5 Why qualia and consciousness seem mysterious

Summary Qualitative experiences (qualia) and consciousness seem mysterious, but are easily understood when we realize that they are *neural processes* that provide *language-independent information* about external objects and about the state of the organism. Thus, colors, sounds, smells, and emotions can be named, but they are ineffable because they cannot be transmitted through explanations. Experiences are neural processes that compress large amounts of information into messages that are directly perceived and understood by association to other experiences, which provide their *aboutness*. Qualitative experiences are phylogenetically determined and allow humans and organisms without language to navigate in their environment, communicate, and satisfy their biological needs. Consciousness is an active process maintained by oscillating neural activity, which can focus on specific subjects or produce the simultaneous awareness of multiple experiences.

5.1 The puzzle of experiences and consciousness

Experiences provide the "what-it-is-like" or the non-verbal qualitative representations of the internal and external worlds, that we perceive through our senses, emotions and internal needs. Conscious experiences are among the most primitive forms of biological awareness that give us information about our surroundings and ourselves. This information is essential for the individual to survive long enough to reproduce. We can infer from our contact with domestic animals that our early ancestors also had experiences before language originated, probably millions of years ago. Experiences are biological processes that cannot be transferred as such through language.

Philosophers frequently ask, "How could the *physical* brain give rise to *conscious experience*?" This question implies that some do not believe that consciousness and experiences are physical processes that take place in the brain, and that provide essential information about the organism and its

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surroundings *in the absence* of language. The impression that experiences are non-physical processes may have been produced by the imperceptibility and transparency of the brain and its functions. The puzzle about the nature of phenomenal experiences and conscious processes has been revived during the last few years in several books and articles [1–3]. In a more recent book, Chalmers [4] catalogues a large portion of the literature about consciousness and experiences, but he does not explain how what he believes is a non-physical consciousness could interact with the physical body without violating the laws of thermodynamics.

To further complicate the issue, Chalmers' theory of *property dualism* proposes that consciousness can have both physical and phenomenal properties. He emphasizes that the phenomenal properties of consciousness, the "what-it-is-like" that characterize experiences—as viewed from the first person perspective—are irreducible to physical properties, because experiences are ontologically independent [2, 4]. This is questionable because non-physical phenomenal properties have never been proven to exist, much less to have any kind of causal efficacy. Chalmers insists that the hard problem of consciences is that of explaining conscious experiences.

In contrast to Chalmers' property dualism, neuroscientists believe that *conscious processes,* including all phenomenal properties, are realized by well-studied neurophysiologic mechanisms that detect their state of individual functions and the needs of the organism. There is nothing mysterious in hunger, pain, thirst, the need for love, or avoidance of predators. The physical nature of all these functions is well understood, because they have been functionally characterized and are modified by diseases and by the administration of drugs that act on specific brain systems. Chalmers refers to some neurophysiologic processes as neural "correlates" of consciousness. However, it is seriously misleading to call the neural mechanisms of consciousness "neural correlates", because when the mechanisms that maintain consciousness are suppressed, consciousness is also suppressed. This means that we are in the presence of an identity.

The contrast between the subjective, apparently spiritual nature of experiences and the physical nature of the body has preoccupied philosophers and biologists since René Descartes (1596–1650), who championed the idea of the *duality* of body (*res extensa*) and spirit (*res cogitans*) or thinking substance [5]. Many people also believe that consciousness is a manifestation of a hypothetical soul or spirit, as taught by most religions. However, this view has been discredited not only by the neurobiological and scientific perspectives, but also by common sense observations. Despite our feeling that experiences are transparent and seem non-physical (see Sect. 5.1.3), they consist in neural processes that are easily disrupted by physical agents such as diseases and trauma, as well as by the ingestion of psychoactive drugs or alcohol.

One of the confusing features of the puzzle is that the brain, which senses the body and the external environment, is imperceptible to itself. There are at least two reasons for this; one is that the brain does not have to be sensitive because it is well protected by the hardness of the skull and by the sensitivity provided by the hair and scalp. The second reason is that the brain, as the last member of the sensory chain, must be itself insensitive to avoid the infinite regress implied in sensing the sensors that sense the brain sensors and so on (see Chap. 4). The first-person impression is that all brain functions are mysteriously realized by a supernatural soul or spirit, as discussed in Chap. 2. Despite these naïve feelings, all sensations, perceptions, and emotions are known to be carried out by the brain, even if the brain cannot sense itself. Neurology and neuroscience clearly show that qualitative experiences are neural processes by which we sense the properties of external objects and the internal state of the organism.

Qualitative experiences evolved millions of years before language, so they are language-independent and their message is directly perceptible as experiences such as pains, hunger, or emotions. They are hard to explain, not because they are mysterious, but because language was recently acquired and experiences actually give *meaning* to language by serving to ground words. Ineffable words get their meaning from the experiences that they name. Thus, these words can neither be explained nor understood by persons who have never had such experiences. This is why we cannot explain an orgasm to a very young child, or "what-it-is-like" to see red to a color-blind person by mentioning ripe tomatoes, stop signs, or sunsets. In essence, the words that name experiences cannot be understood by persons who have never had such experience. There is no doubt that there is a fundamental difference between the phenomenal view and the propositional explanation of consciousness and experiences [6].

5.1.1 The ineffability of experiences

The impossibility of explaining qualitative experiences is a vexing problem that has preoccupied philosophers for decades. As Dennett indicates, qualia are the paradigm of ineffable items [7]. This means that we cannot explain qualitative experiences, e.g., the what-it-is-like to see red to a color-blind person. Consider a classic example the imaginary case of Mary, a scientist that grew up in a closed room without ever seeing anything red. To compensate, Mary read many scientific papers that explained what happens in the brain when we see something red, but she still could not figure out what-it-is-like to see something red. Eventually, Mary was let out of the room and had the experience of seeing something red, which neither language nor science could explain clearly enough to *transfer* a novel experience. Some philosophers use this example to show that we are not intelligent enough to understand experiences [1], whereas others believe that experiences are facts that are not describable by words. As

Nagel said, to know what it is like to be a bat and navigate the world through echolocation, you must be a bat [8].

According to David Chalmers: "We have no independent language for describing phenomenal qualities. ... [T]here is something ineffable about them.... In talking about phenomenal qualities, we have to specify the qualities in question in terms of associated external properties, or in terms of associated causal roles [2]." He coined the term *hard problem* when he wrote: "The really hard problem of consciousness is the problem of experience." "How can we explain why there is something it is like to entertain a mental image, or to experience an emotion?" Chalmers wonders why physical processes give rise to a rich inner life. He believes that experiences cannot be reduced to neural processes, so he supports a property dualism, which postulates irreducibly mentalistic properties that cannot be produced by physical processes.[1] However, the real problem is quite different: it consists in the fact that verbal

Table 5.1 The many connotations of "Red"

Because of the transparency of phenomenal processes and the ambiguity of our language, several distinctions are essential for referring to the different meanings in which "red" can be used
***Objective*-red** is the objective light reflectance of ripe tomatoes, a non-internalizable physical process which consists in an electromagnetic radiation of wavelengths around 600–650 nm, and which is an intrinsic feature of the *external object*
***Neural*-red** is the internalized signal of the red light, which becomes an experience when it is incorporated into conscious processes. It consists in the neurophysiological activity elaborated in the brain by sensing red light. It is comparable to the *sensor data* of robotic systems and *AI*. *Neural*-red is what Mary presumably studied in her room. However, *neural*-red cannot be produced by propositional explanations
***Phenomenal*-red** is the sense-datum produced when the activity of *neural*-red is incorporated into conscious processes through binding. It is perceived and remembered as the what-it-is-like to see red; it is what Mary learned outside her black and white room. The experience can be described physiologically, but it cannot be duplicated in other brains through explanations. *Phenomenal*-red is both, a neural process and an ineffable qualitative experience that serves to anchor "red" in the verbal-phenomenal lexicon (Musacchio [6])
***Phenomenal concept* of seeing red** is produced by experiencing what-it-is-like to see *objective*-red. This anchors the meaning of seeing red
The *aboutness* of experiencing red is a relational phenomenal concept that is object-dependent and is established through additional experiences, like seeing red fruit, red faces, red signs, etc., in which "red" has different meanings
The word red is anchored in the verbal-phenomenal lexicon by giving a name to the experience, phenomenal concept, and aboutness of seeing red (Chap. 6)

[1] David Chalmers [2, 9].

explanations of experiences cannot generate the physical processes that realize experiences in the brain of the listener. The physical realization of experiences is part of our phylogenetic endowment, which is essential to ground words and to develop a language. Moreover, the grounding of words in the common phylogenetic endowment is essential to translate languages.

Many philosophical problems have their origin in the lack of precision of our language [10]. For example, some verbs, such as to know, see, and feel, have different meanings depending on their context. A similar ambiguity, which is not trivial, can be found in the meaning of the properties of objects, such as colors. For example, "red" may refer to an *objective* property of the surface of a tomato (*objective*-red) or to what somebody sees as *phenomenal*-red in a veridical perception, afterimage, illusion, or hallucination (see Table 5.1). Thus, *red* refers either to the *objective property* of the surface of a tomato or to the *experience* of seeing something red. The experience of seeing something red (phenomenal-red) is mediated by the *binding* or incorporation of *neural*-red into conscious processes. However, the *intrinsic features* (*or the details of the neurophysiologic processes*) that realize neural-red are never perceptible to the subject. I will refer to the different aspects and properties of experiences using "red" as an example (See Table 5.1). As explained, qualia are part of the phenomenal-propositional lexicon in which *we anchor the ineffable words of our language*, which are those that name qualitative experiences.

5.1.2 The transparency of experiences

Qualitative experiences are said to be transparent because they convey the feeling that we perceive the qualities of objects and the needs of the organism directly, "as they really are", and without any interference from our perceptive machinery and language. There seems to be no separation between the experience of seeing a ripe tomato and ourselves. Transparency is one of the essential qualities of experiences, which explains not only its role, but also some of the puzzling characteristics of experiences.[2] Harman notes that we are only aware of the features of the object (the redness of the tomato—*objective*-red), but not of the neural mechanisms of seeing red (*neural*-red—the neural mechanisms of the experience itself) [10]. Brian Loar also observed that we seem to be directly aware of the properties of objects rather than the properties of experience itself [20]. The transparency of experiences is biologically necessary, but as Levine indicated, the side effect is that transparency increases our "intuitive resistance to materialism" [21].

[2] I have reviewed the transparency of experience in Refs. [6, 11]. See also Refs. [2, 12–19].

Experiences have an *aboutness or intentional sense*, a meaning that is transparently evoked by association to other experiences. Clearly, hunger is about the desire to eat. Experiences and their meanings bring us directly in contact with our biological needs and with the external world. The aboutness of experiences is what motivates us to pursue or avoid them. Transparency also means that we are not directly aware of the neural mechanisms that implement the experience [10]. The imperceptibility of the neural realizers (such as *neural*-red) has clear biological advantages, but it creates the highly misleading illusion that experiences and the mind are nonphysical entities. A cognitive system that has a limited capacity of perceiving its own hardware is simpler and avoids the infinite regress implicit in sensing the sensors and the analyzers, and so on. To be useful, the neural mechanisms that realize experiences *must be imperceptible* to the subject. Metaphorically, the lens of the eye—like the lens of the camera—*must be transparent*; the camera and the lens must not appear in the pictures. The cognitive value of experiences and phenomenal concepts would be downgraded if all their neural mechanisms were also perceptible to the subject. Experiences are biologically useful *precisely* because through them, the external world and the needs of the organism are immediately perceptible without irrelevant details.

Our incapacity to perceive the neural mechanisms of the cognitive system contrasts sharply with the richness of everyday experiences. The objects of the external world seem real and clearly *physical* as opposed to the quality of the experience, which is often thought of as mental, psychological, or spiritual, and distinct from physical experiences. This reinforces the illusion that cognition and the mind are *nonphysical*. However, contrary to our common sense psychology, science indicates that the presumed immateriality of the mind is an illusion. Thus, the anti-physicalist intuitions of popular psychology are derived from the imperceptibility of the brain mechanisms that realize experiences and not from the character of the mind itself. Sensing and being aware of all our brain mechanisms would be detrimental to our perceptions and survival.

The only way to stop the potential regress of a sensory (or phenomenal) system is to have a limited ability to sense the sensors. Sensing all the components of the cognitive system would create not only an unnecessary biological handicap, but also infinite regress. To be efficient, the brain machinery must be *imperceptible to itself* and devoid of biologically irrelevant complexity. Unlike the brain, the sensory organs have sufficient pain sensitivity for elemental protection and survival. The uniqueness of the brain in not sensing itself provides protection against the *proliferation of superfluous structures* and the *regress* implied in sensing the sensors *ad infinitum*. The brain is insensitive, as indicated above, but it has an exquisite sensitivity for its essential nutrients, which are constantly monitored and controlled, such as the concentration of oxygen, glucose, and hormones in the blood.

The downside of simplicity and the price for the efficiency of our perceptive machinery is that, through introspection, *we cannot perceive the inner workings of the brain*. Thus, even if the imperceptibility of the basic neural processes provides a biological advantage, the resulting illusion is *a serious philosophical handicap* that drastically diminishes the value of introspection and phenomenology as exclusive methods for exploring our nature. This implies that the cognitive limitations of the subjective perspective must be supplemented by the empirical knowledge provided by science.

5.1.3 Conscious processes are maintained by specific activating systems

The contradictory opinions that originate from different philosophical or non-scientific approaches indicate that these approaches are not capable of defining experiences or conscious processes. In contrast, science and medicine have proven their effectiveness in producing consistent and reliable explanations that are verifiable by different observers. The biological bases of conscious processes have been established using a variety of different procedures and approaches, and we often find deep insights coming from unexpected places, as illustrated by the following story. The legendary neurosurgeon Wilder Penfield, in his efforts to remove brain areas that caused epileptic seizures without disturbing the speech mechanisms (Chap. 4), operated on patients using only local anesthesia so he could communicate with them during the operation [22]. Penfield probed the regions surrounding the epileptic focus with electrical stimulation while talking to the patients before removing any tissue and mapped the *sensory* and *motor* homunculi (Figs. 4.3, 4.4). He knew that the electrical stimulation of some of the brain areas that control language inhibits speech. In the process, Penfield also observed that when the base of the brain is disturbed, near the subthalamic nucleus (Fig. 5.1) patients might immediately lose consciousness. In contrast, he could remove large areas of the cerebral cortex in a conscious patient using only local anesthesia to open the skull. Curiously, no pain is perceived because, as we said above, the brain cannot sense itself, and the patients remain unaware of any change until asked to turn their attention to certain parts of the body, or to perform certain tasks that require the use of the removed brain region.

The understanding of the brain mechanisms that sustain attention and consciousness was also greatly advanced by previous studies showing that electrical stimulation of the brain stem in lightly anesthetized cats produces the electroencephalographic pattern of arousal that is characteristic of attention and alertness [23]. Lesions of the same regions in monkeys also produce various coma-like states that resemble deep sleep. Some of the neural networks that control arousal and attention are embedded in what was initially known as the *ascending reticular activating system*, shown in Fig. 5.1 [23]. In higher animals, including humans, this neuronal network reaches the intralaminar

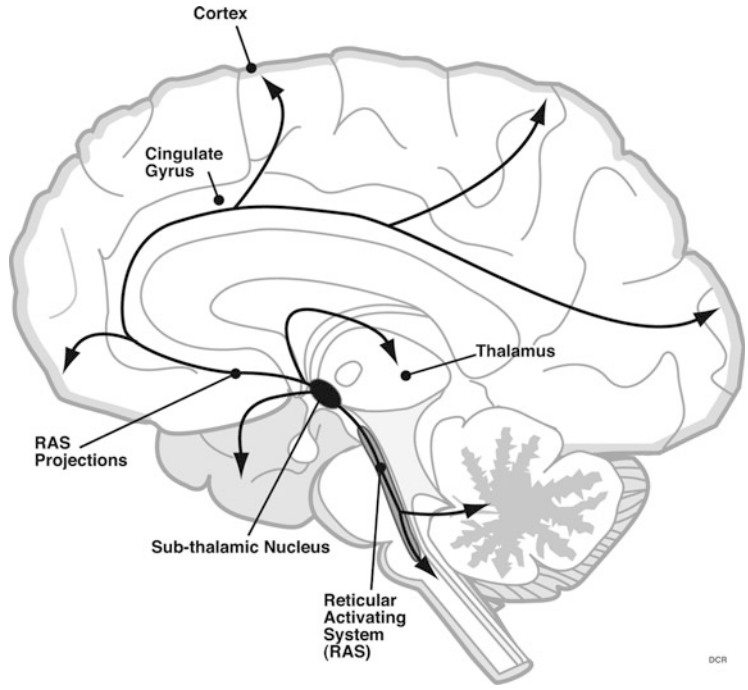

Fig. 5.1 Schematic drawing of the reticular activating system. The reticular activating system (RAS) consists of neuronal networks originating in brainstem regions that project upward to the subthalamic nucleus and from there to many cortical and subcortical brain structures as indicated by arrows. The RAS is responsible for maintaining conscious activity and is very sensitive to hypnotics and general anesthetic

nucleus of the thalamus, whose outputs can produce excitation in almost every brain region. These complex networks of neurons are involved in behavioral arousal, attention and sleep, as well as in the regulation of motor and autonomic reflexes [24–26]. These systems are similar across species and can be depressed or stimulated by the same drugs that are effective to induce sleep or alertness in humans.

Higher animals—including chimpanzees and domestic animals—also have night and day circadian cycles, as well as basic feelings and perceptions that are similar to ours. There is no doubt that these animals have some understanding of their own world or that, at least in a limited sense, they can communicate with us and with each other using signals that they learn to interpret. However, animals—perhaps with the exception of whales—do not have the complex language that could help them understand each other and improve their knowledge of the environment. Thus, how do they manage to satisfy their basic needs and communicate? The answer is probably through observations

and experiences. As discussed in the next sections, qualitative experiences are *functional equivalents* or neural models for objects and processes that *cannot be internalized* by the brain or that represent internal states of the organism, such as hunger or pain.

5.2 Sensing and understanding internalized information

During childhood and adolescence, almost everyone believes that they perceive the world as it is. However, experience later reveals that neither the objects nor their properties are directly perceived as they are. Similarly, it was assumed by early philosophers and scientists that we could internalize *images or impressions* that faithfully represented the external world. The problem with this early assertion is that it needs a mind's eye or an internal observer that must also internalize images, a situation that implies an infinite chain of observers and regress.

Despite their limitations, qualitative experiences are the most basic and essential forms of acquiring information, without which we would not be able to have any knowledge. In the early stages of our cultural development, humans would have operated in an automatic fashion, *without really understanding what was being sensed*. However, knowledge of the surrounding space, as well as the perception of time and movements improved rapidly because of better knowledge of the environment. The cultural transmission of knowledge in higher animals and humans was crucial for competitive survival and natural selection.

The illusory nature of some sensations and perceptions was already known to early Greek philosophers. As Aristotle (384–322 BC) already thought, we can perceive three-dimensional space and temporal intervals through more than one sensory modality, such as vision, touch, and hearing. However, most other perceptions, such as taste, smell, and color depend on where in the brain the sensory stimulation arrives. Thus, the what-it-is-like of the experience is provided by the region of the brain that receives the stimuli. Even though sensing is essential for knowledge, not all philosophers seem to be concerned about how we physically internalize information through the senses. To understand sensing, we cannot rely only on introspection. First, we must be aware of the biology of our senses and cognition. Language is not necessary for understanding the meaning of most experiences, because experiences are unique and refer to other experiences. Together, these associated experiences form a cognitive network that is limited, but essential and sufficient to sustain conscious life and to promote survival in a language-independent fashion. The ability to communicate without language is also quite evident in babies and small infants. Qualitative experiences are *language independent*, but as discussed in Chap. 6, experiences are essential prerequisites to anchor words and to develop a verbal language.

5.2.1 Sensing the external world

Sensing the external world and sensing our bodies are important cognitive abilities, which developed before anyone knew about knowledge, philosophy, or language. Today, as evolved creatures with a language, we can reflect and say with confidence that animal survival has been made possible by sensing the environment and by knowing about food and predators. In contrast, the survival of plants, bacteria, and lower animals is based on their enormous reproductive ability.

There are some facts that are not evident to the subjective perspective and that should be taken into account to understand sensing [27]. Our brain can only internalize nerve action potentials (Fig. 5.2) produced by specialized sense receptors.

Thus we cannot experience the external world directly. In contrast to telephones and televisions, the information elaborated by the senses and entering the brain cannot be transformed back into the original stimuli (such as voices or light). Thus we must understand the world indirectly, through the neural signals internalized by the different senses. Understanding is achieved only through several additional processes, such as getting information through other senses and taking into account the reference (aboutness) provided by associated experiences.

The problem of acquiring information through the senses without a language was solved by Nature with the development of qualitative experiences that were initially used to navigate the environment and to deal with prey and predators. We know today that sensations or qualitative experiences are an *absolute necessity* for animal survival; they are also essential for developing other forms of knowledge and the capacity to reason using experiences, images, words, and symbols. However, many—and perhaps all—qualitative experiences *falsify* reality, because we actually do not perceive things as they are. The *what-it-is-like* that we experience is not identical to the *what-it-is*. We manage to survive only by *learning to interpret* the meaning of our experiences. However, before getting into the aboutness of experiences, I will discuss the problems of sensing and internalizing information.

Despite the many difficulties in understanding sensing, we know that knowledge is possible, even though limited and distorted. The empirical success of being able to modify our surroundings gives us additional confidence that the world is cognoscible, even if our knowledge is initially indirect and we cannot perceive reality as it is. The crucial question is whether *all experiences* provide direct and genuine knowledge of the properties of external objects and organic needs, as a realist would think, or if it only *seems* that they do. The evidence is contradictory: on one hand, we know that we can accurately perceive shapes and the space that immediately surrounds us. On the other hand, we know that we are subject to illusions, although we tend to believe at

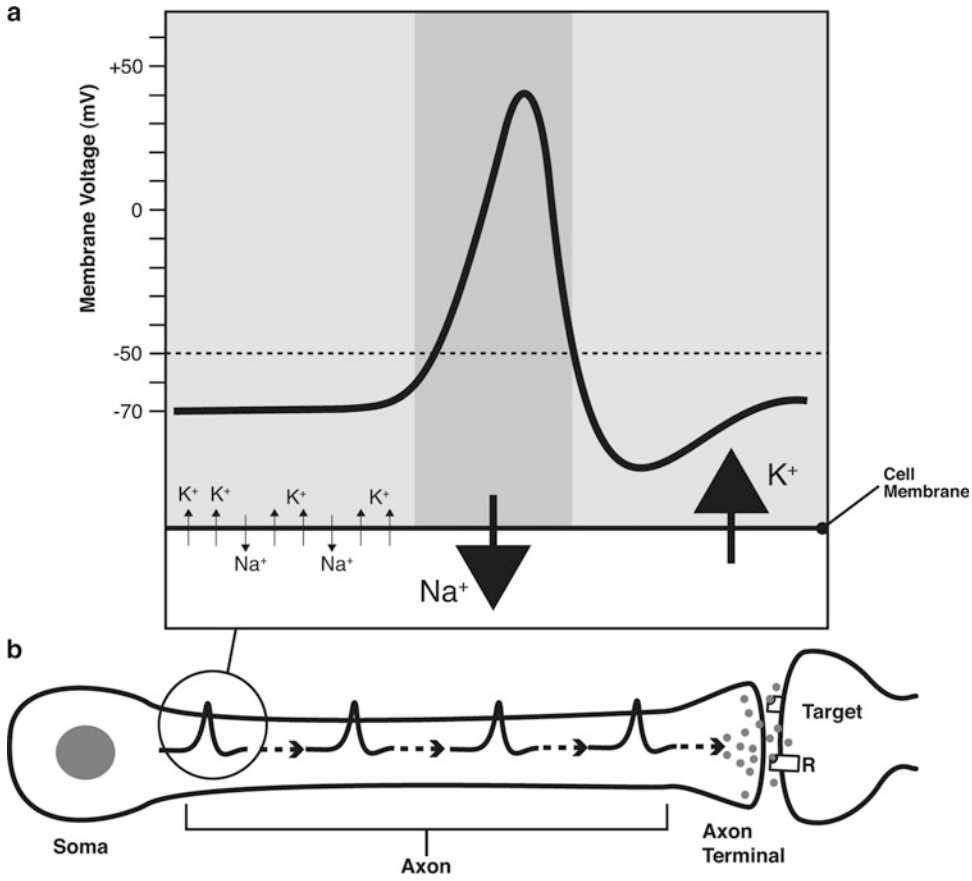

Fig. 5.2 Illustration of an action potential. An action potential (**a**), which is part of a train of action potentials along the axon of a nerve cell illustrated in (**b**). (**a**) Shows that there is a constant flow of Na+and K+through the nerve membrane. When a nerve impulse takes place (upward curves), a train of action potentials can be measured by registering the electrical activity inside the nerve (axon) with a capillary pipette, which acts as a recording electrode (not shown). The action potential is produced by the rapid entry of Na+to the nerve (large arrow down), which is followed by a compensatory, slower exit of intracellular K +(large arrow up). (**b**) Shows the propagation of the nerve impulse from the cell body (soma) through the axon in the direction of the axon terminal. The arrival of the action potential at the nerve ending results in the release of neurotransmitter molecules (small grey circles) that bind to receptors (R) located on the surface of the target cell. The target cell is stimulated or inhibited, depending on the neurotransmitter and receptors involved

first impression that things are just the way they seem to us. For example, most people do not know that colors are made up by the eyes and the brain and are not the exclusive properties of the external objects. Thus, qualitative experiences are internal processes that are not identical to what exists in the

external world. However, some of our more objective experiences, such as the perception of time and space are somehow expressible by referring them to minutes or hours or to inches and yards. For example, we measure time and space by standards that are external to us, whereas hot or salty are ineffable terms because they are grounded on qualitative experiences that cannot be rigorously quantitated. We have all experienced that some foods or drugs change the taste of the next food we eat. The fact that experiences are modifiable by diseases, surgery, or drugs indicates that they are physical processes taking place in our brains.

5.2.2 Sensing the internal world

In contrast to the qualitative experiences generated from the external world—*exoqualia*—we have direct access to the endogenously generated qualia—*endoqualia*—that are unique experiences, such as thirst, hunger, satiety, anxiety, and sexual desire. Endoqualia are generated by the needs of the organism and by its relation with the external environment. They are contingent cognitive shortcuts that lack intrinsic meaning, but have high survival value, because they are associated to essential organic needs. Some experiences, however, such as emotions and pain, are innately hardwired, so they can rapidly trigger biologically advantageous responses. In lower animals, some of these states might not even be conscious. The physical agents that trigger *exoqualia* are easily identifiable in general, but the task is not so simple for *endoqualia*. Such is the case of experiences that refer to organic needs (hunger, thirst) or to the self, such as fear, love, depressive feelings, and other emotional states. These experiences are highly influenced by innate components, such as the sexual drive. All these considerations indicate that internally generated qualitative experiences are a direct, *nonverbal, phenomenal language* by which all organisms are motivated to satisfy their organic needs, *even without knowing what they are doing*. There is no doubt that endoqualia—all our desires—are major factors that influence most forms of human and animal behavior and shape our culture and advertising industry.

Today, we know that emotions are physical states that process information about the organism in its relation to the environment. Unknown through the subjective perspective, all emotional processes are realized in specific neural circuits, which are mediated by changes in neurotransmitters, hormones, and other cellular messengers. The effects of drugs, electrical brain stimulation, and anatomical lesions, as well as electrophysiological and fMRI studies clearly indicate that emotions are physical processes taking place in the brain [28]. These aspects as well as the neurobiological bases of fear have been thoroughly

examined in several reviews and recent popular books by Joseph E. LeDoux,[3] that clearly implicate the amygdala, in the anterior part of the temporal lobe, as the main site where fear and other emotions are processed (see Fig. 7.3).

5.3 Experiences require binding for integration into consciousness

Our intuitions cannot be used as reliable sources for understanding either the nature of experiences or how the brain operates. All intuitions are potentially misleading, so the problem of the nature of experiences must be approached from a scientific perspective. Besides, we need a vocabulary that implies neither images nor internal observers.[4] The internalized information contained in neural processes that form a core of the sensation must be incorporated into conscious processes to produce an experience. We sense the internalized information as colors, sounds, or smells, but we cannot sense either the nerves or the brain that provide the intrinsic features of the experience. If the neural processes necessary to realize experiences were not bound into conscious experiences, these experiences would be considered "unfelt pains", unattended sensations, unconscious processes, etc. Stimuli that remain unconscious, even for a short time, would account for the automatic responses to sensory input that take place before we could perceive them. In addition, the physicality of all neural and mental processes dissolves the problem of the "mental" causation, which consists in explaining how the "mental" (in the non-physical sense) and the physical could interact.[5] We do not have a detailed answer to how neural encoding takes place, but there is a lot of information on the processes involved [38–42].

Through the subjective perspective, we have the undeniable impression that we can hold images in mind, dream about them, and recall them at will, but as indicated, this requires internal observers. Thus, the question that remains unanswered is: How is it possible to experience "mental images" when there are no mental images in the brain? There seems to be no doubt that the information is stored mainly in the cerebral cortex (Fig. 4.2) and subcortical circuits of the brain, but there are no indications on how the information is incorporated into conscious processes. Graphic images seem to require an individual observer and create some kind of Cartesian theater and regress.

[3] Joseph E. LeDoux [29–32].

[4] The anthropomorphism of our terminology is so ingrained in our language that it is difficult to find common words that do not imply any regress. The best option is to use technical descriptions of the neurobiological processes that have been obtained through the third person perspective. However, the task is not easy because words that refer to phenomenal experiences are ineffable [33], so they only can be described or understood from the neurobiological perspective.

[5] The problem of mental causation is discussed in Refs. [18, 34–37].

However, this is not necessary, since in normal perceptions, the neural models produced by sensations seem to be directly incorporated into conscious processes. The incorporation into conscious processes takes place by synchronization of the electrical oscillations at "40 Hz.", or in the gamma band of 30–70 Hz. The idea that perceptions may require an internal observer is a carryover from Descartes' assumption about the existence of internal images [5].

As indicated previously, neurologists and neurosurgeons discovered that small tumors or cysts in the base of the brain or in the pituitary gland produced progressive loss of consciousness and coma, which in some cases were reversible after an operation. Additional studies made it clear that the mechanisms of wakefulness, sleep, and maintenance of consciousness take place through synchronization of an activating system that includes multiple brain regions.[6] We now know that wakefulness is associated with a low-amplitude, high-frequency electroencephalogram, whereas deep sleep (physiological unconsciousness) is characterized by high-amplitude, low-frequency waves [43, 45, 49]. In addition, the level of consciousness during anesthesia can be accurately predicted by sophisticated analysis of the electroencephalogram [50].

Many of the recent studies on cognition have been conducted on the visual system, probably because this system has the greatest capacity to internalize high volumes of information in an almost isomorphic fashion. Processing of visual information starts in the retina, where specialized cells capture different elements of the sensation and project them to the brain's occipital cortex through two major pathways[7] (Fig. 5.3).

From the occipital cortex (Fig. 5.3a), parallel pathways convey information to the posterior parietal cortex (dorsal pathway), which provides information about the location of the object, and to the inferior temporal areas (ventral pathway), which provides information about the identity of the object. This is an oversimplification, but what is important is that the information is not projected on the brain like a photograph. Color, motion, depth, shape, contours, distance, etc. are processed in multiple cortical areas in a parallel distributed processing. Therefore, the neural models corresponding to the different elements of the retinal image must be brought together again by *multiple stages of binding* [52]. To complicate things further, color and form are processed almost simultaneously, but movement perception is delayed about 50 ms [53]. This implies that the subjective coherence of the visual perception is dependent on several analytical processes, the results of which must be reconstituted in time and space. Again, as stated by Kandel and Wurtz [26],

[6] Additional information and references can be found in Refs. [11, 23, 25, 43–48].

[7] The complexity of the visual system is enormous and cannot be summarized in the space available. For additional information, the reader should consult [51] or [26].

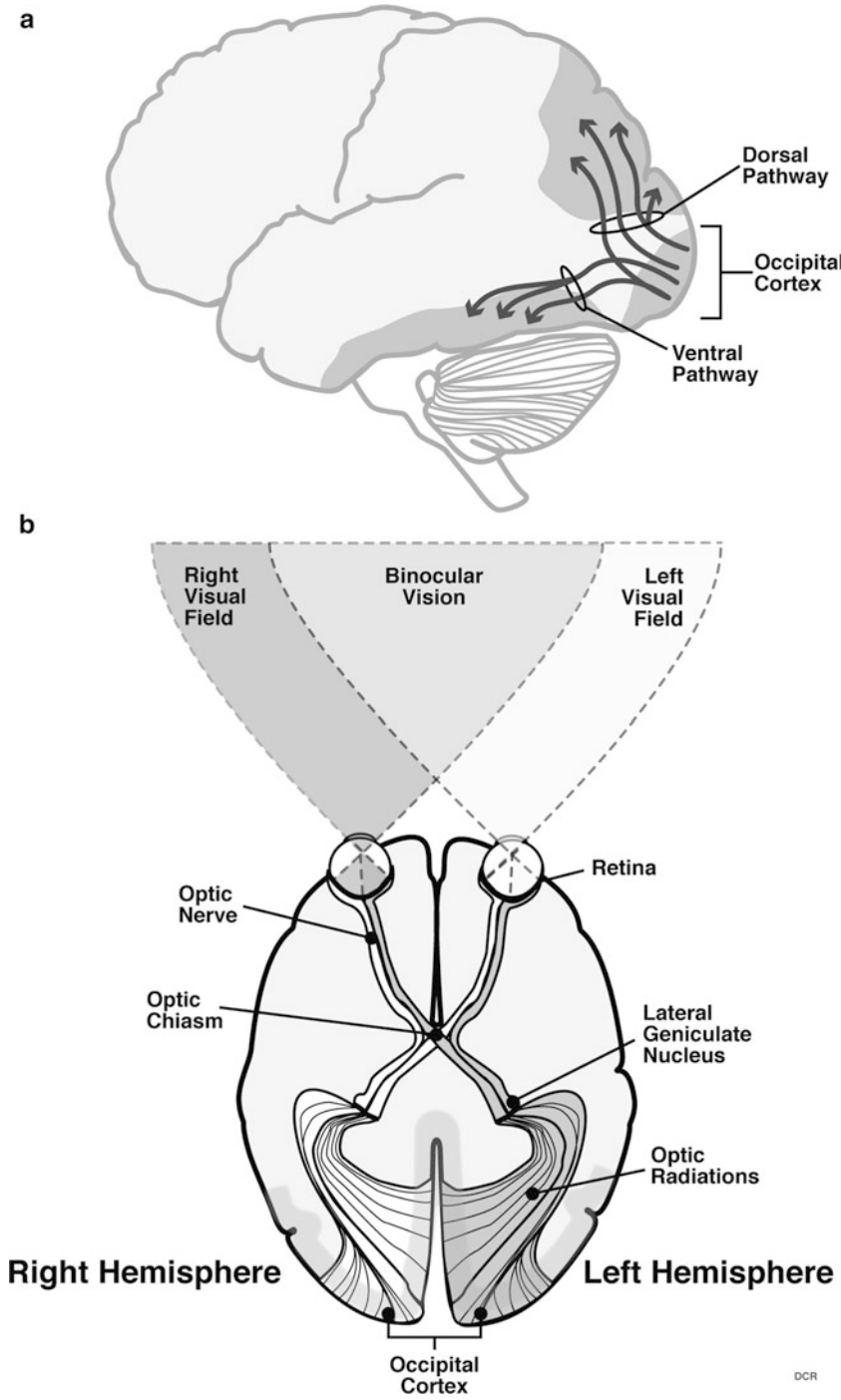

Fig. 5.3 Visual Pathways. Drawings of the visual pathways by looking in (**a**) at the left side of the brain, and in (**b**) by looking from below at the ventral surface of the brain. In (**a**), the visually activated portions of the occipital cortex are shown to project through the dorsal

visual perception is a *creative* process. The same could be said about the binding that creates the self, the dynamic process that constitutes us as we are.

5.4 How qualia acquire their meaning

Qualitative experiences acquire their meaning by association to other experiences that provide their *aboutness* or reference; this allows organisms without language to navigate the environment and to satisfy their biological needs. Infants quickly learn what to do when they feel thirsty, hungry, or in pain. Actually, there is evidence that the aboutness of most experiences may be innate, especially in some animal species that are born more mature than humans are and seem to know what to do immediately after birth. Even so, all animals including humans learn progressively more about how to interpret experiences and what to do about them. This knowledge is language independent, so their understanding is what gives origin to *phenomenal concepts* (see Chap. 6). Thus, most endoqualia are spontaneously associated to other experiences. For example, thirst produces the desire to drink water, even if the subject does not understand the nature of dehydration. Animals learn empirically that an uncomfortable feeling can be eliminated by certain actions. The empirical association between an experience and its aboutness is obviously sufficient for survival under natural conditions, even if it is not enough for true understanding.

We can distinguish several kinds of aboutness; for example, *innate aboutness* and *phenomenal aboutness*, which are common to all animals. The *innate aboutness* of some experiences is hard-wired and is characteristic of some instinctual reactions, which may not necessarily be conscious. Encountering a fear object such as a snake is an example of a primary inducer of fear [54]. Rats and humans are both frightened by the sight of snakes. Similarly, infants and newly born mammals are hard-wired to suckle, and some baby birds have an instinctive reaction to hide or escape at the view of predators [55]. Laboratory-reared rats will also either freeze or try to escape in the presence of a cat, even if

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Fig. 5.3 (continued) and ventral pathways. The dorsal pathway is mainly concerned with the location of objects within the visual field, whereas the ventral pathway projects toward the ventral temporal region and is mostly concerned with the recognition of faces and objects. In (**b**), the view of the brain from below shows that the central portion of the visual field is projected to both sides of the brain, providing right and left independent images of the same object, which generates binocular or stereoscopic vision. In contrast, the extreme right and left visual fields, which provide peripheral vision, project onto the nasal side of the same side (ipsilateral) retina, whose fibers pass through the optic nerve and cross the midline in the optic chiasm, before reaching the lateral geniculate nucleus, optic radiations, and occipital cortex of the contralateral brain hemisphere

they have never seen one before [31, 56]. These are all prime examples of innate aboutness or hard wired instinctual reactions.

Phenomenal aboutness is established through additional experiences and its value resides in having a *language-independent capacity to refer* (Table 5.2). Phenomenal aboutness is the most basic mechanism that animals have to make intelligent choices and to relate to each other. With the exception of a few experiences that have innate aboutness, most experiences do not have any predetermined semantic content until their meaning is learned by association with other experiences. This is clearly true for animals without language, which use phenomenal aboutness to navigate the world. One of the best-studied examples of learned phenomenal aboutness is that of fear conditioning [29, 31]. Phenomenal aboutness *corrects the lack of intrinsic meaning of most experiences*. The aboutness of experiences is learned implicitly by animals, as in classical and instrumental conditioning. The bell ringing before the meals meant for Pavlov's dogs that food was coming, so they started secreting gastric juice. For Skinner's rats, the view of the lever in the cage meant that they could get food by pressing the lever previously associated with food delivery. We all know that domestic animals readily show their understanding when we start to

Table 5.2 The fundamental differences between phenomenal and propositional knowledge (Modified from Musacchio [6])

Phenomenal knowledge	*Propositional knowledge*
• *Language-independent* neural models that are associated to their aboutness and serve to ground ineffable words	• *Language-dependent*, highly symbolic and translatable propositions. Language includes ineffable and partially explainable words
• Consists in *phenomenal* concepts (the what-it-is-like) generated by qualitative experiences	• Consists in *propositional* concepts acquired through language and layers of symbolism
• Implemented by mostly *hard-wired*, innate circuits, which like the visual system, require usage to fully develop their potential	• Innate capacity of *highly plastic* circuits, that use language and symbols developed through cultural influences and practice
• Self-sufficient	• Phenomenal knowledge-dependent
• *Ineffable*, private. Refers through the associated aboutness	• *Explainable* through several levels, public. Refers through propositions
• Common to higher animals and humans	• Exclusively human
• Implemented in phylogenetically old, anatomically well-determined structures, which are symmetrically distributed on both sides of the brain	• Implemented mainly on one side of the brain, in the dominant hemisphere, around the perisylvian fissure and in other phylogenetically recent structures
• *Concrete thinking* and language-independent analogue reasoning	• *Abstract thinking* and highly symbolic reasoning that can utilize several languages

prepare their food. The meaning of experiences is an essential component of a virtual language-independent *phenomenal-intentional lexicon,* in which the "entries" are the what-it-is-like of experiences and their "definitions" consist in their aboutness and in their indexical reference [33] (see also Table 5.2).

The *indexical reference* consists in relating an observation (a sign of present or past occurrence) to another event or consequence that naturally follows [57]. Calls, gestures, attitudes, and facial expressions (laughing, crying, etc.) are generated in some organisms, probably without the initial intent to communicate. However, they can be interpreted as *predictors* of behavior. This indexical form of reference is more complex than learning the aboutness of the organism's own phenomenal states, such as thirst and hunger. Indexical reference is an interesting concept which has not been fully developed, and which has untapped heuristic value to understand the enormous power of non-verbal thinking. The observation of natural processes may have an indexical value that can be used to infer rudimentary forms of causality, logic, and elementary mathematics in the absence of a verbal language.

The what-it-is-like of experiences that we perceive immediately and the associated what-it-is-about, are both cognitive signals that allow for intelligent choices and integrated responses. This is true even if most experiences have no intrinsic meaning and falsify reality, or if we do not know exactly how they are realized. However, the integration of the neuroscience perspective into the philosophical discourse allows us to conclude that phenomenal concepts and their aboutness are instrumental in determining behavior. The capacity for choosing the right alternatives also fosters the development of higher intelligence, because the most intelligent (and devious) individuals are the most likely to succeed in leaving descendants. The aboutness of experiences also makes it possible to develop signals, language, and other symbolic forms that open the doors for higher forms of knowledge. *Propositional aboutness* is characteristically human and is established through verbal explanations.

The lack of association between the phenomenal character "the what-it-is-like" of experiences and their aboutness becomes evident in some emotional processes in which the agents that produce the experience cannot be identified subjectively, such as in anxiety, panic attacks, or endogenous depression. These abnormal processes are qualitative experiences without subjective aboutness, or "false alarms". In these cases, the independence of phenomenal character (sadness and depressed mood) and reference (what the depression is about) has been empirically corroborated by the success of antidepressant drug therapy and the absence of a reason to be depressed. This indicates that the feeling of sadness could occur as a brain process independently of any subjective reason.

All these considerations indicate that qualia, phenomenal concepts (the what-it-is-like), and the establishment of their reference are the most basic and essential elements to build knowledge. This serves to ground words in a virtual dictionary, the verbal-phenomenal lexicon, which is analogous to a

bilingual dictionary that makes language and propositional knowledge possible (Table 5.2). Thus, the meaning of language is actually grounded on experiences (see Chap. 6 and Table 6.1 for discussion of the word-grounding problem).

5.5 How experiences generate the self

Magnetic tapes, DVDs, and memory chips encode images and sounds in a way that we cannot perceive without the appropriate playback machinery. In analogy with gadgets, we could reason that, in addition to the sensory mechanisms that encode information in the brain, we need a system to decode the information perceived or stored in order to recall, dream, or hallucinate. However, we must resist the temptation of postulating an "observing self", which would imply a mind's eye or a Cartesian theater and regress. Thus, whatever we internalize must be incorporated through binding into conscious processes, suggesting that there must be neural processes or models that encode each sensation, perception, or recollection.

The self could be conceived as the integration of the innate phylogenetic endowment of the species with the repository of our life experiences and aspirations. We are the functions of our brain, a collection of processes in constant change. Past memories are integrated with present experiences in an always-changing modular, dynamic entity. The ever-changing self derives its versatility from the binding of constantly changing brain processes. The self is composed of brain modular activities that are distributed and integrated or bound together in time and space by the general mechanisms of awareness, which include the activity of the brain systems that synchronize neuronal oscillations [25, 48]. The modularity of the self is evident from the multiple examples of personal fragmentation produced by neurological lesions (see Chap. 4). We are aware of our physical body, not because it belongs to us, but because it is wired and connected to "our" brain. The brain internalizes and integrates all information coming from our body, which becomes part of the body scheme [58, 59] and the self.

We are "our" functional brain, meaning that the self cannot be different from the functioning brain in which those processes take place. Thus, it is incorrect to say, "I have a brain". Instead, I should say, "I am the current state of my brain". One of the problems is that language reflects the bias of the first person perspective, which cannot perceive the physicality of the conglomerate of functions and states that we are. The self is perhaps the most complex function of the brain. Occasionally, we adopt a dissociative or schizoid way of referring to "our brain", as if it were not part of our own self or as if our own brain did not have anything to do with the genesis of our experiences or our thoughts. I can lose a limb, but not even a fraction of my brain and continue to be myself. My experiences and my thoughts are the physical processes that take

place in the brain that I am. Actually, we are some of the ever-changing functions of "our" brains.

Caring for the self is encoded through aversive and reinforcing emotional experiences that result in the preservation of the integrity of the system through feedback mechanisms. This results in the survival of those organisms that are able to make the "best" choices. The unity of the self is dependent on the integrity of the brain. A variety of brain lesions and the consequences of cutting the corpus callosum, a fiber bundle connecting the right and left brain hemispheres and other brain connections in humans [59, 60], demonstrate the modularity of the self (see Chap. 4). Moreover, the self disappears entirely during deep surgical anesthesia, deep coma, and most likely after death.

All these observations have important philosophical consequences, because they imply that (ontologically) *consciousness and the self are neither a thing nor a substance*, but a collection of processes that include sensations, perceptions, and memories. In other words, consciousness and the self are a collection of *dynamic processes*, which incorporate not only the current experiences, but also all our current thoughts, memories, and emotional states. The dynamic character of the mechanisms of awareness is able to focus on current perceptions, phenomenal or propositional concepts, or on any aspect of the self, thus eliminating the need to postulate different *kinds* of consciousness. This is why *conscious processes* refer better than *consciousness* to what we are. An easy demonstration of the dynamic nature of the self is provided by the administration of a rapidly acting intravenous anesthetic, such as profolol or pentobarbital. These anesthetics produce a rapid loss of consciousness and changes in the electrical brain activity that is indicative of the level of anesthesia.

In summary, this chapter reviews the neural mechanisms underlying the apparent mystery of consciousness and experiences. The physical nature of these processes explains the impossibility of duplicating conscious processes in other people through explanations. A key concept is that qualitative experiences are neural processes that function as internal models of the external world and of the internal states of the organism. To perceive an experience, qualitative experiences must be integrated into conscious processes through the 40 Hz thalamo-cortical rhythmic activity (Fig. 5.1). A major conclusion is that consciousness and experiences are physical processes that take place in the brain. Previously, brain mechanisms were considered as non-physical or spiritual events, because they are imperceptible to the subject. Actually, the perception of the brain mechanism in all its complexibility would be detrimental to the perception of the external world and what is essential for survival (such as hunger, pain, or predators). Thus, the neuronal mechanisms that generate our feelings, sensations and perceptions are transparent to avoid infinite regress (see Chap. 4).

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