Neuropsychologia 51 (2013) 1050–1060

Contents lists available at SciVerse ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Anchoring visual subjective experience in a neural model: The coarse vividness hypothesis

Florence Campana, Catherine Tallon-Baudry *

Cognitive Neuroscience Laboratory INSERM-ENS U960, Ecole Normale Supérieure, Paris, France

ARTICLE INFO

Article history:
Received 16 November 2012
Received in revised form
18 February 2013
Accepted 27 February 2013
Available online 13 March 2013

Keywords:
Perceptual consciousness
Subjective experience
Visual system
Scene categorization
Sperling experiment
Change blindness

ABSTRACT

Subjective experience often accompanies perception and cognition. This elusive feeling is difficult to characterize, both theoretically and experimentally. Perceptual subjective experience is at the heart of a theoretical debate in consciousness research: does it correspond to a genuine psychological and biological process independent from cognitive abilities, or is it a cognitive illusion, a post-hoc construct, implying that perceptual consciousness can be reduced to a sum of cognitive functions? We reconsider this debate in the light of known properties of the visual system, derived from studies on visual object and scene recognition but not specifically targeting consciousness issues. We propose here that initial visual subjective experience is characterized by two key properties, coarseness and vividness: initial subjective experience is integrated, meaningful, but does not contain detailed information. Subjective experience is likely to arise first in high-level visual areas, in which information is encoded in a coarse and integrated manner. We propose that initial subjective experience is related to the concept of "vision at a glance", thought to result from a fast, implicit feed-forward sweep of activity in the visual system progressing from low-level areas to high-level areas (Hochstein and Ahissar (2002) *Neuron*, *36*, 791–804). The details needed to overtly guide behavior would be retrieved in a secondary processing step of "vision with scrutiny", proceeding in a feed-back manner, from high-level to low-level areas. This secondary and optional descending process could thus later enrich conscious visual percepts with details. Our hypothesis provides parsimonious explanations for two intriguing findings: the double dissociation between attention and consciousness, and the mismatch between objective measures and subjective reports, that is sometimes used to argue that subjective experience is an illusion. We argue here that because visual subjective experience is initially coarse, it should not be probed by asking subjects to specify details. The coarse vividness hypothesis therefore offers a framework that accounts for the existence of an initial genuine subjective experience, defined by its coarseness and vividness, optionally followed by more refined and detailed processing that could underlie finer perceptual and cognitive abilities.

1. Introduction

Perceptual subjective experience refers to the way the world appears to us via our senses. It is an intuitive notion, fundamentally constitutive of our human nature. We all share the intuition that a robot, however smart, is lacking any feeling associated with the complex operations that it can execute: a robot is not human, therefore it lacks subjective experience. Subjective experience nevertheless remains an elusive notion, difficult to frame in a scientific theory, since it is essentially a private experience, that is not easily accessible to the experimenter. Nagel (1974) famously illustrated this idea by pointing out that even if we were an expert about the machinery of a bat, we could not imagine what it is like to be a bat, what it feels like to be a bat, or more generally what it feels like to be anyone else. Here, we concentrate on subjective visual experience, the sensation that sometimes accompany neural visual processing (Kanai & Tsuchiya, 2012).

In the last 20 years, the search for the neural correlates of consciousness has been very active. Leaving aside concepts and theories, most studies on visual consciousness adopted a pragmatic approach (Crick & Koch, 1990), and contrasted neural responses to stimuli that were consciously perceived vs. stimuli that remained unnoticed. But what does such a contrast tell us about visual consciousness? Does it pertain to information processing that could take place in a robot, or does it pertain to the neural basis of subjective experience? Since these questions were most often not explicitly addressed, subjective visual experience remains an underspecified issue in cognitive neuroscience. On the

* Corresponding author. Tel.: +33 144 32 27 93; fax: +33 144 32 26 42.
E-mail address: catherine.tallon-baudry@ens.fr (C. Tallon-Baudry).

0028-3932/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.neuropsychologia.2013.02.021

other hand, the nature of subjective perceptual experience is hotly debated from a theoretical point of view. Some philosophers argue that subjective experience is a cognitive illusion (Dennett, 1991; O'Regan & Noe, 2001), a post-hoc cognitive reconstruction rather than an immediate experience (Cohen & Dennett, 2011; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006), whereas others emphasize that subjective experience is central to consciousness and is distinct from cognitive abilities (Block, 2007). At the other end of the spectrum, many visual scientists do actually study consciousness without mentioning it, since any study on explicit visual perception pertains to visual consciousness.

In this paper, we review neural and behavioral studies on visual recognition, whether or not addressing directly and explicitly the issue of subjective experience, and show how the architecture of the visual system constrains conscious perception. In the light of those constraints, we propose that the distinctive feature of initial subjective experience is coarse vividness: initial subjective experience is rich, integrated and meaningful, but does not contain much details. We provide a physiologically plausible model that accounts for this property and that articulates the quality of subjective experience with neural information processing. We then show how two intensely debated issues in consciousness research, namely the interpretation of change blindness studies and of the Sperling experiment, and the dissociation between attention and consciousness, can be parsimoniously interpreted in the framework of the coarse vividness hypothesis.

2. The disputed status of subjective experience

Subjective experience is at the heart of a vivid theoretical debate questioning the possibility that conscious experience exists independently of cognitive functions. Some argue that consciousness is reducible to cognitive functions (Cohen & Dennett, 2011; Kouider, de Gardelle, Sackur, & Dupoux, 2010). In this functionalist approach, consciousness is mainly considered as a combination of high-level cognitive functions, and, in this view, subjective experience is either absent or thought to arise somehow from the interactions between those high-level cognitive functions. In the original formulation of the global workspace theory, Baars wrote that "Consciousness seems to be the publicity organ of the brain. It is a facility for accessing, disseminating and exchanging information, and for exercising global coordination and control" and defined conscious experience as "the spotlight of attention shining on the stage of working memory" (Baars, 1997). Dehaene and Naccache (2001) further proposed that "this global availability of information [...] is what we subjectively experience as a conscious state". Alternatively, subjective experience could be distinct from the cognitive functions often associated with consciousness (Block, 2007; Lamme, 2006; Tallon-Baudry, 2012). If this were the case, then we are back to the "hard problem" (Chalmers, 1995): "The hard problem is hard precisely because it is not a problem about the performance of functions. The problem persists even when all the performance of all the relevant functions is explained". In other words, how can we account for the fact that we are *experiencing* those items we attend to, we exert control upon, we remember? What is the nature of this subjective experience? Could it be distinct from cognitive functions?

2.1. The difficulty of studying subjective experience

Subjective experience is a private experience, that is not easily accessible to the experimenter. Psychologists operationalized measures of subjective experience in detection tasks. Typically, in such experiments, a weak stimulus is presented or not, and subjects have to report whether they saw a stimulus or not. Detection is subjective and private: what matters is the experience of the subject, independently of the physical presence or absence of the stimulus. The experimenter cannot objectively verify the veracity of subjects' reports—a subject could be systematically lying for instance. Besides, even if subjects try to report faithfully their experience, the final outcome depends on subjects' willingness to report faint impressions. Signal detection theory (Ratcliff, 1978; Swets, Tanner, & Birdsall, 1961) was introduced as an influential tool to map subjects' reports onto the physical stimulus space by computing two hidden variables, perceptual sensitivity, or objective ability at discriminating between stimulus absent and stimulus present trials, and criterion, or willingness to report faint signals as "seen". The notion of subjective experience was excluded from the interpretation framework. Analyzing detection task data in the signal detection theory framework further revealed that subjects' criterion could be highly variable, both within and between subjects: some subjects may be prone to reporting seeing a stimulus in the presence of weak evidence, while others are more conservative and only report stimulus presence when their sensory experience was extremely vivid. Between-subject differences in criterion, as well as potential within-subject fluctuations of criterion over time, were considered as a source of noise in the data. To minimize this source of variability, more objective tasks were developed. For instance, subjects were asked in which time interval a stimulus was presented (Foley & Legge, 1981; Gorea, 1986; Thomas, 1985; Watson & Robson, 1981). More radically, discrimination tasks, in which subjects are no longer asked about their own experience, were introduced: subjects were asked about a physical feature of the stimulus, such as "was it tilted left or right?", or "was it a face or a house?". Such tasks are considered as objective, in the sense that the experimenter can tell whether the subject's answer is correct or not. Those tasks are also often unbiased by criterion issues, since there is no reason why a subject would be more willing to respond "tilted left" more often than "tilted right". The evolution of psychophysics toward objective tasks illustrates well the difficulties that are inherent to the study of private subjective experience. Behavioral methods tailored to study subjective experience are currently being developed (Overgaard, Nielsen, & Fuglsang-Frederiksen, 2004; Sandberg, Timmermans, Overgaard, & Cleeremans, 2010; Seth, Dienes, Cleeremans, Overgaard, & Pessoa, 2008), but have not yet been extensively used in neuroimaging studies.

As a consequence of the inherent difficulty to study subjective experience, neuroimaging studies of consciousness display a full panel of attitudes toward subjective measures. Some studies relied solely on subjective measures, despite potential caveats related to criterion (Ress & Heeger, 2003; Tse, Martinez-Conde, Schlegel, & Macknik, 2005). Others authors were more cautious, and assessed the validity of subjective measures by checking that objective performance was above chance when subjects reported seeing the stimulus, and at chance (Liu, Paradis, Yahia-Cherif, & Tallon-Baudry, 2012; Wyart, Dehaene, & Tallon-Baudry, 2012; Wyart & Tallon-Baudry, 2008) or close to chance (Del Cul, Baillet, & Dehaene, 2007), when subjects reported not seeing the stimulus. The rationale here is that consciously seeing should be accompanied by a marked improvement of perceptual abilities such as discrimination or identification. At the other end of the spectrum, a number of studies relied on objective performance only (Boehler, Schoenfeld, Heinze, & Hopf, 2008; Koivisto, Revonsuo, & Lehtonen, 2006; Schurger, Pereira, Treisman, & Cohen, 2010; Schwarzkopf & Rees, 2011). These examples illustrate the commonly held assumption that subjective experience and the behavior reflected by objective performance are tightly