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Additional Information on Transitioning thoughts into Action

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Abstract

The exact mechanism of transitioning cerebral thought into action has been studied and researched for several years by different investigators. This review cites some of these activities and suggests that there are many mechanisms for this communication in humans.

Keywords: Cerebral Neurons; Action Potentials; Electrons; Charged particles; Neurotransmitter

Abbreviation: EEG: Electroencephalography; ATP: Adenosine Triphosphate; ESM: Electrostimulation Mapping; BMI: Brain Machine Interface

Introduction

Approximately seven years have elapsed since I published "On the Neuronal Connectivity of our Thoughts into Actions" in Personalized Medicine Universe 5(2016) 44-46. Since then, I have given this subject a great deal of thought and recently was inspired by watching golfers look at their golf ball and spend much time just looking and looking. I wonder what in the world is going on in their brain which inhibits their swinging at the ball. Additional research has been published which elucidates this activity and this will be reviewed. Established functions of the central nervous system include functions of the cerebral neurons and how they communicate and relate to each other and other parts of the body. The role of the excitable cell membrane is basic to the understanding of signal transmission. Most cells in the body utilize either or both charged particles and/or ions to send movement between the extracellular fluid and cytosol. [1] That cell membrane regulates what can cross the membrane and what does not cross. The membrane is a phospholipid bilayer and substances can cross through the hydrophobic core via diffusion unaided. Charged particles which are hydrophilic need assistance which usually comes from charged particles which are hydrophilic. Channel proteins make this possible. Transport channels and transport pumps are needed to generate an action potential. The sodium/potassium pump moves sodium ions out of the cells and potassium into the cells while regulating ion concentration on both sides of the membrane. The pump gets its energy from adenosine triphosphate (ATP) which is also called ATPase. Sodium has a higher concentration outside and thus the pump is going against the gradient which requires energy.

Ion channels are the openings which allow specific charged particles to cross the membranes. Proteins cross the membrane including the hydrophobic core and interact with the charge of ions because of the properties of the amino acids found in the protein channel. Thus, hydrophilic amino acids are exposed to the fluid environments of the extracellular fluid and cytosol. The ions will interact with the hydrophilic amino acids. Channels for positive ions will have negative charged side chains in the pore. This is called electrochemical exclusion which means the channel pores are charge specific.

Ion channels can be identified by the diameter of the pore. The distance between the amino acids is specific for the diameter of the ion when it dissociates the water molecules. Larger pores are not for smaller ions as the water molecules will interact by the hydrogen bonds which is called size exclusion. Some channels are selective for charge and not sized and are called nonspecific channels. These allow sodium and potassium cations to cross but not anions. Some channels are opened for certain events which means the channels are gated. A signaling molecule, a ligand, binds to the extracellular region of the channel and is known as an inotropic receptor which is known as a neurotransmitter in the nervous system. This binds to the protein and ions can cross the membrane and change its charge. There are additional types of gated channels such as a mechanically gated channel, a voltage

gated channel, and a leakage channel which contribute to the resting transmembrane voltage of the excitable membrane. The ion concentration in both the extracellular and intracellular fluids is balanced with a neutral charge, but a slight difference at the membrane surface has the power to generate electrical signals, including action potentials.

The resting potential of the membrane is -70mV and as the sodium rushes into the cell, the voltage will be less negative which is called depolarization and can bring the membrane potential to +30 mV. Then other channels open which allows the potassium ions to leave the cell and the membrane potential moves back to its resting voltage which is called depolarization at -70mV. If it overshoots, this is called hyperpolarization. This is a description of the action potential and is the electrical signal that the brain generates for communication. Whether it is a neurotransmitter binding to its receptor protein or a sensory stimulus activating a sensory receptor cell, the stimulus starts the process. Sodium enters the cell, and the membrane becomes less negative. The voltage-gated sodium channel is an important part of the depolarization in the action potential. These channels help the cell to depolarize from -70mV to -55mV. When the membrane reaches that level the voltage gated sodium channels open which is known as the threshold. Any depolarization that does not change the membrane potential to -55 mV will not reach threshold and will not result in an action potential. Any stimulus that does depolarize the membrane to -55 will cause many channels to open and an action potential will be initiated. A larger stimulus will not make a stronger action potential. Action potentials are "all or none". All action potentials are the same. A stronger stimulus will cause more action potential to be released, but each action potential is identical.

All the above occurs in 2 milliseconds. When an action potential is in progress, another one cannot be initiated. This is called the refractory period and that has two phases: absolute refractory period and the relative refractory period. While it is in the absolute refractory period, no action potential can be started. This action potential propagates toward the axon terminals and the polarity of the neuron is maintained. The propagation is different in myelinated axons in that the sodium ions spread the length of the axons until it reaches the first node of Ranvier. The depolarization proceeds at the optimal speed depending on the distance between the nodes. Propagation on the unmyelinated axon is called continuous conduction whereas the myelinated axon has saltatory conduction which is faster because the action potential jumps from one node to another node. The speed is influenced by the diameter and width of the axon. Glial cells are responsible for maintaining the chemical environment in the nervous tissue. If there is an imbalance in the sodium-potassium pump, the cerebral neurons cannot function normally.

Due to the different importance of cerebral neurons in various parts of the brain, important neurons will vary for different movements and individuals. Neurosurgery has contributed a great deal of knowledge to this field of connect omics with electrostimulation mapping (ESM) and information gathered in the operating room. [2] Unfortunately, the study of WMT or white matter tractography, does not provide much information about the function of subcortical fibers even though it is a reflection [3,4]. Electroencephalography (EEG) is an effective tool for some stroke survivors to understand the neural connectivity while evaluating the sensorimotor performance. Functional neural connectivity from EEG may augment knowledge about structural connectivity [5]. To have access to fast microscopic processes, there should be a short excitation (pump) pulse, which initiates the process, and a short probe pulse for taking photos of the evolution of the process. These techniques allow the tracing of changes in the nuclear structure of molecules such as vibrations and the formation of chemical bonds.

In addition to the information concerning the emission of impulses from the cerebral neurons to the peripheral axons, Choi and Jang have shown that the primary auditory cortex has neural connectivity with the prefrontal cortex, hippocampus, fornix, and Para hippocampal cortex and other areas associated with cognition and memory [6]. This suggests that the cerebral cortex can be stimulated directly by sound and may via reflex generate an action potential with a motor response. And this suggests that there may be cognitive impairment following hearing loss. What about other approaches to this issue of cerebral connectivity? The Nobel Prize in Chemistry in 1999 was awarded to researchers who used femtosecond (1015) pulses to study the motion of atoms in chemical reactions. The Nobel Prize in Physics in 2023 was awarded to Pierre Agostini from Ohio State University, Ferenc Krausz from the Max Planck Institute of Quantum Optics in Germany, and Anne Lhuillier from Lund University in Sweden who succeeded in making fast light pulses for studying electron behavior [7]. Lhuillier used attosecond (1018) high energy light waves whose frequencies are multiples of the input laser frequency. Physicists using attosecond science can now probe chemical reactions and ultrafast switches and give a view of fast-moving electrons inside atoms and molecules [8-10].

These studies demonstrate a three-step process which starts with the intense laser field distorting the electric field structure within the atom which allows the electron to tunnel out. The laser field accelerates the liberated electron to higher energy and finally the electron is recaptured by the atom and loses its energy. This released energy appears as harmonic modes. That light depends on the trajectories of the liberated electrons. Agostini devised a technique called RABBIT which showed that the arrival times of the electrons consisted of a train of 250-attosecond pulses. Later Krausz developed a different strategy called streaking which confirmed the presence of 650-attosecond pulses [11]. One of the

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first applications of this knowledge was to study the photoelectric effect, i.e., the production of free electrons when a material is exposed to light of sufficiently high frequency. Now researchers can time just how long it takes to liberate an electron from a material and to track electrons as they migrate around an atom or molecule during chemical reactions.

Another addition to the area of neural connectivity is the brain machine interface (BMI) which can translate neural activity into digital commands to control prostheses [12]. This decoder in BMI models the mechanism relating to neural activity. In fact, this decoder models neural connectivity and the single neuronal tuning property at thesss same time. The decoder in the BMI system translates neural activity into movements and demonstrates how neurons contribute to generate movements. In the brain, the neural connectivity and the single neuronal property both contribute to encoding the movement or stimuli. The electrons within the neuron are in a constant state of Brownian movement, but when stimulated by one of several events, the electrons then line up in some order. It is at that time when the thought translates into action. That this is the only method to translate thought into action is surely not the case in that the researchers at the Allen Institute for Brain Science publish that their brain atlas maps 3300 mystery cells in the brain and brain stem [13]. So far, this group has only sampled a tiny fraction of the 170 billion cells which they estimate make up the human brain. This study also shows that there are 16,000 genes active in the brain and they are activated in different cells in various combinations. These genes are involved in the building of connections between neurons, and these are known as synapses. It is the connection and the synapse that allows the cerebral neurons to communicate with each other.

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