

# Low Frequency Magnetic Fields – Induced Analgesia

Frank S. Prato, Alex W. Thomas

Bioelectromagnetics Group, Imaging Program, Lawson Health Research Institute, London, ON,  
Canada, N6A 4V2  
Department of Medical Biophysics, University of Western Ontario, London, ON, Canada, N6A 5CP

It was first reported in 1984 (Kavaliers et al 1984) that extremely low frequency magnetic fields (ELFMF) abolished the enhanced nocturnal analgesic response to morphine in mice. Then Kavaliers and Ossenkopp (1993) demonstrated that repeated naloxone treatments and exposures to a 0.1mT 60-Hz ELFMF induced analgesia in snails. Betancur et al (1994) found similar effects when mice were exposed to a static field (3-4mT) but the effect was dependent on simultaneous exposure to full spectrum light. Prato et al (1997) confirmed the effects of light modulation when exposure was to ELFMF (30 – 120 Hz, 40 – 280  $\mu$ T). In 2000 Del Seppia et al demonstrated that an acute exposure to shielding from ambient magnetic fields could also reduce stress-induced analgesia while Choloris et al in 2002 not only replicated this effect of ambient magnetic field shielding but also showed evidence that it was due to the shielding from the ambient ELFMF and *not* the shielding from the ambient static geomagnetic field. In 2005 Prato et al demonstrated that daily repeated magnetic field shielding induces analgesia similar to repeated exposures to ELFMF (Kavaliers and Ossenkopp 1993). Koziak et al (2006) demonstrated that this induced analgesia from repeated exposure to a shielded environment is abolished by exposure to full spectrum light. More recently Prato et al (2009) have shown that this effect of light on the effects of magnetic field shielding is wavelength and intensity dependent. In fact the wavelength and intensity threshold effects are very similar to the effects of light exposure on the ability of animals to use the geomagnetic field for orientation. Interestingly the work (Thomas et al 1997) has shown that acute exposures to pulsed ELFMF can have analgesic effects (See Del Seppia et al 2007 for an excellent review of this literature).

The physical detection mechanism for these analgesic effects has been extensively investigated for the case of exposure to ELFMF above ambient (Prato et al 2005). The cumulative evidence from a series of experiments involving approximately 6,000 snails suggested that the effects are most consistent with the predictions of Lednev's parametric resonance model (PRM) (Lednev et al 1996, Prato et al 2000) which has some interesting similarities to the radical pair mechanisms but involves ions in protein wells rather than electron transitions (Prato et al 1996a). However this model does not explain light dependence.

The physical detection mechanism for these analgesic effect has been extensively investigated for the case of repeated exposure to shielding from ambient magnetic fields. This is important as this work strongly suggests that mice respond to a 50Hz magnetic field with a peak magnetic field of 120 nano Tesla. This field intensity is comparable to that which most of the human population is exposed to as a by-product of the generation, distribution and use of electrical power. Experiments presently underway in the ELFMF and low frequency ranges from nanoTesla to microTesla strengths suggest that the effects are inconsistent with iron particle detection (e.g. magnetosomes/magnetite) and the free radical mechanism. Surprisingly, an induced current mechanism is consistent with the data collected to date (Johnsen and Lohmann 2008).

In this tutorial this work will be reviewed and the need for future experiments on biophysical detection mechanisms emphasized. Of paramount importance is the need for experiments in humans to investigate if magnetic field shielding has similar effects to that seen in mice. Do humans respond to 50Hz, 120 nanoTesla fields!?

## REFERENCES

Betancur, C., Dell’Omo, G., Alleva, E., 1994. Magnetic field effects on stress-induced analgesia in mice: Modulation by light. *Neuroscience Letters* 182, 147–150.

Choleris, E., Del Seppia, C., Thomas, A.W., Luschi, P., Ghione, S., Moran, G.R., Prato, F.S., 2002. Shielding, but not zeroing of the ambient magnetic field reduces stress-induced analgesia in mice. *Proceedings of the Royal Society of London – Series B* 269, 193–201.

Del Seppia, C., Luschi, P., Ghione, S., Crosio, E., Choleris, E., Papi, F., 2000. Exposure to a hypogeomagnetic field or to oscillating magnetic fields similarly reduces stress-induced analgesia in C57 male mice. *Life Science* 66, 1299–1306.

Del Seppia, C., Ghione, S., Luschi, P., Ossenkopp, K.-P., Choleris, E., Kavaliers, M., 2007. Pain perception and electromagnetic fields. *Neuroscience and Behavioral Reviews* 31, 619-642.

Johnsen, S., Lohmann, K.J., 2008. Magnetoreception in animals. *Physics Today* 61, 29-35.

Kavaliers, M., Ossenkopp, K.-P., Hirst, M., 1984. Magnetic fields abolish the enhanced nocturnal analgesic response to morphine in mice. *Physiology & Behavior* 32, 261–264.

Kavaliers, M., Ossenkopp, K.-P., 1993. Repeated naloxone treatments and exposure to weak 60 Hz magnetic field have analgesic effects in snails. *Brain Research* 620, 159-162.

Prato, F.S., Kavaliers, M., Cullen, A.P., Thomas, A.W., 1997. Light-dependent and -independent behavioral effects of extremely low frequency magnetic fields in land snails are consistent with a parametric resonance mechanism. *Bioelectromagnetics* 18, 284–291.

Prato, F.S., Robertson, J.A., Desjardins, D., Hensel, J., Thomas, A.W., 2005. Daily repeated magnetic field shielding induces analgesia in CD-1 mice. *Bioelectromagnetics* 26, 109–117.

Prato, F.S., Thomas, A.W., Cook, C.M. 2005. Extremely Low Frequency Magnetic Fields (ELFMF) and Pain Therapy. *Advances in Electromagnetic Fields in Living Systems*. In: Editor JC Lin, Volume 4, Chapter 5, Page 155, Springer, Newark, NJ.

Prato, F.S., Desjardins-Holmes, D., Keenlside, L.D., McKay, J.C., Robertson, J.A., Thomas, A.W., 2008. Light alters nociceptive effects of magnetic field shielding in mice: Intensity and wavelength considerations. *Journal of the Royal Society Interface* 2008 Jan 6;6(30):17-28

Thomas, A.W., Kavaliers, M, Prato, F.S., Ossenkopp, K.P.. 1997. Pulsed magnetic field induced “analgesia” in the land snail, *Cepaea nemoralis*, and the effects of mu, delta, and kappa opioid receptor agonists/antagonists. *Peptides* 1997;18(5):703-9