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The Science behind Avatar (movie)

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Abstract

This paper aims to look at the science behind the movie "Avatar". We will be exploring how Jake's inability to walk as a human can still allow him to walk and fun freely as an avatar in Pandora. Another concept that we will be looking at, is the use of the avatar by Jake that was supposedly made for his twin brother.

Introduction

Avatar is a movie about the relationship between two different species from separate worlds: humans and Na'vi. Pandora is the world of the Na'vi but humans cannot breathe Pandora's air, hence the development of the "Avatar Program". This program enables a link to be made between humans and their own avatar: a genetically bred Na'vi hybrid that allows them to function as a part of the Na'vi population in Pandora.

Avatar – Jake Sully

Jake Sully, the main protagonist of the movie, has paraplegia: an inability to use the lower extremities, after suffering a spinal injury during a war in Venezuela.

Initially, the avatar that Jake uses to access the world of Pandora belonged to his twin brother, Tom: a scientist that was a part of developing the Avatar Program. However, after he died, Jake was asked to take his place in the program. Each avatar is specific to their own human DNA; however, as Jake and Tom are twins, they are genetically similar and Jake can therefore use the avatar designed for Tom.

DNA

All living things are made up of cells, each containing their own unique DNA (deoxyribonucleic acid). A molecule of DNA consists of two complementary chains of nucleotides, held together by hydrogen bonding. In DNA, there are four different nitrogenous bases: Adenine (A), Thymine (T), Guanine (G) and Cytosine (C). These four nucleotides form two pairs of complementarity, A forms hydrogen bonds with T, whereas G forms hydrogen

bonds with C, meaning that A and C would not be able to bind together complementarily. In ribonucleic acids (RNA), however, thymine is replaced with uracil [A], base-pairing with adenine instead [1].

DNA provides a mechanism for heredity, encoding information in the form of nucleotide sequencing along a strand. An individual's genome can be defined as that individual's complete set of DNA information. Its structure allows for genetic information to be passed on from the parent to offspring [1].

However, this is not the case for the Na'vi population; the cellular nucleus does not use DNA or RNA to encode for their genetic information. Instead, this has allowed for a "translation table" to be created, matching the DNA of a human's to that of a Na'vi NVTranscriptase equivalent. It is this translation of information that allows for a strong enough neural resonance, permitting the mental communication between the human body and the avatar body.

Nerve Cells

Neurons are the functional unit of the nervous system, and activity that takes place across neurons is usually generated by a series of action potentials [2].

The typical neuron consists of a cell body, and a varied number of dendrites that appear branch-like. The nucleus is contained in the cell body, as well as many other apparatuses for the synthesis of

substances required for the functions of the nerve cells [2].

Dendrites branch off from the cell body and convey message signals toward the cell body. They are the main component that receives information from other neurons; therefore, the shape and size of the dendrites, as well as the distribution of channels and the population, contribute to the synaptic input affecting the neuron [2].

Cell Communication

Information is conveyed through neural circuits in the form of action potentials via the axons of neurons, or by synaptic transmission between the axons and dendrites [2].

Action potentials are produced from the rapid opening and voltage inactivation of sodium (Na^+) ion channels, and the delayed opening and closing of potassium (K^+) ion channels [2].

Cell communication can take place using electrical or chemical synapses. The first directly connects the cytosol of two neurons, and allows a current to flow between the two. The latter involves the release of a neurotransmitter from the presynaptic neuron, diffusion across the synapse and the binding of neurotransmitters to receptors found on the postsynaptic cell [2].

Neural Networks

It is assumed that memory is the result of changes in the strength of synaptic transmissions throughout neuron. Hebb's law states that, if a synapse is activate at the same time a postsynaptic neuron is also active, then the synapse will be strengthened: a phenomenon known as *Hebbian learning*. Studies have shown that the stimulation of axons of the perforant pathway resulted in a long-term increase in the number of excitatory postsynaptic potentials (EPSPs). This increased number of stimulations

generated larger postsynaptic responses, another phenomenon known as *long-term potentiation* (LTP). It is this mechanism that allows for the learning of new abilities, and the memory of these abilities [3].

Memory

There is evidence to suggest that memory is supported by many different cognitive and neural systems. The brain structures involved in the memory processes differ depending on the type of information being memorised. There are cortical and subcortical subunits that contribute to the learning of skills and habits, especially those that require motor learning [3].

In Context/Conclusion

A developing embryo can split during the first month, resulting in identical (monozygotic) twins whereas fraternal twins develop from two separate egg and sperm cells [1]. The movie suggests that Jake and Tom may have been identical twins due to their genetic similarities but they would not have been genetically identical as mutations can occur in the developing foetus.

Although Jake has lost the ability to use his lower extremities, he has been granted the use of his legs in Pandora as an avatar. Jake is still capable of walking because his ability to walk is still embedded in his memory; that is, the neural networks that were involved in developing movement have been strengthened through long-term potentiation, as suggested by Hebbian learning.

In addition, because of his similar genetics with his brother, he is able to use the avatar to his will. However, if another individual were to attempt to use the avatar, it would be incompatible; the genetics would not link up with the Na'vi hybrid thus becoming dysfunctional.

References

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