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BRAIN ENHANCEMENT IN THE 21st CENTURY

POTENTIAL NEUROPHYSIOLOGICAL CHANGES IN BRAIN STRUCTURE THROUGH NEUROENHANCERS, NOOTROPIC AGENTS AND ORGANIC/ELECTRONIC COMPONENTS

Abstract: This paper deals with the potential future of neurophysiological changes in the brain through the use of so-called memory enhancers, neuroenhancers, cognitive boosters, chip implants and nootropics. Emphasis is placed on current studies, future research, potential ethical concerns and economic considerations, as well as the future legal ramifications of using drugs to enhance brain activity and intelligence. The paper will also refer to the issue as to whether constant use of such enhancers over time, i. e. generations, will affect the genetic make-up of physiological and psychological components that concern learning. Finally, from a socio-economic viewpoint, will such drugs be available to only a select elite or the general public. If so what will be the criteria for such availability.

Key words: *memory enhancers, neuroenhancers, legal ramifications, socio-economic of nootropics, potential ethical concerns, cybernetics, robotics, neurophysiology, genetic manipulation, acetylcholine*

INTRODUCTION

In a society fraught with social inequality, hunger, cultural unrest and fear of war and nuclear holocaust, one may wonder why the discussion of intellectual and learning enhancement is of importance. The best rationale for this theoretical and practical inquiry is that through this line of study, mankind may evolve into a kinder, more caring and socially adaptive civilized life form. This research holds the potentiality of greater revolutional leaps in the arts, sciences and perhaps social and cultural understanding. At least, it will aid mankind in creating better developmental constructs and empirical data.

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It is well acknowledged, based on previous 20th century technological advancements, that the 21st century will provide mankind with many unprecedented and hereto unthinkable advancements in the scientific and technological fields. One of these will most certainly be brain enhancement, through changes in medical science cybernetics, robotics, neurophysiology and genetic manipulation. It is potentially feasible that in time, all of the aforementioned areas will work in tandem with each other. The nexus point of this endeavour is to create a faster, more rational, interactive, socially beneficial organ (brain). Also to form an entity possessing enhanced memory which possesses highly developed recall ability to evoke or reproduce ideas, concepts and intentions through associate systematic methodology. In turn, this central point will reach out to other social and physical sciences as a matrix touching the lives of all humanity.

By using cognitive and brain enhancement technology, individuals may be allowed to not only utilize larger portions of the brain at fasters speeds but have a better synergy between the left and right hemispheres of the cerebral cortex thereby enhancing rational function and a clearer through process. Drugs could also enhance the speed function of the corpus callosum or the great band of fibers uniting the cerebral hemispheres thereby increasing a more rapid and harmonious interaction between these hemispheres. This lateralization or utilization of certain regions of the brain for fundamental functions, could be enhanced by future nootropic agents. Also while searching for drugs to enhance awareness, such research may provide insight into avenues through which brain-body diseases may be eradicated.

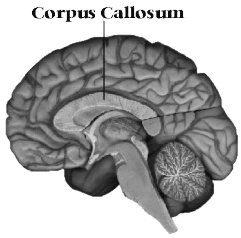

Fig. 1. Source: PETS – Psychology Electronic Teaching Source

Although currently given names such as neuroenhancers and nootropic agents, it is a potentiality that in the future an array of *harmless* neurophysiological drugs will be designed to not only enhance brain function but also reverse brain damage.

An example could be the eradication of right hemisphere cognitive-communication dysfunctionality which besides causing problems with memory, orientation and reasoning can also lead to anosognosia**.** General spacial hemisphere-neglect or anosognosia can be caused by cerebral lesions. Other cases of "negative knowledge disease" may be caused by an interruption in the vestibular system which affect the awareness of body position and movement. In these cases, patients**,** because of the brain damage (ex: stroke, lesions, cancer or injury), are unable to realize their physiological condition, or have no awareness of a certain side of the body or of spacial configurations. Such a multi-faceted phenomenon or multi-element syndrome (as

in conjunction with the aforementioned right hemisphere problems) could be reversed through potentially harmless drugs as opposed to today's temporary fix, surgery, dangerous chemotherapy or other invasive procedures.

1. CURRENT NEUROPHYSIOLOGICAL CHANGES CAUSED BY NOOTROPICS OR "BRAIN BENDING" AGENTS

Nootropic drugs and their neurophysiological enhancing effects are being investigated in network oscillatory or vibrating activities of hippocampal sections [1]. "The development of a new muscarinic acetylcholine[1] receptor (mAChR) agonist that is selective for the M1mAChR subtype, called 77-LH-281, has recently been achieved" [1]. These hippocampal slices, which shows gamma frequency oscillatory activity, points to a potentiality in vivo relationship on protein increase and enhanced brain activity. Broad notes in his doctoral thesis that through the investigation of positive environmental factors and nootropic drugs, there are positive electrophysiological and behavioral changes [1].

Traits of these protective mind or brain bending agents include:

– reducing sleep deprivation;
– needing less sleep;
– more REM or rapid eye movement sleep which can enhance memory;
– general and specific memory enhancement;
– learning augmentation;
– brain cell protection; and
– possessing low toxicity.

Cholinergic agents affect acetylcholine[2] precursors and cofactors. Acetylcholine helps to maintain the brain's higher level thought function, memory ability and concentration.

Piracetam ($C_6H_{10}N_2O_{2)}$ (*2-oxo-1-pyrrolidine acetamide)*, is a cholinergic agent interacting with Lucidril (Centrophenoxine), Alpha-GPC, DMAE, choline,[3] and Hydergine, and is one of the first nootropics, [2] being introduced clinically in 1971 (synthesized earlier in 1964) and was utilized as a neuroprotective drug. The component was initially used to help in the physical and mental abilities of astronauts, while engaged in several stages of space flight durations. Piracetam assists in the improvement of neurophysiological processes including cognitive activities, memory, brain energy metabolism and integrative activity as well as accuracy and speed responses. In various tests, the drug has been shown to positively affect epilepsy, dementia and cognitive decline following brain and heart surgery [3, 4, 5] Although used in

[1] Acetylcholine, (ACh), is an active ester (in some cases being derived by the reaction of an oxoacid and hydroxyl such as phenol) of choline and acetic acid that is a transmitting agent of many nerve synapses.

[2] Acetylcholine agents may be dangerous in large dosages.

[3] Vitamin B5 serves as a cofactor in the conversion of choline into acetylcholine and choline is a precursor to acetylcholine.

many parts of the world, and known to have few side-effects, it is consider to be an unauthorized drug as a nootropic agent in the United States and punishable by fines.

Aniracetam is another neuro-protectant, learning augmentation [6] and cognitive enhancer (speed). The drug enhances AMPA receptors. Aniracetam is more potent that Piracetam but with more side effects. Although used medically for fetal alcohol syndrome, it is commonly used as a drug enhancer by some university professors and students. The drug aids in long term memory and cognitive recognition.

As an individual ages, there is a diminishing of certain hormones, amino acids and enzymes in the brain. This decline of nutritional agents causes a lack of neurotransmitter synthesis. There is also a decline in immune and endocrine functioning. At present there are an array of potentially useful neuro-chemicals that can assist in some form or another with neurotransmitter enhancement. These may include:

- the amino acid Acetyl-L-carnitine (ALCAR), which serves as a precursor of acetylcholine and inhibits lipofuscin formation;
- the blood-brain barrier agent Alpha-GPC (L-alpha glycerylphosphorycholine) which serves as a cholinergic compound and enhances acetylcholine (Ach) in nerve tissue, additionally, the agent potentially reverse the negative effects on cholinergic neurons [7] and maintains membrane viscosity[8];
- DMAE is an adrenal glands hormone and precursor to Estrogen and Testosterone, which is currently utilized in ADD (attention deficit disorder), ADHD (attention deficit hyperactivity disorder) and ADHD-PI (attention deficit hyperactivity disorder with emphasis on lack of attention) treatment;
- a selective α 4 β 2 partial agonist, which has been shown to have memory enhancing properties in rat studies [9]; and
- other noted precursors of acetylcholine.

2. DOPAMINERGICS AGENTS AND BRAIN ENHANCEMENT [10]

Dopaminergic agents affect dopamine (3,4-dihydroxyphenethylamine) neurotransmitter formation and its utilization in nootropic co-factor agents include Vitamin B_6 and Vitamin C as well as dopamine reuptake inhibitors (DRI) which prevent dopamine transporter (DAT) and aids in dopamine concentration and neurotransmission. Some dopamine precursors and co-factors include the amino acid Tyrosine mixed with Vitamin B_6 and C, the drug L-dopa, certain MAO inhibitors, certain MAO-B inhibitors and the agent phenylalanine (Phe). Some of these drugs and amino acids are used in Parkinson and Alzheimer's.

Fig. 2. Source: MATZNERD

3. ACADEMIC BRAIN ENHANCERS AND NOOTROPIC AGENTS

At present, several drugs are being utilized by members of the academic community. These include neuro-enhancers and nootropics such as modafinil which is known to produce cognitive awareness, productivity and memory retention. The drug has been approved by the Federal Drug Administration (FDA) for sleep disorders. It is also utilized for ADHD [11].

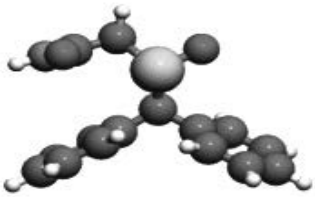

Fig. 3. (±)-2-(benzhydrylsulfinyl) acetamide

Several other drugs used by some scholars and academics to increase production, workload and memory is the stimulant Ritalin (methylphenidate) which serves as a general cognitive enhancer and Adderall (amphetamine). Although the drugs are primary approved for neuropsychiatric illnesses or an imbalance in cognitive function, there is research being conducted relating to the potential effect of such drugs in normal cognitive individuals (middle age or older) to enhance memory and test scores [12].

Fig. 4. Source: Center for Neuroscience and Society

A recent survey conducted, by the writer, at several conservative universities in Mississippi show that the use of such drugs by undergraduate students range between 7–10 percent while graduate student profess to utilizing memory and brain enhancers at a rate of 20 percent. Also students who are part of a fraternity peer pressure group are more prone to use such drugs [13].

4. SEROTONERGICS AS NOOTROPIC AGENTS

A serotonergic substance affects the central nervous system and the neurotransmitter serotonin. These nootropic protecting substances consist of amino acids, cofactors and precursors as well as serotonin reuptake inhibitors (SRIs). A partial list include L-tryptophan, 5-HTP (5-Hydroxytryptophan), small amounts of 2 C-T-7

(2,5-dimethoxy-4-propylthiophenethylamine) and LSD-25 (lysergic acid diethylamide) have shown signs of aiding the increase of neurotransmission and selective serotonin re-uptake inhibitors (SSRI). SSRIs aid in promoting nerve regeneration or neurogenesis (birth of neurons in the hippocampus).

5. OXYGEN THERAPY AND BRAIN ENHANCEMENT

The brain, like other organs of the body, thrive and function better with the enhancement of oxygen levels in the body. The average level is between 95–100 percent.[4] When the level fall below 90 percent certain health issues are manifested. Increased $S0_2$ levels, stable blood sugar levels and co-enzyme ATP (Adenosine triphosphate) production can enhance concentration, brain energy, oxygen co-efficients, hippocampus protection and the safeguarding of neurons. Agents can also effect TPN (triphosphopyridine nucleotide) formation which is an important coenzyme in certain reactions. Chemicals which affect such reactions in the body and brain include over the counter agents and pharmaceuticals such as creatine, Ginkgo biloba, co-enzyme 10, B complex vitamins and chromium.

6. LEGAL RAMIFICATIONS

In the interdisciplinary complexity of brain enhancement and its potential effects on social change, ethical philosophy, religious beliefs and economic configurations, a new course study is emerging in many graduate law programs known as Neurolaw, a term that was coined by Sherrod J. Taylor in 1991 [14]. Neurolaw is an interdisciplinary program which assists the current or potential lawyer in understanding future standards and legal rules that will evolve as scientists produce more effective agents to enhance left and right brain function. This will include, but not be limited to neuron or nerve cell protection, faster transmitting and processing of sensory data through chemical and electrical stimulation between neurons, and the interaction of left and right hemisphere functions. Besides, including rule of law, the program will include: social psychology, philosophy, criminology, forensic hypnotherapy, neuroscience, sociology and the cognitive sciences. Important questions that have emerged from this exploration are as follows:

– can brain injury and tumor growth alleviate criminal punishment;
– will neuroscience influence rehabilitation and sentence guidelines; and
– will brain scans and images be utilized in court proceedings [15].

These issues are being slowly investigated and discussed by neuro-lawyers.

7. FUTURE RESEARCH

Already, numerous neuro-enhancers and nootropic chemicals exist which stimulate brain activity. Many of the current batch of drugs include stimulants, hor-

[4] "Oxygen saturation (SO2), commonly referred to as "sats", measures the percentage of hemoglobin binding sites in the bloodstream occupied by oxygen. *Wikipedia*.

mones, nutrients and herbal enhancers [16]. Present emphasis is being placed on memory enhancers and drugs to enhance attention issues [17]. Modafinil, as previously mentioned provide less side effects and higher performance function. It is still, however, illegal except for specific illnesses. Another facet of enhancements may soon be dealing with the utilization of electrical impulses. In the past biofeedback and alpha techniques has been used to calm the brain and produce more 'centering" of thought and less anxiety.

In the scientific publication *Wired*, "

…scientists stimulated volunteers' brains with mild electric current while they learned new arithmetic operations based on made-up symbols. People who received brain stimulation during training sessions on five consecutive days learned two to five times faster than those who received sham stimulation, and they retained a 30 to 40 percent performance edge six months later… The researchers applied TRNS [transcranial random noise stimulation] to a different brain region thought to play a role in mathematical cognition, the left dorsolateral prefrontal cortex…" [18].

It seems that the non-invasive technique of neuroplasticity may hold promising results in brain research. A technique called transcranial direct current stimulation (tDCS) is also showing beneficial results.

8. FUTURE ELITE POPULATION SCHEME AND MEMORY DRUG DISTRIBUTION

As with all distribution of supplies and technology, money plays an important part in what items are sold and to whom. The same will be true of enhancing drugs, brain nano-technology and nootropic agents. At present, there simply do not exist the pharmaceutical and technological concepts needed to produce true nootropic and neuro-chemical agents that will provide a constant and effective end product on brain development, protection and advanced memory retention and expansion.

However, the time is approaching when scientists will devise new methods of enhancing all aspects of medical and technological advancement needed to create a homo-superior being via advanced mind drug augmentation, cybernetic implants, nanotechnology, genetic modification and subconscious manipulation. However all of these scientific developments will come with a price tag. It is logical to assume that individuals who possess social influence and economic superiority will be able to attain and utilize body and mind enhancements that will simply not be available to the middle or poor social classes. Also, once these agents are utilized by the elite, there will become an even great separation between social classes due to higher intelligence and memory enhancement. As the rich, elite, powerful and influential people allow revolutionary techniques to be utilized on themselves and their off-springs, the division between classes will become ever distant and there are potential probabilities that the middle class may totally disappear, leaving the rich and powerful living in exclusive sections of the world while the poor and those who were once considered middle class living in futuristic slums, because they are unable to compete with the far more intelligent "super humans." Still little is known

as to how these neuro-enhancing agents may affect performance between various family income classes. It is, however important to realize that to stay competitive in the future, it will become necessary to utilize enhancing substances – substances that can only be obtained by the rich and powerful. Also many such items may originally be illegal and while the rich may not be prosecuted, the poor will be severely punished. There is also a strong probability that various religious groups will attempt to impose laws, punishment and chastisement on the avant-garde who utilize these chemicals. There is finally the concern of religious groups that the use of such drugs are –

- an attempt to make man more God like;
- an unnatural striving for perfection and that violates the dignity of man; and
- the potentiality of such enhancing procedures being unethical or cheating.

At present, and in the foreseeable future there exists three noted ethical and potential legal ramifications. They include:

- potential short and long term effects of the drug;
- philosophical issues relating to potential changes in values and morality;
- ramifications of ethical issues as to how such drugs in the future may affect socioeconomic status (employment and educational scores); and
- possible psychological and physiological induced changes from taking neuro-enhancers over a long period and the potential effects of such drugs of the early stage of prenatal development and generational offsprings.

CONCLUSION

As we enter Huxley's *Brave New World* and *Brave New World Revisited*, will it be an era of great advancement, peace, understanding and hope or as many gloomy prognosticate, in the hands of immoral and amoral individuals, the advancement of research will merely breed destruction.

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