Quantifying Consciousness: Electrophysiological Perspective

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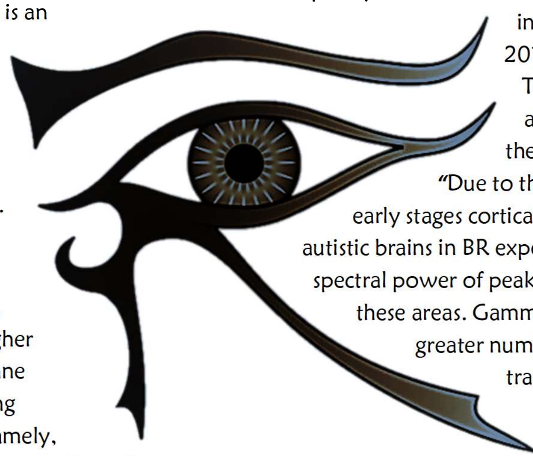
Abstract- In this article, we try to track the neuroelectrical signal from its inception until it signals the human visual awareness through what we called, neurobiological wires to consciousness. We also provide a fulsome electrophysiological metric, namely, brain energy wishing for better quantification to the human global consciousness. Based on the literature review, this metric is expected to quantify the human global visual awareness, namely because of recent special findings in binocular rivalry phenomenon. The article also offers simple ways to build up binocular rivalry experiments.

Introduction

Binocular rivalry, a phenomenon of visual perception in which human visual awareness alternates between different images presented to each eye, is an outstanding psychophysical approach to quantify consciousness. Importantly, both kinds of attention, automatic and voluntary, help in increasing the awareness dominance duration of the corresponding stimulus. In another word, attention controls human global consciousness.



Strength (Levelt, 1965), saliency (Engle, 1956), spiral motion (Malek, 2012), higher spatial frequency (Fahle, 1982), duchenne expressions (Malek, 2018), are all having 'catchy' visually stimulating features, namely, they all trigger automatic attention; therefore they all dominate the visual awareness over 'non-catchy' ones. Voluntary attention to certain details to a certain stimulus also elongates the awareness dominance duration of the stimulus (Lake, 1978).

Time (the awareness dominance duration) had been used as a metric to quantify human visual awareness by vision scientists, however, this metric should be supported by physiological metrics to help scientists to convey awareness to biological science. But what is the best physiological metric for consciousness?

To answer this question, we have to understand how the human visual awareness works (for fulsome comprehension; see reference 11). Namely, it theorized that the neurological roads to the visual awareness are started by the photoreceptors and ended by the final inhibitory neurons. It also hypothesized that, in certain conditions, there might be entanglements between the emitted photons and their corresponding photoreceptors.

Now, let's see a specific example and try to generalize it, namely, let's study the autistic brains. Three interesting facts about the autistic brains:

1- They have hyper-systemizing, hyper-attention to detail and sensory hypersensitivity (Baron-Cohen, *etal.* 2009).

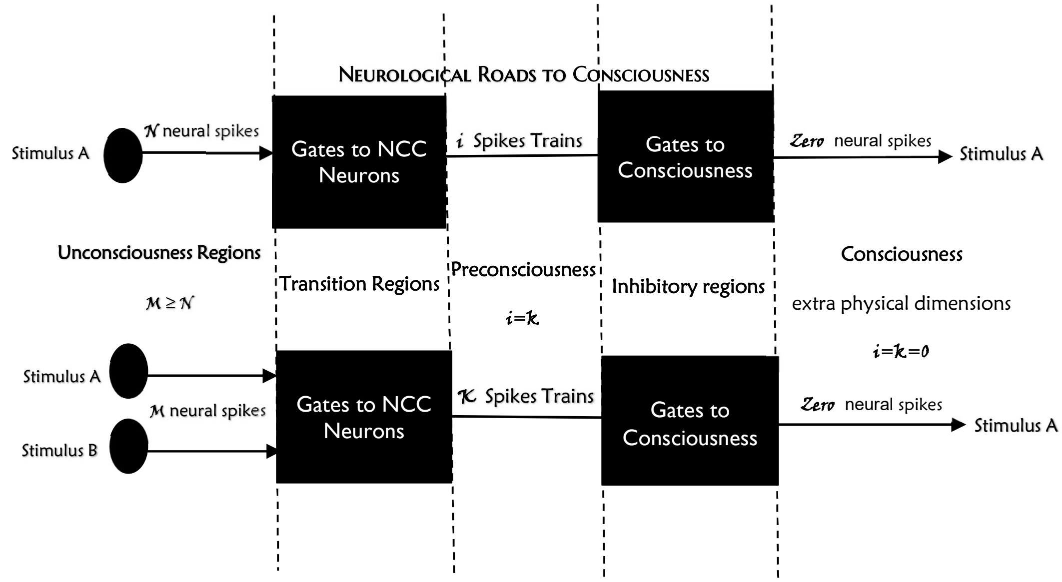
2- They have reduced GABAergic action, (Robertson, *etal.* 2016).

3- They have longer dominance duration in binocular rivalry (BR) experiments, (Robertson, *etal.* 2013). Autistic brains also have higher spectral power of peak gamma frequency due to their slower switching rates; this is an indirect conclusion to (Fesi, *etal.* 2015) findings.

The aforementioned facts may allow me to hypothesize & say the following statement:

"Due to the lack of GABAergic action, early stages cortical inhibition might not occur in autistic brains in BR experiments; and therefore, the spectral power of peak gamma waves is escalated in these areas. Gamma waves might represent greater numbers of 'asynchronous' spikes trains produced by the neurological roads in the ROI. The final destination of those neurological roads are rather in further areas. Noticeably, the neurological roads to the visual awareness are assumed to converge eventually, and thus, the need of GABAergic action will be minimized. To minimize the GABAergic action, a possible scenario can be proposed for autistic brains: They might have longer neurological roads to the visual awareness for certain stimulus (perfect and fulsome detailed consciousness); synchronized with retinal inhibition; pre-retinal inhibition (possible collapses of the entangled wave functions) for the other stimulus perfect oblivion; namely, $M \approx N$ in the unconsciousness regions; see the infographic below, and reference 11 . Normal brains, however, might require greater GABAergic action due to the possible suboptimal detailed consciousness for one stimulus (inhibition before the aforementioned

Comparison between the visual awareness generative processes of 'Stimulus A' through Normal vision (up) and Binocular rivalry (down)



convergence); that might be synchronized with imperfect oblivion for the other stimulus; namely, M > N in the unconsciousness regions. Imperfect oblivion had been be viewed as subconscious brain activities in the literature." Important to mention, the aforementioned hypothesis is based on a pervious hypothesis that assumes the brain as a systemized entity contains of 'biological wires' igniting the visual consciousness. The awareness itself, however, is assumed to reside in extra physical dimensions (See reference 11). The hypothesis also estimates that inhibitory neurons are gates to the consciousness, and therefore, the human awareness is a product of too many parts of the brain; namely, physiological investigations in consciousness should have holistic considerations. Detailly speaking, longer neurological roads might eventually create greater details and fulsome consciousness; shorter ones create weaker awareness, but very short ones in retinal or subcortical regions, possibly due to very low amount of entanglements, create minimal to no awareness about the stimulus. Because highly informative awareness might be a product of fewer inhibitory neurons 'due to the convergence of the neurological roads to the inhibitory neurons'; therefore, the awareness that's produced by a fewer gates 'narrower neurological channel to consciousness' will access the awareness for longer dominance duration in binocular rivalry settings.

Brain Energy -- The neurophysiological validation can be concluded from the available literature; however, to tighten the aforementioned hypothesis tightly, a new mathematical metric for brain imaging may be defined, namely*; Brain Energy*, which can be described as follows:

$$\text{Brain Energy} = \left\{ \sum_{h=0}^{n} \int_{T=0}^{T=dominace\ duration} (ERP)^2 \ \mathrm{dt} \right\}$$

Where ERP refers to event related potentials, and h is the number of the channels of the EEG system. Importantly, different kinds of brain imaging techniques has different metrics, that should be wisely used to estimate accurate *Brain Energy* values. Consider a high density EEG system with 256 electrodes; each electrode will detect localized *Brain Energy* that can be estimated by integrating the $(EPR)^2$ over the time whereas the starting time is the onset of the awareness of a certain stimulus (t=0), until that stimulus disappear from the awareness (t=dominance duration). The *Brain Energy* can be estimated by summing up of all of the 256 localized *Brain Energies.* Advisably, the raw data should be critically analyzed and processed. Detailly speaking, since attention has decent control over consciousness, the gamma waves filter should be so wide up to 150Hz (see reference 12). Moreover, alpha waves should be removed for two reasons; it peaks when gamma waves are minimized (see reference 14), and it proportionally correlated with fast rivalry switching rate (Katyal, etal. 2019). Namely, alpha waves will strength the value of brain energy despite it's not responsible for intensifying the human visual awareness; therefore, it should be removed. Although I don't offer empirical studies here, however, the aforementioned metric seems to produce the most meaningful neurophysiological information for BR experiments; the conventional metrics, however, are unable to holistically quantify the awareness. **Important to emphasize, longer neurological roads to consciousness might lead to weaker inhibition in the early cortical stages; namely, those roads might even decide to be bridging over these inhibitory neurons because they're not their desired destinations.** By converging the recent scientific reports altogether, it's expected to see the *normalized value of Brain Energy* of 'the longer dominance duration' stimulus being much greater than the *normalized value of Brain Energy* of 'the shorter dominance duration' stimulus. After several empirical validations, scientists may confidentially say; greater/weaker inhibition of brain activities due to greater/weaker GABAergic action lead to shorter/longer neurological roads to the inhibitory neurons and therefore weaker/greater fulsome consciousness.

Progressively, quantifying consciousness should be an important procedure in medicine, because it might help the practitioners to have estimated interventions in critical cases (reference 15).

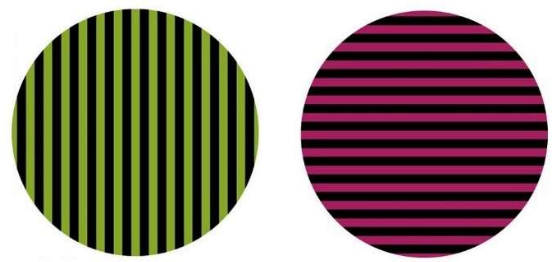
Comprehensive Navigations in the Literature

We had previously reported that voluntary blinks have the ability to stop the binocular rivalry indefinitely, see reference 16. We believe that the aforementioned stoppage is because of massive congestion in the hypothetical bi-directional tachyonic tube, see references 11, and 17; afterwards, watch the video offered in reference 18 for comprehensive understanding of the tachyonic tube. We had also noticed that voluntary hand movements is able to halt the binocular rivalry for an outstandingly long period of time, see reference 19; hypothetically because of severe congestion in the aforementioned tube (from the conscious cloud to the brain). Interestingly, the switching rate can be slow down through deep breathing as well; however, we also noticed that deep breathing could govern the binocular rivalry, see reference 20. Consequently, the primary olfactory cortex and its neighbors in the ventral pathway should have greater neural activities. Important to mention, back to May, 26th, 2015, we had offered our surety about the existence of higher neural activities in the higher areas of the ventral pathway within "slow switching rate" human subjects to corresponding author of reference 21; but without mentioning the reason behind our surety. As expected, the aforementioned author had successfully reported that the slow switchers had greater neural signals in the higher regions of the ventral pathway such as pSTS region. Astonishing to mention; the dominance duration for the emotional faces is greater than the normal faces, see reference 5 and 22; and this is clearly because the active inhibitory neurons out of the emotional faces are within the fusiform face are plus the Amygdala; unlike the normal faces which just activates the fusiform face area.

Summarily, it's noted that when more brain regions are activated, especially, the prefrontal cortex, the motor cortex, the higher areas for both ventral and dorsal pathways, and even the subcortical areas such as Amygdala; the switching rate will slow down! Detailly speaking, voluntary hand movements activate the dorsolateral prefrontal cortex (decision making), in addition to the motor cortex (action); deep breathing, however, activates the primary olfactory cortex, as well as the dorsolateral prefrontal cortex, and finally however, emotional faces activates the fusiform face area and the Amygdala. We accordingly believe that the reason of the slow switching rates is higher neural activities in both cortical and subcortical regions; thus, we think that "Brain Energy" is the best metric to quantify the consciousness!

Binocular Rivalry Installation

Readers can experience binocular rivalry just by moving their eyes towards the page until the two following circles seem to merge. To have a better experience, open the stimulus on portable devices.



Courtesy of Jame W. Kalat, 2005. Introduction to psychology, seventh edition

Important to emphasize, some scholars believe that anaglyph glasses is enough for binocular rivalry experiment, we disagree with them mainly because some stimulus are so complex to be achieved with aforementioned glasses such as those offered in reference 23. We therefore would like to offer a perfect setup for binocular rivalry. To achieve the most efficient, simplest, and cheapest installation kindly follow instructions below:

1- Purchase 9.25 diopters for prism correction base-out glasses from any optics shop. Scientifically speaking, that equals to 8.76 degrees visual angle (DVA) at distance of 24 centimeters; namely, it represents how many degrees does the stimulus subtend on the retina.

2- Create a splitter, using cartoon and glue gun to prevent the interference of light rays among the two circles. The splitter, and the stimuli should be adjustable based on the equation of the visual angle. Assume that human subjects are comfortable to view the computer screen 24 cm away, this should be the length of the splitter. Now, by substituting in the following equation, we can calculate the diameter of each circle: $8.76\ (DVA) = \tan^{-1}\frac{x}{24}$; where x is in centimeters. For this case the diameter of each cycle would be exactly 3.7 centimeters.

Essential Notifications

Scholars who have high density EEG machines and would like to collaborate are welcome to contact the author. Scholars who have low density EEG systems are advised to use compressive sensing techniques (see reference 1).

Scholars who have issues with binocular rivalry setup or want to access a copy of the current codes for brain energy metric, with gamma waves filter are welcome to request it directly from the author.
Scholars who struggle in comprehending any part of this article are also welcome to directly contact the author. Important to mention, we did not receive any acknowledgement from the corresponding author of reference 21, despite the fact that we the originator of the concept; and therefore, in order to comply to the scientific ethics, we will mention the title of the reference but not the authors until further notice.

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