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BRAIN STIMULATION TO TREAT MENTAL ILLNESS AND ENHANCE HUMAN LEARNING, CREATIVITY, PERFORMANCE, ALTRUISM, AND DEFENSES AGAINST SUFFERING

Lewis Mancini, 25 Nottingham Terrace, Buffalo, New York, 14216, U.S.A.

ABSTRACT

Any mental/emotional state or process (MESP) which is considered (a) highly desirable (e.g., sustained concentration, memorization of important facts, empathy) or (b) undesirable (e.g., paranoid delusionalism, delirium) could be, respectively, (a) facilitated or (b) deterred by means of an external (i.e., extracranial, or at least extracerebral, and extracorporal) brain stimulation circuit designed in such a way as to deliver rewarding stimulation as often and only as often as and for as long and only for as long as an electroencephalographic or other kind of brain function characteristic, which uniquely identifies the occurrence of the MESP in question, were being emitted by the individual's (i.e., the subject's) brain, with the intensity of the stimulation at every point in time being proportional, respectively, (a) to the simultaneous magnitude or (b) to the reciprocal of the simultaneous magnitude of the MESP-identifying characteristic. Approaches a and b are generalized examples of a number of hypothetical stimulation paradigms presented below that might be used to treat mental illness, enhance learning, etc. (as in the title). Explanations of the psychodynamic mechanisms whereby these paradigms might exert their intended effects are given in most cases.

INTRODUCTION

The methodology herein proposed is predicated on the inference that can be drawn from substantial experimental evidence (1, 2, 3, 4, 5, 6, 7) that any given mental/emotional state or process that one might want to either induce or suppress has characteristically and uniquely associated, detectable electroencephalographic and other kinds of measurable brain-function features (and a corresponding underlying, uniquely characteristic configuration of excited and inhibited neuroanatomic circuits) which could be used by an external circuit to automatically detect the occurrence of that MESP. Such features, which are characteristically linked with a particular MESP, may be thought of as linked characteristics (LCs) of that MESP. This methodology would require merely that each person's LCs be essentially time-invariant for her or him so that, for example, whenever person A engages in high-level concentration (MESP-CONC), A's brain reliably emits one or more particular

LCs (LC-CONCs). It would make no difference whatsoever whether A's LCs were completely different from anyone else's or not.

What is meant by stimulation is the production or suppression of impulses or action potentials within minute volumes of brain tissue, for example, a sphere or "focal spot" with a diameter of 1mm (8) or less, without any direct production or supression of action potentials in surrounding tissue. For any given application in any given case, the stimulation might consist in a continuous waveform or (more probably) in successive discrete waveforms, that is, pulses. The technical implementation of such a system might entail the use of electroencephalographic, ultrasonic, and/or electromagnetic techniques, such as MRI, for LC determination, detection, and magnitude monitoring. According to Brown and Kneeland (9, p. 495), "More powerful magnets offer the possibility of monitoring phosphorus^{31} and therefore cell energy metabolism" and therefore the possibility of monitoring MESP-specific cerebral activity as reflected in LCs. Stimulation that would be nondestructive might be affected either invasively (but hopefully not), e.g., via surgically implanted electrodes, or (preferably) noninvasively or minimally invasively (e.g., invasively with respect to the skull, such as with an ultrasonic irradiator implanted therein, but noninvasively with respect to the brain) by means of focused electromagnetism and/or ultrasound as is discussed in some detail in another paper (10).

The types of brain stimulation that might be used are (a) pleasurable (PLE), i.e., rewarding, (b) sedating (SED), (c) alerting (ALERT), (d) specific-MESP-excitatory (SMESPEX), (e) specific-MESP-inhibitory (SMESPIN), and (f) otherwise characterizable. Stimulation could be any one of, more than one of, or even all of the above in nature, with its nature in every instance being determined both by the particular neuroanatomic site(s) focused upon and the particular stimulation parameters used. Distressing, i.e., aversive stimulation should never be used.

The essential principle of the methodology, stated in the most general terms possible, is that, by means of an ideally wholly external prosthetic system, the individual would receive brain stimulation of one or more kinds as often as and only as often as and for as long as and only for as long as (and with intensity either directly or inversely proportional to the magnitude with which) the individual would emit a predetermined LC and, hence, would be either facilitated or inhibited with respect to indulgence in the MESP corresponding to that LC. Hence, the delivery and the intensity of the brain stimulation would be dependent upon the magnitude of one or more LCs and, hence, could be referred to as linked characteristic-dependent brain stimulation(LCDBS). Each LCDBS system would consist essentially in:

1. An LC detection and magnitude-monitoring component.
2. An LC-magnitude/stimulation intensity proportionalizing circuit.
3. A stimulating component.

RESULTS OF SOME (NON-LCDBS) BRAIN STIMULATION EXPERIMENTS

Sem-Jacobsen (11,p.379) reported that "We have been able to obtain feelings of comfort, relaxation, joy, and intense satisfaction.... In the ventromedial part of the frontal lobe, regions of pleasure and

relaxation are lower and more internal than those mediating anxiety and irritation. The responses of relaxation and comfort obtained from stimulation of the frontal lobe are so intense that psychotic episodes have been broken up in less than one minute on several occasions.... Stimulation of the ventromedial part of the frontal lobe has a calming effect, as does stimulation of the central region of the temporal lobe."

Heath (12, p.224) found that "With septal stimulation the patients brightened, looked more alert, and seemed to be more attentive to their environment during, and for at least a few minutes after, the period of stimulation.... Expressions of anguish, self-condemnation, and despair changed precipitously to expressions of optimism and elaborations of pleasant experiences, past and anticipated. Patients sometimes appeared better oriented; they could calculate more rapidly and, generally, more accurately than before stimulation. Memory and recall were enhanced or unchanged." Moan and Heath (13) also reported sexual feelings to be associated with self-stimulation of the septal region.

The observations of Higgins, Mahl, Delgado, and Hamlin (14, p.418) that "after one stimulation..." of the "frontotemporal" area, which they define in neuroanatomic detail, a young male subject "...said, without apparent anxiety, 'I'd like to be a girl'", whereas "In the last interview, when he came close to expressing a similar idea under pressure by the interviewer but in the absence of stimulation, he became markedly anxious and defensive" suggest that stimulation of that area could be useful in the treatment of the personality disorders intrinsic to which is the ostensible incorrigibility of maladaptive defense mechanisms. Hence, the neuroanatomic areas explored by these investigators might include appropriate stimulation sites for the applications discussed herein. The septal region in particular may contain utilizable sites (15, 16).

LCDBS AS TREATMENT FOR MENTAL ILLNESS

Examples of paradigms or modi operandi of LCDBS systems designed to treat mental illness and/or affect prophylaxis for antisocial including criminal behavior are as follows.

1. Treatment of Mental Illness Type I, that is, psychosis (including schizophrenia), which may be defined here simply as a phenomenon consisting in gross disorganization of mental processes and/or distorted perception of reality:

PLE stim. int. inc. in prop. as mag. LC-PSYCH dec.
and
PLE stim. int. dec. in prop. as mag. LC-PSYCH inc.

where PLE stim. int. = (i.e., abbreviates) pleasurable stimulation intensity, inc. = increases, dec. = decreases, in prop. as = in proportion as, mag. = magnitude of, and LC-PSYCH = an LC which identifies the occurrence of a psychotic process or state entailing, for example, hallucinations and/or delusions, and/or looseness of associations. Hence, the less psychotic an individual's mentation would become, the more intense the pleasure which he or she would obtain from the system (and the

more psychotic, the less pleasure), so that the individual would be strongly motivated to discard psychotic processes and states. Antipsychotic SMESPIN stimulation paradigms might entail the use of inhibitory stimulation directed at some of the same sites in the brain as where antipsychotic drugs exert their therapeutic effects (17).

2. Treatment of Mental Illness Type II, that is, mental pain (MP), including all forms of neurosis. The three basic kinds of mental pain: (a) anxiety (grading up to terror), (b) depression (grading up to hopelessness), and (c) anger (grading up to rage) pervade all forms of mental illness, especially the anxiety, depressive, personality, and adjustment disorders.

PLE stim. int. inc. in prop. as mag. LC-MP inc.
and
PLE stim. int. dec. in prop. as mag. LC-MP dec.

where LC-MP = an LC which identifies the occurrence of one or more kinds of mental pain. The rationale of this modus operandi would be that, inasmuch as the brain's reward (i.e., pleasure) and punishment (i.e., aversion or pain) systems are reciprocally inhibitory with respect to each other (18), the more intense the mental pain a person is experiencing, the more intense would be the pleasure needed to nullify, that is, inhibit, suppress, or relieve that pain. And the less intense the pain, the less intense the pleasure needed to nullify it. Hence, by dint of this modus operandi, mental pain would be automatically nullified by an intensity of pleasurable stimulation commensurate with it.

3. Treatment of Mental Illness Type III, that is, maladaptive and/or destructive pleasure (MDP), such as constitutes the motivational or affective essence of drug (including alcohol) abuse, sadism, some forms of sexual deviance, and mania:

SMESPIN-MDP stim. int. inc. in prop. as mag. LC-MDP inc.
and
SMESPIN-MDP stim. int. dec. in prop. as mag. LC-MDP dec.

where SMESPIN-MDP stim. = stimulation of one or more neuroanatomic sites which specifically causes inhibition of a particular kind of MDP and LC-MDP = an LC which specifically characterizes that kind of MDP. Hence, the greater the intensity of MDP (and, correspondingly, the greater the magnitude of LC-MDP), the higher the intensity of MDP-inhibitory (i.e., SMESPIN-MDP) stimulation that would be needed and automatically delivered to nullify it.

4. Treatment of Mental Illness Type IV, that is, pathological unconcern for others; facilitation of <u>empathy</u>, <u>compassion</u>, and <u>altruism</u> (ECA):

SMESPEX-ECA stim. int. inc. in prop. as mag. LC-ECA dec.
and
SMESPEX-ECA stim. int. dec. in prop. as mag. LC-ECA inc.

where SMESPEX-ECA stim. = stimulation of one or more neuroanatomic

sites which specifically causes excitation of ECA toward others and LC-ECA = an LC which specifically characterizes the process or state of being empathic and/or compassionate and/or altruistic. Hence, the lower the intensity of an individual's ECA (and, correspondingly, the lower the magnitude of LC-ECA) and, correspondingly, the greater the degree of appropriateness of an increase in the intensity of that individual's ECA, the higher the intensity of ECA-excitatory (i.e., SMESPEX-ECA) stimulation that would be automatically delivered in order to affect that increase. And the greater the intensity of spontaneous ECA, and the less the degree of appropriateness of an increase in ECA, the less SMESPEX-ECA stimulation would be delivered. One or more of approaches 1-4 and/or 1-4-like approaches would be appropriate for prophylaxis of antisocial including criminal behavior.

In cases in which the rudiments of and hence the potential for ECA were so pervasively lacking as to be noninducible by virtually any means, then it might be possible to affect prophylaxis of antisocial behavior by means of what could amount to arresting LCDBS affected by implementation of the phenomenon of cortical suppression (19), that is, suppression of spontaneous electrical activity of cortical area 4 (i.e., the motor cortex) and hence suppression of all movement by dint of the stimulation of specific suppressor areas of the cerebral cortex all of which have been demonstrated to project to the caudate nucleus. And inasmuch as when certain stimulation parameters were used, stimulation of the caudate in humans was found to be rewarding (20, 21), one might surmise that such movement-suppressive stimulation could be made both pleasurable and arresting. Whenever more than one LCDBS system were required, e.g., whenever criminal behavior is motivated by both sadism and anger or whenever a schizoaffective patient suffers from both active psychosis and depression, the two or more appropriate circuits would simply be operated in parallel with respect to each other.

EXAMPLES OF LCDBS SYSTEMS TO ENHANCE COGNITION AND PERFORMANCE

5. To improve learning ability or affect learning facilitation (LF) (22):

PLE stim. int. inc. in prop. as mag. LC-LTM inc.
and
PLE stim. int. dec. in prop. as mag. LC-LTM dec.

where LC-LTM = a linked characteristic which always and only occurs during the formation of a long-term memory trace (LTM) in the individual in question, i.e., the subject. If it were not readily possible to identify the occurrence of an LC-LTM, then a more generalized kind of learning-linked characteristic (LLC) such as an LC-CONC which always and only occurs in the subject in question during high-level, sustained concentration, which might more readily be identified, could be used in place of LC-LTM in this paradigm, by dint of which the process of long-term memory trace formation (or the state of high-level, sustained concentration or some other learning-linked MESP) would become intensely pleasurable for the subject and therefore likely to occur readily, rapidly, and sustainedly. LF LCDBS methods would be based on the idea that if learning could be made intensely pleasurable, for example, at

least as pleasurable as eating and sexual activity are for most of us after long periods of deprivation of these modes of gratification, we would be able to tap into what for most of us are our greatly underdeveloped intellectual potential. Even our IQ scores might gradually rise, though probably not as rapidly or markedly as our actual demonstrable learning ability. In view of the realization that some individuals are far more nearly hedonistically optimized with respect to the learning process, that is, have far larger appetites for informational details than others do, it stands to reason that some individuals far more nearly attain to what may be considered their upper biological limits of intellectual functioning than others do. Hence, one would not necessarily predict a very high correlation between pre- and post-LF IQ scores. LF might prove to be of value not only for intellectually normal individuals but also, as a treatment modality, for the mentally retarded and for neurologically impaired individuals such as aphasic stroke victims (in particular vis-a-vis relearning language skills) and those afflicted with dementing processes such as Alzheimer's Disease.

6. To create new interests or affect interests' diversification in a person:

PLE stim. int. inc. in prop. as mag. LC-ATUN inc.
and
PLE stim. int. dec. in prop. as mag. LC-ATUN dec.

where LC-ATUN = a linked characteristic which characterizes the process of attending (AT--) to details of a kind, for example, details of car mechanics, robotics, or a foreign language, which would naturally, that is, without LCDBS be uninteresting (--UN) to the particular subject in question. Hence, by dint of this modus operandi, attending to and processing information of a kind which would otherwise bore the individual would become intensely pleasurable and therefore likely to occur.

7. To enhance performance of skills or affect performance enhancement (PE):

PLE stim. int. inc. in prop. as mag. LC-METT inc.
and
PLE stim. int. dec. in prop. as mag. LC-METT dec.

where LC-METT = an LC which characterizes metticulousness (METT). Hence, the process of being metticulous would become intensely pleasurable and therefore likely to occur. By virtue of PE, working (like learning, by virtue of LF) could be rendered as pleasurable as eating and sexual activity are for most people. Consequently, productivity in the context of work might dramatically increase.

8. To enhance creativity:

PLE stim. int. inc. in prop. as mag. LC-CR inc.
and
PLE stim. int. dec. in prop. as mag. LC-CR dec.
operated together with

SMESPIN-CRIN stim. int. inc. in prop. as mag. LC-CRIN inc.
and
SMESPIN-CRIN stim. int. dec. in prop. as mag. LC-CRIN dec.

where LC-CR = an LC which characterizes one or more creative processes such as might occur during dreaming when, unfortunately, under natural circumstances, that is, without brain stimulation, the individual's capability of converting concept into actuality is minimal, because he or she is immobilized by the sleep process. And SMESPIN-CRIN stim. = stimulation of neuroanatomic sites which specifically causes inhibition of the inhibition of these creative impulses which naturally occurs during the waking state in most people and is inherent in the perceptual and cognitive rigidity imposed by the conscious mind. And LC-CRIN = an LC which characterizes the naturally inhibited state of these impulses during the waking state.

THE ABOLITION OF SUFFERING WITHOUT COMPROMISE OF ADAPTIVENESS

The following example, entailing the simultaneous use of paradigms 9-11, suggests ways in which any and all suffering (e.g., anxiety, dyspnea, nausea) could be abolished without any compromise of its naturally associated adaptive value.

9. SMESPIN-POA/MP stim. int. inc. in prop. as mag. LC-POA/MP inc.
and
SMESPIN-POA/MP stim. int. dec. in prop. as mag. LC-POA/MP dec.
together with, i.e., operated in parallel with
10. PLE stim. int. dec. in prop. as mag. LC-POA/MP inc.
and
PLE stim. int. inc. in prop. as mag. LC-POA/MP dec.
11. SMESPEX-AVOID stim. int. inc. in prop. as mag. LC-POA/MP inc.
and
SMESPEX-AVOID stim. int. dec. in prop. as mag. LC-POA/MP dec.

where POA = pain and other forms of bodily aversiveness, SMESPIN-POA/MP stim. = stimulation of neuroanatomic sites which causes inhibition of POA and MP. And SMESPEX-AVOID stim. = stimulation of neuroanatomic sites which causes excitation of avoidance or withdrawal behavior. LC-POA/MP = an LC which characterizes one or more kinds of POA and/or MP. With LCDBS systems 9 through 11 operating in parallel with respect to each other, the more closely a person's body were to approach or be approached by a noxious (i.e., LC-POA/MP-inducing) stimulus, the more strongly his or her POA and/or MP would be inhibited by paradigm 9, so that he or she would experience no pain (23, 24, 25), other bodily aversiveness or mental pain, and the less pleasure he or she would be gratified with by 10 (so that the person would be motivated to promptly move away from the noxious stimulus to a more highly gratifying distance from it), and the more strongly (what would effectively be reflex) avoidance or withdrawal behavior would be excited by paradigm 11.

One might object that the nullification of all pain and other aversiveness would undermine the diagnostic skills of internists and surgeons. A rebuttal to this objection is entailed in the realization that LC-POA/MP recording devices, LC-POA/MP-based alarm systems, etc.

could be used to monitor and record the time course of the intensity and anatomical distribution of POA- and MP-engendering pathophysiological processes (so that physicians would have precise and accurate records to refer to) and to inform physicians instantaneously of dangerously high intensities of these processes without the patient ever having to actually experience any of the POA or MP.

Pharmacologic and LCDBS approaches could readily be made therapeutically complementary to each other as is suggested by the observations that some pharmacologic agents facilitate self-(administered-brain-) stimulation behavior (26). Some LCDBS systems might even entail a pharmacologic component in the form, for example, of an implanted reservoir of some medication from which a minute quantum thereof would be released with each pulse or after every predetermined number, e.g., 10 or 100, of pulses of brain stimulation. It is clear that precautions against overdosing would have to be built into such prosthetic systems.

CONCLUSIONS

If, at times, in what will hopefully prove to be the relatively utopian future, we should want to nullify all selfishness, egocentricity, and loneliness and render all of us (or as many as would want to participate) optimally altruistic, that is, precisely as concerned about each other as about ourselves, we could accomplish this by telemetrically interconnecting every reward and punishment site in every participant's brain with its neuroanatomic counterpart in every other participant's brain. We would thereby affect interindividual cerebral telemetric interconnectedness, IICTI, by virtue of which we could all truly and thoroughly share our joys and sorrows (if there were still any of the latter despite LCDBS and possibly other aversiveness-annihilatory approaches) with each other.

Ideally, the neurobiological basis of the capability of experiencing distress of any kind, that is, possibly, for example, modes of functioning of certain intraneuronal structures in certain areas of the brain, might be prevented from ever developing as such by means of the individual's brain's being subjected at one or more ontogenetically opportune times to certain drugs, electromagnetic or ultrasonic waves, recombinant repressor genes, antibodies, other immunological entities, or some combination thereof, directed against this neurobiological basis. Such prevention of development would be ideal because it would preclude even the potential for suffering.

The mind recognizes that there is a common denominator among the experiences of reading a book one enjoys, eating a food one enjoys, engaging in a favorite hobby or pastime, having sexual relations with a preferred partner, achieving a goal, etc.. That common denominator, of course, is pleasure. The fact that the mind experiences pleasure as a distinct entity despite the great diversity among the numerous contexts and forms in which it can occur, suggests that there is an electrophysiological process common to all of these contexts and forms which could be objectively detected and quantified as an LC for pleasure (LC-PLE). This LC could be used as a measure of any and all of the various kinds of pleasure one can have to enjoy such as happiness

(which may be defined in the present context as pleasure which is consonant with one's idealism and/or aspirations), joy (which may be defined as pleasure which is anxiety-free and exhilarating), bodily or sensual pleasure, etc.. Hence, LC-PLE, cumulated or averaged over time or in some other form, could be used to derive a concept and a value of a person's positive aspects of subjective state of being.

Analogously, one would expect that all distressing or aversive experiences could be quantified in terms of an LC-AVERS which could serve as a measure of a person's negative aspects of subjective state of being. The measure of a person's overall subjective well-being (SWB) would be a function of both LC-PLE, which, being a positive quantity, would add to its value, and LC-AVERS, which, being a negative quantity, would subtract from its value. The standard deviation of the distribution of all of the SWB scores (SD-SWB) of everyone in the world or universe could serve as an index of the equitableness of the distribution of happiness and other aspects of SWB among the members of the population of the world or universe and, hence, as an index of the degree of actualization of the democratic principle. Inasmuch as from an objective standpoint each individual's SWB is equally as important as every other individual's SWB, the smaller the value of SD-SWB, the more equitable the distribution of SWB among the population.

Consistent with Bentham's ideal (27) of "the greatest happiness of the greatest number"' the quality of our world or universe (QW) could be assessed in terms of the ratio or quotient of the magnitude of the sum total of the SWB scores of everyone in the world or universe (SWB-TOTAL; the larger its value, the better) divided by SD-SWB (the smaller its value, the better).

$$QW = \frac{\text{SWB-TOTAL}}{\text{SD-SWB}}$$

In a similar way as the Dow Jones Index provides a means of assessing broad-based economic strength, this ratio, the QW, would provide a means of assessing broad-based (ideally universal) happiness and other aspects of SWB. It might also serve as a means of determining whether or not the lot of humankind were actually improving over time, that is, whether or not the changes which will come about in the world will actually be constructive. The larger the value of QW, the more worthwhile, humanistic, and heavenly we could consider our world to be.

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