Exploring Reality with Genetically Engineered Senses

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PREFACTORY NOTE

This article suggests that the acquisition of enhanced senses and new senses by genetic engineering could lead to insights that reveal new features of reality including an improved perception of the true nature of the brain/mind system. Some of the key terms and concepts used in the discussion are technology, genetic engineering, qualia, variation in the capabilities of the senses among humans, animal senses not possessed by humans, complexity, semantic frustration, epiphenomenalism, inner and outer models, dualism, entanglement, illusions, and things not real but true.

INTRODUCTION

Everything we know or think we know about reality is informed by our senses. They are our only links to reality; there are no other means to access what is real. Of course there is technology. Indeed, most of our current knowledge about what is real is the result of technology. But technology does not inform us about things by itself. It is coupled with our senses – mediated by one or more of them so to speak. When technology is used to investigate something, the results must be "read" by these senses in order to be interpreted and added to the corpus of our knowledge.

Technology simply enables us to extend the range and powers of discrimination of our senses. Telescopes, microscopes, X-ray and MRI machines, cyclotrons, cell-phones, television, satellites, computers, night-vision binoculars, planes, rockets, etc., extend our senses in time and space from the smallest to largest scales in ways that were unimaginable in the past. So, technology enhances the senses, which in turn inform us about everything we know or think we know about everything.

Of course technology will continue to extend our senses, and will always be indispensable in our drive to expand our knowledge. Most astonishing perhaps is that the advent of genetic engineering technology makes it plausible to envision the acquisition of nonhuman senses currently possessed by other living organisms or even designed from scratch. To understand how remarkable it would be to add a new sense to the senses we already have, think of how impoverished our picture of reality would be if humans could not see color, or could not see at all. Each sense adds a specific dimension to reality that is essential to our grasp and appreciation of things. The more senses, the merrier.

Not everyone will agree with this perspective on the acquisition of new or enhanced senses. Cogent arguments will be made about natural selection being the best arbiter for determining the human genome. But what comprises natural selection? Is the food we eat the consequence of natural selection? The truth is that cultural evolution, which is a derivative of biological evolution, is now a major force shaping the history of biological evolution on the planet. The competition of ideas, cultures, technologies, and economic and political structures is determining selection pressures for a significant number of species on Earth, including the human species.

Genetic engineering of plants and animals is already happening and because of its potential health benefits and quality of life benefits, it is inevitable that the practice will be extended to humans. Once the competitive advantage of senses that have been enhanced or restored by genetic engineering has been demonstrated, both individuals and nations will embrace the acquisition of enhanced senses and of new senses by genetic engineering.

CHALLENGES AND POSSIBILITIES

What are some of the senses that might be considered for acquisition by genetic engineering? Before we attempt to answer this question it is useful to explore the relation between sensing and knowing a bit further. Many essential aspects of reality are unknown because they remain unsensed. They are not detected by man or machine. Sharpening or extending our existing senses, or acquiring new senses would widen our current windows to reality and open new windows. Understanding the genetic basis for our human senses and the senses other organisms possess, particularly those that humans do not, is now within the realm of possibility. This possibility makes the genetic engineering of enhanced or new senses plausible. Solving the technical and ethical problems regarding the genetic engineering of new or enhanced senses in humans will be extremely difficult, but there are no compelling reasons to believe that accomplishing this is impossible. Furthermore, the only possible approach to achieve an understanding of how subjective sensory phenomena emerges in the brain as a result of the workings of the neural networks is to undertake this line of research.

The emergence of *qualia* – sensory experiences – from the action of neural networks is perhaps the greatest enduring mystery in science. Additionally, once the rules describing the transition from objective reality to subjective experiences are known it might be possible to create new designer senses that provide insight and feelings about features of reality that possibly go completely unnoticed by existing organisms. These new senses would be new in every sense of the word, not describable by appealing to a vocabulary based on the existing senses. Attempts to do so would be as futile as trying to describe color to someone who was born blind but can hear well by talking or playing music.

Our senses are so effective in what they do that their magic and mystery go largely unnoticed. This is not surprising; we are genetically programmed to use our senses to survive and enrich our lives, not to understand how they work. Nevertheless, understanding how they work can lead to the acquisition of new senses that enhance our current chances for survival and add to the enrichment of our lives. An immense benefit that will derive from research on the genetic engineering of the senses will be the repair or restoration of senses that have been damaged or lost, or the genetic engineering of normal senses that individuals may have been born without. This should be the goal of the first phase of the research.

Efforts already in progress show promising results in reclaiming damaged senses using electronic devices.[11] Although the use of electronic devices and implants differs in principle and methodology from genetic engineering technology, both approaches should be encouraged. Each approach complements and informs the other, and working in tandem it will be possible for the reclaiming of damaged or lost senses to proceed at a swifter pace. Identifying the genes responsible for the construction of a specific sensory organ and the neural network that interprets and creates the correlate sensory experience is daunting to say the least. As was mentioned before, no suggestion is being made that this is a problem that can be easily solved. Nevertheless, unlike the solution of Fermat's *last theorem*, the general solution for achieving this result for both humans and other organisms should not require 300-plus years. It should take much less time and, of course, its consequences are of much greater importance. A similar argument can be made for the development of successful genetic engineering technologies and the solution of ethical problems that they engender.

EXAMPLES

Once the ability to reclaim damaged or lost senses by genetic engineering has been solved the next step will be to enhance the existing senses in ways that open new windows to reality. There is much variation in the acuity of the senses among humans, much of which has a genetic basis. Perfect pitch is a good example. People with perfect pitch hear music differently from those like myself who don't have perfect pitch. It is well known that perfect pitch confers a competitive advantage to musicians. Many musicians who do not have perfect pitch would probably opt to obtain it if it were available at an affordable cost. A related example in music is the jazz saxophonist Ornette Coleman, who is said to hear and play quarter-tone chromatic music that is revered by his aficionados but reviled by the average listener. His resolution of quarter-tone pitch that allows him to play between the semitones of the Western chromatic scale is probably genetic in origin. It enables him to write and play music that is neither understood nor cared for by many people. According to the jazz educator and author Gary Giddens, in Louisiana, in 1949, Coleman's music so infuriated the audience that he "was summoned from the bandstand and beaten bloody by a mob which also destroyed his saxophone."[2] Yet his gift opens a window to an aesthetic world that is closed to most of us.

Certainly there are many other examples where an individual's ability to see, hear, etc., is far superior to the norm as a consequence of her or his genetic endowment. Although there may be no extensive records of people with such gifts, it should not be difficult to develop an inventory of them, with their consent of course. It is also imperative that legal procedures be developed to ensure that genetic property is not stolen.

While the genetic engineering of the human gene pool is being mastered in an effort to reclaim or enhance the 5 senses, efforts should be underway to use the gene pool of other animals and organisms to further enhance our existing senses or to add new senses that further our understanding and appreciation of the full breadth of reality including, especially, the ubiquitous world of subjective experiences. Many animals sense known features of reality that humans do not. In the case of birds, reptiles, and mammals it is safe to assume that the structure of their brains is sufficiently complex to enable them to experience sense data – subjective sensory experiences – in much the same way that humans do when we see the color red or hear a bell ring.

MORE EXAMPLES

The ultraviolet range of the electromagnetic spectrum provides a good case in point. Human vision is not sensitive to ultraviolet light but with their vision system birds can see colors in the ultraviolet range of the spectrum. These additional colors are different from the colors that humans see-- colors generated by combining the colors red, yellow and blue.[3]

Additionally, birds can see more colors (or hues) than humans can in the range of the spectrum visible to humans. In a sense birds can see quarter-tones or other fractional color-tones that humans are unable to see. Compared to birds, humans are color-blind. That is to say, the ratio of colors that color-blind people see compared to normal people is much greater that the ratio of colors that normal people see compared to birds. Moreover, although birds see every color that humans see, most of the colors that birds see look nothing like the colors seen by humans. Were humans able to acquire the ability to see colors as birds do, the revolution that would take place in the world of art, fashion, commerce, etc., would be unprecedented.

More significantly, any new acquired sensory abilities that result in sensory experiences that correlate with known or discovered aspects of reality will alter the state of consciousness of the experiencer. It will also lead to the creation of a new vocabulary and syntax for describing

or encoding reality. Again, it is important to reiterate that the new sensory experiences of which we speak cannot be perceived by any of the 5 human senses, even when these senses are aided or assisted by external mechanical or electronic devices. These are experiences that exist beyond the pale of the 5 senses. They will expand the richness and girth of sensory experiences and subjective phenomena, and because objective reality is derived from interpretations of sensory experiences and subjective phenomena, they will have the same impact on our views of reality.

Another sense possessed by birds that might be considered for addition to the human sensarium is the ability to "see" the Earth's magnetic field. The protein cryptochrome which was discovered in the eyes of birds is believed to be a magnetoreceptor.

According to the science writer John Bohannon,

> When light strikes this protein, it produces two possible intermediate states differing in the configuration of a single electron. Their ratio depends on the orientation of the cryptochrome--and hence, the orientation of the organism -- relative to the ambient magnetic field.Because cryptochrome is in the retina, (the biophysicist Thorsten) Ritz and other scientists have proposed that it feeds magnetic information to the brain through the optic nerves,(enabling) birds (to) "see" the Earth's magnetic field with a few turns of the head.[4]

Seeing the Earth's magnetic field sounds like something from science fiction. Nevertheless, it seems certain that our sense of reality would be altered if we could see the Earth's magnetic field with the shake of a head. There are a number of other sensory organs that animals are believed to have, including mechanoreceptors that can track movement or turbulence, and electroreceptors that can detect electric fields.[5] Obviously there may be many more senses that exist that we know nothing about.

COMPLEXITY

As each new sensory organ is identified, analyzed and genetically engineered, significant progress should be made in understanding how sensory experiences – qualia – emerge from the combined workings of the physics, chemistry and biology of the body and the brain. Then, with luck, we might finally discover what the mysterious stuff is that dreams and all things sensory and subjective are made of. Notwithstanding the claims of hard core reductionists in science and philosophy, the stuff is not made from the mass-energy and space-time vocabulary and syntax of Standard Model physics or M-Theory. It is made of things that are much more mysterious and complex.

To understand why this is so, it is helpful to borrow terms and concepts from complexity theory, and to add a new term and concept. Theorists believe that complex systems are characterized by the confluence of the following three phenomena: *emergence*, *universality*, and *frustration*.[6] Emergence refers to complex behaviors that arise in collective entities from simpler transition rules; universality refers to a given simple property that arises in different

complex systems; and frustration refers to dynamical characteristics of a complex system that are necessarily at odds with each other.[7]

Emergence and universality apply readily to the senses inasmuch as sensory experiences are obviously universal phenomena that emerge in humans and other animals as a result of the working of their brains. The application of frustration is a bit less obvious. In complexity theory frustration is manifested as geometric frustration, scale frustration and computational frustration. No examples of these types of frustration need to be stated because none of them capture the nature of the frustration that applies to the complexity of the brain and its sensory outputs. I have identified a new kind of frustration that applies to the brain and its sensory outputs which I have named *semantic frustration*. Semantic frustration is the inability to create a vocabulary and logical framework that applies equally well to the brain as a physical entity and to its sensory and other subjective outputs in a way that illuminates the connection between the physics of the brain and its phenomenological outputs.

The problem is that qualia and other subjective experiences are a different *kind* of reality with no seeming common denominator; least of all, no common denominator that can be found in the mass/energy/space/time matrices of modern physics. Attempts to connect the language of subjective experiences with the language of science lead at best to correlations. Unfortunately, the correlations do not unravel the mystery of seeing, hearing, hurting, consciousness, etc., nor the mystery of how physical processes in the brain give rise to these phenomena. This is the essence of the semantic frustration experienced by neuroscientists, cognitive scientists, philosophers of the mind and others who ponder the mysterious connections that bind mind and mass/energy.[8]

This frustration has led to the theory of epiphenomenalism which is the belief that mental or conscious processes simply accompany certain neural processes but have no effect or subsequent influence on the neural processes. Epiphenomenalism runs counter to the following basic principle of cause and effect which is bedrock in science and philosophy; namely that every cause is itself an effect and every effect in turn causes something. According to epiphenomenalism subjective experiences are effects that are incapable of causing anything. This seems absurd to say the least; it suggests that responses to subjective experiences such as pain are nonexistent, that they are all illusions. In spite of the obvious absurdities inherent in epiphenomenalism, a number of scientists and philosophers are epiphenomenalists.

The philosopher Colin McGinn, who does not believe in epiphenomenalism, states that an impossible conceptual divide (which is an example of the semantic frustration that I have identified) separates inwardness, an introspection-based view of the mind and its mental attributes, from outwardness, a perception-based view of the brain and its physical attributes.[9] Emily Pronin provides a similar view in examining the closely related frustration experienced in trying to reconcile how we see ourselves and how we see others.[10] Pronin is hopeful that the frustration she describes can be ameliorated, whereas McGinn is certain that solving the mind/brain mystery is beyond the capabilities of the human brain as it is currently structured. He suggests genetic engineering as a way to solve the mystery, but unlike what is being proposed in this paper, recommends focusing, "on the brain centers that subserve the faculty of introspection."[11]

Introspection is an odd choice of focus since it utilizes self-referencing which the

logician Kurt Gödel showed gives rise to insurmountable obstacles that prevent a full understanding of semantic structures containing inferential substructures capable of self-representation.[12] The mind is certainly a semantic structure and introspection is simply a set of inferential substructures the mind uses to represent itself. So introspection seems unlikely to unravel the mind/brain paradox or solve the mysteries of qualia, consciousness and other subjective phenomena. If genetically engineering the brain centers responsible for introspection would not work, what other centers or senses might be considered?

THE OUTER MODEL

The answer to this question is perhaps best approached by citing the concepts Kurt Gödel and Paul Cohen used during the mid-20th century to settle the two most outstanding questions in set theory. At the time set theory was considered a theory of everything by most mathematicians, equivalent in detail and scope to the M/string theories currently under development in the physics community. The questions of whether or not two properties of set theory known as the *continuum hypothesis* (CH) and the *axiom of choice* (AC) were consistent with or could be derived from the axioms of set theory were acknowledged as being among the most significant problems in mathematics. In 1948 Gödel proved that if set theory is consistent then CH and AC are consistent with the axioms of set theory. Gödel's proof involved the construction of a substructure or *inner model* for set theory in which both CH and AC are true. In 1962 Cohen constructed a superstructure or *outer model* for set theory which he used to prove that if set theory is consistent, then CH and AC cannot be logically derived from its axioms. Additionally Cohen showed that no substructure or inner model for set theory can be used to prove that CH and AC cannot be derived from the axioms of set theory.

Most models for the brain/mind system favored by philosophers, cognitive scientists and neuroscientists are inner models that identify subjective phenomena as just the workings of substructures of the brain. But there is another way. Perhaps an outer model might be more useful than an inner model in considering how genetic engineering of the senses could be directed to gain insight on the true nature of the brain/mind system. We will construct such a model.

The outer model (OM) for the brain/mind system that will be constructed is inspired by the principle of radical conservatism which was championed by the theoretical physicist John Wheeler. The principle exhorts scientists to explore the most radical consequences of well-established theories of science.[13] One of the most radical consequences of Standard Model physics is the semantic frustration that emerges when attempts are made to use its vocabulary and inferential structures to explain the mind and its attributes. The OM embraces this radical consequence and explains its intrinsic nature by creating a model of the brain/mind complex that extends the inner model of the brain/mind by incorporating elements of dualism.[14] The model also extends the classic doctrine of dualism by positing how mind and matter are linked. Additionally, the model suggests how genetic engineering of the senses could result in experiences/experiments that confirm its validity and shed light on the true nature of the phenomenology of the brain/mind.

The basic properties of the OM are given below.

1. Mental entities and processes are not identical to physical entities and processes, but have equal footing as real entities and processes.

2. Mental entities, including the mind, qualia and consciousness are almost always *entangled* (or linked) with their correlate physical substructures in the brain. This entanglement is similar conceptually to entanglement in quantum physics where two entities can emanate from a single source and change their fundamental characteristics randomly as they separate from each other, but continue to maintain correlated characteristics even when they are vast distances apart.[15] In regard to the human brain/mind system it has not yet been established when consciousness first appears in a person's life but when it does the mind and its correlate substructures in the brain become immediately entangled and changes in one result in correlated changes in the other.

3. For the most part the mind and brain remain entangled during a person's lifetime, but in rare instances such as the occurrence of near-death experiences (NDE) the entanglement can dissipate and the mind and brain can decouple and become stand-alone entities.

4. When entangled the mind and brain usually occupy the same space and time; nevertheless, in very rare cases they can remain entangled and become separated in space and/or time.

5. There are specific areas in the brain where entanglement is mediated. Stimulation of these areas can give rise to the illusion that the mind and body have decoupled or that the mind and body have traveled elsewhere. These areas include the substructures that mediate the concept of *presence* – a feeling of being there, of being in some specific place and/or time.[16]

6. The entangled brain/mind has the capacity to perceive things that are not real but that are true. In particular a given sense may be able to perceive some truths only by means of illusions. The perception of motion provides perhaps the best example of this phenomenom. The retina can only register a finite sequence of still images when the eye sees something moving. Nevertheless the brain/mind does not perceive a sequence of still images, instead it perceives an object in motion. The motion is an illusion but it is also true.

   In truth, many of the things we perceive are illusions that are imagined. The brain/mind adds, deletes, remembers, forgets, free associates, etc., when interpreting information received from our sensory organs. This is why rabbit tastes like chicken the first time. The flip side is, as is the case with the perception of motion, that the brain/mind often "senses" the truth without receiving adequate information from our sensory organs. Such is the beauty and power of the brain/mind entanglement.

7. The perception of the truth based on sensory data may at times be inexpressible. This is easy to understand when one considers the possibility that someone could have a sensory organ that produces sensations which reflect the truth but are not experienced by the general public and consequently have no meaning. As the philosopher Ludwig

Wittgenstein pointed out, language is a public tool.[17] There can be no private language that speaks about phenomena that others can neither experience nor imagine. Furthermore, language is a product of a theory of mind in which one assumes that other minds can experience the same qualia (sensations) that ours do.

8. The true nature of the brain/mind duality, the entanglements, correlations, symmetries, etc. may be perceived but cannot be captured in language that is sensible to someone who has not perceived the true nature of the duality. Indeed, those who perceive the truth may remain unable to explain the experience to themselves. This truth cannot be constructed from words or mathematics; it must be experienced and once experienced it cannot be shared in any meaningful way.

9. The sense (or senses) required to perceive this truth can be genetically engineered into the human genome. It is likely that we all have one or more of these senses but that they are very weak and overwhelmed by the other senses, except in cases where they have been enhanced by practices such as meditation, or super-activated by the appropriate drugs or severe physical trauma such as a near-death experience. Because they are weak and occur sparsely in the general population these senses are likely to be unreliable and prone to static and distortions. Genetic engineering could correct this problem by extending the horizons of the senses and increasing their acuity. When this happens standard procedures can be developed for confirming or deconfirming the properties of the brain/mind duality and new ways of knowing will emerge.

The model disallows any resolution of the semantic frustration currently experienced in trying to understand the brain/mind system. According to the model the dual nature of the system can be perceived but it cannot be explained with words or formulas. The complexity of the brain/mind system is genuine and, as is the case with all truly complex systems, the frustration is an inherent feature of the system.

The enduring character of the semantic frustration suggests that the ability to perceive the true nature of the brain/mind is by no means the last word on the subject. There are always deeper truths about what is being perceived that the perceptions do not reveal. For example, seeing colors reveals no information about the electromagnetic radiation that is responsible for the colors seen. The same can be said about the vibrations responsible for sounds or the chemicals responsible for scents. There are always deeper truths and there will always be unanswered questions.[18] Nonetheless, additional sensory capabilities will enhance our shared experiences and sensibilities as participants in this thing we call reality. And the richer and more profound our shared experiences and sensibilities, the richer and more profound our lives will be. Genetically engineering enhanced or new senses can contribute much to the realization of this possibility.

CONCLUSION

This has been a thought experiment on what might happen if new or enhanced senses could be acquired by genetic engineering. The indelible connection between what we sense and our concepts of reality was explored and the extensive variation in the range and powers of discrimination of human senses was validated. The potential benefits of certain animal senses not possessed by humans were cited. The complexity of the brain/mind system was examined and the concept of semantic frustration was introduced as a defining feature of this complexity.

The basic properties of an outer model for the brain/mind were then outlined. The key elements of the model are the dual nature of mental and physical entities and processes, the concepts of entanglement and presence, the perception of things that are not real but true, the capacity to perceive truths not expressible with words or formulas, and the realization that the true nature of the brain/mind system may be perceived but cannot be articulated.

Finally, the ability to perceive the true nature of the brain/mind will not reveal all the truths about the brain/mind as a participant in what we call reality. Nevertheless, genetically engineered senses-- enhanced or new -- will increase shared experiences and sensibilities and enable our lives to be more profound and perhaps more rewarding.

NOTES

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[13] K. Thorne, "John Archibald Wheeler (1911 – 2008)", *Science*, 20, June 2008, 1603.

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