Science and New Sciences

Scents and consciousness: a model of how DNA defines experience

Abstract:

This year is progress in the making on consciousness research in the mainstream of science community. “Non-human animals are conscious beings” – finally, now we can read a statement from The Cambridge Declaration on Consciousness released by the Francis Crick Memorial Conference in July 2012. However, many mainstream scholars may think consciousness exist far beyond animals and even beyond brains. Interesting matters, therefore, continue to emerge throughout this year. For example, New Scientist published two featured cover stories to discuss how a plant knows on August 25, 2012, and gut instinct, when the body does the think on December 17, 2012. I have also observed that there are still some opinions against my proposed principle - DNA defines consciousness, and therefore I felt the need to further elucidate it. Thanks to a recent symposium at Massachusetts Institute of Technology, during which, I was updated by Dr. Richard Axel’s presentation on olfactory perception. I concluded that the scent processing by a species is an important part of consciousness, which can be used as an example to support my proposal on consciousness. In this essay I report some important current status on consciousness research, how DNA defines olfaction, how to relate scent perception to consciousness, and propose two new details in smell mechanisms – DNA transtruction during olfactory stem cell differentiation, and casting – decoding model of odorant and receptor interactions for scent recognition.

Introduction

Impressed by Dr. Richard Axel's presentation on the theory of olfactory function, scent awareness, and brain processing, I approached him after his talk. (The presentation was given at MIT, on the 10th anniversary symposium of the Picower Institute on November 6, 2012). I introduced my name and we shake hands. I asked my questions on consciousness, which is one of my favorite topics these days. Not having many opportunities for long conversations, I can only catch up any possible occasions for an exploratory brief discussion on the topic of consciousness with any scholars happened be around. I asked him – You discussed in your lecture on scent awareness using mouse and fruit fly as experimental models, which seems to me related to consciousness. Has anyone asked you questions on consciousness? What is your opinion on consciousness research? He said - I do not work on consciousness. Apparently this is a question that he has not thought much and prepared to answer. I then made my comment – Those work you are doing on olfactory perceptions in mouse and fruit fly are perfect models for the study of consciousness. Are you interested in further exploring along this line? Dr. Axel told me – You plan it. Then we talk.

Current status on consciousness research - progresses in the making

I began to read Dr. Axel's Nobel Lecture, "Scents and sensibility: a molecular logic of olfactory perception". [1] Dr. Axel and Dr. Linda Buck shared 2004 Nobel Prize for physiology or medicine for their 1991 discovery of olfaction receptor. I can tell the lecture is a good introductory essay for a scientist like me, who is not specialized in the study on sense of smell, to get into some important details in this field. While I am reading it, quickly I entertain the data that can be used to further support my proposals of consciousness research, in which I will provide details in the next section of this essay. In the same time I began to read related chapters on neural science, [2] and current publications in this field. I found, for example, a recent review is also helpful. [3]

My interest in the study of consciousness began in 2008, when I explored the mechanism of faith with scientific approach. I concluded the need to redefine the concept of consciousness and I made a generalized conclusion, "consciousness exists in all life forms". One of the key mechanism I arrived at in 2010 is – "DNA defines consciousness". [4] Last year, I wrote a review with my opinion on how to revive consciousness research in mainstream science community, postulated bioconsci - a short form for biological consciousness, which would include mental consciousness, and I believe that it is more likely a proper way to explain the genetic basis of consciousness. [5]

However I have read and heard scholars as well as laity persons arguing against my conclusions - either directly or indirectly. For example, Dr. Christof Koch, who has done remarkable work on consciousness research for many years, wrote - "Yet consciousness does not appear in the equations of physics, nor in chemistry's periodic table, nor in the A-T-G-C molecular chatter of our genes. Somehow it emerges from the nervous system." [6] Here "the A-T-G-C molecular chatter" means DNA. For another example, on July 7, 2012, at the Francis Crick Memorial Conference held in Cambridge, UK, a group of scientists, led by Dr. Koch, claims that non-human animals are conscious. This conclusion demonstrates a progress made among this group from the current mainstream scientists. [7] A gap, however, still remains, comparing to my 2008 conclusion that all life, from the simplest virus to the most complicated mankind, has consciousness. The conference declaration does not mention any genetic basis of consciousness at all. Also they do not claim that all animals are conscious. For example, which I think it is even more controversial, or debatable, in the conference Dr. Bruno van Swinderen presented "Neural correlates of unconsciousness in Drosophila". He presented the data that fruit fly has two brains, attention, sleep and EEG activities et cetera but he claimed that flies are not conscious based on his criteria of consciousness. The conference Declaration, however, stated that the neural circuits in insets and cephalopod mollusks (e.g, octopus) that are responsible for behavioral and electro-physiological states have been the evident for the basis of consciousness. May be the criteria of consciousness Dr. Swinderen based on needs to be renewed. Not even to mention that the Conference would certainly not agree that plants should have their own consciousness.

Not many scholars, however, from the mainstream science community may agree with the Cambridge conference claims. For example, a cover story on plant experience - "Tree sense - How plants see, hear, taste, smell and touch" was published by New Scientist on August 25, 2012. [8] The author, Dr. Daniel Chamovitz carefully did not use the term consciousness, rather using experience. I would use a term that is called plant consciousness and we should know that plant consciousness is much more limited and more specialized in some way, comparing to human mental consciousness. [4, 5] While others may have actually held conference on plant consciousness, for example the Society of the Anthropology of Consciousness has held its annual conference this year for a theme of plant and consciousness, although it may not be strictly from the perspective of science. [9]

Dr. Koch seems feeling not easy as well after the conference conclusions. He made his own progresses since the Cambridge Declaration. On August 15, 2012, Dr. Koch published a blog essay on Puff Post Science, reclaiming that bees are conscious.[10] Therefore, we would infer from his newer essay that fruit flies are conscious too since bees and fruit flies are in the same class of insect although they belong to different orders. Bees rank higher than drosophila since bee's behaviors show much well organized and demonstrate relatively higher consciousness. Furthermore, Dr. Koch's essay title - "Consciousness is everywhere" seems to me out claiming much of what it has been delivered from their July conference. I hope at some point in the future, Dr. Koch would tell us how he has made a leap of his faith – changing his opinion within about a month to believe in that consciousness exists everywhere, which is like what some philosophers have been talking about for long time.

Dr. Koch has also mentioned his work including that he has done with Dr. Francis Crick, and their theory of the Neuronal Correlates of Consciousness (NCC), "the minimal neuronal mechanism that give rise to any one conscious experience". He, however, acknowledged - "But knowing that the number of neurons contributes to the level of consciousness is only the beginning. The challenge that remains is to understand how the whispering of nerve cells, interconnected by thousands of gossamer threads (their axons), give rise to any one conscious sensation. This is a problem that is being vigorously being tackled by neuroscientists. Indeed, it will be essential to 'crack the neural code' to finally understand the ancient mind-body riddle".

He has commented on Dr. Giulio Tononi's work on the theory of Integrated Information of Consciousness (IIC) that links information to consciousness - "prove crucial", as he also did at the Cambridge meeting. [7] He wrote that TIIC has provided a precise measurement for the extent of consciousness, which is called Φ (phi). He did not provide the equation in his short essay, which I provide here: [11] $\Phi = (X(mech, x_1)) = H[p(X_0(mech, x_1) \,||\, IIp(^{K}M_0(mech, \mu_1))]^{forK}M_0 \in MIP$ Here the X is a system (e.g. in brain), x_1 is its status, *mec*h is its mechanism, H is relative entropy, and P is possibility. MIP is minimal information partition. It states that consciousness is the product of all the probability distributions of each part of the system in MIP. If one is not used to see an equation, you do not need to remember it, or simple remember the point - it is an equation to describe consciousness with an information theory.

Dr. Koch concludes - "The theory assigns any state of any network of causally interacting parts (these neurons are firing those are quiet) to a shape in a high-dimensional space." But he also said, "I've been careful to stress that any network possesses integrated information." It seems to me that both Dr. Koch and Dr. Tononi are focusing on the mental consciousness, proposing theories at the neuronal level. They may not make any conclusion on the consciousness beyond brains.

From my personal conversations, I experienced that my proposed mechanism of DNA defining consciousness may meet difficulties to be recognized. During a break at an NIH (National Institute of Health) symposium on virus research in Bethesda, Maryland, I was asked by Dr. Susan Mackem, a respected senior investigator at NCI (National Cancer Institute), why are you interested in viral research? When I was telling her using virus as the simplest model to study consciousness, and elucidate how DNA defines consciousness, Dr. Mackem told me right way (a common response – I have met), consciousness has nothing to do with DNA. I exchanged my opinion with a short answer - if the DNA in a species genome does not encode a pair of wings, the organism, for example, a bird, would never have an experience of flying. If one engages an evolutionary thinking, one can relatively easily understand the concept, "DNA defines consciousness". [12]

Also I have searched the internet from time to time and I found that consciousness beyond human beings has been discussed and people generally accept the statement that DNA is unrelated to consciousness. The argument is that your parents have passed their DNA to you but we do not see that they have also passed their consciousness to you. Sounds reasonable, right? But I think they may need to be guided for how to think in a different way that is a better answer on this question.

Therefore, all these evidence have pointed toward that my proposal of bioconsci may have been a radical idea, and I am naturally put in the defensive position. I feel that it is necessary to write in more details to provide further insight to support my proposal, and also come up with more plans on how to further study it.

Scents and consciousness through DNA coding

To my limited understanding, the existence of an olfactory function in a species can be a good example of how DNA defines consciousness.

Consciousness is knowing. Consciousness is awareness. Consciousness is experience. These are all examples for us to define the complicated nature of consciousness in simple ways.

Generally speaking, it is better for one is able to see everything. However, it is not everything can be seen. When it is not visible, one is better off to be able to smell it, or hear it, or feel it with touch, and et cetera. To smell a scent, a species must have an odorant receptor (OR), which is the very molecule to be able to bind the scent and initiate the signal transduction pathway(s), which alter the action potentials (AP), generate varied frequency (Hz) of signaling, and deliver the message to the receptive neurons in the brain. The brain would process the scent information – an oscillation with the incoming Hz of current waves, sense it and decide how to response. Therefore, the brain would have an experience of smelling the scent. If the experience of the brain with the scent is food, the organism may start to move towards the source and may find a meal. If the experience of the brain with the scent is a dangerous situation, the organism may simply begin to run away from the resource. Scent have been used by an organism for numerous other functions, such as mating, prey, detection of predator, territorial marking, group / family communication, entertaining, and et cetera.

How many different types of OR genes encoded in the DNA sequences in the species genome will provide a limited capacity for the species to smell and to have the experience of a limited types of scents. About 80 OR genes have been identified in the Drosophila genome, [1] and another report with more recent survey by Guo and Kim described 752 OR genes including psuedogenes from 11 Drosophila species. [13] About 396 OR genes and 425 psuedogenes were identified in human. [3] Therefore, the most of the odorants that can be experienced by human beings cannot be detected by drosophila. However, OR genes are quite diverse. A mouse has more than 1035 OR genes, 28 truncated and 328 psuedogenes. Rat has more than 1207 OR genes, 52 truncated, and 508 psuedogenes. Numerous odorants that can be experienced by mouse or rat cannot be detected by human. Dogs have 811 OR genes, 11 truncated, and 278 psuedogenes. Genetically speaking a dog may smell a lot of more scents than a human being. Also interestingly, a *C. elegans*, with only 302 neurons of a total body cell number of 959, has only 16 neurons for olfaction that expresses about 1000 OR genes.

Not only the number of OR genes plays a role in the scent and experience, the gene type of OR also plays an important role. For example, a fly has less number and a mouse has more number of OR genes than that of a human being, but both a fly [14] and a mouse [15] can smell CO_2, which is odorless to a human being. Therefore, mankind does not have the experience of smelling CO_2 but both flies and mice would be aware its existence.

Even within the same species, not every individual among the same population always has the identical OR genes. For example, among human beings, not everyone has the same sets of OR genes and can experience the same sets of scents, though this is unusual and may indicate genetic deficiency. Anosmia, a defect of smelling some special scents among certain individuals but can be experienced by the most of the same populations, have been identified for decades, though much of the genetic mechanism remains to be studied. One in 10 among the general population of human beings lacks of functional OR for an extremely poisonous gas, hydrogen cyanide, which has an almond-similar odor to the general population. The 10 percent among the general population have no experience of smelling hydrogen cyanide, arguably due to the lack of the OR, and gene mutation may be among the possible pathological mechanisms. One in 1000 in the general population may have trouble to smell the odor from an animal skunks, in which butyl mercaptan is the similar chemical component, an odor makes the most people feel fetid. [16] It would be interesting to see how the underline genetic variations have led into such an anosmia.

Less severe than anosmia is hyposmia, in which the individual becomes less sensitive to an odor. Many clinical disorders may associate with anosmia or hyposmia. Their genetic mechanisms, if any, remains under elucidation, for example, see a reference. [17]

To the opposite of anosmia or hyposmia is the hyperosmia, a hypersensitivity to an odor, which can also be determined by genetic variations. For example, Menashe et al report that individuals, who carry at least one allele of a pseudogene OR11H7P, will show hypersensitivity to a sweet odorant, isovaleric acid, which is the major component in a smelling foot. [18] For another example, which is reported by Keller et al. [19] An odorous steroid androstenone as a derivative from testosterone, can perceived as pleasant (sweet, floral), offensive (sweaty, ruinous), or odorless among different individuals. Its receptor is called OR7D4. OR7D4 can actually selectively recognize both androstenone and androstadienone from a panel of 66 odorants and 2 solvents. The impact of genetic variations, using single nucleotide polymorphism (SNP) as example on the odor - OR interactions was observed. Thirteen SNPs on the OR were tested respectively. It was found that 7 out of the 13 increased the response, in which two of them also increased at even up to ten folds of lower odor concentration. When a substitute of two amino acids appeared on its OR through two SNPs - R88W and T133M, which is called RT replace WM, the in vitro response was also increased. An in vivo survey also supports the conclusion that either RT/WM or WM/WM was less sensitive to the odor than RT/RT. Therefore, this is the evidence among many others that genetic variations can alter one’s experience hence can define a differed consciousness.

Exploration of possible new mechanisms of olfaction

The discovery of OR gene family among the largest super family of G proteins since early 1990s has led significant advance in our understanding of the olfactory mechanism. Details from an initial binding of the odorant to its receptors to the transmission of the electric signaling to the process within the brain, neural network have been mapping out. Here I propose two general principles based on some of my recent studies and conclusions, which may add to new lines of research on the explanation of olfactory mechanisms.

DNA Transtruction

I recently proposed a complement of the central dogma of molecular biology, a modification from DNA – RNA - Protein to Protein – RNA – DNA – RNA - Protein, through a processes Transduction – Transtruction – Replication – Transcription - Translation, respectively. DNA Transtruction is a proposed general mechanism that a genome must undergo reorganization before replication, which would lead the differentiation of a cell into more specialized new cells. [4, 38] This mechanism may advance the doctrine of accurate replication of a species from parental genome to its offspring. It was developed when the mainstream began to focus on epigenetic mechanism to explain the fine differences among individuals within the same population of a species. [20] Applying this new thinking, it can be predicted that olfactory stem cells can communicate with the existing neural network and received regulatory signals from both surrounding environment as well as central nervous system for its destinations, which is a well-coordinated developmental and differentiation process. Each time when a basal cell (olfactory stem cell) differentiates, it undergoes reorganization at a genome level. Though there is no data from single cell genome available for a direct proof of the hypothesis at this time, [21, 22] numerous genome data can be interpreted in new ways with new observations and may provide convincing indirect evidence. For example, gene families related to olfaction have been observed that they have been extremely variable, and for example, in vertebrates alone, the pseudonization of OR gene family can be as high as 20-60%. [3, 4, 17, 23]

Casting – decoding model of OR gene variation

One of the major mysteries of olfactory physiology is the relationship between odor and receptor. Manic et al proposed a modified "lock and key" theory, also called as Weak Shape Theory, for the mechanism of olfactory response. [24] It holds that a combination of activated receptors is responsible for recognition of any one odorant. It also holds that one receptor can recognize multiple odorants. This theory replaced the long holding doctrine, one receptor, one shape and one smell, and it has been widely accepted. There are also alternative theories, for example, quantum physics based theory, called "Vibration theory", was postulated. [25, 26, 27] It argues that a binding of odor with its receptor must also generate certain energy frequency, which my couple with the threshold of the receptor energy to generate action potential. The Feedback model assures a stable expression of a functional OR. [28, 29, 30] Positive selection and gene conversion et cetera are observed, [31, 32, 33] and also debated. [33, 34, 35] These currently available theories can explain many aspects of the odorant recognition at the binding event. But they remain facing several challenges. For instance, what about the learning process, which is one of the most fundamental nature of life? Can the stem cells learn to generate more specific and high affinity receptors? Why basal cells are continuously and frequently renewal to adapt the ever changing environment? How a species learn to smell an odorant that it has never met before? Is the increasing of its receptor numbers the only answer for increasing the sensitivity?

From the data we can see that about 20-35% receptors only bind to one odorant. [24] An alternative interpretation of the data is that many of the receptors are multi-specificity, among them mostly with lower affinity. But the single odorant receptors are generally with higher affinity. I see from Figure 6 of the referred article, that S1, S3, S18, S19, S25, S41, S51, S83 and S85 are multiple binding receptors and S6, S50, S86 and possibly S46 and S79 are single binding receptors out of 14 ORs. Also from another data, a point mutation, for example, SNP can increase the sensitivity of a receptor to bind its odor up to 10 fold. [19] In the referred essay, the SNPs are S84N and C139Y in Figure 2D. I found these observations of the documented data as well as many data in other mentioned articles as above can be further used to support a new model of "Casting – Decoding" for ligand (here the odorant) and receptor interactions. I postulated this model recently for the generation of high quality antibody. [36] In this model, the binding of an odorant with some multi-specificity OR will induce a fit that will cast the best configuration, which can be decoded by RNA and deliver the message for the correct DNA sequence for transtruction, and which in turn to generate an improved OR with higher specificity and affinity toward the particular odorant.

For example, a multi-specificity OR, OR7D4 or a similar one may be able to bind to an odorant, Androstenone, and generate an induced fit. The induced fit is a casted configuration. An RNA sensor (with function similar to tRNA, to recognize the structure and derive the code) will decode the casted configuration to derive a SNP or other variations, which in turn will guide a transtruction of OR genes, for either S84N or C139Y, and which will generate the ORs with 10 fold increase of the affinity. Stem cell differentiation can well be part of the process.

Added to further prove

Added to further support the idea of consciousness beyond a brain - most recently, New Scientist also published another cover story - Gut instinct, when the body does the think, an article by Emmy Young. The essay reviews that the human digestive system has a neural network as the second brain of the body. Though the idea of the second brain itself is not new, but new details and interpretations have been presented. [37]

Here I also add for a further proof of the concept of DNA transtruction – it can be considered already directly proved by the recent results of viral genome sequences, though a single cell genome may not be currently available. [4, 38, 39]

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