Epilepsy & Behavior 30 (2014) 58–61

Contents lists available at ScienceDirect

Epilepsy & Behavior

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

Review

Ictal alterations of consciousness during ecstatic seizures

Fabienne Picard [a,*], Florian Kurth [b]

[a] Department of Neurology, University Hospital and Medical School of Geneva, Switzerland
[b] Department of Neurology, UCLA School of Medicine, Los Angeles, USA

ARTICLE INFO

Article history:
Received 24 September 2013
Accepted 26 September 2013
Available online 26 October 2013

Keywords:
Epilepsy
Ecstatic
Self-awareness
Consciousness
Insula
Meditation

ABSTRACT

Patients with ecstatic epileptic seizures report an altered consciousness, which they describe as a sense of heightened perception of themselves – they "feel very present" – and an increased vividness of sensory perceptions. Recently, the anterior insula has been proposed as the region where these seizures originate, based on the results of ictal nuclear imaging in three patients, the first induction of ecstatic auras by electrical stimulation, and the functional characteristics of the anterior insula in neuroimaging literature. Specifically, the anterior insula is thought to play a key role in integrating information from within the body, the external world, as well as the emotional states. In addition, the anterior insula is thought to convert this integrated information into successive global emotional moments, thus enabling both the construct of a sentient self as well as a mechanism for predictive coding. As part of the salience network, this region is also involved in switching from mind wandering toward attentional and executive processing. In this review, we will summarize previous patient reports and recap how insular functioning may be involved in the phenomenon of ecstatic seizures. Furthermore, we will relate these hypotheses to the results from research on meditation and effects of drug abuse.

This article is part of a Special Issue entitled Epilepsy and Consciousness.

1. Introduction

> "*The feeling of life, of self-awareness, seemed to grow stronger in such lightening moments.*"

The first description of the state of consciousness observed in ecstatic epileptic seizures was given in the 1860s by Dostoevsky, who described the symptoms of such seizures mainly through the characters in his novels. Prince Mychkine, the main character of "The Idiot", suffered from such seizures, which were characterized by a sense of bliss. He felt "*flashes of lucidity with hyperesthesia of sensory stimuli and of awareness*" and "*an incredible hitherto unsuspected feeling of bliss and appeasement…*". "*My mind grows extraordinarily clear…*". "*Such moments represented an incredible effort toward awareness and at the same time the most direct expression of self-awareness.*" "*Once I returned to normal consciousness, I felt that such illumination, such awareness of a higher consciousness, of a "superior being", was a kind of illness, a distortion of the normal state. But it was neither mirage nor vain illusions such as those induced by hashish or alcohol that degrade the mind…*". "*All my problems, doubts and worries resolved themselves in a limpid subtle peace, with a feeling of understanding and awareness of the 'Supreme Principle of life'*". While the majority of patients with ecstatic epileptic seizures report similar feelings, they may find it more difficult than Dostoevsky to describe these surreal symptoms. Most describe a sense of heightened perception of themselves – they "feel very present" – and an increased vividness of sensory perceptions during their seizures. At an initial stage, these ecstatic epileptic seizures are not accompanied by a loss of consciousness. Thus, they correspond to "simple partial seizures" according to the old ILAE Classification of Epilepsies and Epileptic Syndromes [1], a term now replaced by "focal seizures without impairment of consciousness or awareness" [2].

2. Patients

Seven patients have been described, who all reported a state of heightened self-awareness coupled with feelings of enhanced well-being and intense positive emotion. Picard and Craig reported five patients with ecstatic seizures, whose descriptions of ecstatic auras were very similar to that of Dostoevsky's [3]. Picard later described two more patients [4]. The heightened awareness actually affected both the internal "self-awareness" (feeling of being "more present") and, according to some of the patients, the awareness of the external world with a more accurate, more acute perception of external stimuli. Among the descriptions of the ictal symptoms in the first paper, subject 1 reported: "*it is as if I were very, very conscious, more aware, and the sensations, everything, seems bigger, overwhelming me.*" Subject 2 used these words: "*I feel light inside, but far from being empty. I feel really*

Abbreviations: SPECT, single photon emission computed tomography; EEG, electroencephalogram.

* Corresponding author at: Department of Neurology, University Hospital of Geneva, 4 rue Gabrielle Perret-Gentil, 1211 Geneva 14, Switzerland. Fax: +41 22 37 28 340.
E-mail address: Fabienne.Picard@hcuge.ch (F. Picard).

1525-5050/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.yebeh.2013.09.036

present…. I feel a stronger consciousness of the body and the mind, but I do not forget what is around me". Subject 4 described: "*I feel more conscious of myself, more concentrated on myself… I feel more present from a psychological point of view, with more sensations…*". "*Being very conscious of myself, I feel like discharged from anything else, from any worries*". Subject 5 reported: "*It is a feeling of total presence, an absolute integration of myself, a feeling of unbelievable harmony of my whole body and myself with life, with the world, with the 'All'*" [3]. Another subject explained: "*This would result in a sense of vividness which derived from the fact that each object in my visual field was emphasized, so to speak, by everything else*" [4].

3. The insula

According to Picard and Craig's hypothesis, the symptomatic zone of the ecstatic aura would be the anterior insula, for a variety of reasons. Specifically, the results of ictal nuclear imaging reported in the literature for three patients [3–5] described a maximum of activity in this region. Ictal SPECT showed an increased blood flow in the whole right anterior insula in the first patient [3]; in the left anterior insula and mid-insula on both sides in the second patient [5]; and at the junction of the right dorsal mid-insula and central operculum in the last patient [4]. In addition, ecstatic auras were induced by electrical stimulation of the anterior–dorsal insula in a new patient with ecstatic seizures who underwent a presurgical depth electrode evaluation [52]. Finally, the different physiological roles of this region are abundantly described in literature. The insula is both, segregated into different subregions that are involved in a variety of functional systems, and at the same time a major hub for integrating the information from these different functional systems [6]. Specifically, the insula's functionally defined subregions are involved in interoception, gustation, olfaction, somatosensation, processing of emotions, and cognition. Connectivity studies in animals revealed that the different parts of the insula are extremely well interconnected [7], which enables a rapid flow of information to the anterior insula. In the anterior insula, this incoming interoceptive/sensory, emotional, and cognitive information is finally integrated into a sense of well-being [8] and emotional regulation [6,9], and used in salience detection, switching between brain states, and predictive coding [10–12]. This integration has been hypothesized to produce self-awareness and the experience of a present moment [9,13].

The rich interconnection between insular subregions [7] may well enable a rapid propagation of seizure activity. This rapid propagation may lead to ecstatic seizures with different attendant symptoms like gustatory, olfactory, or auditory sensations (depending on the exact location of the ictal discharge), which were previously described [3,4]. Interestingly, very close connections also exist between the insula and the temporopolar region [14]. These connections, as well as the observation that ictal discharges can propagate directly from the temporal neocortex to the insula without a mesiotemporal relay [15], may explain how seizures originating in the temporal pole may immediately propagate to the insula [3]. Once ictal activity reaches the anterior insula, it may directly alter its functioning and elicit ecstatic seizures rather than classical temporal lobe epilepsy symptoms [3]. Specifically, changes in well-being, emotional regulation, and awareness of the present moment as reported in ecstatic seizures can be expected. In the following sections, we will discuss alterations in salience detection and switching brain states, changes in "awareness of the present moment", as well as possible effects on predictive coding.

4. Possible underlying mechanisms of ecstatic seizures

The anterior insula shows highly correlated activity with the dorsal anterior cingulate cortex (dACC) during the resting state, constituting a functional network which has been implicated in a broad range of affective and cognitive processes, including interoceptive–autonomic arousal, salience detection (that is, behaviorally relevant stimuli detection), emotional processing, tonic alertness, and decision-making, in order to adequately process high-priority signals [9,16–19]. The most ventral part of this network was referred to as the "salience network" because of its role in the identification of the most salient stimuli and switching between the default mode network (which is activated during mind wandering) and the executive network, which enables the ability to fix attention on the external world and associative interoceptive state/changes [9–11,17,20,21]. It inhibits the default mode network and initiates the executive network (with a consequent activation of other attentional control-related networks). The salience network is implicated in the detection of salient external events as well as internally generated events, such as conscious awareness of errors. Hasenkamp et al. reported robust activations in the bilateral anterior insula and dACC when subjects became aware that their mind had wandered away from the breathing sensations on which they had to maintain attention [22,23].

During ecstatic seizures, the capacity to feel "more present" and have an increased perception of external stimuli could be related to a sustained activation of the salience network despite the absence of salient stimuli. An abnormal (seizure-induced) activation of this network would give rise to a switch away from mind wandering and to an unusual state of sustained high alertness and awareness without cause and without specific aim. Any current internal or external stimulus would then be perceived as if it was salient, giving rise to a feeling of extreme inner and external vividness at any given moment during the ecstatic aura.

It has been suggested that the anterior insula is a key structure for the "present-moment awareness" [9], another possible underlying mechanism. Different studies showed that the anterior insula is consistently involved at the moment of perceptual recognition, for example, when subjects become aware that their mind has wandered away from the task [22]. However, this involvement has been particularly shown in conscious error perception or "error awareness". In a visual saccade task in which it was possible to be either aware or unaware of errors, the anterior insula was activated only when participants could signal awareness of such errors [24,25]. The anterior insula can also analyze intersensory temporal synchrony and is activated during visual–auditory asynchrony detection [26]. According to Craig, the anterior insula integrates internal (interoceptive), external (sensory), and emotional information at each moment, giving rise to an image of 'the material me' or the sentient self at the immediate moment of time – 'now' – which he calls a "global emotional moment" [9,13,27]. The succession of global emotional moments would produce a cinemascopic 'image' of the sentient self that is continuous across a moving window of present time and would constitute the basis of time perception with an approximate frame rate of 8 Hz (i.e., each global emotional moment lasting about 125 ms) [3,13,27]. An important aspect of this model is that the sampling rate is not fixed but is rather dependent on salience. That is, sampling occurs more frequently for salient moments, leading to a subjective dilation of time, thus explaining the strong link between emotions and subjective time perception.

The ecstatic seizures could allow a sustained "present-moment awareness" state. Patients all indicate a subjective time dilation [3,4]: their several-second seizures seem to last much longer, as if time had stretched ("*I could not say if it lasts one second, hours or months*", Dostoevsky). In the present model, if each stimulus is perceived as salient, the extremely high number of consecutive salient moments would increase the sampling rate to a maximum, leaving the patient subjectively timeless in the 'here and now'.

Finally, a third possible mechanism involves uncertainty. Overall, there is a strong motivation to avoid ambiguity and uncertainty [28], since these have been characterized as aversive states [29]. Generally speaking, uncertainty can be minimized by making inferences about future states with the greatest possible precision [30]. For this purpose, the brain predicts future states and continuously compares these predictions with current states while trying to minimize the prediction