Biological Sciences

Demonstration of Electromagnetic Energy Emanating from Isolated Rodent Whiskers and the Response to Intermittent Vibrations

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In the present study we provide evidence of inherent electromagnetic (EM) energy in the isolated rodent whisker and the induction of electromagnetic waves (EMWs) emanating from the follicle area. A solution containing aliquots of nano-sized iron particles and Prussian Blue Stain (PBS Fe 2000) was applied between two glass slides which also held a rodent whisker. Vibrations of the whisker was caused by application of air puffs to the tip of the shaft protruding from one side of the slide "sandwich" (SWD). Spontaneous EMWs emanating from the whisker were imaged as a continuous circulation of the iron particles outlining the magnetic lines of force surrounding the follicle and bulb area. Intermittently electromagnetic radiations were recorded as visible rays of white light penetrating the magnetic field resulting iron particle tracks. The inherent electromagnetic energy of the rodent whisker showed reproducible egress images with and without triggering vibrations in solutions containing nano-sized particles and PBS Fe 2000. *Journal of Nature and Science, 1(3):e52, 2015.*

Rat whisker | magnet fields | whisking | follicle

Introduction

Recent studies have shown that rat whiskers, when subjected to vibrations, can serve as conduits of electrical signaling to specific areas of the brain. This effect is called, "whisking" which was reproduced by the application of air puffs on whiskers normally attached to the skin in live rats [Honhjoh, 2014 Laurens, 2014]. In the present report we present evidence that isolated rodent whiskers have inherent electromagnetic energy which creates electromagnetic fields (EMFs) surrounding the follicle as well as projecting electromagnetic radiations (ER) as rays of light from the follicle which also can be triggered by induced air puffs, mimicking whisking.

Materials and Methods

Preparation of the Iron and Staining Solutions

A fine iron particle solution was prepared by mixing several grams of powdered iron filings (Edmond Scientific, Co., Tonawanda, NY) in 200 cc of deionized water (resistivity, 18.2 MΩ.cm). After standing for several hours the supernatant was carefully decanted for sizing of the iron nano-sized iron particles.

The particle size and distribution of the nanoparticles from the supernatant was determined using dynamic light scattering (DLS) and the zeta potential using phase analysis light scattering by a Zeta potential analyzer (ZetaPALS, Brookhaven Instruments Corp, Holtsville, NY). For sizing, 1.5 ml of the solution in de-ionized water was scanned at 25 °C and the values obtained in nanometers (nm). A similar aliquot of the fine iron particle solution was scanned for 25 runs at 25 °C. for determining zeta potentials (in millivolts).Using a transfer pipette an aliquot of the solution containing the iron particles (mean particle size 2000 nm) was combined with a similar aliquot of Prussian Blue Stain solution (PBS, 2.5% potassium Ferrocyanide. 2.5% hydrochloric acid). This combination solution will be referred to as (PBS Fe 2000) in this study.

Procedures

All animals were handled according to the guidelines of the American Veterinary Medical Association (AVMA) for the Euthanasia of animals. Tissues were harvested after euthanasia was induced in an approved protocol by the Animal Care and Use Committee (IACUC) of the University of Oklahoma. Specifically, exposure of the rodent to carbon dioxide in an enclosed chamber was monitored until breathing ceased for more than 5 minutes and no heartbeat was detected. The chest was opened to ensure respiratory arrest and there was no cardiac activity. A portion of the skin pads (right and left) were surgically removed at the snout and immersed in saline solution in separately labeled beakers.

Care was taken in plucking 6 of the longest C line whiskers bilaterally as depicted in the whisker rodent diagram (average length 45 mm) (Figure 1). Then the rest of the whiskers were plucked and stored in two empty slide boxes, covered and classified as right or left. One specimen was mounted and processed before the next SDW was prepared. Observations were recorded in microphotographs during and after the evaporation process, this allowed documentation of temporal changes occurring as the evaporation line moved until eventual drying occurred. The complete evaporation in the SDW ranged from 8 to 12 hours.

Figure 1. Drawing of a rat facial whisker locations. Each whisker act as sensory organs by touching the environment and relating signals to a specific area of the brain. This signal is initiated by a process of rapid oscillation dubbed "whisking". The long whisker location corresponds to the one we selected from our bilateral (right & left side snout) compressed air puffs experiments.

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***Protocol 1*:**
The whiskers from the anesthetized rats were totally encased within their individual SWD. Several drops containing a solution of PBS Fe 2000 were placed on a glass slide. Each of the whiskers (n=6) from the C line was then sequentially placed in the solution and "sandwiched" by the addition of a second glass slide. This protocol was designed to observe and record inherent electromagnetic forces (EMFs) in and projecting from undisturbed rat whiskers.

Protocol 2:
Another set of rodent whiskers from line C (n=6) were also mounted, this time with half of the hair shaft from the tip exposed to air, the other half, containing the follicle inside the SDW. The operator could then mimic the whisking process by applying bursts of air to the exposed end of the whisker. This protocol was designed only for the purpose of documenting whether inducing oscillations by air puff vibrations would evoke a synchronized EMF response from the whiskers. Pictures of the SDWs. were obtained in the normal unfiltered mode at X10 magnification with a microscope (Celestron LCD Digilat Microscope II model #44341 Torrance California USA).

Results

Protocol #1
The undisturbed whiskers (n= 6) showed evidence of electromagnetic activity in the area of follicle by the detection of circulating iron particles around the circumference of the follicle (Figure 2). Furthermore, individual images taken sequentially showed the magnetic lines of force imaged by the aggregated iron particles surrounding the follicle. Moreover, this sequence also captured another form of electromagnetic energy emanating from the follicle as a ray of white light. Note that the ray of light not only penetrates the magnetic lines of force but also diverts the aggregated iron particles to follow its path (Figure 3)

Protocol #2
The air puffs applied to the tip of the whisker induced vibrations, i.e., intermittent movement, which triggered the development of visible electromagnetic radiations manifesting as trails of aggregated iron particles as shown in Figure 4.

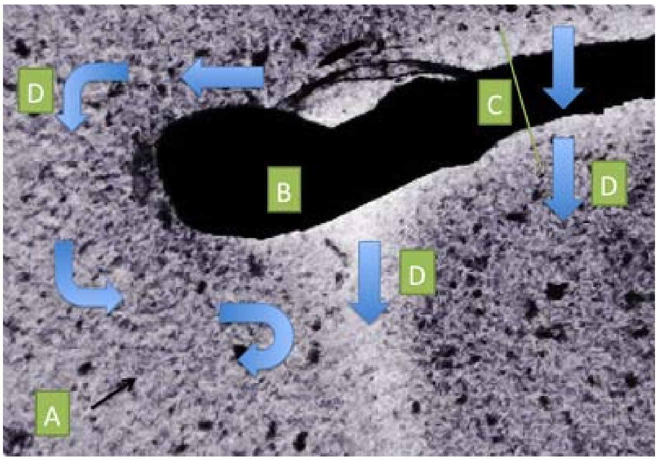


Figure 2. Microphotograph of the viewing field which captured the line of force outlined by the aggregated iron particles surrounding the follicle. This figure demonstrates the inherent magnetism of the rodent follicle. Note the ray of light, which penetrates the EMF and diverts the stream of particles to move parallel to the light ray, as well as the iron particles circulating around the follicle/bulb are. A) Iron particles B) Rat follicle C) Bulb D) Notice iron particles not influenced by the follicle/bulb magnetic forces. Also notice the white Ray of light spontaneously emitted by the follicle. The white ray serves as barrier to the circulating iron particles (please refer to Video).

S1. This figure has a supplemental video available online: http://www.jnsci.org/files/video/e52/S1.htm

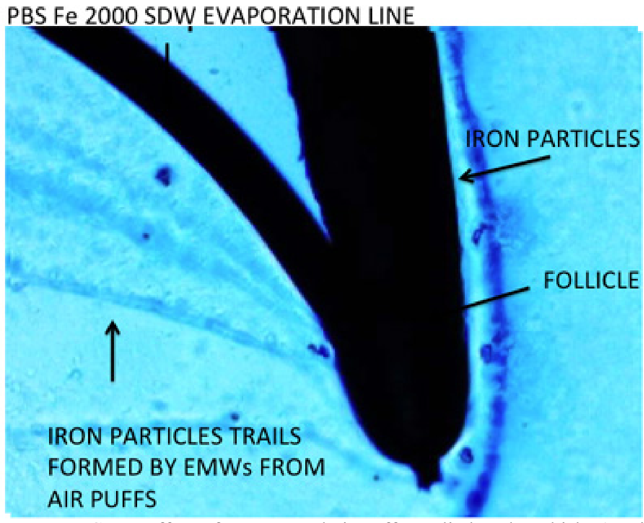
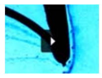


Figure 3. Cause effect of compressed air puffs applied to the whisker's tail (refer to Fig 1). The iron particles trails are a reflection of the magnetic waves emitted due to the air puff stimulation (simulating "whisking") The SDW contains a solution of iron nanoparticles that aggregate as iron particles and are sensitive to the magnetic forces (forming the iron trails)

S2. This figure has a supplemental video available online: http://www.jnsci.org/files/video/e52/S2.htm



Discussion

Background
In the case of rodents and other nocturnal animals, the lack of visual input in the dark, is compensated by a sensory input mechanism derived from long hair like structures arising from the proximal end of the head that resonate [Hartmann ,2003] These specialized structures termed vibrissa are commonly referred to as whiskers [Diamond, 2013].The term vibrissa is derived from the Latin *vibrio* (to vibrate), this property allows for resonance during nocturnal exploratory activities. Previous published reports have shown that each whisker has its corresponding somatosensory area in the rat brain. These areas are called barrels due to their shape. The mimicking of whisking by air puffs has resulted in a contralateral barrel brain activity in the rats [Honjoh T et al. 2000 & Melzer P et al. 2006].

Previous reports have provided evidence for the maintenance of metabolism and growth of rat hairs and whiskers separated from the skin [Philpott MP et al. 2000 & Robinson M et al. 1997]. These characteristics of life extend for several days in vitro.

Major findings of the present studies

We found that the isolated whisker contains inherent electromagnetic energy as evidenced by the circulating iron particles seen in the viewing field movimg around the whisker follicle/bulb area and moving along magnetic lines of force as seen in (Figure 3). In addition we showed that electromagnetic waves in the form of intermittent light rays occurred spontaneously or could be triggered by simulated whisking using air puffs to vibrate the hair shaft (figure 4).

Basis for electromagnetic properties of the rat whisker follicle: Response to vibratory stimulation.

Early studies of cuticle cells composed of keratin in wool and hair were shown to have piezoelectric properties [Martin, 1941]. The piezoelectric effect refers to that property of matter which may convert electromagnetic oscillations to mechanical vibrations or mechanical vibrations can induce electromagnetic activity. We hypothesize that an electron transfer due to ongoing metabolism within the follicle creates the inherent electromagnetic state. We also hypothesize that the metabolizing follicle induces the external EMF that captures the ambient iron nanoparticles particles as aggregates, which along with the PBS Fe 2000 provide the images of the circulating magnetic field surrounding the follicle. Furthermore, we also hypothesize that the conversion of external

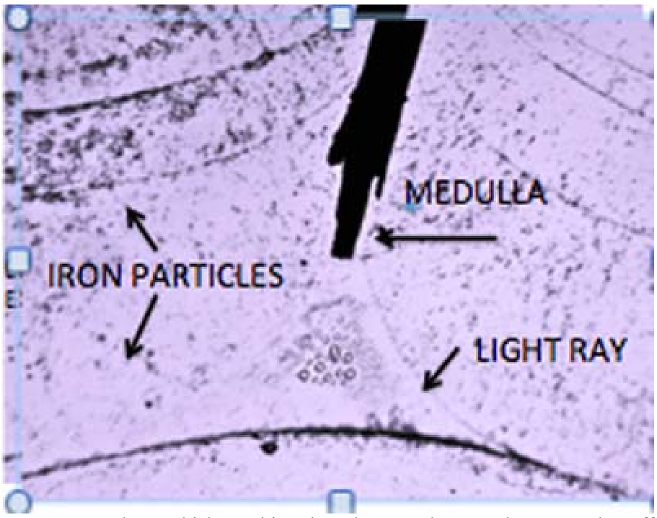


Figure 4. Rodent Whisker. This microphotograph was taken post air puff stimulation of a rodent whisker. This whisker was 8 days old and stored in an empty glossy slide box. When retrieved the follicle detached from the medulla. Shown is the effect of the piezoelectric effect (vibration liberating electrons) on the whisker's tail. There are two important findings seen: 1) The electromagnetic energy exiting the medulla as a light ray displacing the iron particles in its path and 2) The iron particles outlining the magnetic forces emitted by the shaft.

energy introduced in the whisker by the piezoelectric effect caused by air puffs, allows for trails of aggregated iron particles attracted to the transient electromagnetic radiations (Figure 4). In other words, the burst of air applied to the hair or whisker introduces energy in (disturbing the elements) whereas some energy out must be prosecuted in order to maintain the dynamic metabolic equilibrium within the tissue. In our experiments, the energy out is expressed as different forms of electromagnetic radiations, EMFs, light, emitted by the whiskers which are converted into trails by the attracted iron aggregates.

Limitations

We recognize that these studies constitute a series of observations describing the electromagnetic character of the isolated rat whisker, particularly, the follicle area and the response to induced vibrations. These novel descriptive findings, can serve as the basis for further studies employing quantitative methods and mathematical analyses of the factors involved in the demonstrations provided in the present study. For example, It may be feasible to study the effects of light with different wavelengths, e.g., red, blue lasers, applied to isolated rodent whiskers in order to determine the photoelectrons released when the follicle is triggered by coherent light rather that vibrations.

Conclusions

We have documented the inherent characteristic of magnetism in the rat whisker. The mimicking of the whisking effect was reproduced by applying air puffs bursts on to the whiskers. The media in which the whiskers were placed contained nano-sized iron particles; as well as Prussian Blue Stain which allowed for the visualization of the inherent magnetism by observing the iron particles moving around the follicles as magnetic lines of force. Furthermore, a cause/effect correlation was documented by the application of air puffs inducing electromagnetic emissions from the follicle (Figure 3 + video). The significance of these magnetic energies expressed by the rat's whisker follicle and their role in signal transmission to the brain is in need of further research in the emerging field of Bioelectromagnetism. "Fundamental mechanisms of the interaction between biological material and electromagnetic fields at non-thermal levels are not fully understood" [Shupak. 2004]. We hope that this study opens a new dimension in this understanding.

Acknowledgements

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