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Magnetic Variances Associated with 'Haunt-type' Experiences: A Comparison Using Time-Synchronised Baseline Measurements

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Abstract

Recent laboratory studies have revealed that human exposure to low-frequency complex electromagnetic fields (EMFs) can induce strange and exceptional hallucinatory experiences under controlled conditions. A number of field-studies have also shown that reputedly haunted locations can be magnetically distinguished from non-haunted areas in the natural setting. However, none of these studies have employed appropriate time-linked baseline measurements taken from haunted and baseline areas simultaneously. This study presents the first magnetic investigation of a reputedly haunted location that employs and formally compares high-speed time-linked magnetic baseline measurements. The results show separate effects of both elevated levels in the ambient spatial magnetic field, and the nature of how magnetic fields vary over time (i.e., their complexity) in areas of interest. The implications of the current findings for the magnetically remarkable nature of reputedly haunted buildings are discussed.

Introduction

Recent evidence suggests an association between the presence of variable *geomagnetic fields* (GMFs) and/or power-frequency *electromag-*

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netic fields (EMFs) with changes in neurophysiological activity and behaviour (Bell, 1992, 1994; Cook & Persinger, 2001; Fuller, Dobson, Wieser, Moser, 1995; Gearhart & Persinger, 1986; O'Connor, 1993; Papi, Ghione, Rosa, Del Seppia & Luschi, 1995; Persinger, Ludwig, Ossenkopp, 1973; Persinger, 1988, 1993; Persinger & Koren, 2001; Randall & Randall, 1991). Similarly, a growing number of studies have suggested that such GMFs/EMFs could also underlie some reported instances of *'haunt-type'* experiences – see Persinger & Koren, 2001, Roll & Persinger, 2001 for reviews. Based on these findings researchers are proposing that perhaps some aspect of these *'Experience Inducing Fields'*[1] could be present at locations that have been associated with producing multiple instances of these experiences spontaneously (Persinger et al., 2001; Persinger & Koren, 2001; Persinger & Richards, 1994; Persinger, Richards, & Koren, 1997; Roll & Persinger, 2001). The implication from this is that many strange (i.e., haunt-type) experiences reported at such locations could actually represent a spontaneously occurring magnetically induced hallucination. Individuals who report haunt-type experiences may well have been exposed to crucial EIFs present at that location, and at that time. The general prediction here is that discrete changes in the localized magnetic field will correlate with discrete changes in the neural activity in observers and these will have very real consequences for cognition under certain circumstances.

Inspired by findings from laboratory studies many researchers are now visiting particular locations of interest in an attempt to define the presence and mechanisms for the spontaneously occurring natural homologue of these fields. The idea of an environmental component to the induction of these experiences can be a useful approach to the field-based investigation of a haunting as it does generate a number of helpful and testable notions concerning the spontaneous occurrence of apparitions in the natural setting.

Perhaps the most prominent question here is whether these microenvironments are indeed 'magnetically remarkable' in any way compared to baseline locations? If this is the case, then the question becomes, what exactly is remarkable about them? There are a number of possibilities. For instance, perhaps the ambient GMFs/EMFs are generally and permanently more elevated or excessive when compared to

[1]Research suggests that both GMFs and EMFs of diverse frequencies and amplitudes could have consequences for human experience. Therefore, these fields are given the generic term here of *'Experience Inducing Fields'* to encompass any form of magnetic field with potential stimulatory properties.

baseline locations? Alternatively, perhaps the crucial EIFs are more transient, variant and volatile, occurring sporadically from time to time? Perhaps both these factors are crucial and high variances exist in an environment that already contains magnetically dense and excessive fields? The possibilities are legion. With respect to the first scenario, one prediction would be that researchers should be able to quantify such constant and stable differences quite easily during field-studies carried out at any time. A useful metaphor here seems to be one like a cardiac arrest can leave in a heart trace recording. In this sense, significant events can take place, they can come and go, but there is always an underlying current or signature that can be identified and distinguish such traces even in the absence of the significant event itself.

In contrast, the second scenario suggests that simply taking measurements at any given instance may in fact miss the occurrence of the crucial EIFs that could exist, but may well be indistinguishable at the time of measurement. The implication here is that measurements must be taken before, during and after the event in order to truly evaluate the spontaneous occurrence of the anomaly relative to the background measurements. Irrespective of these possibilities, carrying out detailed magnetic surveys of reputedly haunted locations could potentially be very revealing. Indeed, if the laboratory studies have identified a mechanism that could operate in the natural environment, a true test would be to show that such a mechanism is, at the very least, present in some form in these natural settings.

There are a couple of points, often overlooked, but worth highlighting regarding the field application of the magnetic stimulation account. Firstly, it is important to remember that such stimulation has been shown to be particularly likely in labile and neuronally hypersensitive brains (Persinger, 1999a, 1999b, 1995, 1987; Persinger & Richards, 1994; Persinger, et al., 1997; Persinger & Koren, 2001; Persinger & Maharec, 1993). This interaction between susceptible brains and environment may suggest that excessive fields themselves are not necessary, and may also explain why many people report anomalous experiences in certain environments while others do not. Indeed, the emerging picture seems to suggest that it is the complexity of the magnetic fields and not necessarily the overall amplitude or strength that is crucial for brain stimulation to occur (Persinger, 1999a, 1999b, 1995, 1987; Persinger & Richards, 1994; Persinger & Koren, 2001; Roll & Persinger, 2001). Such complexity could come in a number of forms including the existence of multiple frequency components, highly variable amplitudes, phase differences, or a combination of all these factors. Secondly, reports of strange experiences do not happen instantaneously, but rather after a more prolonged period of exposure (approx 20–30mins in the laboratory). This suggests that the mechanism of interaction is a subtle one perhaps at the level of psychopharmacological effects between synapses of neurons or increased hyper-polarisation of specific inhibitory neuronal systems. The consequence of which would be disinhibition, the neuronal basis for hallucination and altered states.

Irrespective of how such stimulation could occur, demonstrating that a magnetic anomaly exists at certain locations is one side of an important theoretical equation that may also require certain types of individuals in order to respond to these EIFs. Although the laboratory studies are convincing, natural field studies of haunted locations present a somewhat more mixed picture.

Magnetic studies of 'haunted' locations

Magnetic surveys of reputedly haunted locations have suggested that both increased levels of the localized ambient GMFs (Nichols & Roll, 1999; Roll & Nichols, 1999; for reviews see Persinger & Koren, 2001; Roll & Persinger, 2001) and increased levels in EMFs (Nichols & Roll, 1998; Persinger et al., 2001; Roll, Maher & Brown, 1992) can be associated with anomalous effects and strange experience. It has also been argued that the ambient geomagnetic field varies more over small spatial distances (e.g., in a room) than what would be expected naturally (see Persinger & Koren, 2001; Persinger et al., 2001; Roll & Nichols, 1999; Roll & Persinger, 2001; Roll, Moody & Radin, 1996). In relation to the possibilities outlined above this could mean that such studies revealed a more permanent magnetic characteristic of the locale as being important or that the researchers were present at the same time as the more variant fields (though this last point seems unlikely). Either way the implication is that ambient magnetic anomalies are associated with reputedly 'haunted' areas and are an important distinguishing factor.

Other studies have identified nothing remarkable about the ambient background fields at all, but suggest either that odd and significant pulses occurred during the measurement session or that the manner in with the field is varying is crucial (i.e., their complexity: Persinger & Cameron, 1986; Wiseman, Watt, Greening, Stevens, & O'Keeffe, 2002; Wiseman, Watt, Stevens, Greening, & O'Keeffe, 2003). This is in line with the predictions from laboratory findings. Finally, it is worth noting that some researchers have failed to find any magnetically distinguishing feature between haunted and non-haunted areas in locations of interest (Maher & Hanson, 1997; Maher, 2000). This may be due to the equipment used in those studies, or indeed that the experiences reported by witnesses do not have an underlying magnetic anomaly associated with them. It is likely that many environmental cues can contribute to the induction of haunt-type experience.

Problems with prior studies

One problem with the magnetically induced hallucination account is that terms such as *'complexity'* are often unclear and ill defined. What contributes to this complexity? Is it amplitude variance, frequency components, waveform shapes or all of these together? It is certainly the case that 'complexity' can refer to many components and indeed all these components combined. Furthermore, even if we accept the term complexity in terms of exposure to the human brain, in the natural setting this could happen in a number of ways. For instance, 'complexity', or indeed the crucial aspect of it, may well be a time varying property of the incoming magnetic signal or field itself. In this sense the source could be many things both natural and man-made but the complexity is based in the signal. It is a time-based component or property contained within the signal. Another way to conceptualise complexity could be that in small areas (i.e., a room) the actual background fields are constant, but highly variant across space with peaks and troughs distributed across the microenvironment (as noted above, see, Persinger & Koren, 2001; Persinger et al., 2001; Roll & Nichols, 1999; Roll & Persinger, 2001; Roll, Moody & Radin, 1996). In this sense the complexity is not in the signal per-se (as this is relatively constant) but an individual's movement through a spatially variable field. Again at the level of exposure and stimulation, the brain may be receiving a time-varying component to the strength of the signal but, under these circumstances, there is no time changing component to the signal itself. This could be conceived of as complexity over space (not time). This is important as what it highlights is the need to check for a number of potential sources, using a variety of methods over both space and time to disambiguate the nature of such field variances (see Roll & Persinger, 2001 for a similar discussion). Both the above scenarios could expose the brain to a time varying component in the magnetic field (which could be further boosted by our movements through these fields). We know what we are looking for (a magnetic anomaly) but we do not necessarily know what it will look like! These points may also account for some of the confusion surrounding this debate and the mixed findings across many studies. The laboratory studies have shown one way that magnetic stimulation works (by using artificial time-varying signals), but this may not be the only way.

One major problem with the field studies currently available is that few, if any, have employed the use of time-linked (i.e., synchronized) baseline measurements. A recent, but by no means unique, example is the study of Wiseman, et al. (2003) where it appears measurements were taken sequentially from either a baseline location or 'active' locations. These separate measurements are then formally compared statistically.[2] Although perfectly legitimate, this method is open to some criticism. For instance, how do researchers know that as they are measuring one area, the other areas are not also displaying the same magnetic qualities at that very point in time? They do not. To put it another way, many previous studies have attributed what may be a variance in the signal over time (across the different recording periods) to a difference in the characteristic in the signals available from those locations over space. A more conservative test would be to measure reputedly haunted and non-haunted baseline areas simultaneously. There are a number of advantages to this approach. Firstly, the researcher could ascertain to some degree how localized any magnetic anomaly could be. If a particular magnetic event was measured on one sensor but not the other sensor then it may be that such an event was localized (for whatever reason). However, if all sensors in different areas measure the event it may represent a more general change. Secondly, it is a more direct test of whether the overall ambient field levels or the nature of the variance itself really is distinguishable across areas at any given point in time.

One argument against these suggestions might be that it is unlikely, for instance, that geomagnetic fields would change significantly across the time period for taking the measurements. Although this is a valid

[2]It might be argued that in a recent study Wiseman et al (2002) did use two magnetic sensors running at approximately the same time. However, in that study the data from both sensors were never formally compared together and no detail was given as to how these were time-linked. Furthermore, no information or figures were presented that provided detail concerning the signal shapes between the sensors (see Figures 2 to 5 here). The main focus of that study was to link magnetic anomalies (high fields and variance) to questionnaire responses. Therefore this remains the first study to employ and formally compare two independent and highly detailed magnetic data series, over a prolonged time period in this manner.

point, it is important to note that geomagnetic fields are not the only contributor to the magnetic environment, and these other electromagnetic fields can vary considerably over space and time. Furthermore, it is not always clear from the literature what the overall time periods were for recording sessions and for the measurement period overall so this is often difficult to ascertain from the studies available. Nevertheless, it would seem that a time-synchronised baseline would be the most useful, effective and conservative test of magnetically remarkable locations.

To summarise, previous studies have attributed what may be a time-based variable component in the magnetic signals to a space-based variant characteristic between haunted and non-haunted areas. However, the difference may simply reflect a change in the fields present across time, not space. This of course is still important and interesting but the only way to disambiguate these factors is to take time-linked recordings from sensors occupying different spatial locations. Only then can one really compare differences across areas and claim that levels or variances truly are different in some manner.

Motivation of the present study

The present study was designed to investigate the general claim that locations associated with haunt-type experiences may be magnetically remarkable in some way. Furthermore, as a number of studies have associated some magnetic anomalies to such environments, it seems reasonable to assume that there may also be a relatively constant *undercurrent* of fields that could be of interest at these locations. However, unlike prior studies, here a new system that employed a time-linked baseline recording was used to gather detailed time-series data of the magnetic environment over space and time (this system is outlined below). Note that the claim that 'haunted locations' may either contain higher than normal, or more variant than normal, magnetic fields has often been made in relation to field amplitude measurements (Persinger & Koren, 2001; Persinger et al., 2001; Roll & Nichols, 1999; Roll & Persinger, 2001; Roll, Moody & Radin, 1996; Wiseman, et al., 2002, 2003). In line with this, the present study concentrated on providing detailed field amplitude data (e.g., overall levels and variances). It is worth noting that an important area of future study would be to evaluate field frequencies (also a source of complexity) associated with the amplitudes measured. Nevertheless, of the studies that do evaluate field amplitudes, a detailed time-linked baseline analysis capable of disambiguating potential space-based and time-based magnetic anomalies has not been carried out. This was the purpose and context of the present study.

The study was carried out at *Muncaster Castle*, Ravenglass, in Cumbria, England. This location has been actively investigated exclusively by the author since 1992. It represents one of the longest running continued field investigations into a haunting ever carried out. A detailed review of case events is beyond the scope of the present article, suffice to say the following: over the course of investigation numerous eyewitnesses have been interviewed and their testimonies evaluated, many site examinations have taken place, and field-based investigations have been carried out continuously since 1992. Although striking experiences have been reported in a number of areas, the longitudinal research has revealed that a definite epicentre is the Tapestry room (TR) located on the first floor in the Castle. This was chosen as the room of interest for this study.

Data gathered from the research project carried out by the author (JJB) has revealed that eight reliable eyewitnesses have reported extremely similar experiences from the same location (the sounds of children crying/secondary adult voices comforting the children). These particular experiences span from the early 1960s to the mid 1990s. None of these eyewitnesses were aware of the reputation of the haunting in the room (indeed the room was being used as a guest room at the time), or that other people had reported similar experiences at the time they had reported theirs. However, one curious fact that has emerged is that not only was the same room involved, but that six of the eight observers were all in relatively the same position in the room (settling down in the bed) at the time of the experience. Furthermore, a detailed analysis of their accounts revealed that they all claimed the phenomena was initially emitting from relatively the same distal location in the room (just to the right hand side of the window area; approx 5–7m away: this would be to the left of the observer if they laid on their backs in the bed). These somewhat unique experiences provide an ideal context with which to test for magnetic anomalies. Knowing the approximate body/head position of a number of crucial eyewitnesses allows us to investigate a relatively specific region for the presence of constant magnetic anomalies. For instance, if some of the TR experiences can be thought of, at least in part, as magnetically induced hallucination then one might suppose that perhaps such anomalies would be present around the head/pillow area of the bed in the TR. Arguably this represents a point in space where observers may have been exposed to stimulatory magnetic fields. This study sought to test this idea. There are four main issues related to magnetically remarkable locations that are important to the current study. These were touched upon earlier but can be summarised as follows:

1. That the overall magnetic field strength (amplitude) is greater at areas of interest relative to baseline areas.
2. That the overall field strength is not important, it is the way in which the fields vary (e.g., their complexity) that is crucial and defines these areas.
3. That it is a combination of both strength and complexity that distinguishes areas which produce experiences from areas that are not associated with strange experience.
4. To disambiguate potential space-based and time-based magnetic anomalies.

In relation to the present experiment, the first point would predict that the overall magnetic field would be much higher at the crucial pillow area than at the baseline area. The second point would predict that the variance (measured by standard deviation) would be greater at the crucial pillow area relative to the baseline area. The third point would predict that the pillow area would be distinguishable in both terms of strength and complexity relative to the baseline. Furthermore, a time-based anomaly could occur on one or both sensors, but would be revealed by continuous measuring with dual-sensors. Finally, quite different field amplitudes measured between the sensors would reveal an important space-based anomaly (across sensor locations).

Overview of the present study

To truly establish whether there is anything magnetically remarkable about specific areas where people have reported anomalous experiences, relative to baseline areas, a simultaneous time-linked baseline measurement must be taken. The present study is the first study ever to employ continuous dual time-linked magnetic measurements of a reputedly haunted location. This included a measurement from the area of high interest and a proximal synchronised baseline measurement.

The magnetic measurements for this experiment were carried out using the dual sensor *Magnetic Anomaly Detection System* (MADS). The MADS consists of two separate high-speed digital fluxgate magnetometers. The sensors are customised versions of the model 540 from Applied Physics Systems USA (see http://appliedphysics.com). One sensor is labelled as the Active sensor (Sensor A) and the other as the Baseline sensor (Sensor B). Each sensor can be configured to sample 250 times a second (every $4ms$) in three orthogonal (x, y, z) directions simultaneously (slower rates can also be selected) and independently. This provides a full 3-dimensional representation of the magnetic environment. These sensors are incredibly sensitive (down to 0.5nT) and capable of measuring both the AC and DC components of the magnetic field. The MADS sensors are interfaced to their own individual dedicated laptop PCs (Dell computers) via the serial port and are equipped with their own data acquisition software. The MADS is the most appropriate configuration to truly detail the nature of magnetic complexity in the natural setting.

The present study consisted of placing the Active sensor in the pillow region of the bed (simulating where approximately the observers head would be) in the TR and the Baseline sensor at some proximal distance from it in the same room (the area the voices were heard coming from). The data measuring duration lasted for a continuous 4 hours period in total. This period was subsequently decomposed into 4 separate 1–hour measuring sessions.

Method

Design & procedure

The study was carried out over the course of one evening from 11:30pm to 3:30am on the 31st March 2004 at Muncaster Castle, Ravenglass, Cumbria. Researchers present included the author (JJB) and fellow researcher Ian Topham (IT) who assisted in setting up the sensors and taking measurements. The *'Active'* sensor was placed just above the pillow area on the TR bed at a height of 110cm from the floor to the middle of the sensor. The midpoint of Sensor A was 35cm from the north wall (behind the headboard), and 170cm from the west wall that adjoins the staircase. These coordinates placed the sensor roughly in the middle of the pillow area and it was 120cm from both side lamp fittings either side of the bed. The *'Baseline'* MADS sensor (Sensor B) was placed at the same height from the ground as Sensor A, but located towards the opposite end of the bedroom to the right of the window location. The distance between the midpoints of both sensors was 514cm with Sensor B being placed diagonally southeast from Sensor A. Sensor B was 210cm from the east wall (containing the window and a wall mounted metal radiator), and 120cm from the south wall adjoining the next room. Sensor B was also approximately 160cm from the dressing table lamps near the east facing window wall (see Figure 1).

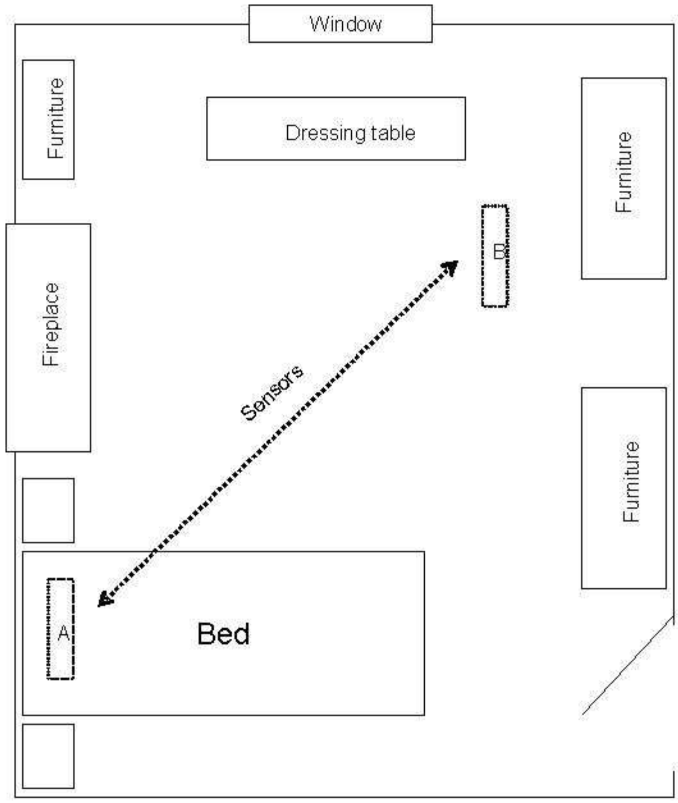

Figure 1. Schematic floor plan of the Tapestry room showing the room layout and sensor locations (A and B) for the study.

Each sensor was orientated (using a compass) so that the x-axis was pointing East/West, y-axis was North/South, and the z-axis Up/Down and were fixed so that the x and y axes were parallel to the floor. The calibration of the sensors was checked before the experiment began following guidelines from the manufacturer. The sensors were configured to gather data at a baud rate of 9600, which equated to a rate of 33 samples a second. These settings can be configured via the data gathering software provided by the sensor manufacturer. The clocks on both laptop computers were synchronised (using the internet) and the data files configured so that they provided a time stamp with every reading. Before the beginning of the experiment both sensors were placed together and a time-calibration test was carried out. This involved passing a low-strength magnet a few centimetres in front of the sensors, which produced a significant peak in the signals. These peaks were used in the data file for further time-based alignment calibrations. The measurement session lasted for 4 hours of continuous time-linked monitoring. All data gathered were recorded and stored automatically by the software on the laptop computers. In terms of nearby electrical devices, the room is only equipped with side lighting and these were left on. There were table lamps either side of the Tapestry room bed, and two lamps situated on either side of a dressing table near the window area. With the exception of the sensors, and a ceiling mounted fire alarm, these were the only electrical devices in the room (and a similar arrangement is employed in all adjacent rooms). No individual entered the TR during the measurement period.

Results & Discussion

The results were analysed in the following manner. The data files from both sensors were checked and matched for the time calibration test and edited down so each sensor master file now contained 4 hours worth of raw time-series magnetic data. Firstly, four separate time-linked one-hour session files were created for both sensors independently. Overall descriptive statistics were calculated on each sessions-worth of data. This included a mean total overall field value (AC and DC fields summed), a range, and a standard deviation for each axis (x, y, z). These values are summarised for each session and sensor in Table 1. This gives an initial indication of where and when the strongest fields and highest variances occurred. All values are given in nanoTesla (nT). Secondly, the data from both sensors for the full 4-hours was merged into one large data file. This file contained over 900,000 magnetic samples across the two sensors combined. Formal analyses were carried out on these data and the results are also given below.

Descriptive analysis

Table 1 suggests the following, firstly there seems to have been a large and clear difference in total field values gathered from the different locations. Sensor A (pillow area) provided an overall value of 30491nT whereas Sensor B (window area) produced an overall field of 77857nT (a difference of approximately 47366nT). This difference is considerable

Table 1: Descriptive statistics and averages for both Sensor A and Sensor B for all four sessions (one hour intervals). All values are given in nanoTesla (nT).

		Sensor A			**Sensor B**		
		Mean	Std Dev	Range	Mean	Std Dev	Range
Session 1	Mag X	10873	00057	00372	24597	00031	00232
	Mag Y	-17205	00027	00174	09065	00008	00052
	Mag Z	-22702	00016	00100	73302	00011	00076
	Mag Total	30491	00015	00108	77848	00012	00087
Session 2	Mag X	10870	00055	00366	24566	00029	00199
	Mag Y	-17201	00027	00192	09077	00007	00043
	Mag Z	-22701	00015	00103	73317	0007	00061
	Mag Total	30489	00014	00103	77855	00010	00068
Session 3	Mag X	10869	00055	00345	24544	00029	00226
	Mag Y	-17197	00028	00177	09079	00007	00040
	Mag Z	-22711	00015	00098	73333	00007	00061
	Mag Total	30491	00015	00092	77860	00010	00076
Session 4	Mag X	10870	00053	00348	24528	00028	00222
	Mag Y	-17194	00027	00202	09082	00007	00043
	Mag Z	-22716	00014	00092	73339	00006	00055
	Mag Total	-30493	00013	00086	77864	00009	00064

for such a short spatial distance (less than 7m). There were also some interesting differences across the planes. For both sensors, the z-axis (up/down) contributed most to the overall field amplitude level, this being 74.5% of the total field for Sensor A, and 94.2% for Sensor B. This is to be expected given the dip in the Earth's magnetic field at the latitude and longitude of the building.

Within each sensor, the highest standard deviation and range came from the x-axis (East/West). This may indicate that both sensors were picking up on a general and more global variance from these directions. However, the range of values from the x-axis was far higher overall for Sensor A (358nT, standard deviation = 55nT) relative to sensor B (220nT, standard deviation = 30nT). Between the sensors, the biggest difference seems to have come from the y-axes (north/south) with the variance being much higher for Sensor A. To summarise the descriptive analysis, Sensor B (window area) produced the total highest background field readings. However, Sensor A (pillow area) measured considerably higher variance in the magnetic field when decomposed across the axes. The significance of these differences were analysed more formally below.

Formal analysis

The patterns revealed by the descriptive analysis were more formally analysed in the following way. Firstly, a 2 x 4 (Sensor x Session) between-subjects Analysis of Variance (ANOVA) was carried out with the total-field magnetic measurements as the dependent variable. The ANOVA was based on mean averages taken every 15mins throughout the measuring period (4 hours) for both sensors.[3] This revealed a significant main effect of Sensor, $F_{(1,24)} = 8.8, p < .001$. As suggested by the descriptive analysis, the fields measured by Sensor B were significantly higher than those from Sensor A. The analysis also revealed a significant main effect of Session, $F_{(3,24)} = 17.9, p < .001$. The sessions produced reliably different field patterns over the 4-hour measuring period. The Sensor x Session interaction was also significant, $F_{(3,24)} = 10.5, p < .001$. This last result was probably due mainly to an overall rise in field amplitudes of around 25nT for Sensor B, relative to a rise of only 5nT for Sensor A, over the measuring period. Figure 2 shows total field data from Sensor A and Sensor B averaged for every half-hour for over the 4-hour period. Here the differential increase for Sensor B can clearly be seen.

The ANOVA carried out on the total magnetic measurements revealed significant differences based on the measured samples of the total combined magnetic field at both locations in space. The nature of these fields were decomposed and explored further by comparing the actual variances of the separate *x*, *y*, *z*-axis magnetic series themselves. The descriptive statistics summarised across Table 1 suggest that the most variant fields measured occurred during Session 1 for both sensors (indicated by the increased standard deviations and range). If field variance is important then a crucial difference may exist between the variance in the signal from the separate individual axes of Sensor A compared to the time-linked axes of Sensor B. To test this, the variance was compared between the separate axis measurement from Sensor A

[3]One might argue that the use of parametric statistics is questionable here as magnetic signals are known to be non-stationary and produce non-normal distributions. However, there are a number of ways of correcting for this. To cater for this, the present study here summarised and averaged the raw signal samples into overall means for particular time periods (i.e., every second or every 15mins). These averages are known to be normally distributed (mean sample distribution) and are suitable for such an analysis (see also Wiseman et al., 2002, 2003 for a similar procedure).

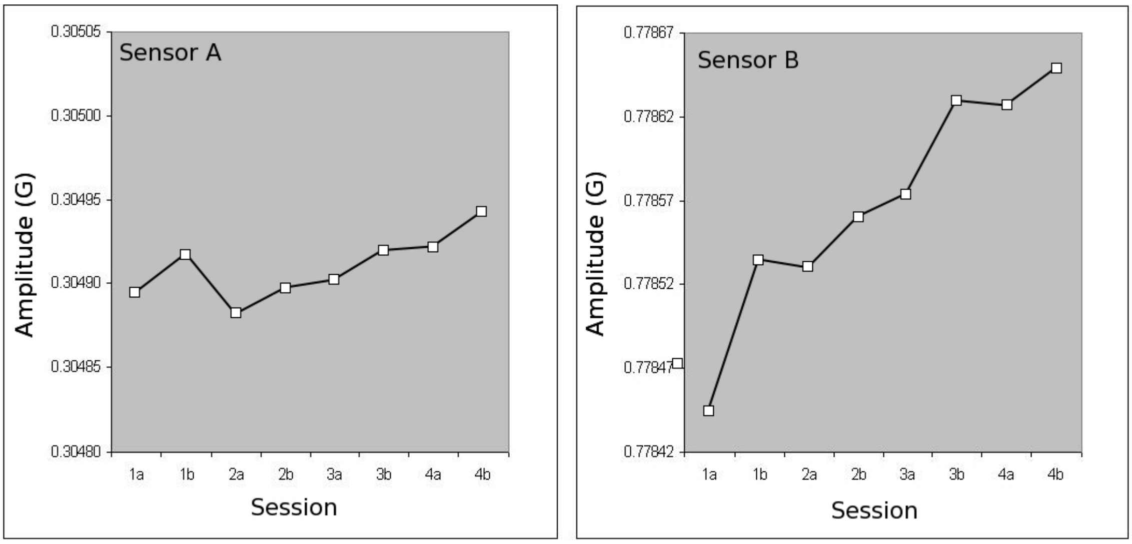

Figure 2. Total magnetic field measurements averaged over 30min segments from each session for both Sensor A and Sensor B. Here the clear increase in total amplitude for Sensor B, but not Sensor A, can be seen. Note for simplicity and comparison, the *y*-axis on this and subsequent figures is set for increments in Gauss (G). To obtain the correct value in nT simply read the value from the right of the decimal point.

and Sensor B for session 1. This was done by averaging the raw sample series into 1 second means for 120 seconds of time (2 mins) at the beginning of session 1.[4]

This was carried out separately for the x-axis, y-axis and z-axis on both sensors. A F-ratio was then calculated on these measurements by dividing the variances computed from the sensor data. This revealed a significant difference between the variances for both the x-axis ($F_{(119,119)} = 3.3, p < .001$) and y-axis ($F_{(119,119)} = 9.9, p < .001$) of Sensor A relative to Sensor B. The difference between the z-axis on the two sensors just failed reach significance ($F_{(119,119)} = 1.9, p > .05$. These results confirm the idea that the magnetic variance measured by Sensor A was, on the whole, much greater and statistically distinguishable from that obtained by the baseline sensor. The majority of this difference in variance came from the comparison between the y-axis (north/south) and the x-axis across the two sensors. Figures 3 to 6 show the time-linked signals compared between the sensors for the three axes separately and the total combined field. These signals are based on 184 raw samples, which equated to approximately 5 seconds taken from the start of ses-

[4]These comparisons were also carried out at other random sections of the data series at approximately 30mins (mid point) and 60mins (the end) of session 1. The results remained the same as those formally reported. For reasons conciseness we do not report these further replication comparisons.

sion 1. The increased amplitude variance and complexity in the signal from Sensor A can clearly be seen relative to the time-linked simultaneous baseline signal (Sensor B).

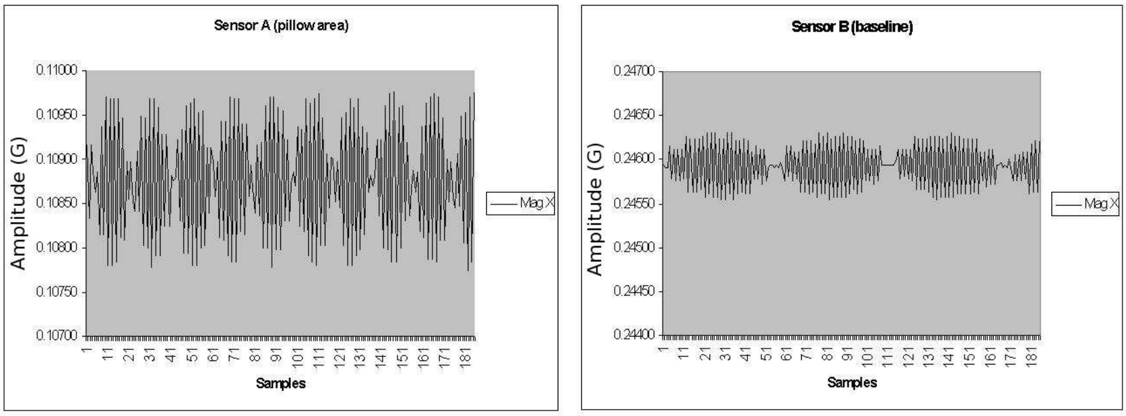

Figure 3. Time-linked signals from the *x*-axis only from Sensor A and Sensor B. These signals, and subsequent ones, are based on 184 samples, which equated to approximately 5.2 seconds taken from the start of session 1.

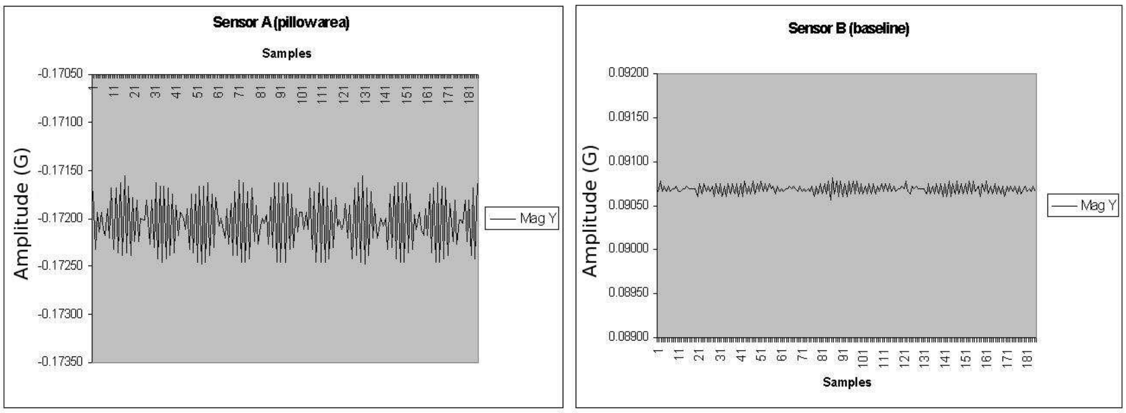

Figure 4. Time-linked signals from the *y*-axis only from Sensor A and Sensor B.

To summarise the formal analysis, as well as there being an overall significant difference between the amplitudes measured from the two spatial locations, there was also a strong reliable difference across the sensors in the time-based varying component as well. Finally, although a detailed analysis of frequency components is beyond the scope of the present article, a preliminary examination of the signals for session 1 revealed a small but continuous peak at 7Hz to 8Hz (picked up in both *x* and *y*-axes) from the pillow area. This peak was absent from the baseline

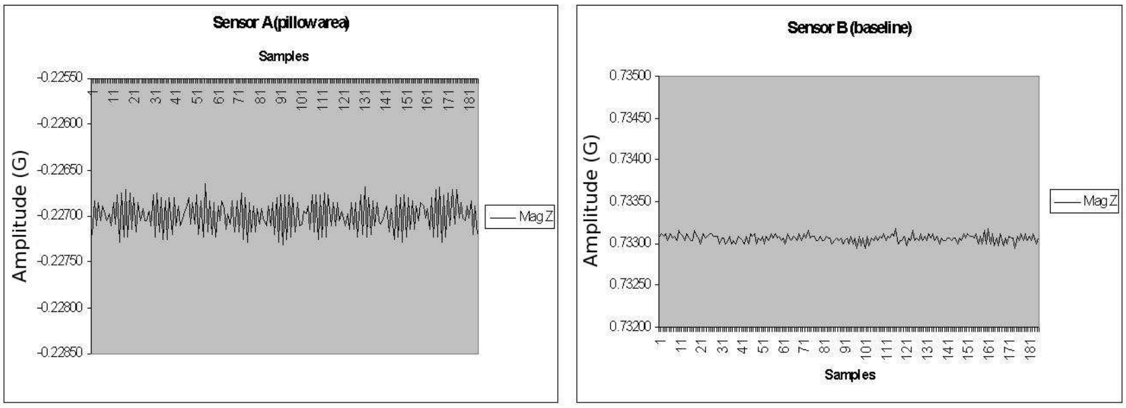

Figure 5. Time-linked signals from the *z*-axis only from Sensor A and Sensor B.

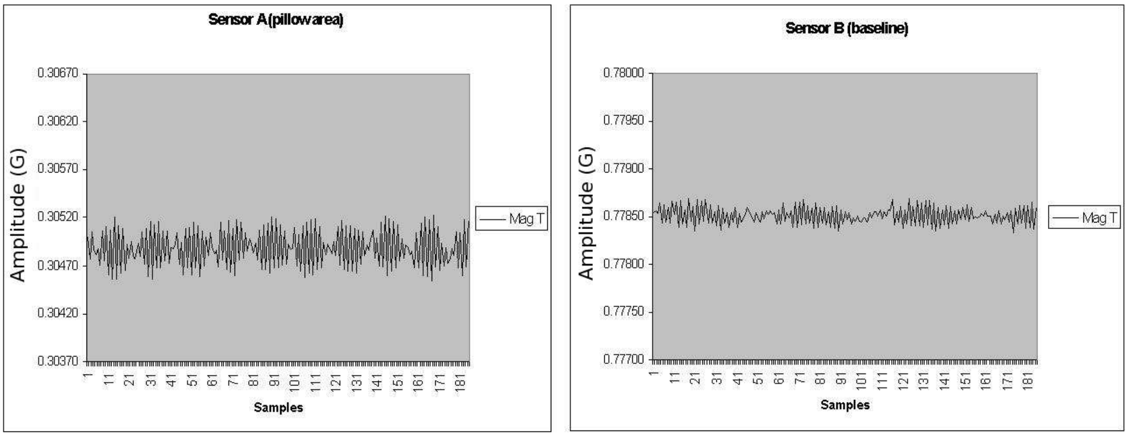

Figure 6. Time-linked signals for the total magnetic field (*x*,*y*,*z* combined) measured from Sensor A and Sensor B.

signal. One suggestion could be that this frequency component could be related to natural Schumann-type resonances generated in the Earth's atmosphere. However, if this is the case it is odd that it was only picked up in the pillow area. A full and detailed examination of frequency components throughout the measuring session will be the subject of a future article.

General Discussion

It has been claimed that some haunt-type experiences could be associated with magnetically remarkable environments (Nichols & Roll, 1998, 1999; Persinger et al., 2001; Persinger & Koren, 2001; Roll & Nichols, 1999; Roll & Persinger, 2001; see Persinger & Koren, 2001; Roll & Persinger, 2001 for reviews). The implication is that perhaps these environments can stimulate labile brains and induce strange experiences in observers. The idea that such locations could contain neurophyiso-logically relevant magnetic anomalies is attractive as it provides a useful and, most importantly, testable framework. However, one problem with studies so far carried out in the natural setting is that none have employed detailed magnetic surveys over separate spatial locations using simultaneous time-linked baseline recordings. The present paper outlined the first experiment to use a high-speed time-linked and synchronised baseline sensor to evaluate magnetic components at specific locations of interest. This has provided the most conservative and detailed test of magnetic anomalies and reputedly haunted locations carried out so far.

The location chosen to test the idea has produced numerous anecdotal spontaneous experiences of striking similarity. An analysis of these testimonies revealed an epicentre (the TR) and area within in it (the pillow area of the bed) that could be of prime interest. The present experiment consisted of placing a sensor approximately where the experient's head would have been, and placing the baseline sensor at the location where witnesses have reported the crying and sounds originated. This experiment revealed significant spatial and time-based differences in the nature of the magnetic fields measured across the sensors. These differences and their implications are outlined below.

Amplitude levels

The average steady-state strength for the earth's geomagnetic field is between 48000nT to 50000nT (.480mG to .500mG). Average hourly time-based variances in this field are typically in the region of 1 to 10nT. Although local geological factors such as tectonic strain, quartz-based rock and magnetic mineral properties can greatly influence the spatial distribution of magnetic anomalies (see Roll & Persinger, 2001), an accepted average is around 5nT per kilometre. Keeping these figures in mind, it is clear that both sensors measured fields vastly outside these estimates. In relation to the overall expected amplitude average, Sensor A provided a much lower overall measurement and Sensor B a much higher one. Furthermore, a large spatial difference occurred between the sensors in the region of 47000nT. Although other field studies have also demonstrated excessive spatially variant and distributed GMFs in the 10000nT to 40000nT range, these are more typically distributed over larger distances than those reported here (see Nichols & Roll, 1999;

Persinger & Koren, 2001; Roll & Nichols, 1999; Roll & Persinger, 2001).

One reason for the very low amplitudes measured in the pillow area could be related to the dense metal lattice mattress support under the central area of the bed itself. This could be artificially causing a constant distortion in the ambient magnetic field reducing the overall amplitude in the pillow region (note the dense metal fixtures are not in the pillow region itself but cover an area consistent with the upper back to ankle region on the beds occupants). To test this we also took some preliminary measurements above the mattress around the central bed area where we did measure a substantially high and constant field of around 96457nT (the highest field encountered). This is considerably above the natural geomagnetic field. However, approximately 90cm from this position in the pillow area the field dropped dramatically to around its average of 30491nT (a difference of around 60000nT!). Irrespective of the underlying mechanism it is clear that occupants of the bed are exposed to a highly spatially variant field with ambient levels around the torso area that were double that of normal levels and almost three times that of the pillow area. A full and detailed spatial survey of the TR, bed area, and other baseline rooms is planned for the future to ascertain the nature of the spatial variance in these magnetic fields, the distortion the bed may be causing, and attempt to locate a source.

The overall high field readings from Sensor B are most likely due to the net influences of the localised geophysics and the longitudinal/latitudinal position of the location. The castle is built out of thick granite and sandstone rock and is located on a dense granite plate covering a small area of the Eskdale valley region of West Cumbria. As noted earlier, some research has suggested that rock structures that contain magnetic minerals are associated with higher than normal background magnetic fields (see Persinger & Koren, 2001; for a discussion). This may be a contributing factor here. Alternatively, the high field may be related simply to the dip in the Earth's magnetic field at the latitude and longitude of the building. The suggestion that the castle contains higher than normal ambient levels was confirmed when other preliminary measurements were taken on the ground level of the castle in three rooms, the Guard room, the Great Hall and the Library which produced steady ambient fields of 86538nT, 86532nT and 86527nT respectively.

Another possibility for the generally high fields measured by Sensor B could be due to EMF contamination from man-made sources into the general background ambient field. This could have the effect of artificially increasing the background field far above that of geomagnetic expectancies. However, although possible there are a number of reasons why this does not seem crucial here. Firstly, the fields measured were far higher than those reported in many normal homes that arguably use more modern electrical appliances over a more condensed area. Secondly, it is also unlikely that such high fields should occur in a castle in the middle of the night when electrical use should be very low. Furthermore, the FFT carried out on data from session 1 only revealed a very small frequency component at 7Hz, which is far too low to be coming from internal house wiring, etc. This demonstrates that the variance in amplitude was generally distributed throughout the frequency spectrum, indicating a more natural source. Therefore, although such contamination could occur under certain circumstances, there seems to be little evidence of it here in the present data. This possibility remains to be more directly assessed in future studies. However, irrespective of the potential contributing sources to the field characteristics, what these findings illustrate is the nature of the magnetic environment within which observers are reporting experiences.

Although the exact role of these high constant background fields in relation to strange experiences is open to debate, it is important to quantify the fields that are present. However, it is also important to note that the current data clearly show that they do not exclusively typify the TR. Much higher fields have been measured on the ground floor (with the exception of the bed measurements due to the fittings mentioned above). Of course, experiences have been reported from many areas of the castle but it seems unlikely that constant high amplitudes alone are crucial for the main TR experiences reported here. Indeed, the pillow area seems to have produced the lowest strength fields measured so far. Irrespective of the merits of this suggestion, what seems more crucial for these experiences is how the fields varied over time.

Magnetic variance

The geomagnetic field typically varies slowly over the 24-hour cycle. Time-based variances of around 1 to 10nT are usual, though variance as much as 300nT can occur during magnetic storms or solar activity. Some researchers have suggested that gradual increases of around 20nT – 50nT in GMFs can be associated with haunt-type experiences and reports of a *'sensed presence'* (Persinger, 1975, Persinger & Koren, 2001; Persinger & Richards, 1995). Some animal studies have also shown that overt occurrences of limbic motor seizures increased significantly when a 7Hz amplitude-modulated magnetic field varying between 10nT to 50nT were applied for two hours duration (Michon & Persinger, 1997). Note the preliminary frequency analysis here revealed a small 7Hz to 8Hz field in the pillow area alone.

In the present study, over the course of the 4-hour measuring period, the total combined magnetic field measured in the window area increased more than the combined fields measured in the pillow area (25nT versus 5nT). The difference in the increase between the sensors was significant. The smaller increase at Sensor A is consistent with the field distortion idea mentioned above, where amplitudes may be artificially reduced in the pillow area (or biased away from it) due to nearby fixtures and fittings in the base of the bed.

However, perhaps more interesting was when the total field was decomposed into the individual axes analysis. This revealed that the time-based variances in the magnetic fields measured in the pillow area were substantially and significantly higher than the variances measured in the window area (except for the z-axis). The majority of this increased variance came from the y-axes and x-axes (north/south and east/west respectively). For instance, during Session A the range of readings for the x-axes from the pillow area was 372nT compared to 232nT from the window area. For the y-axes it was 174nT versus 52nT. This distribution of measurements for the pillow area is high and far exceeds the normal expectations of variance for these natural signals outlined above. Even if we assume a further degree of increased variation due to the geophysics of the area, a field varying in hundreds of nT is still unpredictably high. The cause for such variance remains unknown but it did appear to be a relatively constant factor in the fields measured at that time indicating that it may be a ‘natural’ or at least more constant component of the fields in this specific location.

These findings are consistent with prior studies suggesting that it is field complexity (defined here as variance in amplitude) rather than amplitude levels *per-se* that may be crucial for eliciting some haunt-type experiences (Persinger, 1999a, 1999b; Persinger & Koren, 2001; Roll & Persinger, 2001; Wiseman et al., 2003). Furthermore, this study expands previous findings by showing that such complexity is potentially available in a crucial region of the room. The difference noted earlier between the sensors showed an important spatial difference in the amplitudes of the fields measured. In contrast, the temporal variances in the signals show that potentially important time-based transients do exist at such locations.

Magnetically remarkable locations

It is clear from the data gathered overall that the general level of ambient magnetic field measured at Muncaster Castle is much higher than the estimated geomagnetic averages for the country. This could be due to the combined and net influences of the local geology of the area, the material the castle is built out of, local tectonic characteristics, and possibly contributions from diffuse artificial EMF sources (e.g., house wiring etc) impinged upon a geomagnetic field. Although the source of such elevated fields is currently unknown, they are a constant characteristic of the rooms so far measured in the locale. The effects of constant exposure to such increased field strengths on neuronally susceptible people are currently open to debate. The presence of such increased fields is consistent with a number of previous studies suggesting that static fields of these amplitudes and their spatial distribution could be critical for strange experiences. Coupled to these high levels, the evidence presented here also suggests that highly variant temporally defined fields are also present and may well differentiate certain areas.

In relation to the four questions outlined in the Introduction the data suggest the following: Firstly, there seems to be no evidence here that the pillow area contained excessively high fields, either relative to the baseline or the Earth's expected average field strength. Indeed, quite the contrary. However, there was clear evidence that the general ambient fields available elsewhere in the room and castle were higher than those predicted by national averages. There also seemed to be little evidence that high amplitude fields and high variance co-occurred at the same specific sensor position. The highest amplitudes produced the lowest varying fields, and conversely the lowest amplitude fields produced the highest varying (i.e., more complex) fields. If we assume that such complexity is crucial for inducing hallucination then there was clear evidence here that the fields around the head/pillow area of the TR were far more complex and time-varying relative to the time-linked baseline (see Figures 2 to 5). Furthermore, the use of dual sensors has revealed both a time-varying and space-varying difference across the areas surveyed. The large difference between the overall amplitudes is consistent with the notion that reputedly haunted locations may contain highly spatially variant fields (Nichols & Roll, 1999; Roll & Nichols, 1999; Roll et al., 1996; see Persinger & Koren, 2001; Roll & Persinger, 2001 for reviews). Indeed not only was a large difference present between the two main measuring positions, but when a preliminary survey of the bed region was carried out this produced both the highest and lowest amplitude fields over an approximate 90cm distance. Clearly the occupant of the bed area would be exposed to such diverse fields. Furthermore, the time-based measurements across both sensors revealed that although some highly variable magnetic components were influencing both sensors in the same directions (perhaps reflecting local peculiarities in the ambient field of the building) the effect was far greater in the pillow area of the TR. Note that the capacity to disambiguate these time-based and space-based magnetic components would not be possible with a simple single meter or single sensor approach.

If the signals reported here are in any way indicative of the important magnetic characteristics that distinguish haunted locations from non-haunted ones, then it would seem to be the case that there is a constant general 'undercurrent' or signature to them. In other words, these fields or some component of them may be 'available' all of the time. The magnetic properties that characterised the two sensor locations seemed to remain relatively constant over the 4-hour measuring period. This implies that occupants of the bed would, at least in principle, be exposed to the complex field over a more prolonged time period. Whether these 'undercurrents' are sufficient, a change in their magnitude occurs, or a completely different magnetic signature become apparent during anomalous events/experiences remains to be seen.

To summarise, the present study has employed new high-speed technology and a time-linked baseline methodology to assess the magnetic characteristics of a reputedly haunted location. The present study has allowed for the detailed comparison of two areas over precisely the same time periods. This is the first field study of its kind to constantly measure, over a prolonged time period, the nature of magnetic variance at such locations in this manner. This approach places this study much closer to the findings from laboratory studies of magnetic brain stimulation. If laboratory studies are correct then magnetic anomalies should exist at locations of interest, and specific areas within them. Based on the present data, the magnetically remarkable signature of Muncaster Castle has highlighted a spatial disparate and temporally complex amplitude varying magnetic field. Although the exact source of the field is unknown, the crucial initial step is to demonstrate that such anomalies exist in the first place. Further studies are planned to carry out detailed time-based and spatial magnetic surveys of the location to evaluate the implications for strange experiences in a promising contemporary case of a haunting.

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