Perceptual and Motor Skills, 2000, 90, 659-674.

EXPERIMENTAL SIMULATION OF A HAUNT EXPERIENCE AND ELICITATION OF PAROXYSMAL ELECTROENCEPHALOGRAPHIC ACTIVITY BY TRANSCEREBRAL COMPLEX MAGNETIC FIELDS: INDUCTION OF A SYNTHETIC "GHOST"?[1]

M. A. PERSINGER, S. G. TILLER, AND S. A. KOREN

Laurentian University

Summary.—To test the hypothesis that experiences of apparitional phenomena with accompanying fear can be simulated within the laboratory, a 45-yr.-old journalist and professional musician who had experienced a classic haunt four years previously was exposed to 1 microTesla, complex, transcerebral magnetic fields. Within 10 min. after exposure to a frequency-modulated pattern applied over the right hemisphere, the man reported "rushes of fear" that culminated in the experience of an apparition. Concurrent electroencephalographic measurements showed conspicuous 1-sec.-to-2-sec. paroxysmal complex spikes (15 Hz) that accompanied the reports of fear. A second magnetic field pattern, applied bilaterally through the brain, was associated with pleasant experiences. The subject concluded that the synthetic experience of the apparition was very similar to the one experienced in the natural setting. The results of this experiment suggest that controlled simulation of these pervasive phenomena within the laboratory is possible and that this experimental protocol may help discern the physical stimuli that evoke their occurrence in nature.

One method to simulate experimentally the experiences attributed to "haunts" or "ghosts" is to expose individuals who have reported these experiences to complex, electromagnetic fields whose configuration can induce the cerebral conditions that are suspected to occur during natural settings. The present study was designed to discern if a normal person who had reported an experience of a haunt would consider experiences induced by specifically designed experimental, transcerebral magnetic field as similar to those associated with the initial, real experience.

This concept is a variation of discriminative responding that is employed in pharmacological research with nonhuman animals (Appel, White, & Holohean, 1982). In this paradigm only one of two levers is associated with reward if the rat has been preinjected with a pharmacological agent with known properties. The other lever is associated with reward only if a placebo has been preinjected. The extent to which an experimental drug of unknown structure evokes similar internal states can be inferred by measuring the proportion of the animal's responses to the two levers.

In previous studies (Cook & Persinger, 1997) we had found that appli-

[1]Please send reprint requests to Dr. M. A. Persinger, Behavioral Neuroscience Laboratory, Department of Psychology, Laurentian University, Sudbury, Ontario P3E 2C6, Canada.

cation of a frequency-modulated magnetic field primarily over the right hemisphere for 20 min. increased the probability of normal people reporting a sensed presence (or the feeling of "being watched") and negative affect. The "presence" has been experienced as located along the left side of the body. In contrast, the application of a burst-firing pattern once every 3 sec. or 4 sec. over both hemispheres for 20 min. has been reported to evoke pleasant thoughts (Freeman & Persinger, 1996) that were evident in the meanings of the words employed to describe these experiences (Richards, Persinger, & Koren, 1993). The experience of a presence has been reported as pleasant and primarily along the right side of the body. The same pattern has elevated nociceptive thresholds (Fleming, Persinger, & Koren, 1994) in rats exposed for comparable periods.

Method

Subject and History

The subject was a 45-yr.-old professional journalist and musician who had been living in Canmore, Alberta at the foot of the Rocky Mountains. During the year 1993 the subject, his wife, and their two children moved into a house that had been rented several times during the previous years. Within days the members of the family could discriminate experiences of marked anxiety, depression, and malaise. Sounds, described as "knocks" occurred intermittently. Activated light bulbs dimmed or brightened without apparent cause. Some bulbs brightened and then burst. Computers and electronic devices behaved "strangely." A sensed presence or the feeling of being watched was experienced by all members of the family. Disturbing and anxiety-provoking dreams were frequent.

The rooms within the house were experienced as "damp" most of the time; spiders were frequently observed. The subject and a male friend, a local politician, decided to explore the crawl space between the floor of the house and the ground to isolate the sources of the cold spots and drafts that occurred transiently within the house. While within the space both men experienced intense fear and cold. The subject reported that a series of small lights, like a collection of fireflies, exhibited a diffuse ovoid form beneath a light fixture. The presence was also felt by the subject's friend. Shortly after the men talked about the observation and the friend whistled, the form dissipated. The subject sold the house and left the town.

Procedure

The subject had read about the research of Laurentian University's Neuroscience Research Group and requested an opportunity to discern the effects of magnetic fields. On the day of the experiment, he completed the Personal Philosophy Inventory (Makarec & Persinger, 1990; Persinger &

Makarec, 1993). Scores for clusters of items that we have employed to infer temporal lobe sensitivity, truthfulness, the propensity for affirmative responding, numbers of different previous paranormal experiences, and agreement with exotic or traditional religious beliefs were obtained. The subject did not report a history of epilepsy and consequently met the criterion of the protocol that had been approved by the departmental ethics committee.

After completion of the consent form, the subject sat within a comfortable arm chair within a commercial acoustic chamber. He was blindfolded with a pair of modified swimmer's goggles. Electroencephalographic sensors were attached by EC2 electrode cream at the traditional positions F7, F8, T3, T4, O1, and O2. A modified motorcycle helmet, described in previous studies, was placed on his head. The helmet contained four solenoids on each side at the level of the temporal plane. Although the details of the equipment have been published elsewhere (Richards, *et al.*, 1993), a simplified diagram is shown in Fig. 1. The circuitry was designed such that for any given 0.5-sec. interval only one pair (one left, one right) of solenoids was activated so that the flux lines could penetrate through the horizontal axis of the cerebrum. A lapel microphone allowed comments from the subject to be recorded by audiotape. He was told that he might or might not be exposed to magnetic fields and that the experiment would be stopped immediately following his request. The time of presentation or the pattern of the field was not discussed with the subject. During the experiment the chamber was dark except for a single, small photographer's (red) light.

During the first 20 min. the Thomas pattern (Thomas, Kavaliers, Prato, & Ossenkopp, 1997), a frequency-modulated sequence whose structure has been published elsewhere and is reproduced in Fig. 2, was generated from a computer through a commutator into the solenoids within the helmet. The pattern contains 849 values between 0 and 255 which are converted to voltages to generate the fields. The switches were set to favour the right hemisphere such that the magnetic field strength at the level of the scalp averaged 5 microTesla over the right temporal region and 1 microTesla over the left homologous region. The pixel duration, the real time presentation of each value of voltage, was 3 msec. and the time between the generation of each pattern, whose duration was 2.56 sec. (3 msec. multiplied by 849 points + port time), was 3 msec.

With these parameters the averaged frequency of the Thomas pattern was 25 Hz during the first 200 msec. of each presentation and gradually decreased to about 6 Hz during the last 500 msec. of each presentation. The durations of the maximum excursions were between 3 msec. and 6 msec. and the time between the double peaks of the excursions that composed the working pulses was 15 msec. (equivalent to 66 Hz). The duration of the

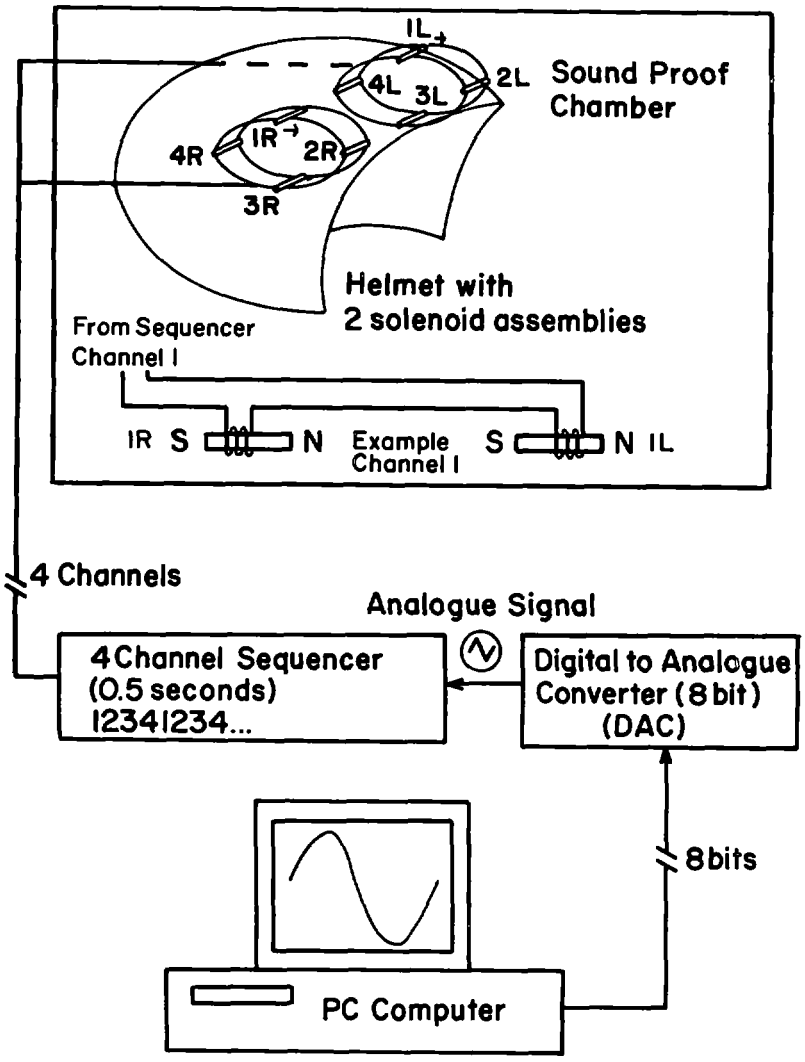

FIG. 1. Schematic of helmet containing the solenoids and the exposure system

double peaks and the interpeak interval was 30 msec. The delay between successive pairs of peaks was 55 msec. during the first 200 msec. and 156 msec. during the last 500 msec. At the end of the 20-min. presentation, the subject's blindfold was removed and he completed our standard exit questionnaire. It contained 20 items of the most frequently experienced phenomena within the setting. The ratings were 0 (no experience), 1 (experienced at

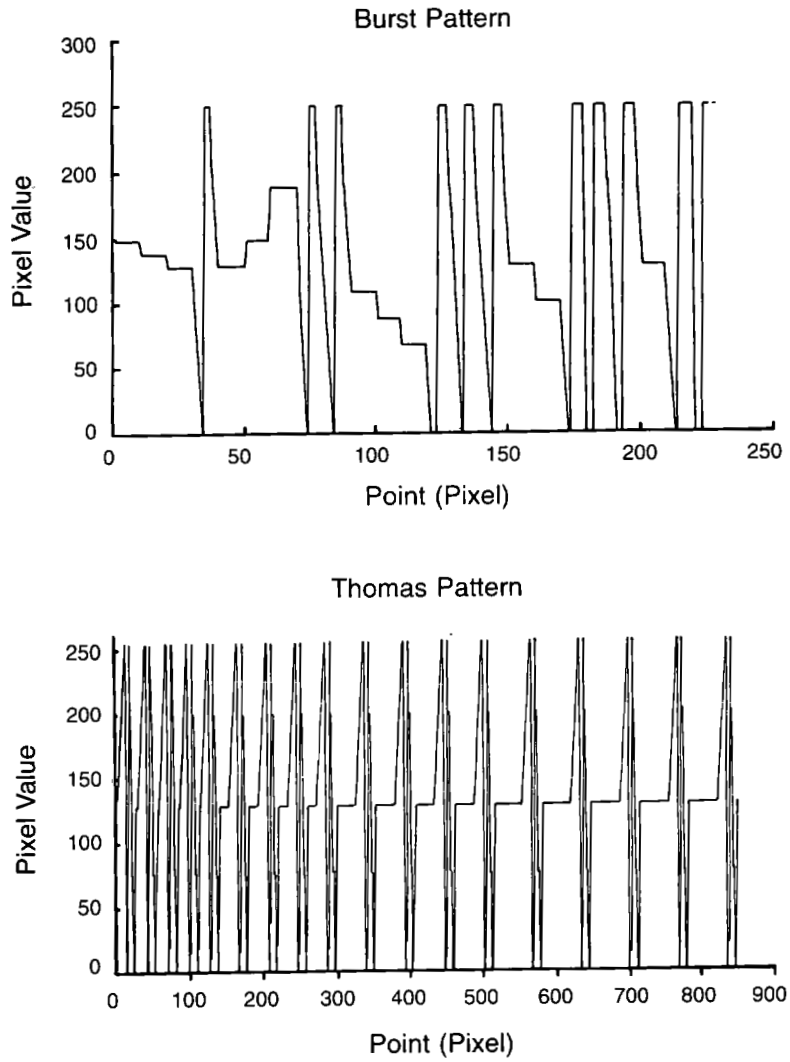

FIG. 2. Pictorial presentation of the two patterns applied transcerebrally

least once), and 2 (experienced more than once). A 5-point hedonistic rating, ranging from −2 (very negative) to +2 (very positive), was also completed.

During the second 20 min. a burst-firing pattern (Fig. 2) was applied with equal strength (peak of 2 microTesla at the level of the scalp) through both sides of the helmet. The pixel duration for each of the 230 points was

3 msec.; this resulted in a duration of 690 msec. This pattern was presented once every 3,000 msec. (3 sec.). Whereas the average frequency was 16 peaks per sec., the interpulse times ranged between the equivalents of 10 Hz and 110 Hz over the duration of the pattern. The durations of the maximum excursions were between 12 msec. and 15 msec. At the end of the session, the subject completed the exit questionnaire again. During all sessions bipolar electroencephalographic activity was monitored continuously by a P79 Grass Polygraph. The results were interpreted by the first author who has evaluated more than 1,000 electroencephalographic readings with this montage during the last 10 years using this equipment within this context.

Results

The subject's z scores for the specific clusters from the Personal Philosophy Inventory were within the average range. The specific clusters and z scores, respectively, were temporal lobe scale: +0.5, yes-responding −2.0, lie scale −0.5, paranormal experiences +0.5, exotic beliefs +0.5, and religious beliefs −0.5. Except for the scale for yes-responding, all scores were within the average range. The below average score for that scale indicated the subject was less likely than the average person to answer yes to the items within the questionnaire.

The subject spoke frequently during the exposures to experimental treatments and reported his experiences. The major verbal comments, listed in temporal order (each comment separated by about 10 to 20 sec.) during the presentation of the Thomas pattern over the right hemisphere are shown in Table 1. The electroencephalographic activity was dominated by beta activity over the prefrontal region and mixed activity within the alpha and beta range caudally until about 12 min. after the beginning of the exposure.

TABLE 1

Experiences Reported Sequentially Over Time by Subject During Application of Thomas Pattern, by Koren Helmet, Primarily Over Right Temporoparietal Region

1.	Shadows-coming from right moving around
2.	Tingling, drooling along right side
3.	Tingling right leg
4.	Someone is touching me along the left side
5.	Left side tingling inside of thigh almost sexual
6.	Feel tense—something between shoulders to left
7.	Tightness in chest
8.	A rush
9.	Dry throat
10.	Tingling inside of thigh
11.	This is not pleasant
12.	Foreboding feeling
13.	Feel my toes twisting

(continued on next page)

TABLE 1 (CONT'D)
EXPERIENCES REPORTED SEQUENTIALLY OVER TIME BY SUBJECT DURING APPLICATION OF THOMAS PATTERN, BY KOREN HELMET, PRIMARILY OVER RIGHT TEMPOROPARIETAL REGION

14.	There's a flash of light
15.	Subtle visual effects—shadows
16.	Shadows
17.	Drooling
18.	Tingling from hands need to scratch
19.	Breathing
20.	I see visuals
21.	Architecture (Gothic) in depth
22.	I'm shaking (first EEG paroxysmal activity occurs)
23.	Shivers
24.	Visuals coming from left side, slight tunnel
25.	Feel elevated
26.	Want to lean forward
27.	Hints of color like the aurora borealis
28.	Tension in left shoulder
29.	Drooling from right
30.	Tunnelling experience
31.	Tunnelling from right side—it shrinks and expands
32.	Left side feels strange under my jaw
33.	Clenching feeling
34.	Left arm spasm
35.	Involuntary movement
36.	Feel like I'm being controlled
37.	I'm easily distracted
38.	Body twitching
39.	Rush . . . I'm suddenly cold
40.	A visual
41.	Visual—I see an apparation . . . that's it
42.	Hands sweaty
43.	Seeing visual dots
44.	Don't stop
45.	It's going now

For the remaining 8 min. the subject's brain displayed a total of 16 paroxysmal patterns of complex spike activity over the temporal lobes. Comparisons of the references and the direction of the initial deflections of this activity indicated the source was within the right hemisphere. Examples of these patterns are shown in Fig. 3. The duration of each paroxysmal event was between 0.5 and 2.5 sec. The time between events ranged between 2 sec. and 242 sec. During the experience of the "presence" (Table 1) six of these events with interevent times between 2 sec. and 4 sec. were recorded. The subject reported intense "rushes" of fear and cold shivering when the events were 2 sec. or longer. Despite the intense fear and the clear distress within the subject's voice, he requested the experiment be continued.

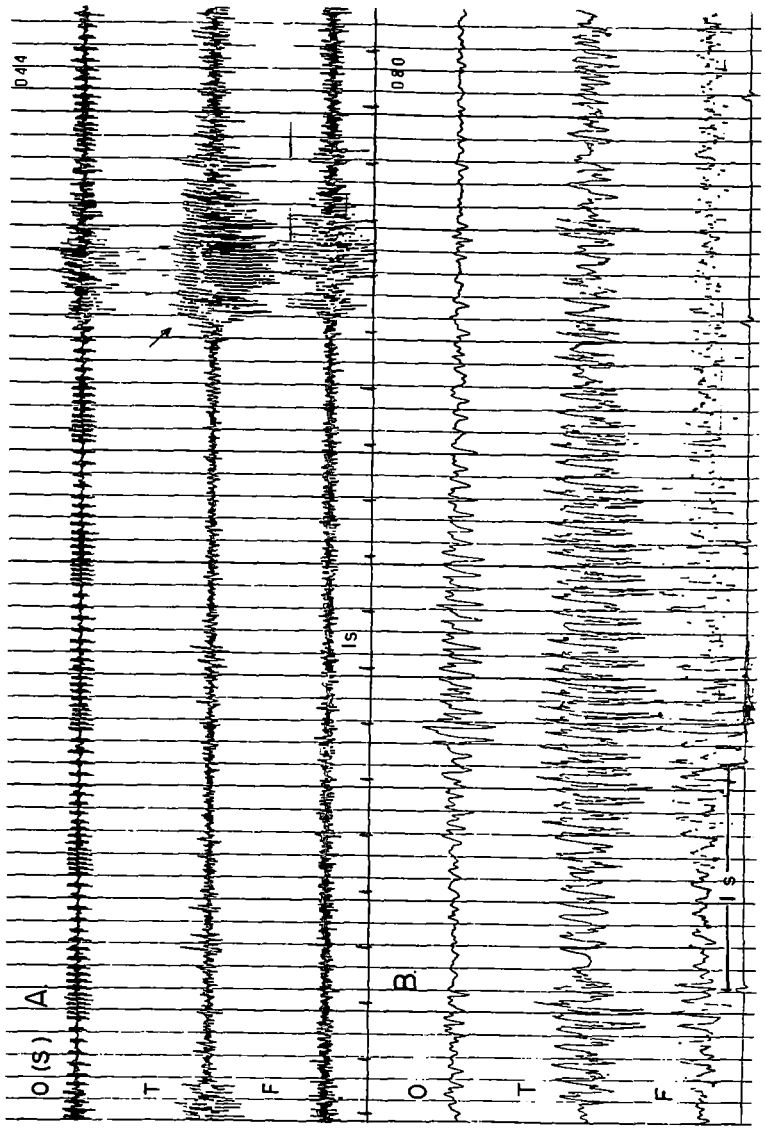

FIG. 3. The occurrence of paroxysmal activity over the temporal lobes (T), associated with a "rush of fear" during the presentation of the Thomas pattern. Two separate episodes depicted by different paper speeds (A, B) are shown. Intervals of 1 sec. are indicated by successive vertical lines. The occipital leads were used as verification of the magnetic field's presence.

The serial narrative during the presentation of the second, bilateral burst-firing pattern (interstimulus interval of 3 sec.) is shown in Table 2. The theme of the experiences changed from aversive to pleasant during this exposure. Six of the same paroxysmal electroencephalographic patterns noted during the application of the Thomas pattern occurred during the first 4 min. During the remaining 16 min. there were no unusual electroencephalographic patterns. All channels were dominated by fast, high amplitude beta activity that had not been evident during other portions of the study. The pattern was very similar to those displayed by some meditators after a 20-min. episode of Transcendental Meditation (Persinger, 1984).

TABLE 2

EXPERIENCES REPORTED BY SAME SUBJECT AFTER RIGHT HEMISPHERIC STIMULATION, DURING BILATERAL APPLICATION OF BURST-FIRING PATTERN

1. Circular object like upside down china plate the color of soap stone hovering over the left upper visual field moving in and out of vision
2. Head wants to fall to right
3. Visual
4. Twitching
5. Hard to collect thoughts
6. Feeling manipulated
7. Urge to burp (actual burp followed)
8. I feel I have no control of head movements
9. Feel like I have parkinsonism—shaking
10. Head feels its sitting strangely on shoulders
11. Head feels like its on my right shoulder
12. Funny thoughts
13. Feel pleasant
14. Burning in stomach
15. Twitching
16. Hands clammy
17. Starting to relax
18. Pressure on right side of head
19. Tingling feet
20. Right side of chest twitched
21. There's a song in my head
22. Things coming from right
23. Unpleasant taste
24. Blue phosphenes
25. Blue phosphenes
26. Sinus pressure
27. Warm feeling along left side
28. Detached
29. Drooling
30. Depression
31. Feeling weepy
32. Burning sensation

(continued on next page)

TABLE 2 (CONT'D)
EXPERIENCES REPORTED BY SAME SUBJECT AFTER RIGHT HEMISPHERIC STIMULATION, DURING BILATERAL APPLICATION OF BURST-FIRING PATTERN

33.	Depression malaise
34.	Want to speak in phrases
35.	Feel like smiling
36.	Want to burst into laughter
37.	I see female genitals
38.	Overall pleasant feeling
39.	Hearing music
40.	I hear music
41.	There are lights on the right side
42.	Lights to the center right
43.	See a pair of eyes approaching looking at me
44.	Its taking definite form

Detailed examination of the electroencephalographic records indicated that 68% of the paroxysmal episodes of complex spike activity shown in Fig. 1 occurred during the last 500 msec. of the application of the Thomas pattern when its equivalent frequency was about 6 Hz. Only one event occurred during the first 1.5 sec. of a presentation of the Thomas pattern. When the 2.5-sec. durations of the patterns were partitioned into five 0.5-sec. segments and an equal probability for the onset of a paroxysmal discharge was assumed for each, this disproportionate distribution was statistically significant ($\chi_4^2 = 27.12$, $p < .001$). The occurrences of the six paroxysmal discharges during the first 4 min. of the presentation of the burst pattern were either concurrent with one of the 600-msec. burst patterns ($n = 4$) or followed the termination of one of the bursts within the first second ($n = 2$). They did not occur during the second and third second after the cessation of the field ($\chi_3^2 = 7.41$, $.05 < p < .10$).

TABLE 3
POSTEXPOSURE RATINGS FROM EXIT QUESTIONNAIRE FOR PREVALENCE OF EXPERIENCES AND FINAL PLEASANTNESS RATINGS FOR ALL EXPERIENCES ASSOCIATED WITH EXPOSURE TO THOMAS (FREQUENCY MODULATED) AND BURST-FIRING MAGNETIC FIELDS

Item	Thomas Pattern	Burst Pattern
1. Dizzy or odd	2	1
2. Felt a presence	1	0
3. Tingling sensations	2	2
4. Saw vivid images	1	1
5. Pleasant vibrations through body	1	1
6. Felt detached from body	0	1
7. An inner voice called name	0	0
8. Experienced anger	1	0
9. Experienced sadness	1	2

(continued on next page)

TABLE 3 (CONT'D)
POSTEXPOSURE RATINGS FROM EXIT QUESTIONNAIRE FOR PREVALENCE OF EXPERIENCES AND FINAL PLEASANTNESS RATINGS FOR ALL EXPERIENCES ASSOCIATED WITH EXPOSURE TO THOMAS (FREQUENCY MODULATED) AND BURST-FIRING MAGNETIC FIELDS

Item	Thomas Pattern	Burst Pattern
10. Experiences were not mine	0	0
11. Heard a ticking sound	0	0
12. Odd smells	0	1
13. Experienced terror	1	0
14. Odd tastes in mouth	2	1
15. Felt somewhere else	2	1
16. Experienced childhood thoughts	0	0
17. Recurrent idea	1	2 (music)
18. Felt spinning around	0	0
19. Images from a recent dream	1	1
20. Sexual arousal	1	1
General Rating	–2	+1

The subject's responses to the exit questionnaire after exposures to the patterns are shown in Table 3. Following the completion of the experiment the subject reported that the experience of the apparition during the exposure to the first pattern was markedly similar to that encountered in his house four years previously. The central theme of the experiences during exposure to the second pattern was similar to those he experienced while playing a musical instrument.

DISCUSSION

Several experiments have suggested that complex temporal patterns of weak magnetic fields whose patterns are generated by computer and applied through the brain from pairs of solenoids can affect the themes of emotional experiences (Richards, *et al.*, 1993), memories (Richards, Persinger, & Koren, 1996) and electroencephalographic activity (Persinger, Richards, & Koren, 1997). More intense magnetic fields, generated by other application geometries as much less complex patterns, have also evoked measurable changes in electroencephalographic activity (von Klitzing, 1991; Bell, Marino, & Chesson, 1992). Our experiments have been inspired by the hypothesis that all experiences are neuroelectromagnetic patterns generated within the brain. These patterns and their correlative experiences can be modified by strategic application of weak complex magnetic fields, now capable of being generated by computer software, that interact with these neuroelectromagnetic fields.

The results of the present study suggest that this technology might be employed to help understand the neurocognitive bases for experiences attributed to "haunts" or to "ghosts" and to isolate the physical characteris-

tics of the stimuli that can evoke these phenomena. Modern science has ignored these interesting phenomena, despite the surprisingly pervasive nature of their reports across all cultures and throughout human history. The possibility that these experiences can be simulated in the laboratory offers an alternate explanation to their sources and a method by which the effective stimuli might be identified.

The marked similarity between the experiences that occurred during the application of the experimental magnetic fields and the original "haunt," however, could be argued to be confounded by the subject's reconstruction of the original experience. Individuals who are imaginative exhibit chronic elevations of metabolic activity within several regions of the right hemisphere (Szechtman, Woody, Bowers, & Nahmias, 1998). Because activity within the right prefrontal cortices is involved with the reconstruction of episodic and autobiographical memory (Bruckner & Petersen, 1996; Fink, Markowitsch, Reinkemeier, Bruckbauer, Kessler, & Heiss, 1996), the combination of the subject's expectations and the generalized activation of the right hemispheric stimulation by the magnetic fields may have enhanced the vividness of his expectations or the revivification of that memory (De Pascalis, 1993; Persinger, 1994; Healey, Persinger, & Koren, 1996; Martin, Wiggs, & Weisberg, 1997).

There are several results which would suggest the intense, fear-associated visual experiences during the experiment were not artifacts of this subject's personality structure or nonspecific responses to the field. First, the negative affective themes reported when the frequency-modulated (Thomas) pattern was applied over the right hemisphere and the pleasant affective themes reported when the burst-firing pattern (interstimulus interval of 3 sec.) was applied bilaterally are consistent with results from other studies involving volunteers without histories of haunt experiences (Richards, *et al.*, 1993; Persinger, Richards, & Koren, 1994). Second, the subject did not display above average scores for clusters of items from which we infer temporal lobe sensitivity (Makarec & Persinger, 1990; Persinger & Richards, 1994, 1995), different types of paranormal experiences, or beliefs in exotic phenomena. These average scores indicated the subject was not particularly prone to experience these phenomena spontaneously and are consistent with the hypothesis that given sufficient optimal stimulation anyone along the continuum of temporal lobe sensitivity will respond to these fields. Third, as the experiences became more intense during exposure to the Thomas pattern (presented without the subject's awareness) over the right hemisphere, the experiences were localized by him on the left side of his body. Such lateralization would be consistent with contemporary principles of neurological function.

Perhaps the most compelling component of this study was the emer-

gence of clear and repeated paroxysmal electroencephalographic patterns with primary emphasis over the temporal lobes. Their one-to-one correspondence, without the subject's knowledge, of subjective sensations of "rushes of fear" suggests that the experimental fields evoked neuroelectrical changes that were associated with both the subjective sensation and the electroencephalographic patterns (Gloor, Olivier, Quesney, Andermann, & Horowitz, 1982; Bancaud, Brunet-Bourgin, Chauvel, & Halgren, 1994; Cendes, Andermann, Gloor, Gambardella, Lopes-Cendes, Watson, Evans, Carpenter, & Oliver, 1994). Because this subject did not have a history of epilepsy, displayed the electroencephalographic anomaly during application of a specific (Thomas) pattern over the right hemisphere, and has not displayed this anomalous activity when exposed to a variety of other configurations of magnetic fields (unpublished observations), these electroencephalographic signatures were more likely to have been experimentally associated than spontaneous or spurious.

The probability that the electroencephalographic discharges were artifacts of induction within the sensors (electrodes) or the passage of the fields over the sensors is minimal. The input from the computer was changed to successive pairs of solenoids every 0.5 sec. while the duration of many of the discharges was 2 or more seconds. The shapes of the 16-Hz discharges were symmetrical and consistent; their amplitudes were comparable and displayed similar intraburst and interburst magnitudes. Consequently, induction artifacts from the spatial rotation of the applied fields by the commutator, which would have resulted in variable amplitudes, were not likely. The discharges did not occur continuously, despite the repeated presentation of the Thomas pattern, and emerged during an average frequency of about 6 Hz which was much less than the consistent frequency of the discharge. The same electroencephalographic configurations and amplitudes occurred during the initial presentation of a different field pattern that was applied bilaterally.

The frequency and shape of the discharges were not typical of classic seizures (Niedermeyer & da Silva, 1987; Barlow, 1993). The double spike, downward deflected, was similar to the intrapulse structure of the Thomas pattern. The (strip chart) time between any two of the double downward deflections was about 33 msec. compared to the interpeak interval of 30 msec. generated by the applied field; these values are within the range of measurement error due to the paper speed. However, unlike the applied field's delay between successive pairs of peaks that ranged between 55 msec. and 156 msec., the interpeak intervals within the paroxysmal discharges were consistently about 33 msec. for the duration of the discharge. Whether the structure of the applied field affected the shape of the discharges or, due to reso-

nance, encouraged the occurrence of a proclivity within the subject's brain that was present before the experiment, is not clear.

Since completion of this study more than two years ago the subject has traveled extensively and has followed work schedules associated with marked disruptions in circadian rhythms and sleep deprivation. Such schedules often encourage the overt display of electrical seizures (Niedermeyer & da Silva, 1987). A portion of his work has been to experience the effects of isolation within a deep mine in the absence of light and sound. Within various contexts, with and without expectancies, he has not experienced any of the phenomena reported during the experimental stimulation.

We have tested about 40 subjects (nonepileptic according to self-report) within this particular paradigm. Although the report of a sensed presence and other mystical experiences (including apparitional-like patterns) have been frequent, the intensity of the experience and the occurrence of such striking electroencephalographic signatures have not approached the magnitude displayed by this subject. Although there are many possible explanations, we suggest that recurrent exposure to natural settings that are associated with special places, such as those attributed to haunts, might sensitize a few thousand neurons within structures that compose pathways within the limbic-thalamic-temporal lobes. Recent calculations by Gailey (1999) indicate that an induced membrane potential of only one microvolt can be detected after 10 msec. by an ensemble of less than 100 million ion channels. This result corresponds to approximately 10,000 neurons that would be a small subset of the estimated tens of millions of neurons that have been shown by magnetoencephalography to discharge in highly organized, synchronous modes (Kelso, 1995). For some people exposures to synthetic fields similar to the original stimulus might either revivify the memory of the experience or activate the experience that is associated with a matrix of sensitized neurons that were modified by the original stimulus.

The occurrence of conditions that simulate our experimental protocol within nature must still be measured directly. The first author (Persinger, 1985) has suggested that a primary source of the energy and neural information that is associated with experiences attributed to "haunts" originates within the earth from focused tectonic strain. Although pulsed fields with simple temporal structures from these sources would be expected to induce electric currents within susceptible objects, including the human brain, time-varying fields with complex structures and potentially containing neural information should also be present. If this hypothesis is correct for most cases then both direct effects upon the observer's brain and the physical influence upon electrical objects, such as light bulbs, televisions, telephones, and computers, could occur simultaneously. The serial experiences would be the synthesis of the two classes of phenomena (Persinger, 1985).

As shown experimentally the induction of a sensed presence, its attribution, and its movement may be affected by the perceiver's changing ongoing neurocognitive processes as they interact with the applied complex electromagnetic fields (Cook & Persinger, 1997). Shifting attention towards the spatial location of the sensed presence and attempts to "concentrate" or to "focus" upon it can induce the perception of movement of the "presence," usually to the opposite side. The egocentric nature of neurocognition might encourage the conclusion that the 'entity' was responding to the experient's thoughts and hence was both "sentient" and "nonphysical."

One of the essential premises of modern neuroscience is that we are only aware of the states of our neurons. This implies that functional alterations in the organization of neuronal activity would allow different states and hence would facilitate perceptions of stimuli that are insensible to normal conditions. From this perspective brief exposures of the human brain to optimal natural electromagnetic fields or to those generated synthetically might allow the perception of stimuli (perhaps always present but not detected) that are filtered or altered by the normal neuroelectrical conditions of the waking state.

That magnetic fields whose temporal patterns contain changing asymmetric shapes (and hence potential neural information) and whose amplitudes range between 10 nT to 1,000 nT (1 microTesla) can affect consciousness and experience (Persinger & Richards, 1995) has been an issue of scientific debate. Whereas the spatial homogeneity, strength, and temporal symmetry of applied magnetic fields are important for the discrete resolution required for the imaging of the structures and the functions of the brain (such as fMRI or functional magnetic resonance imaging), the temporal complexity and spatial heterogeneity of the applied magnetic fields appear to be more critical for affecting complex neurobiological processes once a minimal threshold for intensity has occurred. We have shown in this instance that the application of weak complex magnetic fields generated by computer and applied through a relatively simple system of external solenoids systematically affect subjective experiences and electroencephalographic signatures when the subject was not aware of the characteristics of the patterns or their presentations.

REFERENCES

Appel, J. B., White, F. J., & Holohean, A. M. (1982) Analyzing mechanism(s) of hallucinogenic drug action with drug discrimination procedures. *Neuroscience and Biobehavioral Reviews*, 6, 529-536.

Bancaud, J., Brunet-Bourgin, F., Chauvel, P., & Halgren, E. (1994) Anatomical origin of *deja vu* and vivid memories in human temporal lobe epilepsy. *Brain*, 117, 71-90.

Barlow, J. S. (1993) *The electroencephalogram: its patterns and origins*. Cambridge, MA: MIT Press.

Bell, G. B., Marino, A. A., & Chesson, A. L. (1992) Alterations in brain electrical activity caused by magnetic fields: detecting the detection process. *Electroencephalography and Clinical Neurophysiology*, 83, 389-397.

Bruckner, R. L., & Petersen, S. E. (1996) What does neuroimaging tell us about the role of prefrontal cortex in memory retrieval? *Seminars in the Neurosciences*, 8, 47-55.

Cendes, F., Andermann, F., Gloor, P., Gambardella, A., Lopes-Cendes, I., Watson, C., Evans, A., Carpenter, S., & Olivier, A. (1994) Relationship between atrophy of the amygdala and ictal fear in temporal lobe epilepsy. *Brain*, 117, 739-746.

Cook, C. M., & Persinger, M. A. (1997) Experimental induction of the "sensed presence" in normal subjects and an exceptional subject. *Perceptual and Motor Skills*, 85, 683-693.

De Pascalis, V. (1993) EEG spectral analysis during hypnotic induction, hypnotic dream and age regression. *International Journal of Psychophysiology*, 15, 153-166.

Fink, F. R., Markowitsch, H. J., Reinkemeier, M., Bruckbauer, T., Kessler, J., & Heiss, W-D. (1996) Cerebral representation of one's own past: neural networks involved in autobiographical memory. *The Journal of Neuroscience*, 16, 4275-4282.

Fleming, J. L., Persinger, M. A., & Koren, S. A. (1994) Magnetic pulses elevate nociceptive

thresholds: comparisons with opiate receptor compounds in normal and seizure-induced brain-damaged rats. *Electro- and Magnetobiology*, 13, 67-75.

FREEMAN, J., & PERSINGER, M. A. (1996) Intermittent instructions (disruption) during exposure to transcerebral magnetic fields that elevate nociceptive thresholds elicits irritability: implications for opiate effects. *Perceptual and Motor Skills*, 82, 639-642.

GAILEY, P. C. (1999) Membrane potential and time requirements for detection of weak signals by voltage-gated ion channels. *Bioelectromagnetics*, 20, 102-109.

GLOOR, P., OLIVIER, A., QUESNEY, L. F., ANDERMANN, F., & HOROWITZ, S. (1982) The role of the limbic system in experiential phenomena of temporal lobe epilepsy. *Annals of Neurology*, 12, 129-144.

HEALEY, F., PERSINGER, M. A., & KOREN, S. A. (1996) Enhanced suggestibility following application of burst-firing magnetic fields over the right temporoparietal lobes: a replication. *International Journal of Neuroscience*, 87, 243-247.

KELSO, J. A. S. (1995) *Dynamic patterns*. Cambridge, MA: MIT Press.

MAKAREC, K., & PERSINGER, M. A. (1990) Electroencephalographic validation of a temporal lobe signs inventory in a normal population. *Journal of Research in Personality*, 24, 323-337.

MARTIN, A., WIGGS, C. L., & WEISBERG, J. (1997) Modulation of human medial temporal lobe activity by form, meaning, and experience. *Hippocampus*, 7, 587-593.

NIEDERMEYER, E., & DA SILVA, F. L. (1987) *Electroencephalography: basic principles, clinical applications and related fields*. (2nd ed.) Baltimore, MD: Urban & Schwarzenberg.

PERSINGER, M. A. (1984) Striking EEG profiles from single episodes of glossolalia and transcendental meditation. *Perceptual and Motor Skills*, 58, 127-133.

PERSINGER, M. A. (1985) Geophysical variables and behavior: XXII. The tectonic strain continuum of unusual events. *Perceptual and Motor Skills*, 60, 59-65.

PERSINGER, M. A. (1994) Seizure suggestibility may not be an exclusive differential indicator between psychogenic and partial complex seizures: the presence of a third factor. *Seizure*, 3, 215-219.

PERSINGER, M. A., & MAKAREC, K. (1993) Complex partial epileptic-like signs as a continuum from normals to epileptics: normative data and clinical populations. *Journal of Clinical Psychology*, 49, 33-45.

PERSINGER, M. A., & RICHARDS, P. M. (1994) Quantitative electroencephalographic validation of left and right temporal lobe signs and indicators in normal people. *Perceptual and Motor Skills*, 79, 1571-1578.

PERSINGER, M. A., & RICHARDS, P. M. (1995) Vestibular experiences of humans during brief periods of partial sensory deprivation are enhanced when daily geomagnetic activity exceeds 15-20 nT. *Neuroscience Letters*, 194, 69-72.

PERSINGER, M. A., RICHARDS, P. M., & KOREN, S. A. (1994) Differential ratings of pleasantness following right and left hemispheric application of low energy magnetic fields that simulate long-term potentiation. *International Journal of Neuroscience*, 79, 191-197.

PERSINGER, M. A., RICHARDS, P. M., & KOREN, S. A. (1997) Possible differential entrainment of electroencephalographic activity by weak complex electromagnetic fields. *Perceptual and Motor Skills*, 84, 527-536.

RICHARDS, P. M., PERSINGER, M. A., & KOREN, S. A. (1993) Modification of activation and evaluation properties of narratives by weak complex magnetic field patterns that simulate limbic burst firing. *International Journal of Neuroscience*, 71, 71-85.

RICHARDS, P. M., PERSINGER, M. A., & KOREN, S. A. (1996) Modification of semantic memory in normal subjects by application across the temporal lobes of a weak (1 microT) magnetic field structure that promotes long-term potentiation in hippocampal slices. *Electro- and Magnetobiology*, 15, 141-148.

SZECHTMAN, H., WOODY, E., BOWERS, K. S., & NAHMIAS, C. (1998) Where the imaginal appears real: a positron emission tomography study of auditory hallucinations. *Proceedings of the National Academy of Science*, 95, 1956-1960.

THOMAS, A. W., KAVALIERS, M., PRATO, F. S., & OSSENKOPP, K-P. (1997) Antinociceptive effects of pulsed magnetic fields in the land snail. *Cepaea nemoralis*. *Neuroscience Letters*, 22, 107-110.

VON KLITZING, L. (1991) A new encephalomagnetic effect in human brain generated by static magnetic fields. *Brain Research*, 540, 295-296.

Accepted March 13, 2000.