualization of consciousness proposed in this chapter, only focally isolated neural activations are considered unconscious since they effectively lay outside the margins of the broadcast - that is, outside consciousness.

4. ASSESSMENT METHODS

At an empirical level, we make a distinction between subjective and objective measures of consciousness and, although both methods aim at the same phenomenon, the conceptualizations they employ to define it are remarkably different. Following the criteria of subjective measures, an individual´s consciousness of a percept is assessed on the bases of his or her ability to explicitly acknowledge its occurrence, to access its contents, and to savour the subjective feeling of the experiences deriving from it. On the other hand, objective measures accept the individual´s ability to react to stimuli, to follow simple instructions, and

[7] Such distinction between *consciousness* and awareness echoes a previous instance in literature where consciousness has been described as an individual´s possession of functional mental faculties, while awareness has been taken to define the *content* of consciousness (see Gawryluk *et al.* 2010). See also Abondo *et al.* (2009) for a similar distinction operated within the frames of legal responsibility.

generally to interact appropriately with the physical surroundings as significant indices of consciousness. Put another way, while we could think of the subjective methods as probing the question, "how clearly did the *individual experience* the percept?", the query of the objective approach can be framed as, "to which extents (if any at all) is the *system processing* the percept?".

The divergence of assessment criteria leads then to a crucial consideration: if two measures were truly evaluating two indices of the same process, we should expect a consistent degree of correlation between the data since their underlying mechanism would be a same one. But if we acknowledge that one aspect of a phenomenon does not always correlate with the other, it would then seem logical to assume that we are dealing with distinct mechanisms, each mediating a separate outcome. This conclusion can indeed be supported by the lack of consistent convergence between subjective and objective measures of consciousness (see Sandberg *et al*. 2010; Szczepanowski and Pessoa, 2007; Schneider *et al.* 2003).

4.1. Objective Measures of Consciousness

The rationale behind the employment of brain imaging and physiological measures in the assessment of consciousness is that specific brain activity occurs congruously with the detection and processing of a stimulus (see Ruff *et al*. 2008; Mummery *et al.* 1999; van de Riet *et al.* 2009). An interesting example of one such methodological application has been offered by Owen *et al*. (2002). The researchers employed a $H_2{}^{15}O$ PET technique to compare the mental activations occurring in two patients in vegetative state (VS) against the patterns identified in a healthy control group following the presentation of familiar faces and of different auditory stimuli. Owen and co-workers concluded from the results that, "*the patterns of activation observed in patients KB and DE were similar to that observed in healthy control volunteers while performing identical task*" (p.400). Owen *et al*. formulated then the hypothesis that the brain-imaging data collected during their study reflected some level of "*minimal awareness*" in the VS patients. While such a conclusion might be accurate, it is nevertheless relevant to note that other studies have placed doubts on the causal relationship between specific neural activations and the emergence of an individuals´ awareness of a stimulus. By investigating neural activations during change-blindness and change-detection, Pessoa and Ungerleider (2004) showed that the specific pattern involving parietal and frontal areas - congruently with what other researchers had previously suggested (e.g. Dehaene *et al.* 2003; Baars, 2005) - correlated with the subjects' reports of a visual experience. However, the study also revealed that patterns of neural activity were comparatively similar independently from whether they reflected an accurate or a mistaken report. Such findings could then indicate that the activation patterns registered by Pessoa and Ungerleider (2004) reflected mechanisms involved in the general sensorial detection and processing of stimuli, rather than in their specific appraisal. In fact, by wrongly reporting the change of an otherwise steady stimulus, the participants' accounts did not reflect the objective content of perception, which therefore appeared dissociated from the subjective experience of the visual event. This suggestion could equally apply to the data collected by Owen and colleagues in their previously mentioned study. It could in fact be hypothesised that the patterns of activity

detected in their patients had reflected the general sensorial detection of the stimuli, but not necessarily the individuals´ subjective appraisal of their content.

The occurrence of substantial processing, also with respect to those stimuli that have eluded the individuals´ subjective acknowledgement of their contents, had previously been demonstrated by Vuilleumier *et al.* (2002). In their analysis of fMRI data obtained from patients showing visual extinction and spatial neglect, Vuillemier and colleagues evaluated the activations triggered by emotional faces with and without awareness of the stimulus. The results showed that, although the extinguished fearful faces were not able to determine the emergence of perceptual awareness, these stimuli activated the extrastriate visual cortex, left amygdala, orbito-frontal cortex and superior parietal cortex, which are all areas relatively distant from the primary visual cortex. Such occurrence could accord with the present suggestion that a complex data broadcast can unfold independently from the emergence of awareness.

Recently, the presence of a neural loop seemingly involved in the broadcast of stimuli independently from perceptual awareness has been further confirmed by Schmid *et al.* (2010). The study employed behavioural measures and fMRI data from two macaque monkeys with irreversible V1 damage. Schmid and co-workers demonstrated that, despite the absence of activation in the lesioned area, a visual stimulus in the contralateral visual field did not preclude activations in extrastriate areas V2, V3, V4, V5, superior temporal sulcus and lateral intraparietal area. Even more interestingly, Schmid *et al*. compared behavioural and brain-imaging data relative to disrupted and intact neural activity within the lateral geniculate nucleus. The results revealed the presence of V1-independent neural projections between the LGN and a number of extrastriate areas[8].

In conclusion, far from aiming at discrediting the validity of objective measures of consciousness, my intention is to highlight the frames within which their effectiveness seems to emerge more clearly. Within the frames of the broad conceptualization of *consciousness* proposed in this chapter, it is therefore argued that objective methods of assessment - by indexing specific activation patterns correlating with stimuli´s processing - afford the evaluation of the efficiency of the information broadcast (i.e. *consciousness*). Conversely, evidence of subjective perception of an experience (i.e. awareness) may be arguably revealed by brain imaging and physiological responses.

4.2. Subjective Measures of Awareness

Broadly accepted as the golden standard in the assessment of consciousness, subjective measures are based on the rationale that reportable experience identifies the individual´s perception of specific stimuli. Notwithstanding disputes of validity concerning the different measures (see Dienes and Seth, 2010; Overgaard *et al*., 2010; Seth *et al*. 2008), it is hereby acknowledged that introspection most certainly accounts for the individual´s subjective experience of an event. However, it is arguable whether or not the latter might necessarily reflect the objective processing of the specific stimuli. As the aim is indeed to assess the

[8] The presence of V1-independent pathways mediating visual awareness has also been suggested by Ffytche and Zeki (2011), who have investigated the phenomenon in three patients with hemianopic field defects.

individual´s acknowledgement of the given percept, the very issue of specificity behind such methods deserves therefore careful consideration.

More than 30 years have passed since Nisbett and Wilson´s (1977) controversial article challenged the validity of verbal reports as reliable indices of subjective perception. The argument proposed by the authors was built on evidence showing that participants' reports depended on the subjective evaluation of the stimulus´ plausibility and salience rather than on introspective access to higher order cognitive processes. Despite the richness of supporting evidence, Nisbett and Wilson´s proposal did not fare well and, as of today, introspectionism is considered the ultimate tool to peruse an individual´s awareness of perception (Overgaard *et al.* 2010). Admittedly, if we agree upon the strictly *subjective* nature of a percept, it might make little sense to speculate about whether or not the individual – that is, the very *subject* of the experience - is able to access it. Nevertheless, Nisbett and Wilson´s daring suggestion strongly highlighted the possibility that our accounts might *not always* reflect our perceptions. Following the thread of Nisbett and Wilson's argument, Johansson *et al.* (2005) introduced a new paradigm (i.e. choice blindness) in which they tested an individuals' ability to account for one's own choices. The results showed that, although the participants' original preference had been covertly swapped with an alternative option, they failed to recognize the mismatch, and they actually mended introspective accounts of their motives behind the specific (false) choice. In other words, the verbal reports appeared to have been constructed by the participants in order to accommodate their beliefs, rather than to reflect their actual perception of the stimulus.

Performance represents another commonly employed measure to evaluate an individual´s awareness of task-relevant stimuli. If the subject´s ability to execute correctly a given task is above chance level, it is generally agreed that s/he must have had some degree of awareness of the stimulus. However, Sperling´s (1960) experiments on iconic memory are classic examples of the mismatch between subjects´ performance and their overt knowledge of the relevant stimuli[9]. Although only able to report an average of 4.5 items out of the 12 to which they had been briefly exposed, the subjects´ performance greatly improved when they were cued to report the items that had been arranged along a specific row. In other words, the participants had – at least for a limited period of time – access to more than they could actually account for. Certainly, it could be argued that short-term memory might have played a significant role in Sperling´s results, and that stimuli bearing stronger saliency or higher contextual value might have been reported more efficiently than the letters and numbers that Sperling had shown to his subjects. Such reasoning is however challenged by Fu *et al.* (2010), who have recently supported the discrepancy between the objective processing of stimuli and the awareness of their contents by demonstrating that control over the use of knowledge can occur independently from the awareness of knowing. By probing participants´ higher-order cognitive processes, Fu and colleagues have shown that, although their subjects were able to correctly identify and deploy the implicit rules of the task, they were not able to account for their responses by explaining why their strategy was indeed correct.

In sum, it is not the value of introspective measures per sé that is being challenged in this section. On the contrary, I underline the suitability of these methods in the assessment of the contents of the information that emerges within our accessible, cognitive grasp (i.e.

[9] A number of recent studies have further supported the dissociation between performance and perceptual experience, e.g. Fotopoulou *et al*. 2010; Rosenthal *et al.* 2010.

awareness). Nevertheless, I argue that it remains debatable whether or not the reported knowledge may reliably index the objective sensorial detection and processing of stimuli, and therefore probe the contents of the information broadcast (i.e. *consciousness*).

4.3. Distinct Mechanisms for Consciousness and Awareness

Currently, there is no single method that offers undisputed indices of consciousness (see Gawryluk *et al.* 2010). More so, evidence exists to demonstrate how the presently employed measures appear to address discrete correlates of a rather multifaceted phenomenon. Specifically, objective and subjective measures can be independently taken to index the distinct output of two separate mechanisms – respectively, *consciousness* and awareness. Crucial considerations support such suggestion. (a) We possess evidence showing that subjective knowledge of acquired information can contradict the individual´s performance. (b) We also have data supporting the possibility that verbal reports do not *necessarily* reflect an individual´s sensorial detection and cognitive processing of the given stimulus. (c) Finally, we have evidence that demonstrates that a neural broadcast of information is not always sufficient to determine accessible knowledge about its contents. In the light of such evidence, we would have to recognize the need to conceptually distinguish the mechanisms that appear to lead independently to such different outcomes.

5. DISTINCT ACTIVATION THRESHOLDS

Having argued for a conceptual and functional distinction between *consciousness* and awareness, the final intent of this chapter is to advocate the suggestion that a demarcation in terms of neural thresholds distinguishes the unfolding of the informational broadcast from the emergence of subjective awareness. A similar proposal had already been advanced by Zeki (2003), who based his argument on the empirical observation that specialized cortical areas may be active without necessarily leading to a subjective experience. Zeki had therefore proposed that an experiential event is more likely to be determined by neural activity occurring above specific thresholds. Accordingly, the present suggestion is that, while the informational broadcast might rest on relatively low neural thresholds, **t**he gradual emergence of awareness proportionally reflects increasing degrees of neural amplification. The detailed appraisal of given segments of the broadcast[10] appears in fact to imply the mobilization of specific brain areas leading to a state of enhanced activity focussed on the given percept (Del Cul et al. 2009; Vogeley et al. 1999; Bar and Biederman, 1999). The hypothesis advanced in this chapter is therefore that, although distinct, the mechanisms for consciousness and awareness are strictly interacting and – more so - we must be conscious of a stimulus before we may become aware of it[11]. This hypothesis is also in agreement with Backmann (2000), who showed that 100-200ms are needed to fully process a percept, but that a relatively longer

[10] See Augustenborg (2010) for a detailed consideration of the possible criteria able to determine the emergence into awareness of specific segments of the informational broadcast.

[11] See also Wu *et al.* (2009) in support of the temporal interplay between the occurrence of information processing and the subjective ability of the individual to access its contents.

time interval is required for percepts to eventually acquire an accessible state[12]. More so, Tononi has argued that consciousness "*is a property of a system, not of a state*, [therefore] *the state the system is in only determines which particular experience becomes actual at any given time, and not whether experience is present*" (p.20). Such conceptual representation appears then to further endorse the distinction between the broadcast of a specific informational segment and its emergence into awareness. More so, it seems implicit in such premise that the unfolding of the data broadcast is independent from the eventual access granted to its content. The distinction in terms of levels of neural amplification between the informational broadcast and experiential awareness bears the advantage of shaping both quantitative and qualitative operational parameters of consciousness (understood here in its traditional acception). The informational load carried by the system during the broadcast and the integration of data can in fact plausibly be described in terms of information's magnitude and data complexity (i.e. the value Φ adopted by Tononi). Furthermore, the mechanism administering the broadcast can be reasonably assumed to follow a dichotomous principle: either a percept enters the informational broadcast, or it decays after having perhaps determined strictly isolated neural activations (that is, it remains *unconscious*). It is implicit that instances in which such a mechanism was severely impaired should reflect in the absence of a neural broadcast and in the complete unresponsiveness of the individual (both at neural and consequently behavioural levels). On the other hand, it is proposed that the degree of access into the workspace reflects the level of neuronal amplification generated during the broadcast of specific proto-representations. Therefore, this argument implies that a gradual process is intrinsic in the variable access allowed into the workspace, and consequently that a qualitatively variable degree of perceptual awareness can be experienced by the individual. At a neurological level, this suggestion leads then to the prediction that focal damage in specialized areas could affect the ability to determine the necessary amplification of the neural trace. This hypothesis could account for the seemingly enhanced access that blindsight[13] patients manifest under forced-choice conditions (see Stoerig, 2011) where an imposed effort might amplify their perception.

In sum, by adopting the criteria of variable thresholds of neural amplification, the distinction between *consciousness* and awareness appears more reliably operational than the current divide – i.e. in terms of reportability and performance - between consciousness and unconsciousness. Furthermore, by conceptualizing *consciousness* as a continuum from complete inaccessibility to full awareness, the current proposal strongly supports the gradual nature of perceptual experience[14], but it also lends space to the dichotomous mechanism of access into the broadcast.

CONCLUSION

This chapter has proposed to broaden the conceptualization of the phenomenon to let it embrace both the informational broadcast and the individual´s subjective experience of its

[12] Tononi (2004) has suggested that >500ms are needed for a percept to be fully reportable.

[13] Blindsight is the neurological condition characterized by perceptual blindness following damage in V1. Although the patient is not able to report a stimulus, s/he can – above chance level – 'guess' its location, and offer some rough details about its appearance (Weiskrantz, 1996).

[14] See also Darcy *et al*. 2010; Norman *et al*., 2007; Overgaard *et al*., 2006; Mangan, 2001

contents. A distinction between *consciousness* and awareness has therefore been employed in order to distinguish the former from the latter. Secondly, it has been suggested that the mechanisms respectively mediating *consciousness* and awareness are distinct but strictly interacting. More specifically, the proposal implies that consciousness is the necessary (albeit, not sufficient) condition for the emergence of awareness, and that a distinction in terms of temporal intervals can be placed between *consciousness* and awareness. Finally, it has been proposed that specific neural thresholds separate the unfolding of the informational broadcast from the individual´s awareness of its contents. This suggestion has further led to the hypothesis that specific neurological conditions (e.g. blindsight**)** might impair the level of amplification required for a stimulus to emerge into awareness.

Undoubtedly, the suggested hypotheses need careful empirical investigation. However, if their predictions were confirmed, the results would have significant implications for the neurological and experimental assessment of consciousness, for legal contentions[15], and for the study of the phenomenon in non-human animals. More so, by linking different theoretical perspectives and empirical approaches within a common framework, we would be making a significant step towards a consensus.

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[15] See Abondo *et al.* (2009)

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