Measuring DC in the Head in a Novel Way, and Studying the DC from a Curious Non-Neural Event

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Introduction

We have transformed the 204 gradiometer outputs of our MEG system so that DC (direct current) in the head can be directly displayed, online. The DC is seen as a map of arrows, looking down on the head. What we did is a novel way to directly see currents in the head.

Primitive measurements of this type have been reported[1] many years ago by one of us, measured by only a 2-channel system, at only one head location at a time. In that report, an attempt to see the DC sources in the brain was masked by an unforeseen DC in the scalp. This source was hair follicles, activated by mild pressure on the scalp. Each follicle seemed to act as a DC battery, never reported previously. We here decided to re-visit and extend those early measurements, but this time using our advanced MEG helmet.

The follicle DC magnetic field is greater than that expected from the brain itself, but the brain DC measurement are our ultimate goal. Therefore our limited aim here is to quantify and better understand the DC from the follicles, to see if we can subtract out this signal, and eventually see the underlying DC from the brain's cortex.

Methods

For a measurement, the subject's head is first positioned outside the helmet. Then the subject puts his or her head into the helmet, and the new arrows are seen and recorded, perhaps in 3 seconds. Because we are detecting the gradients only, we lose the B_z which is uniform across the detecting coils; but this distribution of B_z can only be made by a distant source, of no interest, so we have lost nothing of value. Our method is useful because it is rapid, using only a single in-out motion.

Ideally, we wanted the arrows to perfectly mimic the currents in the head, so we would see the actual current flow. To do this, we have used a number of transformations. But we have attained that goal only very approximately. Using an actual element iΔl as the source at the helmet surface, we obtain the map shown in Fig 1.

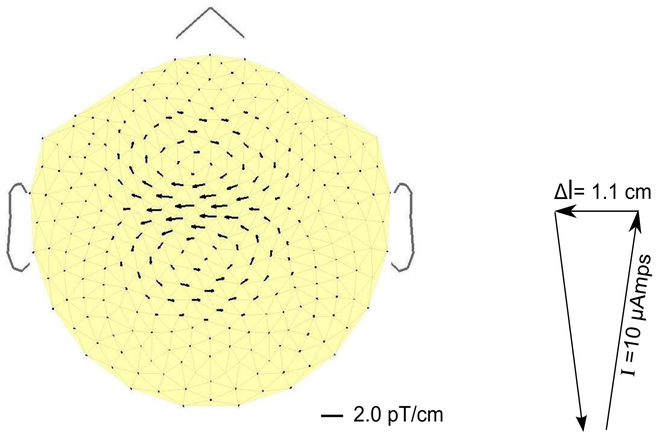

Fig.1. On-line arrowmap due to a test current element, iΔl=11 μamp-cm. This is placed tight against the helmet inside, about 20mm from the closest detection coil. The current element is here enlarged for clarity.

The side lobes are unwanted, and are only an artifact of our transformations; a more complex source of current, made up of such elements, will be distorted by these lobes. However, to a crude first approximation, this display does show the actual current. As a further check, we have measured simple current configurations such as a wire, and a continuous sheet. These show that these maps roughly do show the actual underlying currents.

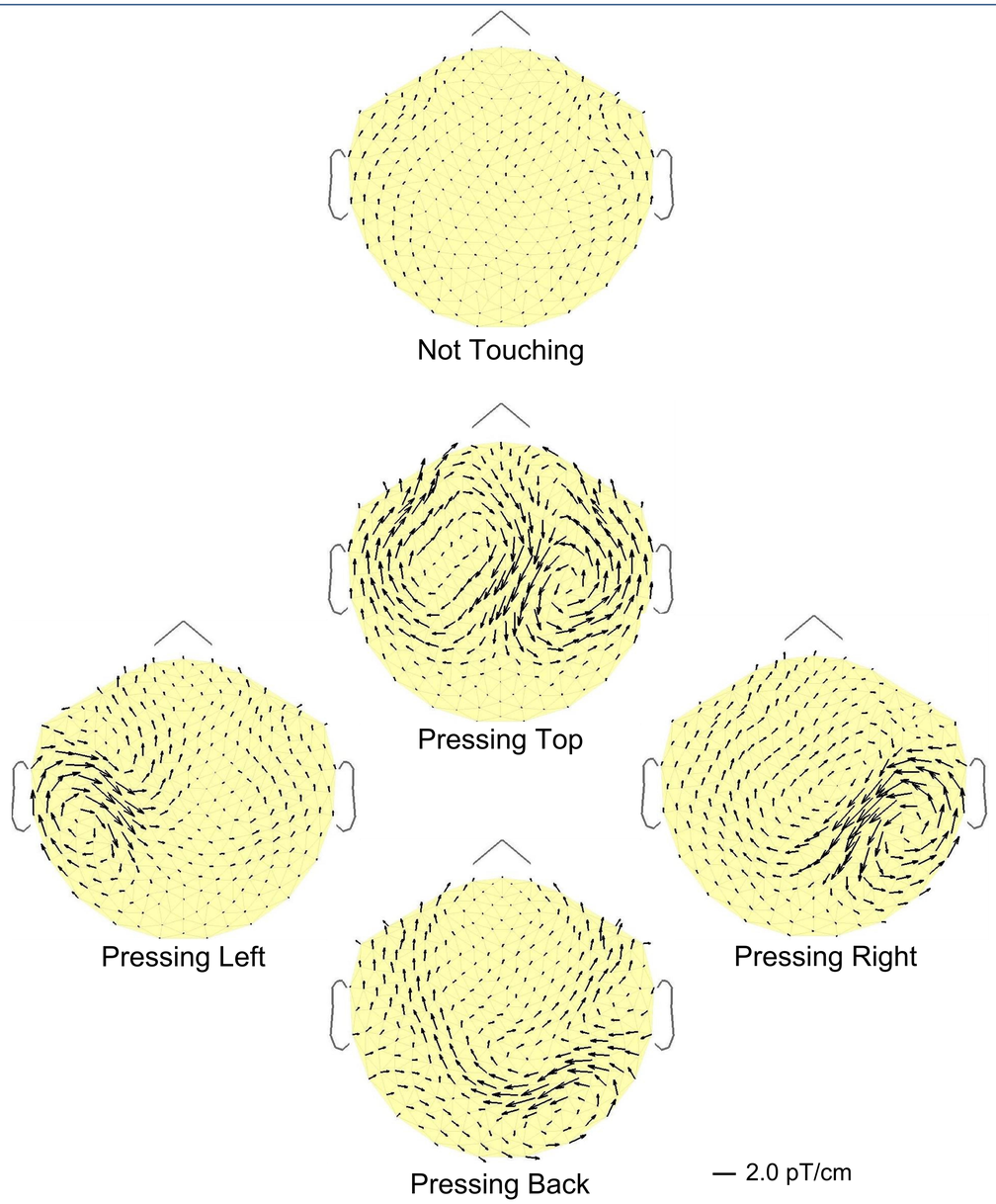

Fig. 2. Arrows roughly show the DC in the subject's scalp. Upper: head in, but not touching the helmet. Lower four: DC due to pressing different parts of the scalp against the inside of the helmet.

Results

By now we have looked at the follicle DC during about 30 recording sessions of the head, from about 15 subjects, including both men and women, and two alopecia subjects (inactive follicles). Results confirm the head findings of the old report[1], that pressing on the scalp generates DC from healthy follicles, and inactive follicles show no DC whatever. Fig. 2 shows typical results from one male adult subject with healthy hair.

The upper head, not touching anything, shows some DC flowing, typical of all subjects, but at this time we have only partially discovered the sources of this non-hair DC (some from the mouth). The lower four heads are typical of young men and women with healthy hair, shaved or not. The direction of the largest (source) currents, always opposite to the slant of the hair exiting the scalp, confirming that the DC is due to hair follicles. The rise and fall times of the signals are of the order of a second or less. The magnetic gradients and fields are larger than most reported DC levels from the brain.

Conclusion

All our subjects with healthy hair show a strong DC flowing in the scalp when the hair follicles are pressed, which is quantifyable, and should be subtractable. This phenomenon, never reported elsewhere, might be a new marker to see healthy hair follicles.

References

1. Cohen D, Palti Y, Cuffin BN, Schmid S.J. Magnetic fields produced by steady currents in the body. Proc Natl Acad Sci 1980; 77:1447-51.

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