

HEMOENCEPHALOGRAPHY

(HEG) THE STUDY OF regional CEREBRAL BLOOD FLOW rCBF & rCBO₂

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Neurofeedback using HEG

Neurofeedback using HEG trains the subject to increase blood flow to a targeted area of the brain.

Neurofeedback, as we have known it so far, measures the electrical activity of the brain, EEG, as a feedback signal to be controlled by the patient. Here we have substituted blood oxygenation for the same purpose.

You have probably tried shining a flashlight through your hand and have seen the dark side light up. Our tissues, flesh and bone, are translucent. It's not dark in there.



Fig. 1 - Frontal Lobe

In the sunlight, if you were in there with your brain, you could read a newspaper by that light. In HEG a light is shone on your brain through the translucent scalp and skull.

A spectrophotometer device is worn on the head. Flashing red and infrared lights are shown in the figure as one optode. The light collection amplifier is another type of optode. It responds to the returned light that is reflected and refracted by the encountered tissue. These optodes are spaced 3 centimeters apart so as to conduct most of the available light at the depth of cortical tissue. As can be seen the application is very simple.

Red, 660 nm, and infrared, 850 nm, lights are alternately shown on brain tissue. The graph above shows the large difference in red light attenuation between oxygen rich and oxygen starved hemoglobin whereas the infrared light is minimally changed. (Elwell 1999)

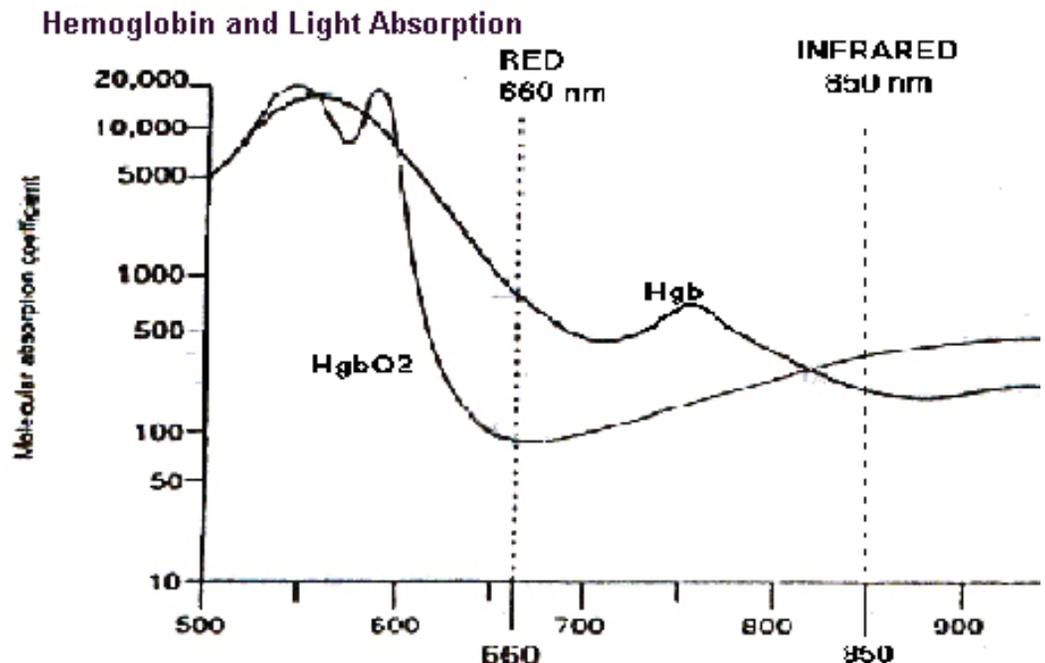


Fig. 2 - Hemoglobin Absorption

A computer program receives a measure of each light color, calculates their ratio, and graphs the value for the patient to see, hear and alter.

During the summer of 1994 it was discovered that the author could intentionally increase cerebral regional oxygenation. The computer graph responded to thoughts. Brain oxygenation increased merely by intensely willing it. A neurofeedback system was born.

Neurofeedback using this new technique provides a means to exercise selected brain areas. Exercise increases blood flow to the chosen brain module. Capillaries and dendrites grow with brain exercise (Kaiser 1997, Thompson et al. 1998, Joyce and Seiver 1997, Rossiter 1996, 1996, Kaiser 1997). An audible tone was devised that increased in pitch to signify increased blood oxygenation. To increase oxygenation one would merely attend to the highest note in each trill and will the next higher note to sound. Application of the headband and monitoring patient progress is simple. The treatment process is divided into ten-minute segments. Usually three to four such segments constitute a treatment session.

Marion Diamond (1965) first showed the importance of enhanced environments in 1965. She demonstrated that brain exercise increased the weight of rat brains. Dr. Diamond undertook to determine if old rats could learn new tricks. Rats live to an old age of 900 days. She selected seven hundred-day old rats for her experiment. She divided the rats into three groups: 1. One rat in a cage, 2. Two rats to a cage, and 3. Six rats to a larger cage. All the rats were fed standard laboratory chow. Cages with six rats were provided with new toys; mazes to solve, rotating drums for exercise, etc. almost every day. These rats were held and petted by the lab assistants. (Rats love to be tickled.) After a month the rats were sacrificed and their brains were examined. Those of the high-stimulation group were found to be 8% heavier compared to the solitary group. The additional weight was supported by denser capillary beds. Microscopic examination of enhanced environment cortical slices revealed dendritic trees resembling a dense rain forest. Those of the solitary group resembled a carefully manicured landscape.

What if you could produce the same effects in a different manner? The following SPECT images show (permanent) changes in blood flow after treatment for a manic-depressive patient.

Single Photon Emission Computerized Tomography (SPECT), demonstrating blood flow pre- and post-treatment

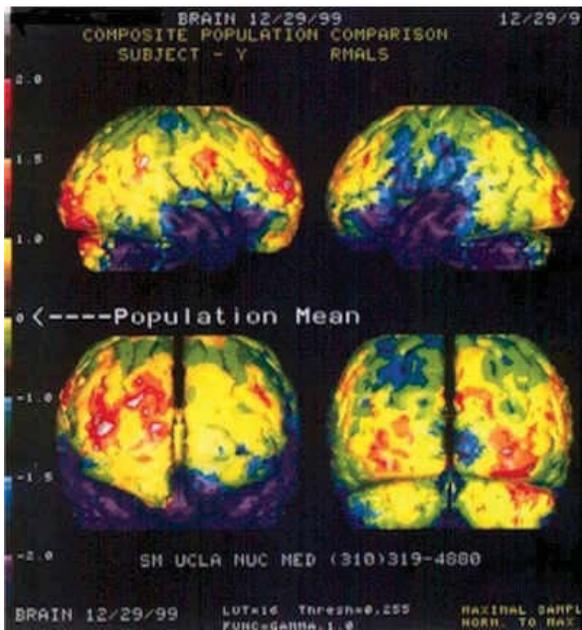


Fig. 3: SPECT study of manic depressed patient before treatment

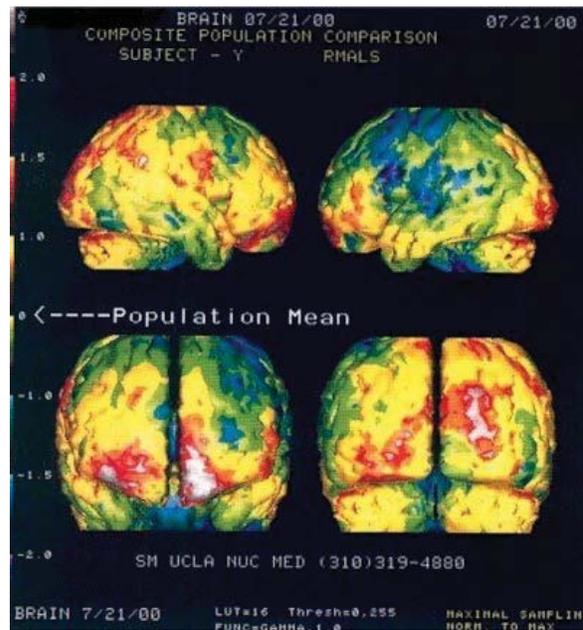


Fig. 4: SPECT study of manic depressed patient after 23 treatment sessions

These SPECT studies are compared to an age related, standardized data. The false color blood flow levels are shown by colors ranging from purple (unusually low) through white (unusually high). The scale on the left side of the images shows z-scores (standard deviations) from the mean. The population mean is depicted in yellow. The left margin color scale defines standard deviations relative to the population mean.

This pre-treatment study of a bipolar, manic-depressive patient shows several seriously hypoperfused areas (Heuser et al. 1994). These include the medial frontal subgenual region, the right and left temporal lobes, both

hippocampi, Broca's and Werneke's areas as well as the left superior frontal and parietal association areas. Not shown in this view is the blue to purple right subgenual orbital-frontal lobe. As Drevets (Drevets et al 1999), showed, this area, when below normal, is common to bipolar disorder and depression (Ito et al. 1996). The right orbital-frontal area, a gateway between cortex and the limbic system, seems to provide cortical control of emotion. Such control is lacking in bipolar disorder. In this emotional vein we have yet to see a bipolar patient who has a good relationship with her mother.

This study (Fig 4) was completed after 23 HEG sessions, 7/21/2000. As of this writing this patient, previously a rapid cyler, has not experienced a manic episode. At the time of this SPECT study she was depressed. That this is to be expected is shown by the below normal blue area in her left frontal cortex.

At present she is coping competently with her mother's newly diagnosed metastasized breast cancer. She is a nurse and is too busy to feel depressed. This is interesting since she has never before been able to live peacefully with her mother.

Literature study examines brain areas involved in ADD/ADHD, Schizophrenia, and Autism.

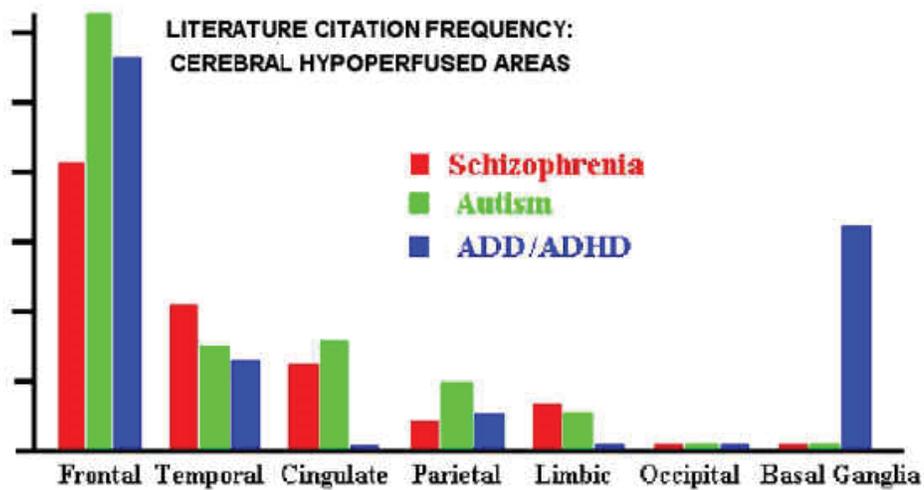


Fig. 5

Fig. 5

The National Library of Medicine search turned up many imaging studies of Autism, Schizophrenia and ADD/ADHD disorders (Andreason et al.). The citation frequency for hypoperfused brain modules is illustrated here. It is clear that hypoperfused frontal cortex dominates the field. Knowledge of the distribution of hypoperfused areas is useful in determining brain areas to be treated.

The dominance and importance of frontal hypoperfusion fits our experience in dealing with Depression (Drevets et al 1999), Toxic Encephalopathy (Heuser et al. 1994), Epilepsy and Schizophrenia (Andreason et al. 1997) as well. The importance of the frontal lobes cannot be over emphasized (Ito et al. 1996). These areas are particularly easy to reach from the forehead with the spectrophotometer headband.

Disorders with Abnormal Regional Blood flow

- ADD Senile Dementia
- Aging Memory Loss Dyslexia
- Alzheimer's Disease Epilepsy
- Anorexia /Bulimia Lupus Erythematosus
- Aspberger's Migraine
- Autism Multiple Sclerosis
- Chronic Fatigue Schizophrenia
- Depression Toxic Encephalopathy

Test of Variables of Attention. (T.O.V.A.) A computerized test that measures response time, consistency, inattention, and impulsivity.

The TOVA is useful in tracking patient recovery. Frontal cortex, the executive part of the brain is most often compromised in any brain disorder. The TOVA indicators, speed of response and stability of the prefrontal cortex, are a useful index of improvement of brain function following HEG neurotherapy. Many brain studies have validated the proposition that healthy brains respond to problem solving and other stimuli more rapidly than compromised brains. Thus working memory problems are suitably tracked with TOVA to determine the most appropriate dose for ADD/ADHD children.

Each study in the following graph used TOVA scores as a pre-post training measure. The graph shows the gains for all published studies with TOVA scores as the dependent variable

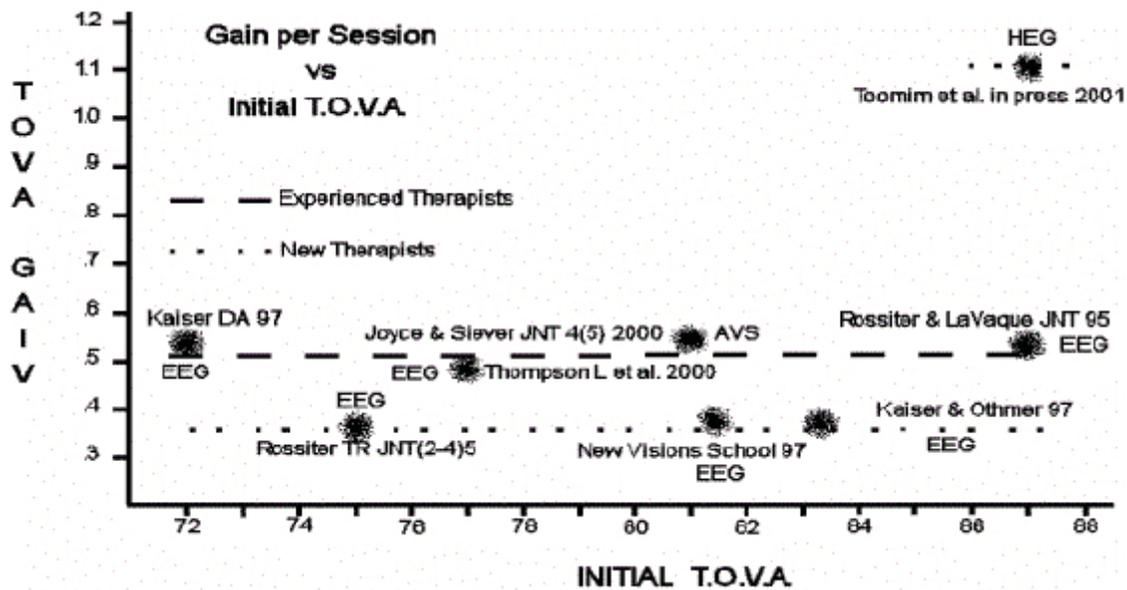


Fig. 6

Fig. 6

Treatment TOVA gains per session vs. initial TOVA scores for various treatments reported in the Neurofeedback literature. There are EEG, Audio-Visual Stimulation (AVS), and HEG studies presented. The number of sessions ranged from 10 to 40 in these studies.

The TOVA gains per session of these published studies (Kaiser 1997, Kaiser Othmer 1997, Thompson & Thompson 1998, Joyce & Siever 1997, Rossiter 1995 1996, Joyce, 1997) present some very counterintuitive information.

These results fall naturally into two groups:

- 1) Studies done by the most accomplished providers gained 0.52 TOVA points per session.
- 2) Studies done with home, school, or average providers cluster about 0.37 TOVA points per session.

That the per session scores cluster so closely about either 0.52 or 0.37 is completely unexpected since the number of reported sessions ranged from 20 to 40 and each provider had a favorite set of parameters and procedures. It is also unexpected that the initial scores that measure the degree of dysfunction of the patients had no effect on the gains per session.

One would expect gains to decrease as the number of sessions increased and the patients approached normal. That this didn't happen suggests 40 EEG sessions is insufficient for the average patient even with the most accomplished providers.

It is noteworthy that the HEG study falls into a completely new treatment efficiency category. HEG gains are more than double the gains shown for other techniques.

From these studies we can see that the procedures are very tolerant of provider skills. One can hardly go wrong. The major variable is the cost to the patient. There are no known side effects for HEG treatments.

Can't remember? Can't focus? Misplace things? Slow learning? Always tired? Turned around?

These are some common physical brain problems.

Healthy brains have adequate blood flow.

Problem brains have insufficient blood flow to limited brain areas.

Several brain areas are involved in whatever you do. Finding the affected areas is key. A non-invasive directed brain exercise is indicated.

Please refer to Toomim's Questionnaire, designed to point out the brain areas needing exercise to counter hypoperfusion.

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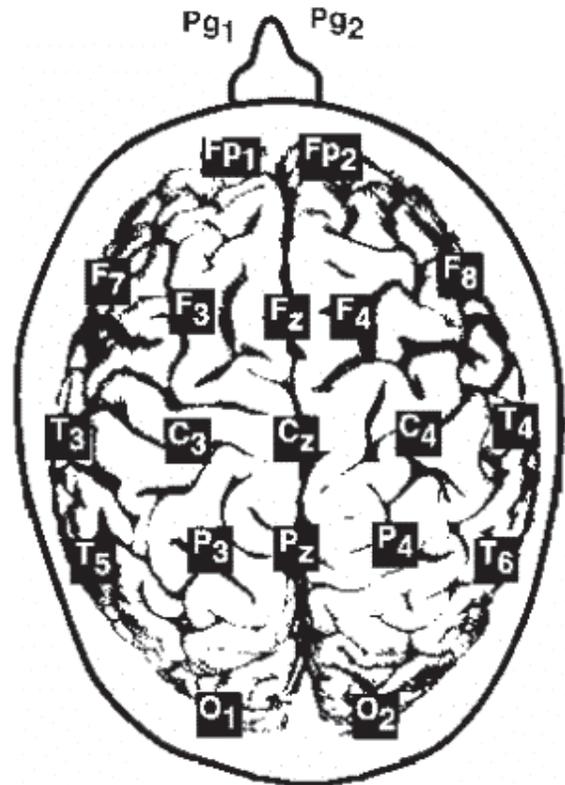
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