

Qualia Field Parameters and Confounding of neural code

Abhijit Manohar
armanohar977@gmail.com

Summary: The paper proposes the 5 parameters of qualia and how they contribute to the generation of subjective experience. The qualia chosen for analysis are colour perception, auditory perception, olfactory perception, gustatory perception, pain, temperature, orgasm and emotion (fear). The paper further explain how amplified and sustainable local cortical activity or activity of an attractor state/ resonant loops (Orpwood 2013) or neural code through attention gives rise to qualia which are governed by 5 parameters of qualia field. All 5 parameters of qualia together locate and generate qualia experience. The above qualia are scaled against each other on the basis of the 5 parameters. The paper analyses the epistemology of explanatory gap in the “hard problem of consciousness”. The paper also discusses the generation of self in the qualia field and reviews few alternate models of consciousness.

The paper proposes that the parameters of qualia converge ultimately to one single neuron. This paper analyses the neuronal codes as a confounding of many codes, each of a separate parameter to generate a “pixel” of quale in the qualia field. I proposed a minimum of 4 primary parameters (1 secondary parameter – secondary impression not analysed in this study) necessary to locate a quale in the qualia field. The study focuses only on the visual perception and its temporal neuronal code.

Keywords: Neuronal code, qualia, parameters, information, brain, hard problem of consciousness, Qualia field, qualia, parameters, properties, information, explanatory gap

Section 1

Theory

The philosophical theory of perception known as Direct Realism claims that we see the universe the way it is rather than as computed by the brain. The light which is an electromagnetic wave falls on objects and reaches our retina from where the neural signal is sent to the brain for processing. If the objects are a different entity than the observer how can the actual object reach us? Even the light bouncing off the object is a field of varying electric and magnetic field not the object. So, light does not bring object to you. Also, even if the light brought the object to you, it never travels beyond the retina. You can only see the objects the way they actually are if you were the actual objects. That is the only way objects can reach you. So, if qualia are the final result of cortical processing, a separate field, called qualia field, should be allotted to them

Over the last century a new theory has been developed which suggests that there is a physical world and a qualia field both connected by Humean causal interactions (Symthies, J 2003). Each neural activity may be differentiated by its own unique spatial and temporal neural network output. This uniqueness corresponds to a unique location and quale in the “qualia field”. As will be detailed later, the qualia nature, secondary impression (secondary qualia which is not always necessary for generating basic quale), localization, externality and discrimination of qualia field correspond to a unique activity in the brain. The

quale of luminance is not considered in this paper. The very fact that quale is observed “outside” the brain (visual, auditory or somatosensory cortex), not something observed “inside” your brain (like the default network creating imagination located inside your brain) lends support to the “qualia field” theory. The compelling thought that the qualia is, at least some of them, experienced outside the brain supports qualia field theory. Imagination is not a quale and is “seen” completely inside the brain. However pain, vision, sound etc. are experienced outside the brain.

It is known that neural activity in the local cortical areas decay in the case of “subliminal perception” but in case of supra-liminal perception there is a bottom up signal to prefrontal cortex, cingulate cortex which may amplify and sustain the activity in the local cortex by re-entrant connections and also broadcasts it to many local brain areas such as language, long-term memory etc., according to Global Neuronal Workspace (Dehaene). An alternate explanation of the sustenance of local cortical activity is that the prefrontal cortex encourages the local cortex to go into an attractor state (Orpwood 2017). The third origin of qualia is the hypothesis of neuronal coding such as rate coding, temporal coding etc.

The quale’s secondary impression, its location, externality and discrimination are experienced by the

individual's own neural activity while that of others cannot be experienced. However, the brain evolved in such a way that the quale's nature, secondary impression, its location, externality and discrimination is coincident with the physical reality and hence different observers agree with their qualia and locations. Evolution and neural Darwinism has "designed" the output of neural network or neuronal code not only to agree with other individuals but to match the physical reality.

The qualia field impinges upon the physical reality. The unique electrical output gains access to qualia field of which we become conscious. Each unit volume of qualia field has its own parameters of qualia.

The electrical activity of the brain lends access to the qualia field. Each unit point in the qualia field can gain values based on the output of the electrical activity in the brain. The ontology of qualia field is fundamental such that it is not required to explain the origination of qualia. The qualia field takes up the value of qualia such as red colour corresponding to the activity in the local cortical network. The qualia field is not made up of physical objects but objects of qualia field called qualia. The values of each point in the qualia field depend on the 5 parameters discussed in the next section.

The 5 parameters described below are coded by different neural networks in the brain but the 5 information cannot be integrated by physical connecting them. The 5 neural networks have to converge to one neuron to establish location, nature, discrimination and externality. Secondary impression is a derivative of above 4 parameters. The unique output of that one neuron places qualia in the field, at least where localization is involved. Without location information the quale is experienced inside the body. The location of quale in case of the visual experience is of course coded by the brain by computing the difference between the outputs of the two eyes but eventually the location information along with other parameters *should be represented by single neuron*. This is the main theme of this paper. Parallel processing of 5 parameters of qualia, even if connected with each other cannot create subjective experience. That is, the experience is impossible if the 5 parameters are processed in a parallel. How will the qualia field create green colour

without knowing where in the visual field it needs to be created. In case of pain quale, the perception of pain is meaningless without the information for its location. Perception of pain 10 meters from your body is meaningless. The scales of the parameters are correlated with the output of the neurons in attractor states or the neuronal coding.

The "secondary impression" combines the output of these single neurons to generate secondary qualia such as shape, outline or orientation, in case of visual perception. The secondary impression parameter may not be required for each quale as it is secondary qualia.

The firing of other neurons in the ensemble of neural network does not create access to qualia field due to incomplete information represented by them. Either the attractor state is not established or the neural code does not access the qualia field. Subliminal perception does not have sufficient strength to gain access to qualia field and either decay quickly or is unable to develop an attractor state after encouragement from prefrontal cortex by the process of attention.

Qualia field does not manifest into a particle like the 17 fields of standard model. Hence it is impossible to "see" it objectively. String theory postulates the existence of 11 dimensions in the physical space time, 10 spatial and 1 time dimension. However, we postulate that qualia field is 3 dimensional spaces with a time dimension.

The localization, discrimination, externality and intrinsic qualia nature though represented in the brain by ensemble of neurons, all the above 4 parameters need to converge into a single neuron. The ensembles of neurons are connected to each other however that does not unify the 4 parameters. We cannot experience location alone without qualia nature (intrinsic quality of the quale such as red colour which different than smell of coffee). It is also meaningless to talk about discrimination of quale without its location. Mere connecting the output of ensemble of neurons for 1 parameter to another ensemble of neurons for other parameter cannot generate the "pixel" or unit quale.

The spatially distributed input (not only across dendrite fingers but each receptor in a dendrite finger) to an ensemble of neurons in an "attractor state" (Orpwood 2013) may be an alternate theory. The code whether spatially distributed input or temporal neuronal code

should have sufficient variations to represent, for example 10 million discriminations of colour. Most primates, especially apes such as humans can perceive about 10 million colours. I propose the confounding of temporal code of individual neuron to generate unit quale experience.

Action potential is a stereotyped response and its shape and amplitude do not convey information. The firing of

a neuron is dependent on activation of ion channels, concentration of calcium and various other secondary messenger molecules.

The paper first goes over the theoretical model to decompose an output signal of 1 neuron into its components – discrimination, nature and localization

Section 2

Theoretical model decoding of temporal code

The subscript $\mu \equiv \{d, n, l\}$ stands for discrimination, nature and localization respectively. The subscript Φ stands for spike trains responsible for each individual parameter namely discrimination, nature and localization.

The final function produces a pattern of times with confounding of above 3 parameters. Each of the 3 components of the final function can be measured by varying 1 parameter and keeping the other 2 constant.

$$f_{\mu}(t) \delta(t - t_{\Phi}) = f_d(t) \delta(t - t_i) + f_n(t) \delta(t - t_j) + f_l(t) \delta(t - t_k)$$

The delta function is used just to remove the redundancy of the 3 components of the neural code in the graphing of model. So, If $(t - t_i) = 0$, then $(t - t_j)$ and $(t - t_k)$ are $\neq 0$

$$f_{\mu}(t) \delta(t - t_{\Phi}) \text{ where } \mu \text{ and } \Phi \text{ together go from } \mu = d \text{ and } \Phi = i \text{ to } \mu = l \text{ and } \Phi = k, \mu \equiv \{d, n, r\} \text{ and } \Phi \equiv \{i, j, k\}$$

The final function $f_{\mu}(t) \delta(t - t_{\Phi})$ can be the sum of nature, localization and discrimination parameters considered here or an entirely new function

$$f_{\mu}(t) \delta(t - t_{\Phi}) = g(t)$$

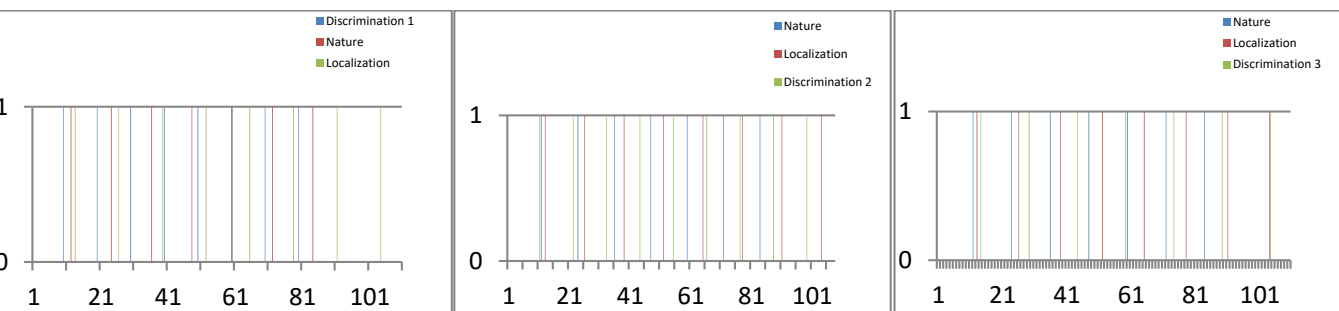


Fig 1

Fig 2

Fig 3



Fig 4

The theoretical experiment has 3 stimuli with same nature (colour) and same localization (for every pixel in the above box) but the discrimination varies across them as shown above. Then function of distribution can be separated out of the general $f_{\mu}(t) \delta(t - t_{\phi})$ function. The same process is repeated for varying nature and localization keeping other 2 parameters constant. The variation in the output for 3 different discriminations,

Fig 5

Fig 6

keeping other parameters constant is done by taking the difference.

The luminance is certainly a parameter which needs to be explained by the code but is not dealt with in this paper for simplicity. The externality parameter is also omitted as it possibly is a function of localization.

Fig.7

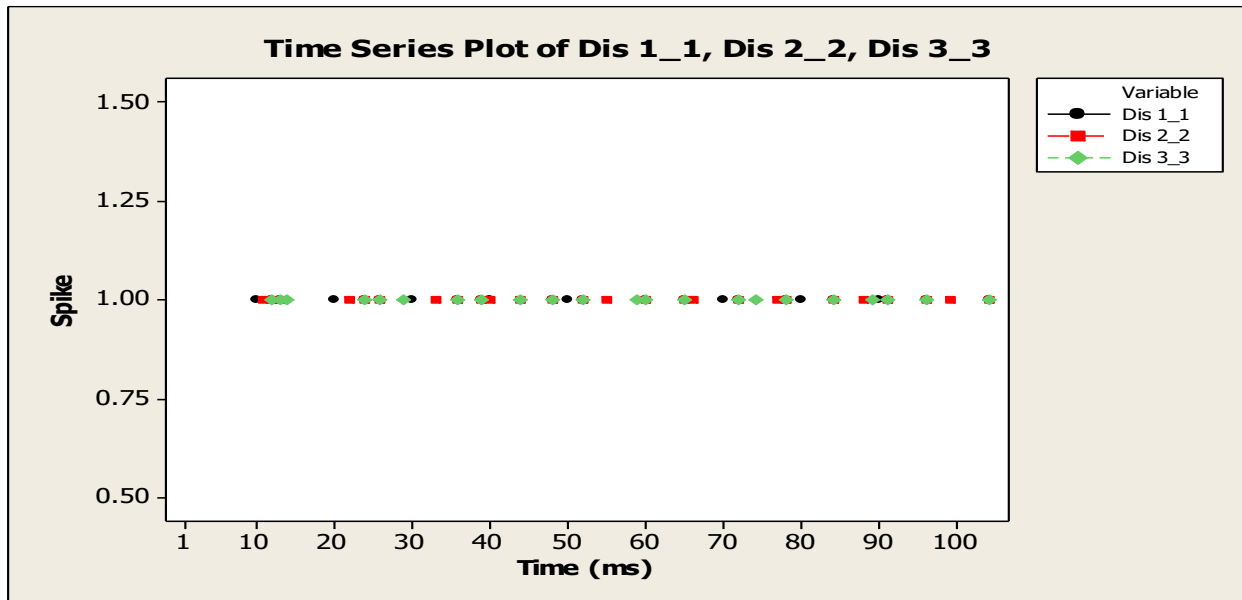


Fig 7. is the combined time series plot of the spikes for all the 3 discriminations shown above.

Fig 8

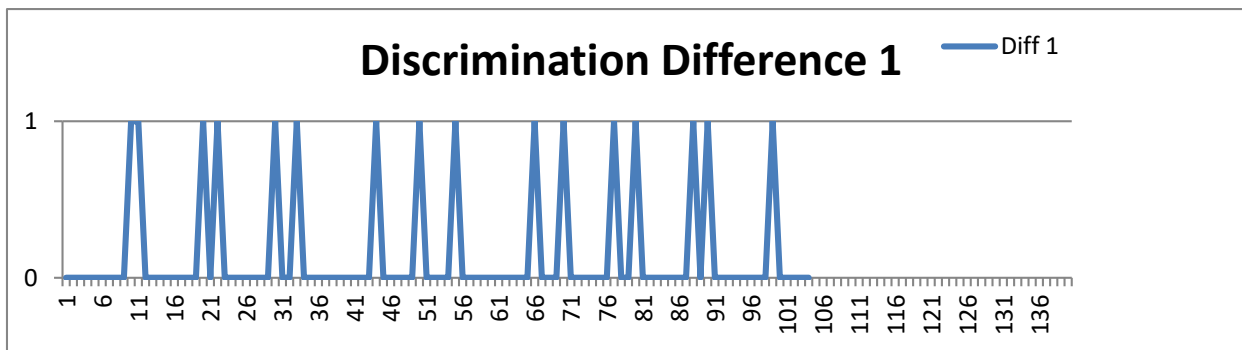


Fig 9

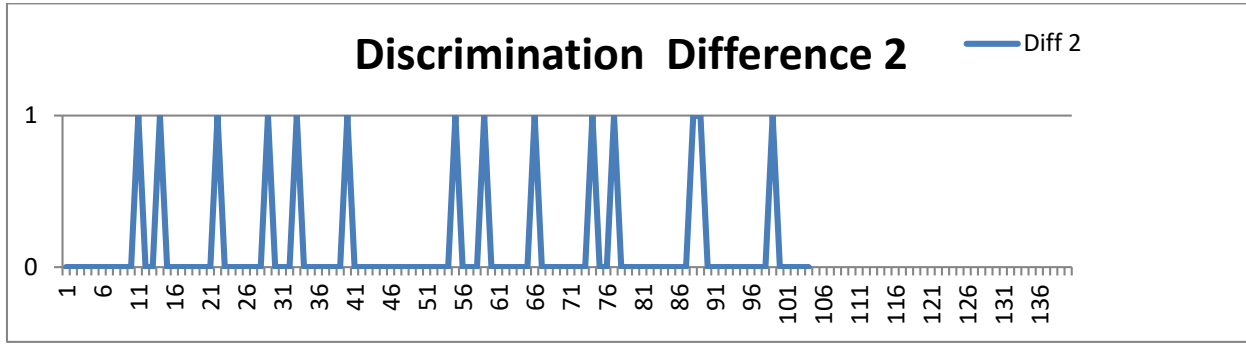


Fig 10. The average of differences of discrimination against time (ms).

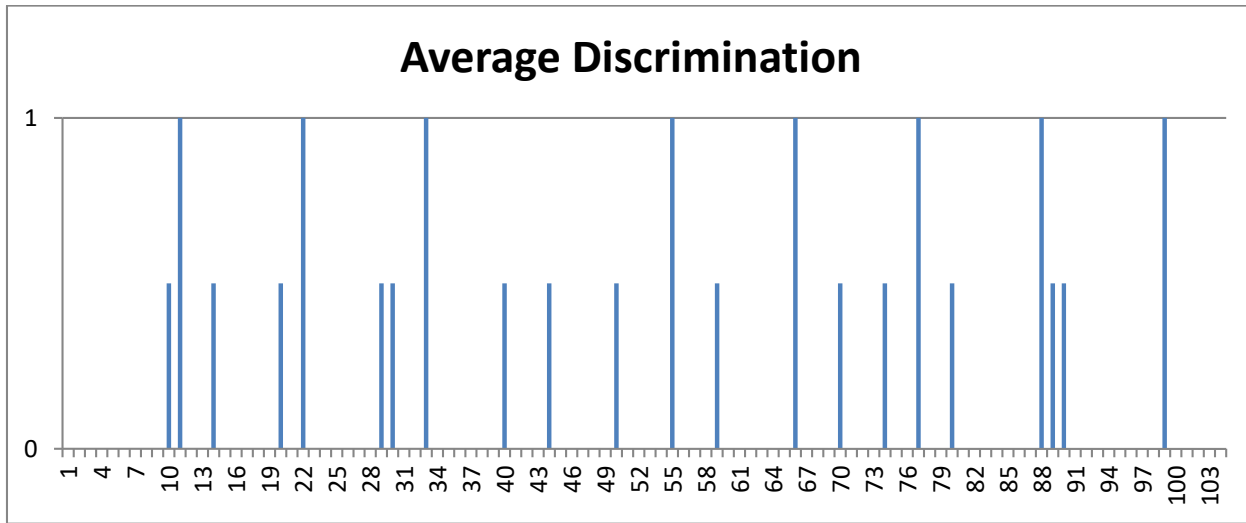


Fig 11

The above average of difference in functions $f_{\mu}(t) \delta(t - t_{\phi})$ for varying discriminations shows a repeating pattern. The above theoretical idealized output is verified in the experimental study detailed in the next section.

Section 3 – Empirical Study

The difference between 2 final functions $f_{\mu}(t) \delta(t - t_{\phi})$ is plotted to see patterns by varying discrimination in the graphs below.

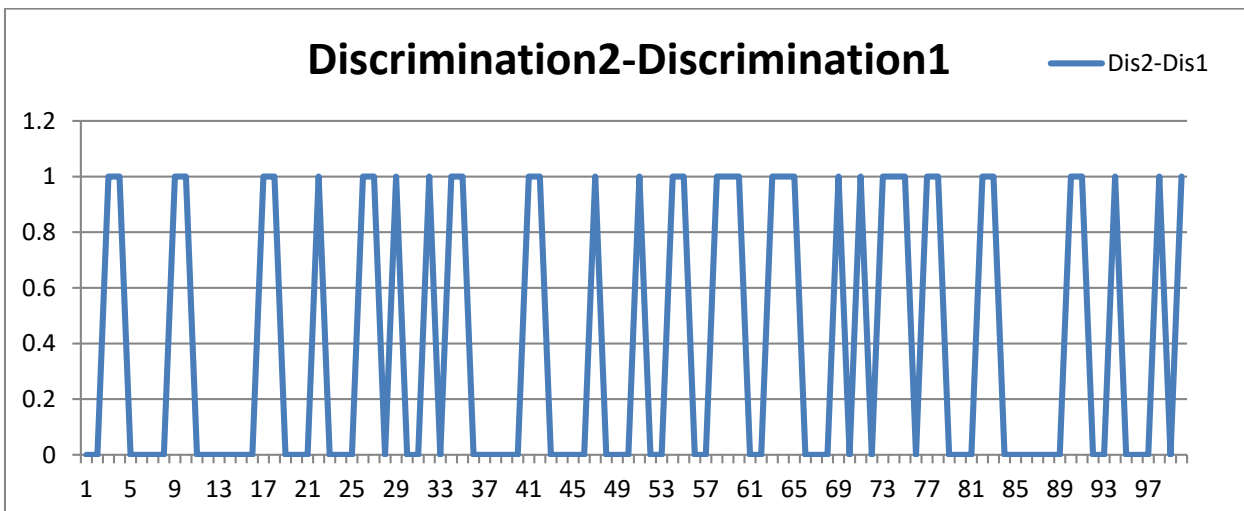


Fig 12.

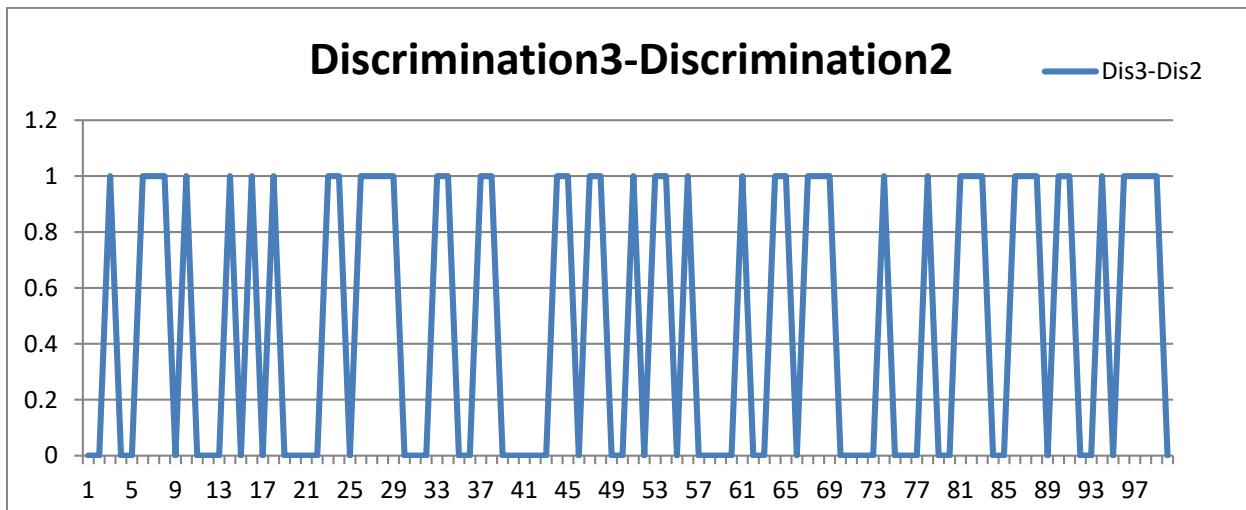
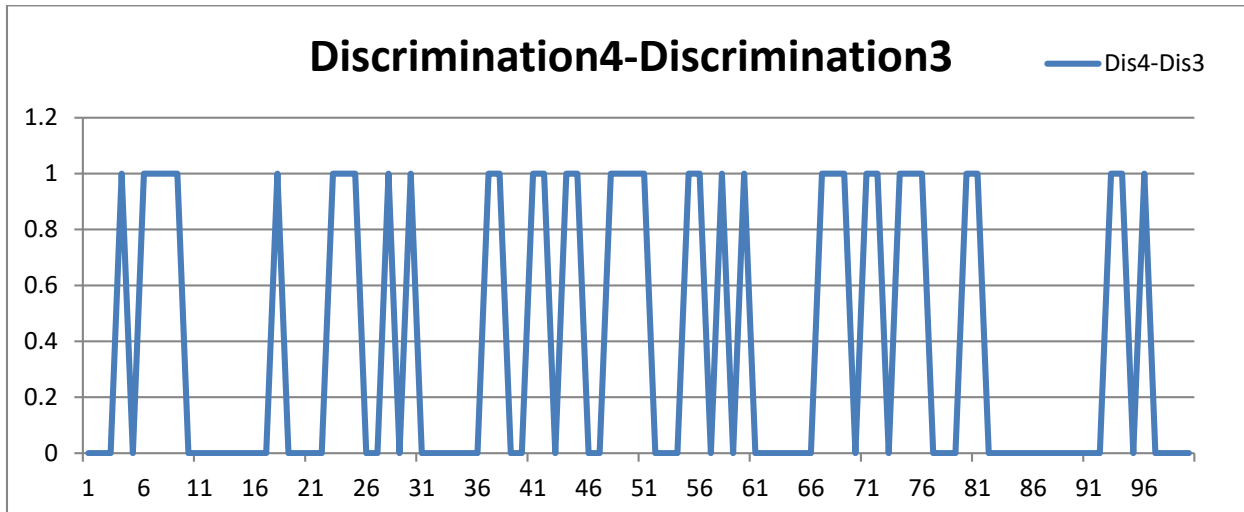
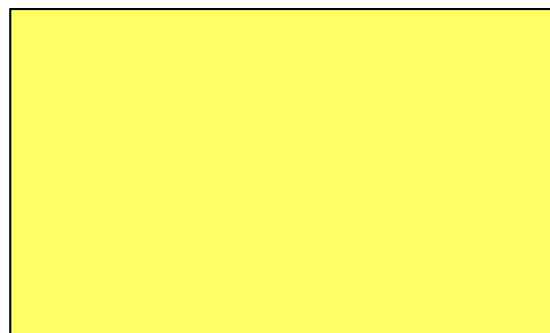
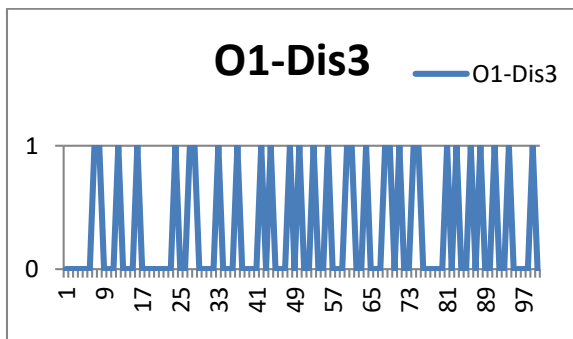
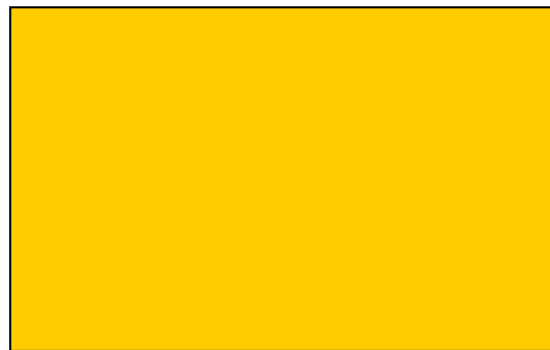
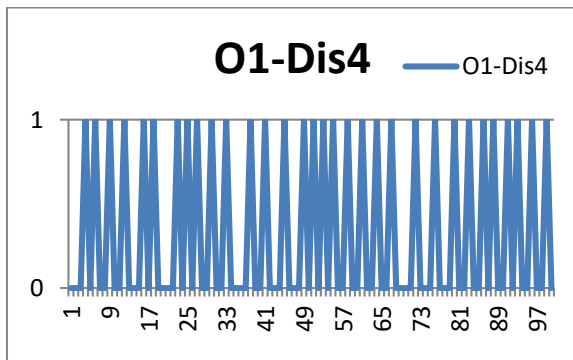
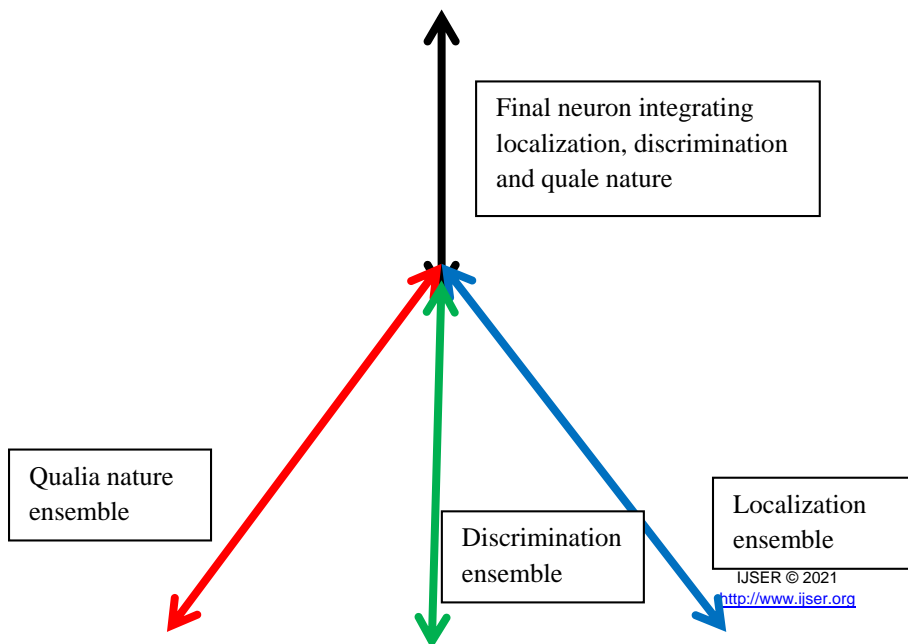
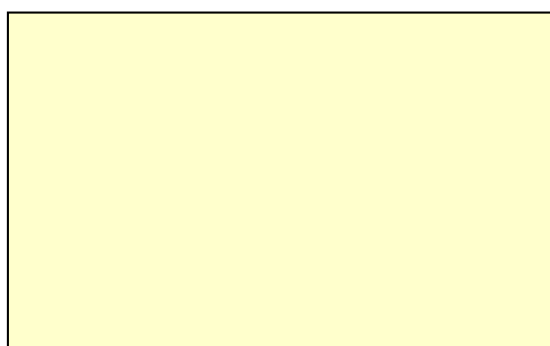
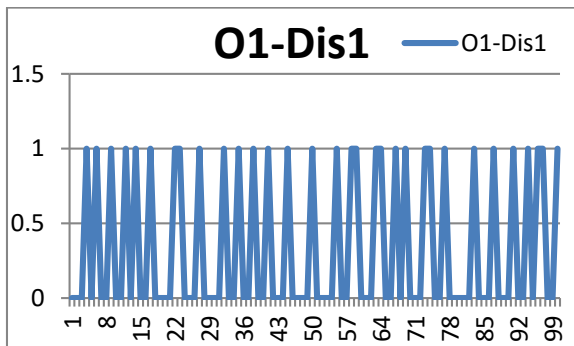
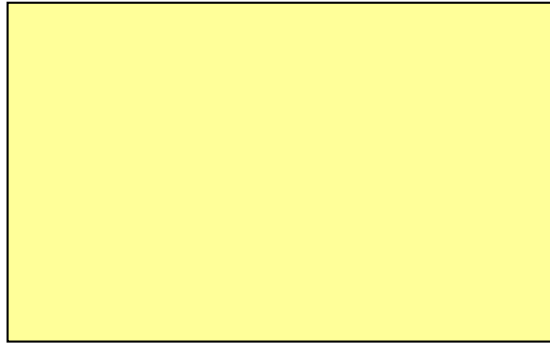
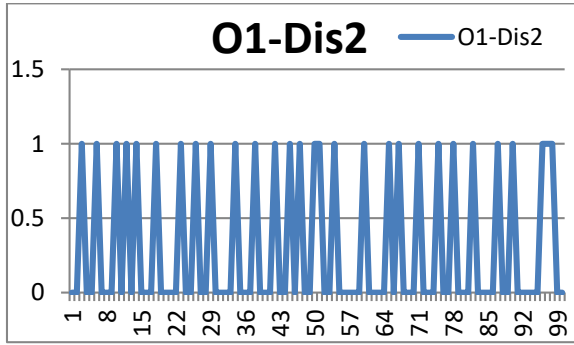


Fig 13.



4 graphs below are EEG waveforms for corresponding colour on the right. The frequency remains in the beta range without any obvious pattern





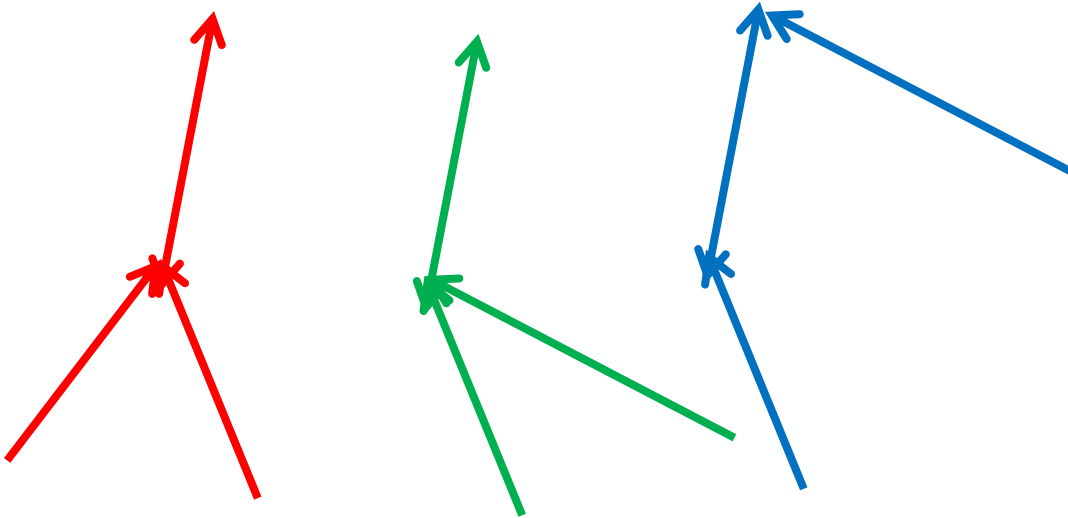


Fig 14. Depicts the confounding of discrimination, nature and localization parameters into 1 neuron

Visual Perception	A
-------------------	---

Population and Rate coding

Population coding is a method to represent stimuli by using the joint activities of a number of neurons. In the visual Medial Temporal (MT), the neurons are tuned to fire for motion detection. In an experiment done on monkeys who were trained to move the joystick towards a lit area, it was found that individual neurons fire for multiple target directions. The firing is fast for “preferred direction” and slow for other directions. The resultant direction is the vector sum of all the neurons that fired for direction ^[2].

The vector sum cannot be calculated until the various individual neurons responding to the motion stimulus converge to one single neuron. A neuron is blind to the activity of other neurons firing in parallel until the

output of all such neurons is input to one single neuron. The “synchronized response” is not a neural code, if neurons are blind to the activity of other neurons activating for the same stimulus.

The rate code will require the averaging of number of spikes until the average represents the expected value. This would require time but sensory stimuli are processed within few milliseconds so I propose temporal code for sensory processing. Rate code for motor processing, however was shown in a simple experiment where different weights were hung from the muscle. The spiking rate increased with the increase in weight.

Section 3

5 Parameters of Qualia

Auditory sensation	B
Olfactory sensation	C
Gustatory sensation	D
Temperature	E
Pain	F
Emotion (Fear)	G
Orgasm	H

Table 1: Qualia Nomenclature

In this paper, only 8 qualia are considered for the sake of simplicity. The scale of the parameters on which

1) Qualia Nature: The nature and experience of qualia may differ from a colour perception in case of vision to the impression of sound in case of audition to an impression of pain in case of somatosensory experience. Qualia nature cannot be graded on a scale like other parameters below and may depend on the nature of output (spatial and temporal) in the local cortical networks or the neuronal code such as rate code or temporal code.

Qualia nature is the intrinsic quality of the quale. It is how it feels like to experience the smell of coffee. Qualia nature is confounded with the other 3 parameters

2) Secondary Impression: Secondary Impression is the number of different parameters that combine to create gross qualia. Vision for example, combines colour, motion, shape, orientation etc. to generate resulting qualia. Colour, location and luminance *should* be the primary visual parameters which combine to create shapes, orientations, motion etc. Colour, location and luminance are sufficient to define a “pixel” in qualia space.

Vision informs us about the details of space while auditory stimulus is mostly localized in space. Imagine sound represented into the auditory cortex as colours spread out in space. The intense colours indicate the precise location of where the sound is originating from.

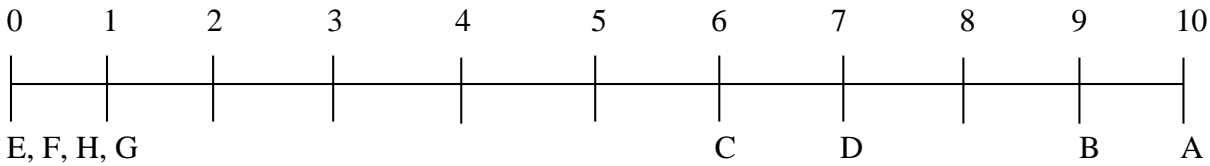
qualia are compared is partially subjective (myself) but assisted by empirical data wherever possible.

of localization, externality and discrimination (secondary impression is secondary and not necessary to create basic qualia) in the neural network output in an attractor state or neuronal code.

Qualia nature gives special experience once the qualia field is accessed. Qualia nature is ineffable because the qualia field is causally closed. It cannot write back to the information processes of the brain to make it reportable. We know the word “red” or “something” just by association. Neurons that fire together wire together. The neural output of the brain feeds into the language centres of the brain for reporting.

However, evolutionarily speaking, this representation of sound like vision is computationally intensive causing energy burden. Evolution creates simpler qualia. So a simple “ting” (yes/no) is adequate to represent auditory stimulus. However, sound does require variation in the “ting” to represent frequency range (20 Hz to 20,000 Hz) and amplitude (0 dB to 130 dB for middle frequency range).

Sound qualia are more evolved than olfactory qualia having higher secondary impression. Sound represents 2 sub-modalities – frequency and amplitude as against olfaction which has only 1 sub-modality, the olfaction itself. Olfactory qualia are simpler than auditory qualia in terms of secondary impression.

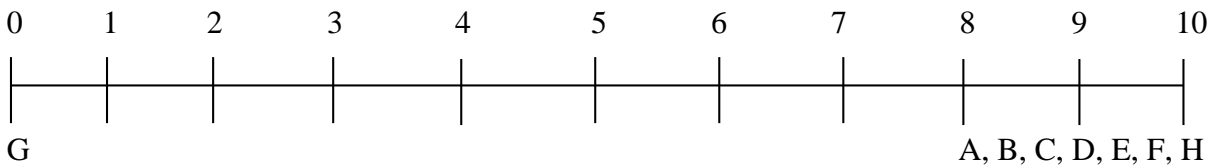


The secondary impression parameter may or may not have a value per unit space. This parameter is the derivative of the other 3 – discrimination, localization

and externality and may appear as a bigger area than unit area of qualia field.

3) Externality: Externality of qualia indicates the location of qualia. Emotions are experienced inside the brain but visual perceptions and auditory sensations appear to be located external to body. Pain, taste, smell, orgasm, temperature appear to be located on the body (outside). What neurophysiology is responsible for some qualia like emotions to be felt inside the brain

while other sensory qualia to be projected outside either on the body or into the space? What brain structures are responsible for projecting qualia? Understanding the neurophysiology of externality as a parameter of qualia can shed some light on how the qualia are located in the qualia field.



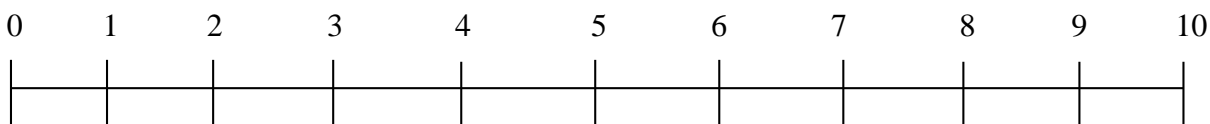
The qualia could very well have evolved to create a model experienced completely inside the brain.

Externality provides further support to the existence of qualia field.

4) Localization: Localization is the amount by which the location of information is known precisely. Visual sensations are highly isomorphic to the external reality however, the location of origination of auditory information cannot be known as precisely as visual information. Localization accuracy of auditory information is 1 degree for sources in front of the listener and 15 degrees for sources to the sides. Because sound stimulus typically does not vary across space it has a lower localization parameter than vision. Without

localization, as in case of emotions or core self the quale is experienced at the location where the neural network output is created.

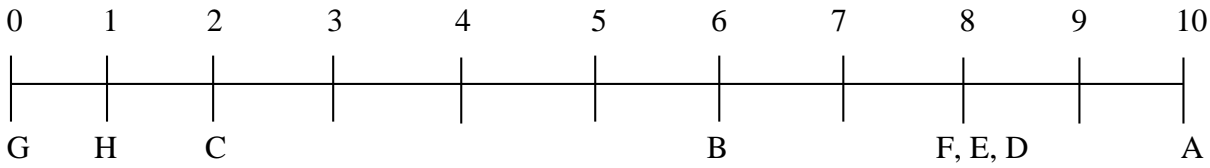
The azimuthal visual location can be easily located by neural code or unique output of the neural network. However the location of depth of visual experience is approximate. Of course, the neural code or output is not variable enough to locate each and every depth point in the universe.



G H C D B F, E A

5) Discriminatory Power: Discriminatory Power of information is the ability to discriminate between sub-modalities. Most primates, especially apes such as humans can perceive about 10 million colours. The smallest frequency change that normal-hearing adults

can detect is about 0.3% which is the minimum value across the entire range (20 Hz – 20,000 Hz). So maximum number of sound frequencies discriminated are



The qualia field ideally has unique values of localization, discrimination and externality per unit space. However, based on how precise the values of localization, discrimination and externality are the qualia assume arbitrary values in the qualia field.

qualia field by parameters of nature, secondary impression, discrimination, location and externality. A quale of emotion has a zero value for localization, and externality but assumes values for nature, secondary impression and discrimination.

In case of visual perception a unique output in the visual cortex may take make take up “red” value in the

Section 4

Explanatory Gap

The hard problem of consciousness is the problem of explaining the gap between or transition from physical brain to the non-physical qualia. Theory of qualia field understands qualia as fundamental to the corresponding physical substrate which is electrical activity in the local neural networks.

The neural networks which are not amplified and sustained through attention cannot gain access to qualia field. This explains lot of unconscious activity in the brain.

Fig X

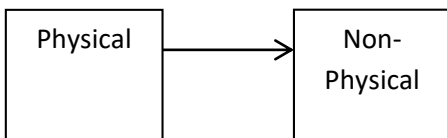


Fig Y





We will discuss in section 5 that qualia is not necessarily information (Physicalism). There are instances of activity in neural networks which are not conscious. So, not only do the qualia need to not be information but something non-physical is experienced in case of certain neural activities in the brain. Also, illusionism is refuted by the very fact that we experience qualia. The third worldview is that only consciousness exists. However, it's hard to deny that photons of visible light bounce off the objects in the universe and get scattered. At least, the waves in the electromagnetic field do exist. Neither is it all physical nor is it all phenomenal.

So, we have 2 ontologically different entities “physical” and the “non-physical” as shown in diagram X. You can add n number of physical or non-physical entities to close the explanatory gap as shown in Diagram Y but somewhere the physical has to touch the non-physical. It is counter-intuitive that physical can gain access to non-physical as we evolved without ever experiencing such transition in everyday life. But, because both physical and non-physical are true, the gap has to be closed as shown in diagram X. This paper holds that transition occur from neural activity in the brain to qualia fields.

Section 5

Review of alternate theories

Integrated Information Theory

Integrated information theory claims that both the quality and quantity (Φ) of consciousness depend on the differentiation and integration of information in the brain. Complexity of the brain does not provide anything above and beyond a group of discrete, isolated neurons. These neurons are either firing or they are not. It doesn't matter how complexly they are connected. In a thought experiment, imagine putting single neurons 10 miles apart from each other and fire them with electrodes in the same sequence they fire in the brain. Will these discrete, isolated neurons become conscious?

Putting them together in the brain (separated by synaptic cleft) will not generate consciousness.

Integrated information theory claims the integration of information such as localization information and colour information in the visual cortex. The connecting of the above 2 neural networks cannot integrate information or place a coloured pixel at location (x, y, z). The information from the 2 neural networks has to feed into 1 single neural which codes for both location and colour.

Orch-OR Theory

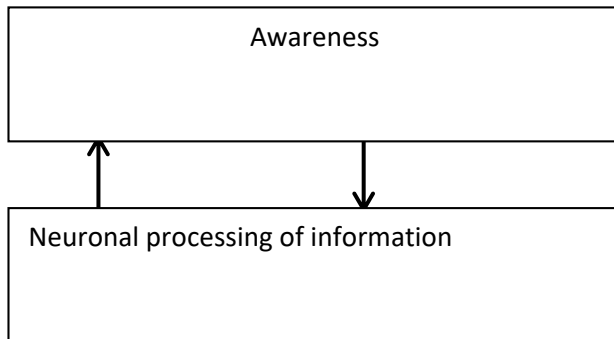
Penrose goes at length to explain that brain is more than a mere computational machine. The theory posits that wave function collapse, through objective reduction (Penrose's interpretation) occurs in the microtubules of the pyramidal cells in the cortical networks of the brain creating conscious experience. Such collapse should also occur during subliminal perception where only local cortical networks are activated. The cerebellum is

not conscious is supported by the fact that it does not have pyramidal neurons, to support Orch-OR but subliminal perception needs explanation. Neurophysiological, anatomical, and brain-imaging data strongly argue for a major role of prefrontal cortex, anterior cingulate, and the areas that connect to them, in creating the postulated brain-scale workspace (Dehaene, S & Naccache, L). Amplification and sustenance of cortical activity or attractor states are necessary through

top down signals from prefrontal cortex, anterior

Attention Schema Theory

Physicalism's primary attempt at denying emergence of qualia over and above the physical substrate of brain or qualia field is explained by the diagram below (Graziano 2013, Consciousness and the social brain). Neuronal processing of brain creates awareness shown by upward arrow. Awareness cannot be written back to



The fundamental error with this logic is that we do not report qualia. We report the output of the local neuronal network. Example – When you see a red object, the local (visual) cortical networks process the stimulus and generate an output which triggers the “red” word in the language centre of the brain. The perception of red colour and the word qualia are only associated in the brain. The awareness does not have to re-enter the brain (as shown in diagram above by downward arrow) so that you could move your jaws and say “I saw red colour”. The output generated by local neural networks is unique and it triggers the appropriate language centres of the brain for reporting. Even if you are seeing red for the first time, the output of local cortical network triggers “I see something” in the brain. Physicalism cannot deny the emergence of consciousness from the substrate (neural networks) or presence of qualia field (fundamental ontology). I am

Section 6

Self: The activity in the posteromedial cortex is associated with the generation of core self in the qualia field. Self is not only the representation of objects in the physical world but a meta-representation of relationship

cingulate etc.

the “neuronal processing of information” as awareness is causally closed. But, according to the author, *we are able to report qualia*. So, awareness is not something created above and beyond the information processing in the brain but awareness is actually information.

not denying Physicalism but just proposing that organized matter can give rise to phenomenal experience. So, qualia can be ontologically distinct to physical universe.

Qualia can be real and clearly, qualia cannot be expressed by or reduced into any other ontology though correlation with the brain is possible. This entails that qualia is fundamental. So, location in the non-physical space is fundamental and a temporal pattern in the neuronal firing can by no means create non-physical space. Qualia field is not created by the networks but the neural networks only “activate” the “pixels” of the qualia field. Every quale pixel is a vector [nature, localization, discrimination]. Externality is assumed to be a derivative of localization parameter. Luminance, though fundamental parameter is not considered in the analysis of this paper.

between the organism and object. Self has its own qualia nature and has no discrimination, localization and externality.

Though the qualia field is one single field for all neural activity in all organisms, an individual's activity in the brain generates individualized self. The existence of one qualia field does not imply that the self is universal or cosmic. The self is a result of cortical activity and experienced as object of perceptual space-time.

The conscious self is not some sort of 'kernel' or concentrated essence that inhabits a special throne at the centre of neural labyrinth, but neither is it a property of the whole brain. Instead, the self seems to emerge from a relatively small cluster of brain areas that are linked into an amazingly powerful network (Ramachandran 2010).

Ramachandran developed 7 aspects of self -
Embodiment – One feels anchored and at home in your

body and it never occurs to you that the hand you use does not belong to you. Privacy – Your qualia are your own unobservable to others. Unity – Though you have a diversity of sensory experiences you feel like one person. Social Embedding – The body defines itself in relation to other bodies. Self-awareness – The self is aware of itself. Continuity – In spite of the enormous number of distinct event in life, you feel a sense of continuity of identity through time. Free Will – Free Will is your sense of being in charge of your actions.

In spite of the numerous attempts to locate neural correlates of consciousness, I think, qualia field generates self as another quale or experience. There is no localization of self and it is experienced at the location of creation or the origin.

Section 7

Conclusion

The empirical evidence clearly inconclusive to separate out discrimination factor confounded with other factors. This is due to 1) omission of luminance and externality parameter 2) EEG records the activity of many neural networks than one neuron. Availability of high resolution, single neuron imaging techniques may become conclusive 3) noise arising from variation in calcium concentration, activation of ion channels etc.

The theoretical, statistical model proposed in this paper describes how the parameters can be separated out from a confounding of many parameters in the code.

The neural networks integrate information based on 5 parameters into 1 single neuron the activity of which creates corresponding quale in the qualia field. Attractor states, amplification and sustenance of signal or neural code of these individual neurons lend access to qualia field. Although it is impossible to actually "see" the qualia field, the projection of qualia outside or on the

body from brain supports the existence of qualia field. Qualia are not the actual physical information as proposed by Physicalism (discussed above). Qualia are also phenomena created in the qualia field as the experience is not always felt inside the brain but also on the body or outside the body.

Further imagining studies are required to know how the 5 parameters are represented physically by output of a neural network in an attractor state or neural code.

The scales drawn in the section for “parameters of qualia” are subjective and need to be corrected for further use.

References:

- Orpwood, R. 2017. Information and the origin of qualia. *Frontiers in systems neuroscience*, 11, article
- Adrian ED, Zotterman Y. 1926. The impulses produced by sensory nerve endings: Part II: The response of a single end organ. *J Physiol.* 61 (2): 151-171
- Chalmers, D. J. 1995. Facing up to the problem of consciousness. *Journal of Consciousness Studies* 2: 200-19.
- Graziano, Michael S.A. 2013. *Consciousness and the social brain*. 198 Madison Avenue, New York, NY 10016 Oxford University Press

Baars, B 1988, A cognitive theory of consciousness, Cambridge UP, NY, USA

Orpwood, R. 2017. Information and the origin of qualia. *Frontiers in systems neuroscience*, 11, article 22

Laureys, S. Tononi, G. 2009. *The neurology of consciousness*. Academic Press. Imprint of Elsevier

Graziano, M 2013. *Consciousness and the social brain*. Oxford university press

Tononi, G 2004. An information integration theory of consciousness. *BMC Neuroscience*

Penrose, R. 1994. *Shadows of the mind, A search for missing science of consciousness*. Orford university press

Dehaene, S & Naccache, L. Towards a cognitive neuroscience of consciousness: basic evidence and a workspace framework. National centre for biotechnology information

Smythies, J. 2003. Space, time and consciousness. *Journal of consciousness studies*, 10, No 3

Ramachandran, V,S. 2010. *The tell-tale brain, Unlocking the mystery of human nature*. Penguin Random house India Ltd.

Symthies, J. 2003. Space, time and consciousness. *Journal of Consciousness Studies*, **10**, No. 3

Appendix

EEG for O1 left occipital from light yellow to dark yellow

