Conscientious Mammalian Magnetoreception Capabilities by Means of the Cryptochrome-2 Protein

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Introduction

The purpose of this experiment is to determine the extent of the magnetoreception capabilities of mice and other organisms, specifically humans. Organisms from all five kingdoms of life possess magnetoreception abilities that influence their orientation and migratory behaviors, with mice being able to do so with use of the cryptochrome-2 protein, also in humans[1]. However, the human ability to use this protein to detect magnetic fields is little-researched and highly debated. By attempting to train mice to exhibit designated behaviors according to differences in Earth's magnetic field, knowledge will be gained as to whether they are consciously aware of and according to Earth's geomagnetic field or if the mice respond to them as a result of subconscious instinct. This will give insight as to the complexity of their biochemistry and biology, insight into their evolutionary history, and offer a new perspective on the controversial topic of human magnetoreception.

Background

- Magnetoreception is the ability for an organism to detect and utilize magnetic fields, typically to direct orientation and navigation
- Mice, as in figure 1, sense magnetic fields as a result of the cryptochrome-2 protein in their retina, a protein that humans also possess
- Earth has a natural magnetic field of its own, between 25,000 nanoteslas - 65,000 nanoteslas -- a stimuli that when interpreted, influences organismal behavior
- Magnetic fields can be cancelled out with magnetic the creation of another magnetic field at the same strength and flow at an opposite direction
- Mice can be trained to showcase their differentiative cognitive capabilities through behavioral training using positive reinforcement

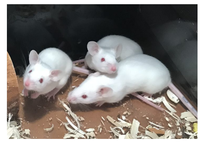

Figure 1. The three CD-1 mice used for experimentation

Methods

1. Train the mice to become comfortable with human handling and other aspects of experimentation
   Using positive reinforcement, gradually familiarize the mice to the various components of laboratory testing
2. Test for cognitive deficits of the test subjects using a T-maze (Figure 2)
   During each trial, each mouse should explore the opposite arm of the maze from originally explored
3. Determine the most motivating reward
   Compare the test subjects' responsiveness to various award times to determine the most effectual
4. Test to see if the mice have a conscious awareness of Earth's geomagnetic field
   Train the mice to go to a designated side of the experimental area (Figure 4) based on the presence or reduction of Earth's magnetic field, manipulated by the set up seen in Figure 3

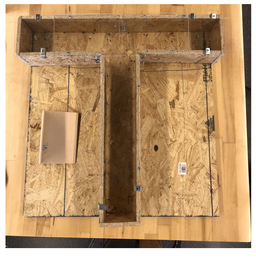

Figure 2. T-maze to test for cognitive deficits prior to training

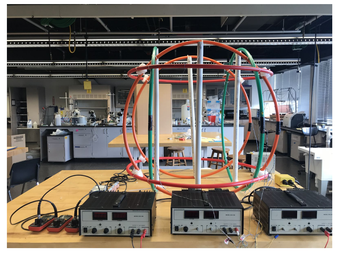

Figure 3. Hoopla system used to cancel out Earth's geomagnetic field in the training environment

Figure 4. Training environment with a split colored floor for indication of awareness of geomagnetic changes

Results

- Mouse 001 roamed 9/16 times when in a normal geomagnetic field environment and 1/16 when in a reduced magnetic field environment
- There was a 50% overall decrease in roaming when mouse 001 was in an environment with a reduced geomagnetic field strength (Figure 5)
- Mouse 001 correctly indicated the state of the surrounding magnetic field 5/16 times in the first half of experimentation and 10/16 times in the second half of experimentation
- There was a 31.25% overall increase in correct choice displaying conscious awareness of Earth's magnetic field (Figure 6)
- Mouse 001 made errors 7/16 times in the first half of experimentation and 3/16 times in the second half of experimentation

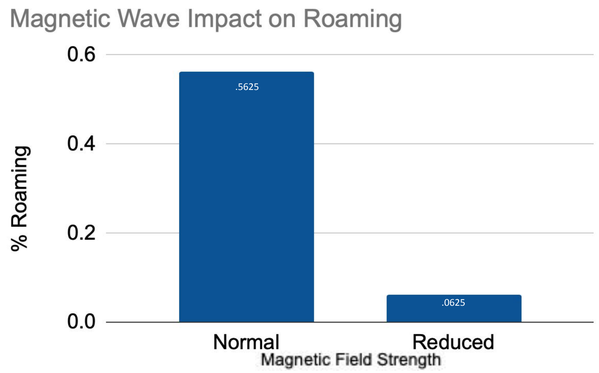

Figure 5. The impact of the magnetic field strength on the roaming of the mouse. There is a significant impact of the presence or reduction of Earth's geomagnetic field on roaming ($p = .0028$).

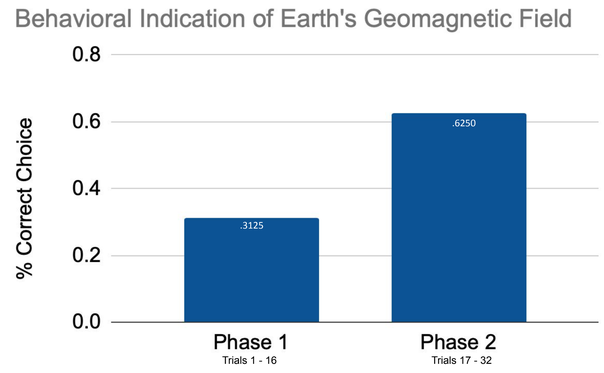

Figure 6. Percent correct indication of the changes in the geomagnetic field throughout throughout experimentation. There is no significant difference between the percent correct choice in the first and second half of experimentation (p-value = .0765).

*Mouse 002 and 003 showed early indication of stress and were relieved from further experimentation. All data is from mouse 001.

Discussion

- This supports previous research that magnetic fields influence mouse behavior on roaming
- Limitation: Mouse 002 and 003 exhibited indications of stress when in a reduced magnetic field enviornment
- Limitation: Only one subject used to achieve final results
- Limitation: The mouse did not always express reward awareness
- Due to the discrepancies in roaming based on the presence or reduction of Earth's geomagnetic field, in addition to the little evidence the mice had a conscious awareness of it, it can be concluded that when mice exhibit a behavior typical to that expected with the magnetic field, it is likely due to subconscious instinct
- The complexity of the biochemistry and biology of mice is still undetermined. I recommend this experiment be replicated with additional subjects for definite conclusions to be drawn regarding mcie' conscious recognition of Earth's Magnetic Field
- This suggests humans do not have the ability to conscientiously recognize magnetic fields

Notable Contributors

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References

1. Malkemper, E., Eder, S., Begall, S. *et al.* Magnetoreception in the wood mouse (*Apodemus sylvaticus*): influence of weak frequency-modulated radio frequency fields. *Sci Rep* 5, 9917 (2015).