Research Essay

The Electronic Waveform of Action Potentials in the Brain

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Abstract

A new research paper has detected a 'never-before-seen' waveform in the action potentials in the pyramidal neurons in the cortex of the brain which are believed to be modulated by neurotransmitters in the synaptic clefts of the dendrites which involve complex variations in the spikes of electric flux of both sodium and calcium positively charged ions. Previously the spikes were thought to be generated by typical all-or-none flow of sodium ions as the action potential propagates along the axon and were not graded in any way. This new finding indicates the waveform of the action potentials carry information which would enable the neural network to perform logic gate type processing like conventional computers. It is argued that as numbers don't exist in Nature it is impossible for an organic computer to execute a numerical code, and the complex variations in amplitude and frequency of the waveforms indicate that the brain is an organic electronic device where the neurons are able to classify linearly non-separable inputs.

Keywords: Brainwaves, electromagnetism, ELF radio waves, dendrites, electric flux, magnetic flux.

Introduction

A recent essay "Solving the 'hard problem': Consciousness is an electronic phenomenon" argues that the action potentials (APs) of neurons occur as a result of electromagnetic processes.[1] Basically magnetite crystals also known as BMNPs (Biogenic Magnetic Nanoparticles) are ubiquitous in the brain and are superparamagnetic. This means that electric flux will magnetize them as will low frequency electromagnetic radiation (EMR) that acts upon them in exactly the same way as a magnetic field.[2] Magnetizing the BMNPs in turn generates magnetic flux which opens ion channels and enables current to flow thru the membrane of the neuron. The 'spikes' generated by action potentials are therefore mediated by this complementary relationship between electric flux and magnetic flux encapsulated in Maxwell's classical equations of electromagnetism. As these 'spikes' are actually an oscillating current along the axon they will also emit radio waves at the same frequency as the current. These radio waves are universally referred to as brainwaves which likewise can magnetize the BMNPs and initiate action potentials elsewhere in the neural network.

A new research paper has detected never-before-seen waveforms in the dendrites of the pyramidal neurons in the cortex of the brain.[3] The paper argues that these waveforms are mediated by neurotransmitters in the synaptic gaps which regulates the electric flux caused by the flow of calcium and sodium ions which actually modulates the amplitude and frequency of

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the 'spikes'. Up to now the spikes of action potentials were thought to be typical all-or-none flow of sodium ions as the action potential propagates along the axon and were not graded in any way but this new finding indicates that in the neurons of the cortex at least, the spikes are creating waveforms that vary in amplitude and frequency in such a way as to suggest that the brain is performing logical processing similar to a computer or a Turing machine. It is argued that the capacity of these spikes to generate brainwaves of a varied amplitude and frequency that can communicate information elsewhere in the neural network indicates that the brain is not a classical computer or Turing machine, but is in fact an electronic device.

The computational model of the brain

Analogies between the brain and a computer are commonplace. There are certainly many similarities that are undeniable. The brain receives input from the external world via the senses, then performs algorithms and the output is mental states or actions. The brain obviously has a memory storage facility just like computers. The neural network resembles an integrated circuit where the neurons are logic gates that are either 'on' or 'off'. This certainly suggests some sort of binary code of 'ones' and 'zeros' just like modern computers that the algorithms are written in. The brain can certainly do basic computational operations just like a computer. Also the brain can perform basic processes of logical reasoning that resemble computer programs.

This computational model only goes so far. The fact is that nerve impulses are way too slow compared with current flowing thru logic gates in modern electronic computers. Computers can perform complex computational processes infinitely faster than organic brains. And computers do essentially serial processing which means that they are basically working on one algorithm at a time. Organic brains on the other hand, although they are slower and less efficient in performing a single computational task, are somehow capable of performing an infinite number of parallel processing tasks simultaneously. The computational model of the human brain only goes so far for the simple reason that the organic brain is so vastly superior to the modern computer in terms of volume and speed of output that it is apparent that its operating system (OS) is fundamentally different. The brain operates at a whole different level and the algorithms it is performing are qualitatively different from those that a conventional serial processor can perform. We have to do away with any analogy with processing involving electric current running thru logic gates to execute a program written in binary code. We need to understand how neurons can be programmed to perform an infinite amount of parallel processing of multiple simultaneous inputs and then instantaneously generate a unified output to diverse terminals.

There is no point in explaining the basics of processing in a Turing machine or a modern computer because there is a short answer as to why the computational model is inappropriate for an organic brain. All processing in man-made computers involve the use of numbers. Binary code consists of numbers, and nothing but numbers. And numbers (whether positive or negative or complex or simple) simply do not exist in Nature. It's almost trite to say it, but in order to understand what the brain is doing and how it is doing it, we need to start with something that does exist in Nature that is capable of communicating information. And here there is only one candidate. Electromagnetic radiation (EMR) i.e. radio waves. To understand what the brain is and how it performs simultaneous parallel processing we need to be looking at the Extremely

Low Frequency (ELF) radio waves that the brain generates, universally referred to as 'brainwaves'.

Brainwaves are ELF radio waves

All of modern electronics that involves the transmission of information via EMR (electromagnetic radiation) are simply different aspects of radio transmissions The radio spectrum extends from Extremely Low Frequency (ELF) waves from 3-30 Hz thru to Tremendously High Frequency (THF) from 300-3,000 THz (one THz is one trillion cycles per second) which ends somewhere in the UV range, even higher than visible light. Human brainwaves are in the same range as the ELF waves, and from the point of view of this paper are considered to be radio waves. The definition of an electronic device is that it generates radio waves for the purpose of communication, which means that the human brain is an electronic device.

In Nature there is only one fundamental force that is relevant to this issue and that's the electromagnetic force, and the apparent plethora of different forms of energy that are at work in Nature are all actually just different aspects of this one fundamental force – electricity, bioelectricity, chemoelectricity, electromagnetic radiation (EMR), electromotive force (EMF), magnetic fields, electronics to name only the main headings. These all then have subgroups like alternating current (AC) direct current (DC), all the different frequencies of EMR, integrated circuits and semiconductor and nano technology in electronics that involve quantum mechanics, and geomagnetics, biomagnetics, electromagnetics etc.

The point is that they are all just different aspects of the fundamental electromagnetic force, and under different conditions they generate each other. For instance a moving magnet will generate electricity, an electric current creates a magnetic field as does electrons lining up in metals, an alternating current (AC) emits radio waves (EMR) at the same frequency as the current, and an electric current in a coil around a stationary piece of metal will cause it to become a magnet and will spin a magnet to create a mechanical force, biophotons which are EMR are spectral lines of atoms emitted from a semiconductor when the electrons fall back from the conduction band to the valence band. The essential point for the purpose of this article is that brainwaves are ELF radio waves and so they are just one aspect of the electromagnetic force and are emitted by an alternating current (AC) in the brain. And the fact that the brain emits radio waves means that it can actually receive radio waves as well. The brain can act as an antenna. In an earlier article I presented a model of the brain as an electronic device that generates our consciousness and asserts that the brains of all living creatures are connected electronic devices.[1]

Brainwaves are recorded thru electrodes external to the skull known as electroencephalography (EEG) which is major area of research. Various band widths have been identified and extensively studied. In addition to the alpha band there are the beta, gamma and theta waves and other regular rhythms besides. Band widths have been associated with various mental states and irregularities in brainwave rhythms have been identified as the symptoms and causes of disease. The body of expertise is growing where brainwaves are being used to allow us to communicate with BCIs (Brain-Computer Interface) and other neuroprosthetics and connected electronic devices. There are research papers in optogenetics where brainwaves have been used to alter gene expression.[4] We have even got to the stage where people are playing video games using only their mind communicating their thoughts via brainwaves.[5]

All this advance in brainwave communication techniques is merely the tip of the iceberg compared with what is coming up. A new research paper has taken the significance of brainwaves to a whole new level. Researchers have for the first time translated thoughts into recognizable words.[6] This is literally the start of mind-reading technology. Neuro-engineers used an AI deep learning device (DNN) and a voice synthesis vocoder to translate into sound the brainwaves from the auditory cortex of a subject who had heard the words. In other words the specific firing of neurons in the auditory cortex generate brainwaves of a precise frequency that contains the information about a specific word that the subject has heard.

Another very recent research paper has demonstrated that the brainwaves on the occipital cortex actually carry the information about the image that the subject has seen.[7] These brainwaves can be converted back into the image that the subject saw through his/her eyes. The pattern of firing of precise neurons is literally generating a radio wave that carries information.

Recent research in neuroscience

A recent research paper has uncovered a novel signal occurring in the action potentials of the cortical neural network.[3] An action potential is essentially in the form of a wave of opening and closing channels that exchange charged particles such as sodium, chloride, and potassium. These signals flow along axons that end in dendrites that connect to the cell of other neurons.

"The dendrites are central to understanding the brain because they are at the core of what determines the computational power of single neurons," says the lead author. This combination of positively charged ions kicked off waves of voltage that had never been seen before, referred to as calcium-mediated dendritic action potentials, or dCaAPs. Brains – especially those of the human variety – are often compared to computers. The analogy has its limits, but on some levels they perform tasks in similar ways.[8]

In these neurons, the researchers discovered a class of calcium-mediated dendritic action potentials (dCaAPs) whose waveform and effects on neuronal output have not been previously described. In contrast to typical all-or-none action potentials, dCaAPs were graded; their amplitudes were maximal for threshold-level stimuli but dampened for stronger stimuli. These dCaAPs enabled the dendrites of individual human neocortical pyramidal neurons to classify linearly nonseparable inputs—a computation conventionally thought to require multilayered networks.

The researchers argue that this is the logical underpinnings of our brain – ripples of voltage that can be communicated collectively in two forms: either an AND message (if x and y are triggered, the message is passed on); or an OR message (if x or y is triggered, the message is passed on). In addition to the logical AND and OR-type functions, these individual neurons could act as 'exclusive' OR (XOR) intersections, which only permit a signal when another signal is graded in a particular fashion. "Traditionally, the XOR operation has been thought to require a network solution," the researchers write.[8]

These novel signals were found in the dense, wrinkled outer section of the human central nervous system; the cerebral cortex. The deeper second and third layers are especially thick, packed with branches that carry out high order functions we associate with sensation, thought, and motor control. This suggests that the disproportionate thickening of cortical layer 2/3, along with its numerous pyramidal neurons and their large dendrites, may contribute to what makes us human.[8]

It is submitted that this new research confirms the theory that consciousness is generated by electronics, that the brain is an electronic device and that the brains of all living creatures are connected electronic devices. In particular it indicates that the 'firing' of specific neurons will emit brainwaves of a unique frequency that will act as a signal to other parts of the neural network. Essentially the firing of specific neurons that have been programmed for individual functions acts as a transmitter of information via brainwaves to other sections of the neural network that have likewise been programmed - 'hard-wired' - to perform supplementary processing of this signal. Essentially neurons in other sections of the brain are 'hard wired' to act as an antenna for this unique signal.

To quote from the research paper, which clearly indicates that the signal is in the form of a 'wave form' of precise frequency and amplitude (AP = Action Potential):

> The waveform of dCaAPs was stereotypical and easily distinguished from that of bAPs. dCaAPs were typically wider than bAPs (withwidths of 4.4 ± 1.4 ms, ranging between 2.6 and 8.0 ms; n = 32 cells), they were slow rising, and they did not have a kink at onset. The majority of the cells (27 of 39) showed a train of (two or more) dCaAPs with a mean firing rate of 4.6 ± 1.7 Hz (dCaAPs per second). In the remaining 12 dendrites, a single dCaAP was triggered immediately after the beginning of the stimulus. Unlike the bAP, the amplitude of the dCaAPs and their upstroke were not dependent on the distance from the soma (average dCaAP amplitude 43.8 ± 13.8 mV, ranging between 13.0 and 67.0 mV; n = 32 cells, measured at threshold). This is consistent with both variability of the dCaAP initiation site and variability of dCaAP properties.[3]

Further observations from the research paper clearly indicate that signals are passing between these neurons (note the phrases in bold italics – my emphasis):

> dCaAPs affected the input–output transformation of the cells. Typically, somatic AP firing increases with the input current intensity injected to the soma. In contrast, in 4 cells (out of 12 cells that had repetitive and coupled dCaAPs) our recordings revealed an inverse behavior where increasing the intensity of dendritic (rather than somatic) current injection resulted in decreased somatic firing. For example the dendritic electrode evoked one or two somatic APs with current near threshold but failed to evoke APs for higher current intensity. In contrast, at the soma of the same cells, AP output increased with the input's

> strength. These results are explained by the unusual active properties of dCaAPs. dCaAPs evoked by the dendritic electrode triggered somatic APs near threshold but were suppressed by further increase in the stimulus intensity. The dendritic activation function (namely, the amplitude of dCaAPs as a function of the intensity of the current injection in the dendrite, Idend) reached its maximal value at the rheobase (i.e., for Idend = Irhe where Irhe is the threshold current for triggering a dCaAP) and decayed for stronger Idend (12 uncoupled dCaAPs). The mean width of the dendritic activation function (defined here as the decay constant of a single exponential fit) was 0.39 (0.38 median; in units of Irhe), ***which indicates that dCaAPs are sharply tuned (highly selective) to a particular input strength***. Additionally, L2/3 dendrites were heterogeneous in their activation function threshold and width. In contrast, in a similar range of input intensities, somatic APs showed a typical threshold activation function; once a somatic AP was triggered, its amplitude was virtually independent of the input intensity. Unlike other dendritic APs in the mammalian neocortex—namely, NMDA spikes and dendritic Ca2+ APs in layer 5 pyramidal neurons—that were previously shown to increase with the stimulus strength, ***the activation function of dCaAPs in L2/3 neurons was sharply tuned to a specific input strength***.[3]

In this model of the brain as an electronic device it is argued that the 'spikes' caused by the flow of these action potentials is not simply the flow of calcium and other positively charged ions thru membranes, which is conventionally described as 'electrochemical' activity, but they are in fact electronic phenomena. In electronics the flow of ions represents electric flux and this has a complementary relation to magnetic flux described by Maxwell's classical equations for electromagnetism. The processes of the brain as an electronic device are mediated by BMNPs (Biogenic Magnetic Nanoparticles) that are ubiquitous in the brain. The essential process is that these BMNPs are superparamagnetic and the electric flux of the flow of positively charged ions will magnetize them, which in turn generates magnetic flux that will open other ion channels to generate electric flux. The brainwaves generated by these 'spikes' carry the information in the form of a signal of a unique frequency. The brainwaves are the 'wave forms' described in the research paper.

Neurons are 'hard wired' for specific functions

In this model we must do away with any suggestion that the organic brain operates like a Turing machine or a conventional computer. The well-worn analogy that the 'on' – 'off' nature of neurons suggests they are performing logic operations to manipulate binary code is quite simply wrong. The new research above indicates that the firing of neurons is mediated by neurotransmitters at the synaptic connections in a very complex way, and it is actually the firing of the neuron itself, or a specific set of neurons, which is directly generating a signal involved in processing output. In the next section I present a brief review of cognitive science where it is quite clear that specific sets of neurons in specific parts of the brain are engaged in performing specific functions. And the overriding question in cognitive science is how the information from these diverse firings of neurons in spatially distant parts of the brain, even from different hemispheres, can somehow simultaneously coalesce into a unified output for multiple terminals i.e. the coordination of all functions of the body and its actions in the environment at once.

It is evident that the neurons are 'hard wired' to play a coordinated role in the generation of all bodily and mental operations, and there are plenty of instances where damage to the neurons in one part of the brain will cause defects in the performance of a function, but will not necessarily extinguish it, which indicates that neurons in other undamaged sections of the brain engaged in generating that function are still operating, and it is only the final coordinated output that is in some way impaired. Also there is evidence that if a part of the brain that performs a specific function is damaged at a very early age, then neurons in another section of the brain will be 'hard wired' to perform that function. At the risk of mixing metaphors, there is evidence of considerable plasticity in the 'hard wiring' of these neurons.

This indicates that the 'hard wiring' of the neurons to perform their allotted functions is in the nature of a 'programming' of the brain. But that's where the analogy to conventional computers or Turing machines ends. There are no programs written in binary code, or any other numerical symbols, that are executed by electric current running thru logic gates, which will result in the neural network generating a specific output, globally coordinated or otherwise. When the neurons themselves receive a certain signal they will fire in a very specific way, which will transmit a very specific signal via brainwaves. That is their sole function: to fire when they receive a precise signal. In other words the programming of the neurons of the brain is just part of the growing process of a living organism, and ultimately the information for the 'hard wiring' of the neurons must be coming from the genome. By the time of birth the human brain is already 1/3rd of the size of the adult brain, and yet the rest of the body is barely 1/6th the size of the adult body. This indicates that the most significant time for the growing process for the brain, and therefore for the 'hard wiring' of the neurons is while we are in utero; before we are even born. Which begs the question how can the neurons be 'hard wired' to perform functions before they are actually receiving sensory input resulting in the performance of those functions.

To answer this question, I propose the theory of famous French neurophysiologist Michel Jouvet, that REM dreaming sleep is a genetic programming mechanism for the brain.[9] Our fetal dreams are actually driving the synaptic connections and 'hard wiring' the neurons to perform their specific functions before we are actually born. By the time we are born our brain is fully functional and programmed to receive sensory input from this alien new environment in which we are thrust. Our brain is already obviously fully functional to perform our bodily processes and also receptive to sensory input, and we also have the capacity to display emotion.[10] It is universally accepted that the new born displays extreme anguish from the trauma of birth, and this involves the firing of neurons in the emotion parts of our brain coordinated with the firing of neurons in motor activities – jaw movements, facial expressions, generation of sounds expressing anguish etc. From the moment we emerge from our mother's womb the neurons are 'hard wired' and our brain is primed and ready to go. We also have limited capacity to display other emotions as well, notably the pleasure of re-finding the mother's body, and familiar tastes, sounds and smells.

Space precludes me from presenting Michel Jouvet's theory in detail. However it is well documented that the fetus spends up to 80% of its time in utero precisely in REM dreaming sleep, and it is widely recognized that this must play a pivotal role in 'the development of the central nervous system'.[11] Arguably REM dreaming sleep in utero is responsible for the 'hard wiring' of neurons involved in 'intelligence'. It's undeniable that we display intelligence in our dreams. Our dreams may not be particularly rational. Indeed at times they seem downright crazy. But they are the product of operations involving intelligence nonetheless. Without neurons 'hard wired' for intelligent operations we could not dream.

A brief review of cognitive science

In cognitive science the dominant theory of brain processes is the representational theory of the mind. All mental states involve representations. The brain makes representations based on the data that is being inputed via the senses. Essentially the representations cause us to become aware of our existence as a physical body living in a world where there are other physical bodies similar to us. The global representation produced by the brain is that we are bodies living in a space occupied by other living beings. We may note at the outset that this global representation is purely mental. In the final analysis we have no more than a belief that we are physical bodies.

Ultimately we need to look to Schopenhauer as the philosophical basis of modern cognitive science. His thesis of the world as will and representation. The world is nothing more than the representations produced in our brain. These are representations of what 'appears' to be physical phenomena existing in an extended space that we also occupy, and representations of our attitude towards that physical phenomena which involve intellect, emotions, language and consciousness.

Much of the discussion in cognitive science involves questions to what extent these representations of things in an external space are a true likeness of the things they are actually representing. In other words although it is almost universally accepted that the brain is generating representations of a world we occupy, it is also almost universally accepted that there really are things with physical attributes, and the concern is to what extent our mental representations of this world give us a true 'picture' of these things. For instance there are problems with the nature of matter. It is made up of atoms which are units of electromagnetic energy which is invisible and colorless. We know that the color of these things is generated in the brain. Which indicates that the mental representation of the thing that is generated in the brain is a complete fabrication. The mental representations could be a complete illusion similar to our dream images.

Most researchers think of representations in the mind/brain in terms of resemblance or isomorphism between the representation and the represented. They talk of topographic maps that represent adjacent portions of what is represented with spatially adjacent areas. The somatotopic maps which represent the body generally have the same look and structure as the body itself, so that points of the body which are nearby are represented by parts of the map which are nearby.

The occipital lobe organizes much of its visual information into what are called retinotopic maps: this means that adjacent areas of the eye's retina are represented by adjacent areas on the map.[12]

All these 'maps' appear in the neurons of the cerebral cortex that are feature detectors. In other words they are 'hard wired' to be maximally responsive to a particular type of stimulus, or have the function of indicating the presence of a stimulus of that type, such as high-contrast edges, motion direction, spatial locations, and colors and so on. This is the causal covariational view of representations that applies to both sensory and motor neurons. In the case of feature detectors, the brain state represents something that causes it. In the case of motor representations, the brain state represents something that it causes: a twitch of a finger, the raising of an arm.[12] The word 'covariational' is stressed. These representations are all totally synchronized and simultaneous 'caused' by the firing of sets of neurons in widely dispersed parts of the brain.

At this point we pause for some philosophical reflection. Aristotle in *De Anima* states that our 'intellect' is an affection of the soul, and his account has been criticized as attempting too great an assimilation of thinking to perception, especially to seeing. However if we accept the representational model of the brain, where the world is in Schopenhauer's words, simply will and representation, then Aristotle is essentially correct. It is impossible to separate our will from the representations of the world produced in our brain.

> Not only primitive man and the child, but also the higher animals spontaneously evolve from the small everyday experiences an image of Nature which contains the sum of technical indications observed as recurrent. The eagle "knows" the moment at which to swoop down on the prey; the singing-bird sitting on the eggs "knows" the approach of the marten; the deer "finds" the place where there is food. In man, this experience of all the senses has narrowed and deepened itself into experience of the eye. But, as the habit of verbal speech has now been superadded, understanding comes to be abstracted from seeing, and thenceforward develops independently as reasoning; to the instantly-comprehending technique is added the reflective theory…A soul-image is never anything but the image of one quite definite soul. No observer can ever step outside the conditions and the limitations of his time and circle, and whatever it may be that he "knows" or "cognizes," the very cognition itself involves in all cases choice, direction and inner form, and is therefore ab initio an expression of his proper soul. The primitive himself appropriates a soul-image out of facts of his own life as subjected to the formative working of the basic experiences of waking consciousness (distinction of ego and world, of ego and tu) and those of being (distinction of body and soul, sense-life and reflection, sex-life and sentiment).[13]

The mere action of moving your head while at the same time keeping your eyes focused involves a complex set of calculations from an entire circuit of sensory and motor regions which is known as the vestibular-occular reflex. The representations are considered to be perception/action cycles. These cycles supply the building blocks for cognition. Biological organisms are set up to sense their environment and react to it. Perception/action cycles can be as simple and inflexible as a knee-jerk reflex or as complex and improvisational as the trip to the market that follows the realization that one is out of milk. One seeming mark of so-called higher creatures like ourselves is that our behavior is governed by perception/action cycles that are more flexible than programmatic – though, to be sure, the more complex perception/action cycles will often depend upon the proper functioning of the simpler ones (e.g., the vestibulo-occular reflex).[12]

Notice that the notion of perception/action cycles does not imply a clean separation between the two in time, so that we first perceive, then act. We are both perceiving and acting all the time, and we often act in order to perceive (when we direct our eyes, for instance) and perceive in order to act (e.g., when navigating through an unfamiliar space). To study the circuit that gives rise to planned responses one would have to study, among systems, those responsible for perception, memory, reasoning, language processing, and motor control. The planned behavior, the output, is the result of coordinated processing from multiple systems in diverse regions of the brain all of which are receiving 'input' from numerous subsidiary mechanisms as well as continuous streaming sensory data.[12]

Space constraints prevent me from detailed discussion of the known functions of specific regions of the brain which all coalesce into our seamless and unified experience of 'consciousness'. However we must consider human language in some detail, and in particular the theory of Noam Chomsky that our linguistic abilities are 'hard wired' into neurons in specific regions of the brain. Noam Chomsky believes in a universal grammar – that is, a core grammatical structure which all natural languages share. He claims that the basis for this universality is that all humans have an innate ability to learn language, due to something in their brains called a language acquisition device.[12] Personally I don't doubt this for one minute. Anyone who has ever attempted to learn ancient Greek or Sanskrit will appreciate that the complexity and sophistication (syntax, grammar and vocabulary) of human language could not possibly have evolved as a result of cave dwellers communicating by grunting and pointing and gesticulating. The happy coincidence of 'spontaneous chemical mutations' that we 'naturally selected' that put language regions in our brain to my mind is nothing short of miraculous.

According to the Wernicke-Geschwind model two principal regions in the brain involved in language are Wernike's and Broca's areas. Wernicke's area, located in the posterior temporal lobe near the auditory cortex, seems to be an important receptive center for language, while Broca's area, on the left side of the frontal lobes, seems to be an important language production center. Other brain areas have been found to be involved in language, including the thalamus and the basal ganglia. Also, the cingulate gyrus seems important for word retrieval, mainly because of the central role it plays in the directing of attention to the task at hand. The anterior superior temporal gyrus, which is located directly in front of the primary auditory cortex, is involved in word and sentence comprehension: it has numerous connections with hippocampal structures that are involved in memory. These recent results also confirm that the classic Wernicke-Geschwind model is far too simple and that language is a process much more distributed across many parts of the brain. This raises the additional new difficulty of trying to understand how so many different, independently functioning structures could have evolved in tandem to produce the synchronized activity necessary for language.[12] Consider that some humans are capable of making an intelligent or witty or funny remark which would require simultaneous input from multiple sensory motor reasoning memory and language regions in a fraction of second.

Language is for representing the world, not only to others in communication, but also to ourselves in thought. It's what sets us apart as humans in this world as will and representation. Whatever their physical bases, natural languages have certain characteristic features. First, they are composed of a set of basic representational elements (i.e., words, prefixes, suffixes, and so on) and proper ways of combining these elements (called a syntax) into larger structures. To this extent, natural and artificial languages are indistinguishable.[12] Human innate language ability must be taken as the prototype for systems of symbols that have meaning operating in human civilization – culture, art, economics, religion, science, mathematics, architecture, fashion etc. All our thinking processes are based on this innate grammar which enables us to manipulate these symbols according to a logic inherent in their meaning.

Then there is the intelligence in our dreams where the symbols are manipulated in illogical ways inconsistent with their meaning. What makes us human is our ability to think about what makes us human, which means that it is simply impossible for us to separate our innate language ability from our consciousness of a world image. The fact that Descartes 'thinks' does not prove that he exists, it merely proves that 'he thinks that he exists'. He was unable to set himself apart from the world as will and representation.

Conclusion

Our consciousness is holistic and yet there is now irrefutable evidence that our consciousness is composed of simultaneous input from the firing of neurons in diverse and widely separated regions of the brain. Recent advances in 'mind reading' technology has established that brainwaves communicate information. Brainwaves are ELF (extremely low frequency) radio waves that travel at the speed of light. New research has revealed a novel waveform in the firing of neurons in the cerebral cortex which indicates that the 'spikes' of the electric flux in the action potentials are in some way mediated or controlled so that the waveform has a precise amplitude and frequency. In other words the waveform carries information about the precise neuron or set of neurons that fired. That information is communicated instantaneously to the entire neural network via brainwaves.

It is submitted that this solves the 'binding problem' in cognitive science. How functions achieved by different parts of the brain somehow combine their output into a single conscious percept. Not only does the problem of binding occur across components of a single modality, for example the shape and color components of the visual modality, but also the problem exists for multiple modalities: how is it that a single conscious experience contains information from vision, hearing, touch, smell, and taste, all at the same time? And sensory input is all seamlessly and instantaneously merged with our body schema and motor modalities, and our thought and language modalities. The problem is that there are too many multimodal areas. There are places in the temporal lobes which receive input from all modalities (the superior temporal sulcus), and places in the prefrontal lobes which also receive input from all modalities. One candidate for the neural substrate of binding is a type of resonation or oscillation which spans all of the bound areas. The binding problem is a problem about how the different parts of a conscious state are realized in such a way that they are parts of the same state.[12]

On the assumption that conscious states are realized in spatially separate brain areas, the binding problem evolves into the problem of discerning which physical process involves all of these disparate parts. Oscillation theories attempt to solve the binding problem by linking the parts of a conscious state with a process of electrical oscillation. The magical frequency seems to be somewhere around 40 times per second. Indeed, such coherent electrical oscillations can be measured across wide areas of the cortex.[12]

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