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Magnetite Biomineralization and Magnetoreception in Organisms

A New Biomagnetism

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Chapter 32

An Attempt to Replicate the Spinning Chair Experiment

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Baker's (this volume) spinning chair experiment is an attractive approach for testing the hypothesis of human magnetoreception. It requires only a few students at a time rather than busloads, and can be run at a low level over a suitably long period of time. It is further amenable to a variety of double-blind controls over the magnetic field and subject positions which are difficult to achieve in the bus experiments.

We ran a modified version of this experiment during the winter and spring of 1982 using 10 undergraduate students at the California Institute of Technology. On the advice of Dr. Baker, subjects were initially screened through a questionnaire, and only N-sleepers who did not regularly use stereo headphones or public transportation facilities were included. Our spinning chair was built of wood like that of Baker, but differed in that it spun smoothly on a nonmagnetic, stainless-steel bearing system rather than on four wheels. Following the recommendation of magician James Randi (personal communication), we used opaqued swimming goggles as a blindfold and built nonmagnetic earmuffs using acoustic fiberboard insulation.

Experiments were conducted in a large basement chamber underneath a student dormitory. The location was chosen primarily for its close proximity to the subjects and for the relatively low local magnetic gradients. Large field values as monitored with a fluxgate magnetometer were only observed near water pipes in the 3-m-high ceiling but no measurable change was observed within the area of the spinning chair.

Rather than changing the field through a subject's head with strapped-on bar magnets as Dr. Baker did, we used two large pairs of square (~ 2-m diameter) coils to deflect the horizontal component of the geomagnetic field. The coils formed a cube with one pair aligned along magnetic north–south which could completely null or reverse the horizontal component around the subject's head, and another which could produce an east or west component of equal intensity. Power was fed to each pair of coils through a long cable which ran up through a narrow conduit hole in the cement ceiling, ran 15 m down a hallway in the overlying student dormitory and to the power supply which was located in a small student library. The circuits were controlled by two switches in the library wired so as to yield either N, S, E, or W resultant fields in the experimental chamber, and pairs of even/odd random numbers read from a table were used to select these directions with equal probability. Although the basement experimenter could signal the library with a small buzzer to indicate the start of a spinning trial and the need for a new random field setting,

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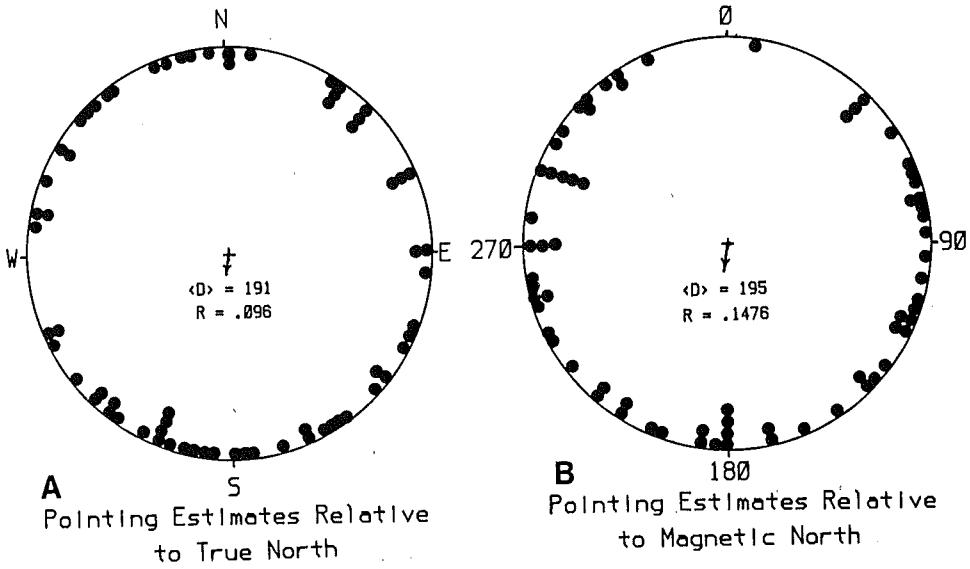

Figure 1. Results of the Caltch spinning chair experiment. Each dot is the average direction from one trail of eight spins. In (a) the directions are measured with respect to geomagnetic (true) north within the basement room, and those in (b) are with respect to the direction of the field during each spin.

the experiment was double-blind, as the "librarian" had no means to signal the basement. New field settings were changed slowly over a period of about 4–5 sec to avoid spark transients or motions in the coils.

Experimental sessions consisted of eight consecutive trials for each subject. At the start of each session, the subjects were shown magnetic north with the power to the coils turned off, and then the blindfolds and earmuffs were positioned. As described by Baker, the experimenter always remained behind the subject and slowly rotated the chair in arbitrary directions, stopping randomly in one of eight directions (N, NE, E, . . .). Stopping directions were chosen with even/odd groups of three digits from random number tables, and a light tap on the shoulder by the experimenter was used to signal the subject for a response. Subjects were instructed to first point in the direction they thought was north, and then state the direction in which they thought they were facing. Although this double response gives the same estimate of where the subjects thought north was, we chose to do it this way as a check on the consistency of their spatial orientation.

All subjects quickly learned the spatial orientations and there was usually little, if any, difference between the direction estimates from the two responses. After each session of eight spins had been completed, the responses were compared with the record of magnetic field directions from the library. Results were analyzed both with respect to true geographic north (ignoring any magnetic changes) and by using experimentally altered magnetic north.

It is clear that each successive directional response within a trial of eight spins depends at least somewhat on the direction in which the subject thought he or she was facing before the spin began. For this reason, we have used the vector average of all eight responses as independent estimates of the orientation accuracy rather than those from each spinning response (see Dayton, this volume). Figure 1 shows these second-order results for the

Table I. Second-Order Results Grouped According to Subjects from the Caltech Spinning Chair Experiments[a]

Subject	No. of 8-spin trial sessions	Estimates relative to room				Estimates relative to magnetic field			
		Pointing azimuth *r*	*p*	Verbal azimuth *r*	*p*	Pointing azimuth *r*	*p*	Verbal azimuth *r*	*p*
A	13	219/0.2545	>0.10	224/0.2672	>0.10	176/0.1519	>0.10	169/0.1468	>0.10
B	11	237/0.2165	>0.10	225/0.2508	>0.10	52/0.2669	>0.10	121/0.2654	>0.10
C	10	30/0.2089	>0.10	359/0.1923	>0.10	202/0.2950	>0.10	200/0.3662	>0.10
D	9	125/0.5526	>0.05	122/0.5787	>0.025	91/0.4633	>0.10	96/0.4178	>0.10
E	8	34/0.3565	>0.10	32/0.3765	>0.10	242/0.5559	>0.05	251/0.4307	>0.10
F	7	250/0.3668	>0.10	243/0.4250	>0.10	271/0.4310	>0.10	265/0.4813	>0.10
G	6	236/0.2711	>0.10	208/0.1358	>0.10	202/0.3581	>0.10	207/0.4861	>0.10

[a] Three subjects who had too few sessions (2, 1, and 1, respectively) have not been listed although they are included in the 68 trial sessions plotted in Fig. 1. Significance levels for the Rayleigh test of randomness are given under the columns labeled "*p*" for the numbers of trials and resultant values shown. Only subject D had marginally significant responses relative to the room, and only subject E gave one marginally significant result relative to the magnetic field.

pointing responses grouped relative to geographic north and experimental magnetic north. Neither grouping shows a significant orientation toward any direction (Rayleigh test of randomness $p < 0.10$), although there is a weak tendency in both cases for the residual vector to point south. Second-order responses grouped according to individuals (Table I) also show only one subject out of seven with a significant orientation, and that direction is southeast!

Although our results contradict those of Baker, there are several procedural differences between our experiments and his which might conceivably have influenced our results. These include: (1) our subjects were spun for a longer time and through wider arcs than were Baker's. (2) Most of our experiments were conducted in the early afternoon and evenings, rather than from 10 a.m. to 3 p.m. (3) Our subjects were permitted to wear their clothing, and we did not check their undergarments for the synthetic fiber or silk content. (4) Finally, we ran the experiment in the basement of a dormitory rather than an isolated wooden shed. We believe these differences to be of little or no importance, and tentatively conclude that Caltech students and perhaps humans in general lack any strong or useful ability to sense magnetic direction. We encourage others to try this experiment.