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( 1 of 1 )

United States Patent 5,800,481
Loos September 1, 1998

Thermal excitation of sensory resonances

Abstract

In man, autonomic and cortical resonances of the nervous system can be excited by inducing subliminal heat pulses in the skin by means of a resistive heat patch, laser, heat lamp, or microwave radiation, or through a slow air jet that carries a small periodic fluctuation in temperature. Deeply subliminal skin temperature oscillations of frequency near 1/2 Hz induced in a subject by any of these means cause sleepiness, drowziness, relaxation, a tonic smile, ptosis of the eyelids, a tense feeling, sudden loose stool, or sexual excitement, depending on the precise pulse frequency used. For certain higher frequencies, the induced subliminal skin temperature oscillations cause fractured thought and a slowing of certain cortical processes. The method and apparatus can be used by the general public as an aid to relaxation, sleep, or arousal, and clinically for the control and perhaps treatment of tremors, seizures, and emotional disorders. There is further application in the form of nonlethal weapons, involving a pulsed infrared laser or a pulsed microwave beam, tuned to a sensory resonance pulse frequency.

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Appl. No.: 580346
Filed: December 28, 1995

Current U.S. Class: 607/100
Intern'l Class: A61F 002/00
Field of Search: 607/96,98,100-101,107,97-102,115.3,148,152,88-89
128/741-743,734 600/26,38 606/2,3,13 219/212 165/46

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Claims

I claim:

1. Apparatus for exciting in a subject a sensory resonance, the sensory resonance having a resonance frequency, the apparatus comprising:

generator means for generating voltage pulses with a pulse frequency in the range 0.1 to 45 Hz;

heat inducing means, connected to the generator means, for inducing in the skin of the subject heat pulses with an intensity less than 10 mW/cm.sup.2, and a frequency equal to the pulse frequency; and

tuner means for tuning the pulse frequency to the resonance frequency.

2. Apparatus according to claim 1, wherein the heat inducing means comprise:

resistor means for producing heat; and

thermal conduction means for partially conducting the produced heat to the subject when the conduction means are in thermal contact with the skin of the subject.

3. Apparatus according to claim 2, wherein the generator means, resistor means, and the thermal conduction means are confined to a single enclosure.

4. Apparatus according to claim 1, wherein the heat inducing means comprise

radiator means for delivering radiative electromagnetic power to the skin of the subject.

5. Apparatus for exciting in a subject a sensory resonance, the sensory resonance having a resonance frequency, the apparatus comprising:

radiation means for producing at the subject a beam of electromagnetic radiation with an intensity less than 10 mW/cm.sup.2 ;

chopping means for modulating said beam, the chopping means having a chopping frequency in the range 0.1 to 45 Hz; and

tuner means for tuning the chopping frequency to the resonance frequency.

6. Apparatus according to claim 1, wherein the heat inducing means comprise:

electric blower means for producing an air jet; and

electric heater means for heating the air jet.

7. A method for influencing the central nervous system of a subject, comprising the steps of:

inducing in the skin of the subject heat pulses with a dominant frequency in the range 0.1 to 45 Hz and a peak intensity less than 10 mW/cm.sup.2 ; and

selecting a value for the dominant frequency appropriate for excitation of a sensory resonance.

8. The method according to claim 7, wherein the inducing comprises applying heat to the skin of the subject by conduction.

9. The method according to claim 7, wherein the inducing comprises applying electromagnetic radiation to the skin of the subject.

10. The method according to claim 7, wherein the inducing comprises applying heat to the skin of the subject convectively.

11. The method according to claim 7, wherein the inducing is initiated by the subject at the time that the need for said influencing is perceived.

12. Apparatus for exciting in a subject a sensory resonance, the sensory resonance having a resonance frequency, the apparatus comprising:

generator means for generating voltage pulses with a pulse frequency in the range 0.1 to 45 Hz;

microwave means, connected to the generator means, for producing microwave radiation pulses with a frequency equal to the pulse frequency; and

tuner means for tuning the pulse frequency to the resonance frequency.

Description

## BACKGROUND OF THE INVENTION

In man, the nervous system responds markedly to certain sensory signals in a narrow band of frequencies near 1/2 Hz; the response to the sensory signals includes sleepiness, drowsiness, relaxation, a tonic smile, ptosis of the eyelids, the feeling of a "knot" in the stomach, sudden loose stool, and sexual excitement, depending on the precise frequency used. The narrowness of the band of effective frequencies is suggestive of a resonance, and the phenomenon is therefore called "the 1/2 Hz sensory resonance". The resonance can be excited through the sense of balance, as we know from "rocking the baby" or relaxing in a rocking chair. But the resonance can also be excited by physical means other than motion, such as externally generated weak electric and magnetic fields, as discussed in the copending patent application Ser. Nos. 08/447394, ›1!, and 08/486918, ›2!. The electric field excitation appears to involve stimulation of Ruffini endings in the skin ›1!, and the magnetic field excitation is believed to occur through stimulation of muscle spindles and the vestibular end organ ›2!. All the receptors mentioned use frequency coding in their data transmission.

SUMMARY OF THE INVENTION

It has been shown in our laboratory that the induction of subliminal heat pulses with a frequency near 1/2 Hz in the human skin can cause sleepiness, drowsiness, relaxation, a tonic smile, ptosis of the eyelids, a tense feeling, sudden loose stool, and sexual excitement, depending on the precise pulse frequency used. The need for rather precisely tuned frequencies suggests that one is dealing with a resonance phenomenon. Since the resonances are excited through the senses and involve the autonomic nervous system, they are called "autonomic sensory resonances". Experiments have shown that, for the mentioned responses to occur, the amplitude of the skin temperature oscillations must fall in a rather restricted range, called the effective intensity window.

Further experimentation has shown the existence of resonances at higher frequencies. These resonances appear to involve cortical processes and are therefore called "cortical sensory resonances". A large resonance of this type has been found near 2.4 Hz, and smaller resonances have shown up near 2.2, 3.9, and 6.9 Hz. These resonances are detected by letting the subject repeatedly count backward from 100 to 70, while the frequency of the heat pulses is varied very slowly. The resonances show up as pronounced peaks in the graph of counting time versus heat pulse frequency. As is the case for autonomic sensory resonances, for the physiological effects to occur, the heat pulse amplitude must lie in a certain effective intensity window. The cortical sensory resonances cause a slowing of certain cortical processes. Furthermore, prolonged exposure to heat pulses near 2.4 Hz can cause mental states that may be characterized as "fractured thought". It takes considerable time for the responses to develop fully.

The heat pulses may be induced in the skin by conductive, convective, or radiative means. For conductive induction, the apparatus can be a battery-powered pulse generator that powers a small resistive heat patch placed on the skin of the subject. The heat patch employs either a resistive wire or a sheet of conductive polymer. Heat pulses suitable for excitation of autonomic or cortical sensory resonances are so weak as to be deeply subliminal.

Convective heat pulse induction may be achieved by an air jet which is heated in pulsed fashion. The jet is aimed at the face of the subject. The full array of physiological responses can be obtained even when the air velocity over the skin is imperceptibly small and the periodic fluctuations of the air temperature in the jet cause skin temperatures variations of subliminal magnitude.

Radiative induction may be achieved by a a pulsed heat lamp, a chopped heat lamp beam, a keyed laser beam, or by pulsed microwave radiation. The effective intensity window for excitation of the cortical sensory resonance near 2.4 Hz has been measured for the case of heat pulses induced in a large skin area by pulsed heat lamp radiation; the window has been found to extend from 0.8 to 3.0 mW/cm.sup.2.

These discoveries open the way for influencing the nervous system of a subject by delivering weak heat pulses to the subject's skin. Devices for such purpose can be used by the general public as a sleeping aid, and as an aid for relaxation, control of anxiety and stage fright, or for facilitation of sexual arousal. Clinical use is seen for the control, and perhaps the treatment, of emotional disorders, tremors, and seizures.

Radiative heat pulse induction lends itself to application in non-lethal weapons for remotely exerting an influence on a subject's nervous system. This can be done covertly with a keyed infrared laser beam or with a pulsed microwave beam. In the latter case, high frequency is desirable since it results in small skin depths in human tissue, thereby minimizing the wasted heat generated in deeper lying tissue much below the cutaneous thermoreceptors.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a preferred embodiment in which weak heat pulses are induced conductively in the skin of a subject.

FIG. 2 shows an embodiment in which weak heat pulses are induced in the subject's skin by means of an infrared laser.

FIG. 3 is a circuit diagram for a pulse generator suitable for use in the arrangement of FIG. 1.

FIG. 4 shows a packaging of the pulse generator and heat patch in a single enclosure.

FIG. 5 depicts an embodiment in which weak heat pulses are convectively induced in the subject's skin by means of an air jet.

FIG. 6 shows a heat patch designed to minimize the emanated electromagnetic field.

FIG. 7 shows schematically an embodiment in which a beam of pulsed microwave radiation is produced for the purpose of thermal excitation of sensory resonances in exposed subjects.

FIG. 8 shows a source of pulsed radiation in the form of heat lamp that is periodically switched on and off by a solenoid.

FIG. 9 shows an embodiment in which pulsed radiation is produced by chopping a beam of radiation from a heat lamp.

FIG. 10 shows cortical sensory resonances in a graph of a subject's 100-70 counting time versus the frequency of radiatively induced heat pulses.

FIG. 11 shows excitation of the cortical sensory resonance near 2.4 Hz, for different levels of power density at the subject's skin, and reveals the effective intensity window.

FIG. 12 shows the effect on the subject of the stray 60 Hz electromagnetic field emanating from the heat lamp.

FIG. 13 shows schematically two cross-coupled timers which produce a chaotic output.

FIG. 14 shows schematically the hookup of two timers such as to produce a square wave of frequency f.sub.1, amplitude-modulated by a square wave of frequency f.sub.2.

DETAILED DESCRIPTION OF THE INVENTION

As mentioned in the Background Section, the excitations of the 1/2 Hz sensory resonance by rocking motion, weak external electric fields ›1! and weak magnetic fields ›2! all are believed to involve sensory receptors that use frequency coding for reporting information to the central nervous system. Since cutaneous thermoreceptors also use frequency coding ›3,5!, and skin temperature fluctuations may occur in rocking motions as a result of induced air currents, the question arises whether perhaps the 1/2 Hz sensory resonance can be excited also through cutaneous thermoreceptors. It has been found in our laboratory that this is indeed the case; when heat flux pulses of appropriate pulse frequency and intensity are delivered to the skin by a small resistive heat patch, the subject experiences autonomic nervous system responses that include sleepiness, drowsiness, relaxation, a relaxed soft feeling in the stomach, a tonic smile, ptosis of the eyelids, a "knot" in the stomach, sudden loose stool, and sexual excitement. The various responses occur at slightly different frequencies near 1/2 Hz. The appropriate frequency for each of these responses can be determined, either by the subject or by someone else in attendence, through manual frequency scanning, wherein the frequency of the heat pulses is manually adjusted, usually in monotonic fashion, in small steps until the desired response is obtained. From the observation that the various responses occur at slightly different frequencies it appears that the 1/2 Hz sensory resonance encompasses a multiplet of resonance frequencies, one for each particular autonomic response. When the heat pulses are first applied, the resonance frequencies are observed to undergo a downward drift, large at first, but diminishing in time. Eventually the frequency drift stops altogether, so that the resonance frequencies become steady. Crude preliminary experiments suggest that the multiplet of resonant frequencies drifts downward as a whole. Upon discontinuing the administration of heat pulses, the multiplet frequencies drift back up again, as can be seen during a brief resumption of the pulses. The frequencies for the various physiological responses depend somewhat on the state of the nervous system.

Of all the responses to the 1/2 Hz sensory resonance, ptosis of the eyelids stands out for distinctness, ease of detection and frequency sensitivity. When voluntary control of the eyelids is relinquished, the eyelid position is determined by the relative activities of the sympathetic and parasympathetic nervous systems. The heat pulse frequency for maximum ptosis is called the ptosis frequency; it can be found by manual frequency scanning. The ptosis frequency initially drifts downward, eventually settling at the steady ptosis frequency. The latter can be determined by manual tracking of the ptosis frequency, in which the frequency is manually adjusted such as to keep the ptosis maximum. At a fixed frequency slightly above the steady ptosis frequency the ptosis oscillates with a period of one or several minutes. Therefore, the steady ptosis frequency can also be determined by finding the frequency setting at which this oscillation ceases, and the ptosis remains strong and steady.

The intensity of the heat pulses delivered to the skin is an important parameter in the experiments; it has been noticed that the heat flux density must be very small, in fact deeply subliminal, for the mentioned responses to occur. This experimental result can be understood in terms of nuisance-guarding circuitry in the brain, that blocks nuisance signals from higher processing. Of course, these signals must exceed a certain strength for the guard circuits to be activated, and this signal strength determines the upper limit of a window of effective stimulus intensities. The lower limit of the window is determined by a signals which are only marginally able to excite the resonance. It has been found that a radiative power density of 0.6 mW/cm.sup.2 from a heat lamp applied to a large part of the skin is suitable for exciting the 1/2 Hz resonance, evoking the whole array of autonomic responses mentioned for various frequencies near 1/2 Hz. At very low power densities it takes considerable time, up to half an hour, for physiological effects to develop. The frequency drift decreases with diminishing power density, but of course the slow development of responses makes frequency tracking difficult.

In extensive sleep experiments it has been found that pulse frequencies effective for inducing sleep are somewhat lower than the steady ptosis frequency. Before using a heat pulse device for the first time as a sleeping aid, it is recommended that a ptosis frequency is first determined by manual scanning. Then, starting with this frequency, the subject should adjust the tuning control every few minutes by a small downward frequency step, until sleep sets in. The final frequency setting should be written down in the morning, as it can be used as a fixed setting for the next session.

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An embodiment in which the heat pulses are induced by microwave radiation is depicted schematically in FIG. 7. Shown are a microwave dish 43 illuminated by a horn 44 driven by a power supply 45, labeled "PWR SUPPLY". A pulse generator 1, labeled "GEN", is connected to the power supply such that the microwave voltage supplied to the horn 44 is modulated by a square wave 5. The frequency of the square wave 5 can be adjusted by the tuning control 6. Subjects within the microwave beam 46 will undergo a weak pulsed heating of an outer layer of their bodies, the thickness of which is about the skin depth ›6! for the microwave frequency used; for a microwave frequency of 250 GHz, the skin depth in human tissue is about 1 mm. In a certain window of microwave power densities, the induced temperature oscillation of cutaneous thermoreceptors will cause excitation of sensory resonances at appropriate pulse frequencies. The device can be used as a nonlethal beam weapon for remotely influencing the nervous system of foes. ... continued at above link.....