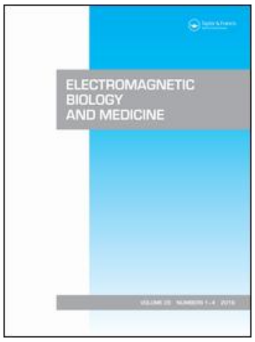

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The electromagnetic basis of social interactions

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ABSTRACT
It has been established that living things are sensitive to extremely low-frequency magnetic fields at vanishingly small intensities, on the order of tens of nT. We hypothesize, as a consequence of this sensitivity, that some fraction of an individual's central nervous system activity can be magnetically detected by nearby individuals. Even if we restrict the information content of such processes to merely simple magnetic cues that are unconsciously received by individuals undergoing close-knit continuing exposure to these cues, it is likely that they will tend to associate these cues with the transmitting individual, no less than would occur if such signals were visual or auditory. Furthermore, following what happens when one experiences prolonged exposure to visual and like sensory inputs, it can be anticipated that such association occurring magnetically will eventually also enable the receiving individual to bond to the transmitting individual. One can readily extrapolate from single individuals to groups, finding reasonable explanations for group behavior in a number of social situations, including those occurring in families, animal packs, gatherings as found in concerts, movie theaters and sports arenas, riots and selected predatory/prey situations. The argument developed here not only is consistent with the notion of a magnetic sense in humans, but also provides a new approach to electromagnetic hypersensitivity, suggesting that it may simply result from sensory overload.

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Introduction

It is increasingly apparent that weak, extremely-low-frequency (ELF) magnetic fields, both natural and man-made, can affect living organisms in a number of ways, including behavior. One striking example is the increase in suicides that correlates with perturbations in the geomagnetic field due to the 11-year solar storm cycle (Berk et al., 2006). Numerous reports (Carrubba et al., 2007; Friedman et al., 1963; Jenrow et al., 1998; Kay, 1999; Prato et al., 2000; Thomas et al., 1986; Vorobyov et al., 1998, Zhadin et al., 1999) have found a wide variety of neural responses to weak ELF magnetic fields. Above and beyond the difficulty in finding a reasonable explanation for such effects, it is especially remarkable that there have been fully replicated experiments indicating that some of these interactions occur at miniscule magnetic intensities, well below, for example, the level of the earth's magnetic field. In all these cases there exists a long-standing, still unresolved problem involving the fundamental physical mechanisms and sources of energy underlying these processes (Adair, 1991).

Following a critical experiment by Zhadin et al. (1998) and its independent replications (Alberto et al., 2008a, 2008b; Comisso et al., 2006; Pazur, 2004), the threshold magnetic intensity for such effects was greatly reduced, down to 40 nT. This level is so small as to suggest that the central nervous system could be involved, not only in its ability to detect such levels, but also in generating them. More recently, it was shown (D'Emilia et al., 2014, 2016) that ultra-weak magnetic interactions occur in pure water, in this case at magnetic intensity backgrounds on the order of 1–10 nT. In all these cases, not only were very weak sinusoidal fields required, but also ion cyclotron resonance magnetic field combinations (Liboff, 2006). We believe that these results open the door to serious considerations of previously unrecognized electromagnetic interactions between animals.

We recently pointed out (Liboff, 2016c) that if one assumes that magnetic intensities from the brain fall off as 1/r (inversely with distance from the source), there is the likelihood of magnetically based interbrain communication for individuals in close proximity, say, within a few meters of one another. One interesting aspect of such interactions is that the transfer of information in this case would not necessarily be cognitive or perceptive, in that it need not lead either to better understanding of the transmitter's thoughts, or even being aware that information is being transmitted. Instead we

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consider merely a transfer of very basic information, a magnetic cue, similar to those responses attached to low-level visual, olfactory and acoustic inputs, of the sort associated with conditioned responses (Pavlov, 1960; Rescorla, 1967). The basic idea underlying the Pavlovian response is that the nervous system has the capacity for automatic associative learning when presented with repetitive stimulation. If the brain is indeed sensitive to weak magnetic fields, then we should expect it to also have the capacity to be conditioned by such signals.

In the present work we extend this concept beyond its obvious application to closely knit family members, to include larger groups, finding possible explanations for a number of otherwise unexplained social interactions. We also examine this idea in relation to the evolutionary distinction between electric fields (E-fields) and magnetic fields (B-fields).

Areas of interest

We find two broad classes of social activity where weak-field low-frequency effects may play a key role in helping understand the interactive response. Somewhat overlapping, these magnetically dependent areas can be divided into Bonding and Predator/Prey activities. The commonality in these categories is the transmission and (unconscious) receipt of vanishingly weak magnetic signals originating in the central nervous system.

Bonding. Although bonding between humans is ordinarily ascribed to the cognitive recognition of shared and continuing joint experiences (Gavrilets, 2012; Miller and Rodgers, 2001), an alternative magnetic field explanation is also possible. When in the presence of nearby individuals the continuous or repeated receipt of magnetic cues outcome is positive, this too can lead to strong relationships, as in family binding in primates, and to a lesser extent in other animals. Magnetic cues can be regarded as similar to olfactory and visual cues. If nothing else, the magnetic cue can also reinforce cognitive recognition. We previously argued (Liboff, 2016c) that outcomes referred to here as magnetic bonding occur for at least three cases in humans: infants in utero, infants suckling and couples in coitus. In these examples the intimacy involved assures relatively easy detection of magnetic cues by the receiver. There is continuing contact between individuals, allowing the bonding to readily transform into long-term relationships. This is seen not only in humans, but also in many other species, particularly where cognition plays less of a role. Wolves, lions, elephants and most primates exhibit long-term socialization. The fact that wolves tend to roam and hunt together in packs is very likely the result of the same sort of magnetic bonding as occurs in humans. There is great intimacy among the wolves of a given pack, with both playfulness and acceptance of social ordering serving to provide the closeness required to enhance magnetic interaction. Mutual grooming plays a similar role among most primates.

There are also categories of social bonding that are short-term, albeit intense. We see this in events where the gatherings are relatively intimate, such as in concerts, movie theaters and sports arenas, as well as in ugly situations such as lynching and riots. It has been often noted in these gatherings that the group response appears to arise separately from that of the individuals in the assembly, giving rise to the term *crowd psychology* (Drury and Reicher, 2000). McDonnell (2014) characterized such behavior as "emotional contagion", where everyone, or nearly everyone, seems to share the same feeling. He compares this to what is observed in large-scale bird flocking, the behavioral phenomenon in which the entire cohort, instead of following visually mediated synchronization (Cavagna et al., 2010), appears to act in what some (Couzin, 2007; Liboff, 2016b) have referred to as a disembodied response.

Yet another type of bonding, universally recognized, even taken for granted, is that between human and dog (Nagasawa et al., 2015), and to a lesser degree, between humans and other pets. It is remarkable that oxytocin, the same neuroendocrine marker that is enhanced as a result of human bonding, is similarly enhanced upon bonding in other animals (Insel et al., 1998; Wang and Aragona, 2004), suggesting a universality in the process of attachment and bonding. For this reason we think it likely that our hypothesis involving magnetic cues can be broadened to include all examples of bonding, intraspecies as well as intergenus.

Predator/prey

It is more difficult to argue for the possible detection of such cues as the distance between the transmitter and the receiver increases. For example, consider predator/prey interactions, where the distance between the hunter and the hunted, instead of being merely separated by meters, can be much larger, say tens of meters. Larger separations result in a net transmitted magnetic intensity that may not be great enough to ensure cue reception. In addition, at greater distances visual and olfactory responses likely serve the hunter and its prey better than trying to detect vanishingly small magnetic fields. On the other hand, as the predator–prey separation is reduced, it is reasonable to expect that magnetic cues can become proportionately more effective, in effect constituting one additional mechanism to the animal's armory of useful senses. There are examples where magnetic sensitivity already exists for unknown purposes, as in Arctic foxes hunting voles beneath the snow (Cerveny et al., 2010). Note especially that examples such as this, where the animal hunts alone, illustrate that the magnetic cues involved in hunting are not necessarily connected to bonding. Predator/prey actions may depend on magnetic cues that also reinforce bonding but can also be independent of bonding.

It is likely that the magnetic signals transmitted by the prey are utilized during hunting, no less than the magnetic warning that may accompany the nearby presence of the hunter. The balance between these signal capabilities is determined by evolutionary adaptation, as are the nonmagnetic hunting strategies exhibited visually by hawks, by felines stalking or by bears smelling. There is every reason to add a magnetic sense to the already existing set of useful senses that both hunter and hunted maintain as part of their survival strategy.

It is important to realize that nature also enjoys a somewhat simpler electromagnetic means, other than magnetic, by which to transfer information between the hunter and the hunted. We can contrast the electromagnetic modalities arrived at by evolution for hunting in seawater as opposed to hunting in an air environment. Sharks and other cartilaginous fish are facially equipped with *ampullae of lorenzini* (Murray, 1959), special anatomical means for detecting nearby *electric* field changes. Instead of using magnetic signal detection, these species sense the electric field. This difference reflects the physical property of the medium separating the hunter and the hunted. The conductivity of seawater is sufficiently great (~5 S/m) to allow the shark to detect changes in electric field. However for hunting on land, given the poor electric conductivity in air, roughly 5×10^{-15} S/m, nature is forced to fall back on using the magnetic field. Magnetic fields transmit readily in air, aside from the usual falloff of intensity with distance.

Discussion

This work suggests that humans enjoy a magnetic sensitivity, something that although a matter of some dispute (Baker et al., 1983; Carruba et al., 2007; Westby and Partridge, 1986) is well accepted in other genera, particularly as regard geomagnetically aided navigation (Wiltschko and Wiltschko, 2005). There may very well be a difference in animal and human magnetic sensitivities, but one dictated by need instead of an all-encompassing provenance. Evolution seems to have recognized the fact that humans can navigate very well using other means without relying on the elaborate physiological mechanisms required by other species. In the present case the human magnetic sense is utilized for socially interactive reasons. Here, the magnetic sense is merely one more addition to the well-known sensory armory that includes the visual, olfactory, touch, acoustic and taste components. Furthermore, as with the wide variations in sensory abilities between animals, as evidenced, for example, by the olfactory capabilities of selected breeds of dogs, or the visual abilities of hawks, it might be expected that certain species will have much greater magnetic sensitivities than others.

This raises the question of electromagnetic hypersensitivity (EHS) (McCarty et al., 2011; Mild et al., 2004). Although this phenomenon, characterized by dermatological and neurasthenic issues, clearly arises in connection with human sensitivity to electromagnetic fields, it differs in many ways from the present thesis. For one thing, the EHS recipient is acutely aware that he or she is being exposed, whereas we are specifically concerned with individuals who remain unaware that they are affected. In addition, the nature of the detected electromagnetic radiation is profoundly different. EHS can be associated with the entire electromagnetic spectrum, including RF, VHF and UHF, extending well beyond ELF. Finally, the most interesting aspect of what we present here is that the magnetic fields that are unconsciously detected are at levels well below those emitted by devices that are considered EHS sources. However, it is still conceivable that EHS can be considered as a manifestation of sensory overload. There are physiological problems encountered when any of the senses is subject to long-term gross exposure to, for example, bright lights or loud sounds. Similarly, EHS may be the consequence of individuals with slightly enhanced magnetic sensitivity experiencing long-term electromagnetic exposure.

We conclude there is good reason to believe that at least some of the bonding behavior exhibited by higher-level animals, including humans, is the consequence of simple magnetic signals transmitted into the local environment by the central nervous system. This is made possible because the levels of detectability of ELF magnetic fields by living things have been shown to be at or below tens of nT. One consequence of this is that fractions of neural activity in one system can be detected by nearby brains. This can happen in a manner that likely precludes cognizance, but nevertheless acts to influence social interactions. Enhanced sensitivity to magnetic fields can be regarded as a previously unrecognized part of the total array of senses, added to the visual, olfactory and acoustic components. Likely examples of magnetically enhanced bonding include effects on family members, animal packs, large-scale human and animal gatherings, and ugly mobs. In a somewhat different scenario, magnetic sensing very likely also plays a role in predator/prey situations.

One factor that may be important in furthering the understanding of this phenomenon is the remarkably weak fields that are required, first, as a constraint on the background intensity (1–10 nT), and second, on the working intensity of the signal strength (≤40 nT). Indeed there is reason to think that the observed ELF effects are larger with reduced background (D'Emilia et al., 2014; Zhadin et al., 1998). Although signal-to-noise considerations might appear to preclude the transmission and detection of the magnetic cues that are proposed, there is the possibility that this is obviated by neural signal conditioning and/or cyclotron resonance specificity.

We have avoided discussing whether the present material might be applied to the question of instinct, mainly because the explanation of this phenomenon requires a more complex analysis than the simple transmission and reception of putative magnetic cues. Instinctive behavior is clearly more complicated. At the very least one must consider a two-step process: the nature of the imprinting of the behavioral response, formed perhaps at a time concurrent with the original speciation, and the subsequent repeated recognition of this tendency in succeeding generations. If indeed there is a magnetic connection, one might consider the proposed transfer of information from mother to egg used to explain geomagnetic imprinting in hatchlings (Liboff, 2016a). In this scenario as it might instead be applied to mammals, the behavioral response would be communicated magnetically from mother to child in utero over succeeding generations.

The contrast between hunting based on electric field sensitivity as opposed to magnetic field sensitivity is very interesting in that it illustrates the deep connection between living things and the electromagnetic field. Evolution has clearly utilized physical principles to develop the parameters used in hunting, specifically the information transfer capabilities associated with E- and B-fields. This observation allows us to generalize further: the basic thesis advanced in the present work can be regarded as merely one more means of electromagnetic information transfer in living things. As in the case of hunting, we can distinguish nature's opportunistic use of magnetic fields to transfer information *between* individuals as compared to the neural transfer of information *within* a single individual, the latter making use of the E-field, and the former, the B-field.

One way to view this work is to regard the weak magnetic signals that are emitted as perturbations of the larger electromagnetic field generated by the brain. This reinforces the notion (Pockett, 2012; Liboff, 2016b) that consciousness is an electromagnetic phenomenon. The fact that one individual can influence another by means of this field, even if only through perturbations, is very interesting, raising the possibility of generalizations about the mind that are yet to be unraveled.

Declaration of Interest

The author reports no conflict of interest. The author alone is responsible for the content and writing of this article.

References

Adair, R. K. (1991). Constraints on biological effects of weak extremely-low-frequency electromagnetic fields. Phys. Rev. A. 43:1039–1048.

Alberto, D., Busso, L., Crotti, G., et al. (2008a). Effects of static and low-frequency alternating magnetic fields on the ionic electrolytic currents of glutamic acid aqueous solutions. *Electromagn. Biol. Med.* 27:25–39.

Alberto, D., Busso, L., Garfagnini, R., et al. (2008b). Effects of extremely low-frequency magnetic fields on L-glutamic acid aqueous solutions at 20, 40, and 60 microT static magnetic fields. *Electromagn. Biol. Med.* 27:241–53.

Baker, R. R., Mather, J. G., Kennaugh, J. H. (1983). Magnetic bones in human sinuses. *Nature*. 301:78–80.

Berk, M., Dodd, S., Henry, M. (2006). Do ambient magnetic fields affect behavior? A demonstration of the relationship between geomagnetic storm activity and suicide. *Bioelectromagnetics*. 27:151–155.

Carrubba, S., Frilot, II C., Chesson, A. L., Jr., Marino, A. A. (2007). Evidence of a nonlinear human magnetic sense. *Neuroscience*. 144:356–367.

Cavagna, A., Cimarelli, A., Giardina, I., et al. (2010). Scale-free correlations in starling flocks. *Proc. Nat. Acad. Sci. USA*. 107:11865–11870.

Cerveny, J., Begall, S., Koubec, P., et al. (2010). Directional preference may enhance hunting accuracy in foraging foxes. *Biol. Lett.* doi:10.1098/rsbl.2010.1145.

Comisso, N., Del Giudice, E., De Ninno, A., et al. (2006). Dynamics of the ion resonance effect on amino acids absorbed at the interfaces. *Bioelectromagnetics*. 27:16–25.

Couzin, I. (2007). Collective minds. *Nature*. 445:715.

D'Emilia, E., Giuliani, L., Lisi, A., et al. (2014). Lorentz force in water: Evidence that hydronium cyclotron resonance enhances polymorphism. *Electromagn. Biol. Med.* doi:10.3109/15368378.2014.937873.

D'Emilia, E., Ledda, M., Foletti, A., et al. (2016). Weak-field H3O+ ion cyclotron resonance alters water refractive index. *Electromagn. Biol. Med.* doi: 10.1080/15368378.2016.1181082.

Drury, J., Reicher, S. (2000). Collective action and psychological change: The emergence of new social identities. *Br. J. Soc. Psychol.* 39:579–604.

Friedman, H., Becker, R. O., Bachman, C. H. (1963). Geomagnetic parameters and psychiatric hospital admission. *Nature*. 200:626–628.

Gavrilets, S. (2012). Human origins and the transition from promiscuity to pair-bonding. *Proc. Natl. Acad. Sci. USA*. 109:9923–9928.

Insel, T. R., Winslow, J. T., Wang, Z., Young, L. J. (1998). Oxytocin, vasopressin, and the neuroendocrine basis of pair bond formation. *Adv. Exp. Med. Biol*. 449:215–24.

Jenrow, K. A., Zhang, X., Renehan, W. E., Liboff, A. R. (1998). Weak ELF magnetic field effects on hippocampal rhythmic slow wave activity. *Exp. Neurol*. 153:328–334.

Kay, R. W. (1999). Geomagnetic storms: Association with incidence of depression as measured by hospital admissions. *Br. J. Psychiatry*. 164:403–409.

Liboff, A. R. (2006). The ion cyclotron resonance hypothesis. In: Barnes, F. S., Greenebaum, B. *Bioengineering and Biophysical Aspects of Electromagnetic Fields*. Boca Raton: CRC Press. Chap. 9, pp. 261–292.

Liboff, A. R. (2016a). Is the geomagnetic map imprinted in pre-emergent egg? *Electromagn. Biol. Med*. 35:167–169.

Liboff, A. R. (2016b). Magnetic correlates in electromagnetic consciousness. *Electromagn. Biol. Med*. 35:228–236

Liboff, A. R. (2016c). A human source for ELF magnetic perturbations. *Electromagn. Biol. Med*. June 29:1–6. [Epub ahead of print].

McCarty, D. E., Carrubba, S., Chesson, A. L., et al. (2011). Electromagnetic hypersensitivity: Evidence for a novel neurological syndrome. *Int. J. Neurosci*. 121:670–676.

McDonnell, A. (2014). The sixth sense-emotional contagion; Review of biophysical mechanisms influencing information transfer in groups. *J. Behav. Brain Sci*. 4:342–374.

Mild, K. H., Repacholi, M., van Deventer, E., Ravazzani, P., (eds.). (2004). *Proceedings of the International Workshop Electromagnetic Hypersensitivity*, Prague, ISBN 978 92 4 159412 7.

Miller, W. B., Rodgers, J. L. (2001). *The Ontogeny of Human Bonding Systems: Evolutionary Origins, Neural Bases, and Psychological Manifestations*. New York: Springer.

Murray, R. W. (1959). The response of the ampullae of Lorenzini to combined stimulation by temperature change and weak direct currents. *J. Physiol*. 145:1–13.

Nagasawa, M., Mitsui, S., En, S., et al. (2015). Oxytocin-gaze positive loop and the coevolution of human-dog bonds. Science. 348:333–336.

Pavlov, I. P. (1960). *Conditioned Reflexes*. New York, NY: Dover.

Pazur, A. (2004). Characterization of weak magnetic field effects in an aqueous glutamic acid solution by nonlinear dielectric spectroscopy and voltammetry. *Biomagn. Res. Technol*. 2:8. doi:10.1186/1477-04x-2-8.

Pockett, S. (2012). The electromagnetic field theory of consciousness: A testable hypothesis about the characteristics of conscious as opposed to non-conscious fields. *J. Consciousness Stud*. 19:191–223.

Prato, F. S., Kavaliers, M., Thomas, A. W. (2000). Extremely low frequency magnetic fields can either increase or decrease analgesia in the land snail depending on field and light conditions. *Bioelectromagnetics*. 21:287–301.

Rescorla, R. A. (1967). Pavlovian conditioning and its proper control procedures. *Psychol.Rev*. 74:71–80.

Thomas, J. R., Schrot, J., Liboff, A. R. (1986). Low-intensity magnetic fields alter operant behaviour in rats. *Bioelectromagnetics*. 7:349–357.

Vorobyov, V. V., Sosunov, E. A., Kukushkin, N. I., Lednev, V. V. (1998). Weak combined magnetic field affects basic and morphine-induced rat's EEG. *Brain Res*. 781:182–187.

Wang, Z., Aragona, B. J. (2004). Neurochemical regulation of pair bonding in male prairie voles. *Physiol. Behav*. 83:319–328.

Westby, G. W. M., Partridge, K. J. (1986). Human homing: Still no evidence despite geomagnetic controls. *J. Exp. Biol*. 120:325–331.

Wiltschko, W., Wiltschko, R. (2005). Magnetic orientation and magnetoreception in birds and other animals. *J. Comp. Physiol. A* 191:675–693.

Zhadin, M. N., Novikov, V. V., Barnes, F. S., Pergola, N. F. (1998). Combined action of static andalternating magnetic fields on ionic current in aqueous glutamic acid solutions. *Bioelectromagnetics*. 19:41–45.

Zhadin, M. N., Deryugina, O. N., Pisachenko, T. M. (1999). Influence of combined DC and AC magnetic fields on rat behavior. *Bioelectromagnetics*. 20:378–386.