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From Aquatic Life to Aviation, Are we affected by the magnetic field of the earth?

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Abstract

There are many illnesses and behaviors that are associated with air travel, yet there is no convincing explanation for the reason of these symptoms. An induced voltage has to be created in the brain due the changing of magnetic flux while flying through the magnetic field of the Earth. An estimation of this induced voltage was performed in this study and an argument was made to suggest that this induced voltage is the cause of air travel symptoms.

Keywords: Magnetic field, Aviation, Induced voltage, Health, Physics

1 Introduction

It is well known that when a copper wire, or any wire, is passed, through the magnetic field of a bar magnet, a flow of electrons, or current I, is induced through the wire following Faraday's law of induction. The induced voltage V across the wire is obtained by ohm's law V = IR, where R is the electric resistance of the wire. The magnitude of the current and voltage depends on the wire's direction (θ) of movement relative to the axis between the North and South magnetic poles of the magnetic field, the speed of the wire *v* when it passes by the magnet, the strength of the magnetic field of the magnet B, as well as the length of the wire L. All these factors follow equation (1) which is described in any physics text book and derived from Faraday's law:

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$$V = B\, vL \sin\theta \tag{1}$$

The Earth is effectively a magnet where the North magnetic pole is located near the South geographic pole, and the South magnetic pole is located near the North geographic pole. The magnetic field of the earth is known to have a maximum value of 50 μT. Thus any movement by any object should induce current and voltage across that object.

As an example, let us look to nature: Sharks are known to be capable of recognizing the induced voltage created in their head as they swim through the earth's magnetic field -- actually they use that induced voltage to navigate [1]. In particular, a hammerhead shark's head is composed of ionic fluids which can be considered a biological version of a copper wire moving by a magnet (in this case the earth's magnet). The strength of this induced voltage depends on the speed and direction of the movement of the ionic fluids in the shark's head relative to the local magnetic field. The lateral elongation of the head (of length say L, see Figure 1) would amplify the induced voltage according to equation (1). There are electric receptors on either side of the shark's wide head, and these receptors provide a great ability to detect the induced voltage [1]. What about Humans? The human brain has about 10 billion neurons and each neuron is composed of ionic material that is sensitive to voltages. This study is about the possible effect of the induced voltage created in our brains when we move on or fly above the earth passing through its magnetic field.

2 Preliminary Notes

Estimation of Induced Voltages:

2.1. Hammerhead Shark:

We are going to do a rough calculation to estimate the induced voltage created across the Hammerhead shark's extended head of length L when it swims, see Figure 1. The Hammerhead shark speed ranges from 1 m/s, which is about a fast-paced human walk, to 4 m/s when the shark is moving fast or jumping [1]. The average head width of these sharks is about 6% to 8% of body length [2] – so L is about 0.4 meters for a large shark of a body length of 6 m. Using the magnetic field of the Earth of 50 μT and assuming an angle of θ= 90 degrees between B and v for simplicity, the induced voltage across the Hammerhead shark can be estimated using equation (1) to be 21μV for 1 m/s speed and 84 μV for the 4 m/s speed. An induced voltage, one as small as 21μV, can be sensed by the shark and used for navigation.

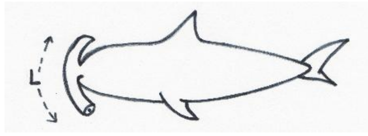


Figure 1: A sketch of the Hammerhead shark showing the lateral elongation of the head.

2.2 The Human Brain:

Let's consider a strip of our brain of width of 0.1 m (approximately the width of our head), and estimate the induced voltage in that strip while we walk, drive, or fly. As the same as the shark, we will use 50 μT for the magnetic field of the Earth and a 90 degrees angle for θ.

2.2.1. Walking with speed of 1 m/s:

For a speed of 1m/s, B = 50 μT, L = 0.1 m and θ = 90^o, Equation (1) will give us 5 μV induced voltage. This is about ¼ of the 21 μV detected by the shark for normal swim at the same speed of 1 m/s. This is because the length of the shark's head is about 4 times longer than the human brain.

2.2.2. Driving at the speed of 30 m/s (about 65 miles per hour)

At 30 m/s using the samevalues of B, L and θ used in part (a), Equation (1) will yield 150 μV. This is about seven times the voltage sensed by the shark at its normal swim at the speed of 1 m/s.

2.2.3. Flying in a civilian jetliner at 280 m/s: (626 mph)

For this speed and same values of B, L and θ used in part a and b, Equation (1) gives us an induced voltage of 1.4 mV (1400 μV) which is 67 times the 21μV that induced in the head of the shark at normal swim at 1 m/s, or about 17 times of the 84 μV when the shark is at maximum speed of 4 m/s.

2.3 Flying the most recent jetfighter at 560 m/s: (~ 1,250 mph)

The newest jetfighter is much faster than a civilian jetliner with a max speed greater than twice the speed of the civilian jetliner. Assuming twice the speed (560 m/s) of the civilian jet, and using the same values of B, L and θ used in the parts a b, and c, Equation (1) gives us an induced voltage of 2.8 mV (2800 μV) which is 134 times the 21μV that is induced in the head of the shark at normal swim, or about 34 times the 84 μV when the shark is at maximum speed of 4 m/s.

3 Main Results

Electrical signals in the human brain move within neurons, which have dendrites and axons. Axons send signals to other neurons by secreting neurotransmitters at synapses [3]. In axons, brief pulses of voltage known as action potentials are triggered when the electric potential changes. A resting potential of negative 60 mV has a threshold potential of negative 40 mV, this is a 20 mV potential difference [4]. An induced voltage of 1.4 mV is calculated above for the strip of the brain while flying in a civilian airliner. It measures 7% of the 20 mV potential difference required for the neuron to “fire”. Can this 1.4 mV affect the electricity of the neuron and thus affect our health when we fly?

There are many illnesses that are associated with air travel such as anxiety, constipation, diarrhea, confusion, dehydration, headaches, irritability, nausea, excessive perspiration, balance and coordination problems, and even memory disturbances [5]. Could the induced voltage created when we fly solve the mystery of air travel illness?

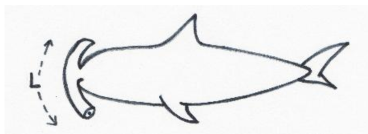
As an example, let us look toward the sky. In military aviation, the newest of the U.S. high speed jetfighters made national news recently for having many incidents in regards to pilots passing out during flight [6].The mental status of pilots was affected including a decreased level of alertness or memory loss after landing and even losing consciousness. The vast majority of pilots experienced lingering respiratory problems and a chronic cough; and some experienced neurological changes [7]. There was no explanation or solution to the chronic cough, and the presence of toxins and particles in some ground crew was considered to be unrelated [8].This jet has a speed greater than double that of the civilian jetliner and faster than any other jetfighter. As mentioned above, doubling the speed will give us an induced voltage of 2.8 mV which is twice the 1.4 mV calculated above for a civilian jetliner. This 2.8 mV is 14% of the 20 mV required to fire aneuron.

There is one other factor to be considered for the jetfighter verses a passenger jetliner. While the civilian jetliner is somewhat consistent with its speed and direction, the jetfighter is highly maneuverable and thus would have an incredible increase in the induced voltage while maneuvering. Maneuvering causes an additional change in the magnetic flux and thus an additional value of the induced voltage. Actually, the death of a pilot was attributed by investigators to the momentarily loss of consciousness during a maneuver [9] while flying one of these new jetfighters. Could a connection be made between the induced voltage created in the pilot’s head while flying these fast jetfighters and the pilot’s ability to control the plane?

4 Labels of figures and tables

Figure 1: A sketch of the Hammerhead shark showing the lateral elongation of the head.

2.1. Hammerhead Shark:



5 Conclusion

In summary, the Hammerhead shark deals with a maximum estimated induced voltage of 0.084 mV, converted from microvolts (used above) for comparison. Our brain deals with 1.4 mV while flying a civilian jet and 2.8 mV while flying the newest jetfighter -- 17 to 34 times the shark maximum induced voltage, and up to 14% of the voltage required for the neurons in our brains to fire. In the authors’ opinions, induced voltages created by changing the magnetic flux while flying through the magnetic field of the Earth is worthy of serious empirical studies. The authors are not aware of a single study of this kind. Flying at a high rate of speed is a relatively new phenomenon of our generation and it will be as well for future generations due to new technologies. Like any new technology, it is a necessity to investigate new effects such as the induced voltage of the earth on our health while flying, an affect that previous generations avoided.

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