REINTRODUCED TIME-VARYING GEOMAGNETIC FIELD ATTENUATES ANALGESIA DUE TO REPEATED MAGNETIC FIELD SHIELDING

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ABSTRACT

Repeated shielding of the ambient magnetic field with a Mu Metal™ box lead to an analgesic response in Swiss CD-1 mice by day 5. The boxes shield both the static and time-varying components of the magnetic field. To determine which factor is responsible for the effect, coils were inserted into the Mu Metal™ boxes to reintroduce a field that mimics the time-varying ambient lab fields. The analgesia was significantly attenuated by the reintroduced fields at normal levels, but not at amplified levels that would represent a geomagnetic storm. This indicates that mice can respond to extremely weak time-varying magnetic fields.

INTRODUCTION

We have previously reported that repetitive shielding of the geomagnetic field with a Mu Metal™ enclosure lead to an analgesic effect in mice [1]. After 5 days at 1 hour per day of magnetic field shielding, a significant delay in foot-lift/lick response is seen when mice are tested on a hotplate analgesiometer. Simply shielding the electric (but not magnetic) fields with a copper clad box was not sufficient to induce the analgesia. In a similar study [2] using a single exposure, zeroing the static component of the magnetic field with a set of Helmholtz coils also did not produce the same effect as Mu Metal™ shielding. Based on these observations, we hypothesise that it is the removal of the time-varying component of the geomagnetic field that is responsible for the effect. The purpose of this study was to investigate whether reintroducing a simulated geomagnetic field would influence the analgesic effect of a 5-day course of repetitive mu metal shielding.

MATERIALS AND METHODS

Male Swiss CD-1 mice approx. 45 days old were housed singly on a 12h/12h light/dark schedule, with *ad libitum* access to food and water, with the exception of the daily exposure periods. All procedures were approved by the Animal Care and Use Committee of the University of Western Ontario. Mice were placed in clean acrylic cages without bedding and held in specially designed Mu Metal™ boxes or equivalent Plexiglas™ boxes (sham condition) for 1 hour per day for 5 consecutive days. Analgesia was measured before and after each exposure by placing the mice on a 50°C hotplate analgesiometer and measuring the time for a foot lift/lick response. The experiments took place within the centre of the light phase of the day/night cycle, and the boxes were kept dim. Within each Mu Metal™ box (but not the sham box) 4 rectangular coils in a Merrit-like configuration were inserted. A recording was made of the extremely low frequency components (0.1 Hz – 2500 Hz) of the geomagnetic field on a day with normal geomagnetic activity (that is, no solar flares as reported by the US National Oceanic and Atmospheric Administration). This recording was looped, with each cycle approximately 13 seconds long, and amplified to three different levels: 50, 100, and 200 nT, where the magnetic field magnitude here refers to the standard deviation of the changing field; used due to the chaotic nature of the waveform. Thus 5 conditions in all were used: sham (n=40), mu metal shielding without active coil inserts, and mu metal shielding with coil inserts activated to give geomagnetic mimicking fields of 50, 100, and 200 nT standard deviation (n=20 for each shielding condition). For data analysis, an ANOVA was performed with Tukey post-hoc tests using SPSS 10.0.

RESULTS AND DISCUSSION

As in previous experiments, mice that were repetitively shielded for 5 days developed a significant increase in the latency time to a foot lick as compared to sham animals ($p < 0.001$), that is, a reduced response to a noxious stimulus (Fig. 1). This analgesic effect was significantly attenuated in the mice that had the 50 nT reintroduced field ($p < 0.001$), and slightly attenuated in the 100 nT ($p < 0.01$) and 200 nT (no significant difference with respect to the shielded condition) reintroduced fields. Repetitive magnetic field shielding induces an analgesic effect. This appears to be due to the shielding of the time-varying component of the geomagnetic field, as introducing a time varying magnetic field that mimics the ambient lab field attenuated the analgesic response. Interestingly, the reintroduced field that was closest to the natural field on a quiet day (50 nT) was the most effective at attenuating the analgesia; variations of 100 or 200 nT in the field would represent geomagnetic storm conditions.

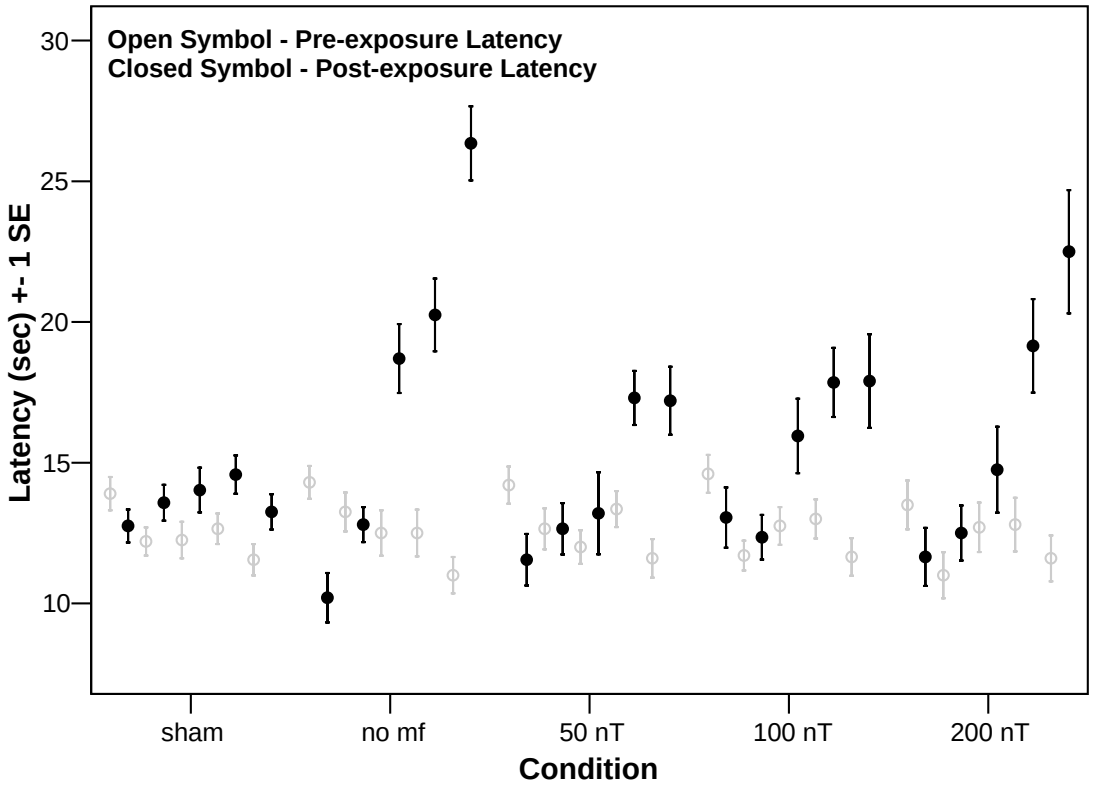

Fig. 1. The average latency to foot lift/lick is shown prior to (grey bars) and following (dark bars) the hour long exposure for each day from left (1) to right (5), for each exposure condition. Each point represents the mean response time per group for that day, error bars represent S.E.M.

These results indicate that it is the time-varying component of the geomagnetic field that is responsible for the analgesia seen following repetitive shielding. Reintroducing these low-frequency magnetic fields attenuates the effect. Interestingly, reintroducing these fields at higher than normal strengths (akin to a geomagnetic storm) does not significantly influence the analgesia. This might suggest that the animals can somehow detect these very weak time varying fields, and altering them – either by shielding with Mu Metal™ or by reintroducing at amplified values – can influence behaviour.

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