Electric Memory

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Introduction

Two years ago I did an experiment testing the polarity of a weakly electric fish in relation ship to the conductivity of its surroundings. Although the experiment wasn't a complete success, the processes behind electrolocation have plagued my thoughts since. Electroreception is a feature common in many species of fish. It is where specialized organs in the body, including sections of the brain, function in sensing, and sometimes sending, electric signals. Electrolocation is the usage of this ability to "see" your surroundings by transmitting electricity, which then bounces back and is received by a sensory organ. Based upon the parameters of the currents' return, the fish distinguishes its surroundings much like radar and sonar –location.

Two types of weakly electric fish exist, those that give off waves and those that give off pulses. The "wave" fish are constantly transmitting electric currents, while "pulse" fish give off separated bursts. The electric organ of a pulsing fish contains multiple electrically excitable organs known as electrocytes, which receive a command from the brain to asymmetrically polarize the cells (Kawasaki). In this way they act as a battery and send out an *electric organ discharge*, or EOD. These processes can be used to navigate, sense predators, and communicate such as hunting in groups, distinguishing the sex of an organism within the species (useful in mating), and territorial competition.

The fish I used for my study, both two years ago and this year, was the elephant nose fish, or *Gnathonemus petersii.* Their habitat is in the wooded areas of west and central Africa. With living in muddy waters and having poor vision, electrolocation is an obvious advantage. When changes occurred in its environment, an elephant nose fish would send out a large number of frequent pulses in order to see if it was in danger. When sensing its environment, its genetic memory would let it know if it was a predator, moving objects, or any other type of possible threat. Recently discovering this for myself, I wondered if the fish could possibly retain a short-term *learned* memory of its spatial surroundings.

Hypothesis

This year I tested the elephant nose fish's short-term memory. I did this by introducing a distinctly conductive and shaped object into the fish's area and monitored its EOD activity several times over short increments. My hypothesis, or scientifically based and testable guess, of this experiment's outcome is:

If an elephant nose fish can retain short term memory of its surroundings, then I would expect that the number of EOD pulses to decrease from those recorded in the original observation as I introduced the object several more times.

Materials

In order to conduct this experiment I used several different tools and resources. The following is a list of those materials.

> Writing utensils, notebook, computer various written resources, all for preparation, and…
>
> Fish tank (with filtration, lighting, thermometer, and clear tube), elephant nose fish, object (ruler with a LEGO horse tied to it by a string), wired probe, external speakers, microphone, computer, and audio recording software, all for experimentation and observations.

Method

To start the experiment, I turned off the filtration of the fish's tank, so it wouldn't disrupt my audio recordings. I did it in advance so whether the fish was used to the surroundings during my experiment did not affect its outcome. Elephant nose fish like being in closed spaces because the ability to feel most of the area around them is securing. I had a wired probe near the tube that the fish stayed in, which was connected to an external speaker. This way each pulse would be audible and picked up by the microphone on my computer.

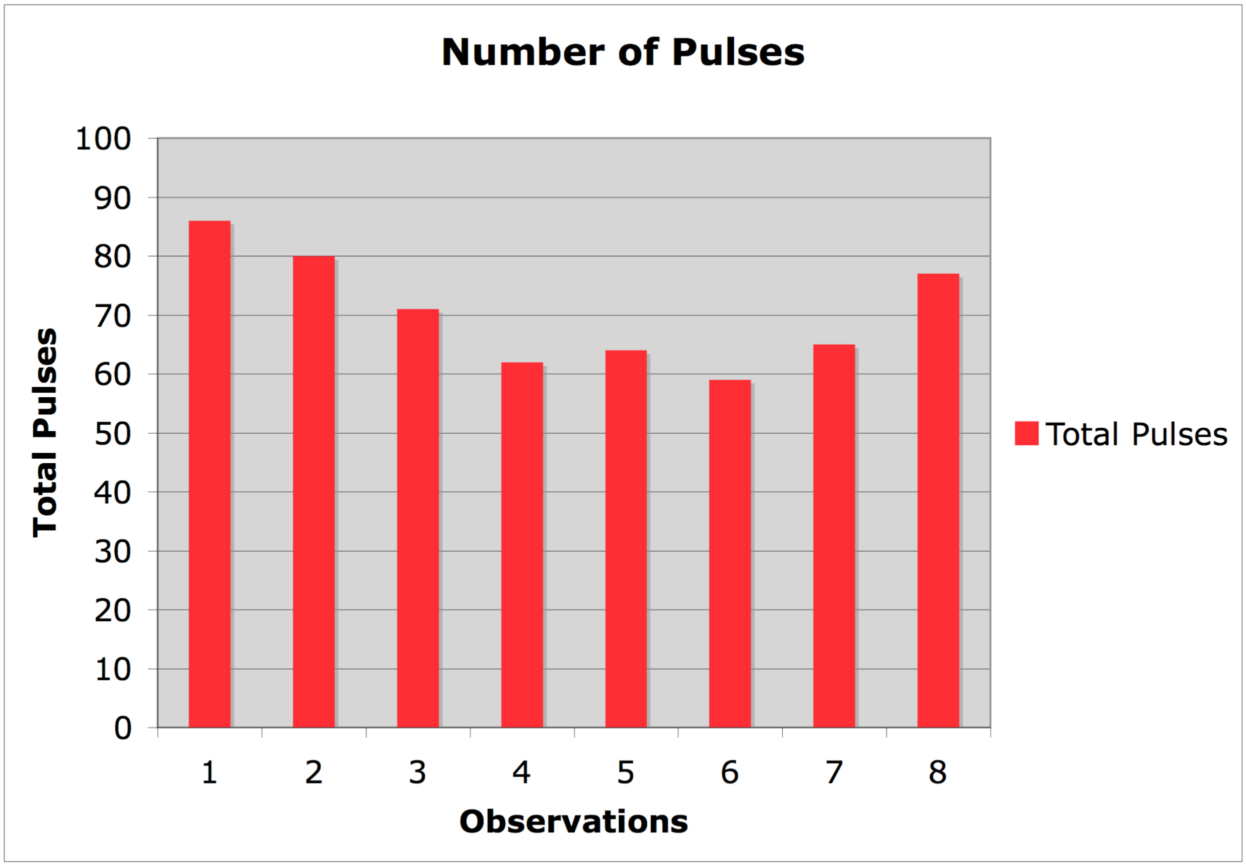
To record observations, I started to record the audio as I inserted the object in the tank, close to the tube. I took an approximately 30 second clip, 10 of which was used to test my hypothesis. I did this eight times, in about 2 minute intervals. During the data-collecting period, all sound and light levels stayed constant, besides the shifting shadows of me moving around. The circumstances of how I preformed experimentation also stayed constant. All of this is important in producing validly comparable results.

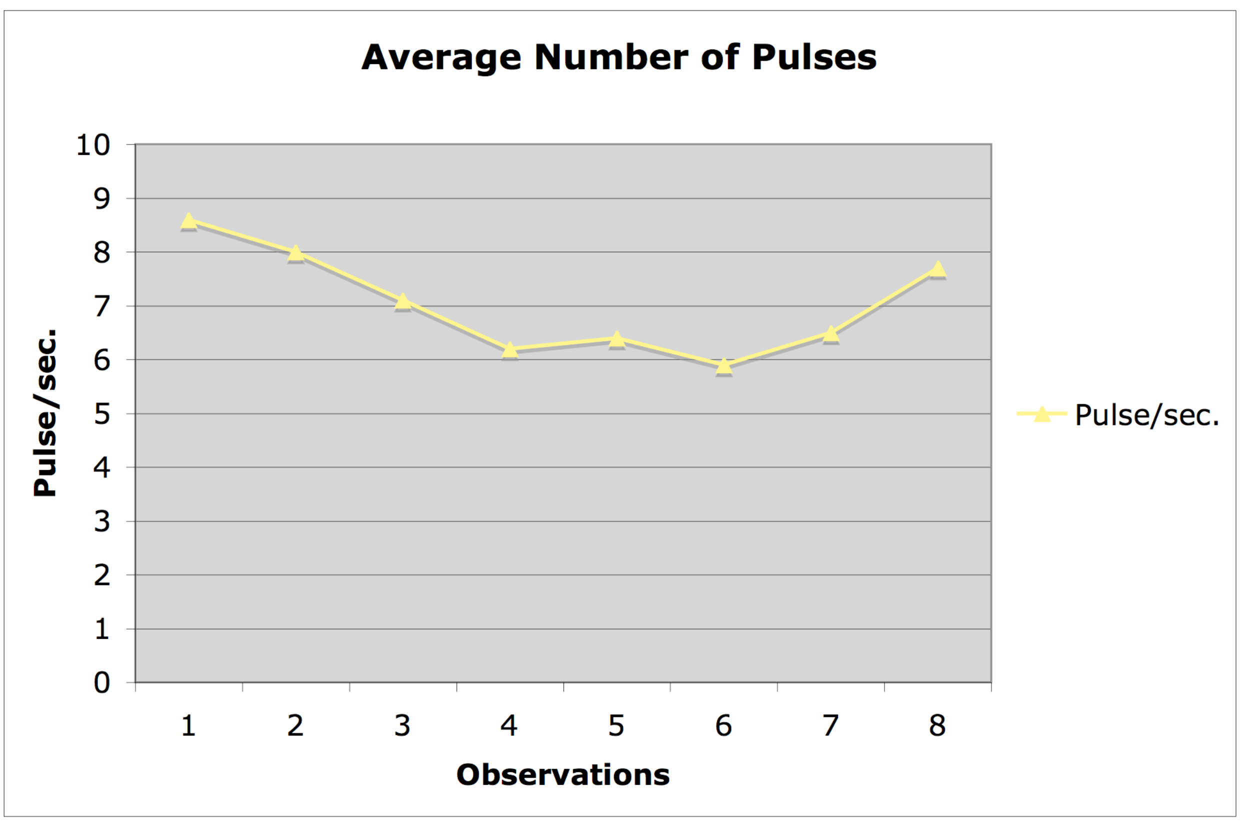
In any controlled experiment, there are two variables that account for the outcome. The *independent variable* is the one controlled by the tester, or me, and causes the *dependent* or *responding variable* to produce a result. Being controlled, the presence of the object and the intervals at which it was introduced to the fish is the independent variable. It would cause the fish to react through electrolocation, so the dependent variable was the number of EOD Pulses observed.

My experiment took place with one fish; therefore my data doesn't necessarily conclude anything for the elephant nose species, just my chosen test subject.

Looking at my data through the charts and table supplied, you can see the pulse response with each 10-second observation. You'll notice from Observations 1 through 4, the total number of pulses decreases. From Observations 4 to 7 the number of pulses is between 59 and 65. Since a fish will always be giving off pulses, it makes sense that the total wouldn't perpetually decrease. The last observation, 8, rose rather aggressively which could be for any number of unaccounted variables, and should be disregarded in respect with the overall flow of the data. Although there isn't a constant negative slope in pulse numbers, the number of pulses dropped from the observation where the object was initially introduced, which is all I was concerned with in testing my hypothesis.

Observation	Total Pulses	Pulse/sec.
1	86	8.6
2	80	8
3	71	7.1
4	62	6.2
5	64	6.4
6	59	5.9
7	65	6.5
8	77	7.7


Number of Pulses
Total Pulses
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
Observations
Total Pulses


Average Number of Pulses
Pulse/sec.
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
Observations
Pulse/sec.

Looking strictly at the data I collected, it would support my hypothesis. The number of pulses over all decreased, and stayed below the first two observations. This *could* mean that an elephant nose fish does, in fact, have the potential of learned short-term, spatial memory, in relationship to EOD's and electrolocation. Whether this would hold true in the wild cannot be determined as many variables are constantly changing and are not controlled.

If I were to redo this experiment, I would conduct it several times and with even more fish to prove its validity and implications. Since learned short-term memory is possible, further experimentation might be used to test how a specimen would respond to certain frequencies over time, such as the type of electricity given off in muscle constriction. This might establish whether a fish may recognize certain conducting objects or species as harmless, thus getting use to their presence and expecting their actions.

Bibliography

Caputi, A. A., Budelli, R., Grant, K., & Bell, C. C. (1998). THE ELECTRIC IMAGE IN WEAKLY ELECTRIC FISH: PHYSICAL IMAGES OF RESISTIVE OBJECTS IN *GNATHONEMUS PETERSII*. The Journal of Experimental Biology, 201, 2115–2128.

Bell, C. C. "Weakly Electric Fish." Tualatin Valley Junior Academy, Biology in Class Lecture. Huntingdon, PA. 22 Jan. 2007.

Bennett, M. V. L. (2003).Electrolocation in Fish: The Electric Organ DischargeElephant Nose Fish. Grass.

Kawasaki, M. Electric Fish. Retrieved April 2, 2007, from Masashi Kawasaki Web site: http://people.virginia.edu/~mk3u/mk_lab/index.htm