# Introduction to HEG-Biofeedback

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## Introduction

HEG biofeedback is a new form of "brain training" modality that is showing great promise for dealing with various problems like ADD (attention deficit disorder), depression or autism. in conjunction with EEG biofeedback.

HEG stands for HEMO-ENCEPHALO-GRAPHY. As indicated by "HEMO", this new form of biofeedback relates to blood - in this case blood flow within the brain. It appears that blood flow is poor in certain brain areas of persons suffering from several types of "brain problems". These include ADD/ADHD, autism, epilepsy, brain injury, stroke, depression, and schizophrenia.

Researchers have found that this poor blood flow in a section of the brain can be increased with biofeedback training in much the same way as EEG biofeedback. Results on ADD/ADHD and Autism to date have been fair to good. Using HEG biofeedback initially, and finishing up with EEG biofeedback, may shorten the number of sessions dramatically, and also may improve the success rate. Hence, HEG by some is considered to be a new and particularly promising form of Neurofeedback.

HEG biofeedback is an effective and drugless treatment for many neuropsychological conditions which involves the self-regulation of cortical activation.

HEG devices measure and feed back changes correlated with blood flow dynamics and cellular metabolism in localized parts of the brain cortex. These measurements are closely linked with brain activation due to the phenomenon of "neurovascular coupling".

HEG biofeedback represents a simple and non-intrusive way for both: monitoring and training cerebral function without the inconvenience of electrode preparation which other neurofeedback methods generally require.

HEG has high compliance by clients and patients and the training can be delivered with a help of entertaining and attractive feedback suitable for children and adults.

## Physiological Basis

HEG devices measure and feedback changes correlated with blood flow dynamics and cellular metabolism in localized parts of the brain cortex. These measurements are closely correlated with brain activation due to a phenomenon called "neurovascular coupling". Briefly, blood carries all the nutrients and oxygen needed to fuel neuronal activation and the localized delivery of blood supply to each part of the cortex is closely linked to the particular metabolic requirements and the level of neuronal activity in that region at every single moment.

The logic behind this biofeedback intervention is that repeatedly engaging in HEG biofeedback, "exercises" the brain in a unique way which confers very promising and long lasting neuro-behavioural benefits for the trainee. Special pre/post SPECT (Single Positron Emission Computerized Tomography) imaging techniques has been already used to verify that HEG biofeedback treatment promotes conspicuous blood flow increases, (activation), below the treated areas.

## History

State of the art HEG methodology is originally based on brain monitoring technologies like nIR Spectrophotometry and Thermoscopy developed in the last 10-15 years.

In 1994 Dr. Hershel Toomim developed his own nIR Spectrophotometer methodology and subsequently was the first to show that that the monitored activity can be self-regulated by biofeedback means. His early work on the application of nIR HEG biofeedback in the treatment of ADD and ADHD and other neurobehavioral conditions followed soon after that.

Slightly afterwards, Dr. Jeff Carmen started experimenting to build and test a device to measure cerebrovascular activation using passive infrared technology in an attempt to both monitor migraine activity and to train control over the associated abnormal cerebrovascular behavior. In 1998 Dr Carmen formally reported success in the treatment of migraine through pIR HEG biofeedback.

In the last five years other researchers and clinicians have joined this exciting area of neurofeedback, (mainly in the USA). However, this technology is still considered to be the newest modality addition to the central biofeedback practice and a therapeutic tool with extremely promising future.

## Methodology

There are two types of HEG measurement in current use:

1. nIR HEG: Active near infrared HEG measures changes in the relative absorption of red and infrared light passed into the tissue below the nIR sensor. The light traverses scalp and skull and reaches brain tissue and the ratio of red to infrared light received back by the sensor is dependent on localized blood perfusion and oxygenation in the underlying tissue. This method is used by Hershel Tommim in his instruments.
2. pIR HEG: Passive infrared HEG measures the heat (IR emission) radiated by the tissue below the pIR HEG sensor, which is dependent on the localized blood perfusion and metabolic activity in that region. This method is used by Jeff Carmen in his instruments.

HEG trains the subject to increase the blood flow to a targeted area of the brain. EEG biofeedback in comparison measures the electrical activity of the brain as a feedback signal to be controlled by the patient. With HEG, the EEG is substituted by blood oxygenation for the same purpose. Therefore, in HEG biofeedback a light is shone on your brain through the translucent scalp and skull.

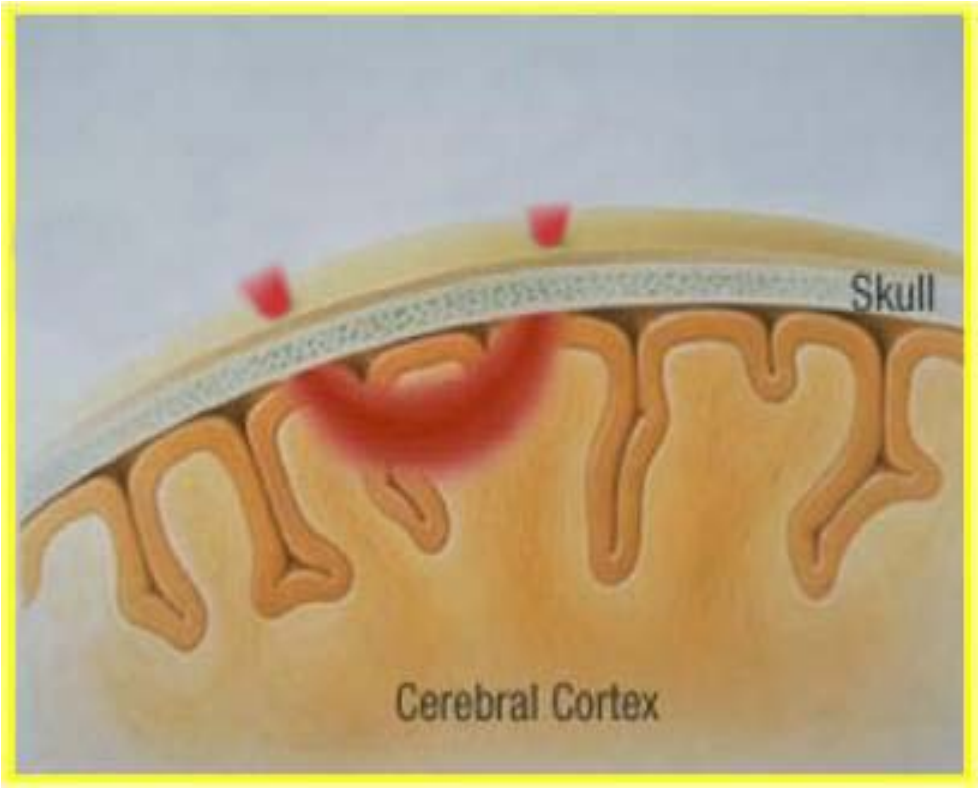


*Figure 1 Principle of light emission and detection in HEG biofeedback*

In the HEG application, a spectrophotometer device is placed on the patient's forehead. Flashing red and infrared lights are represented in figure 1 as one optode. The light collection amplifier is another type of optode. Its main purpose is to respond to the returned light that is reflected and refracted by the encountered tissue. These optodes are spaced three centimetres apart so as to conduct most of the available light at the depth of cortical tissue.

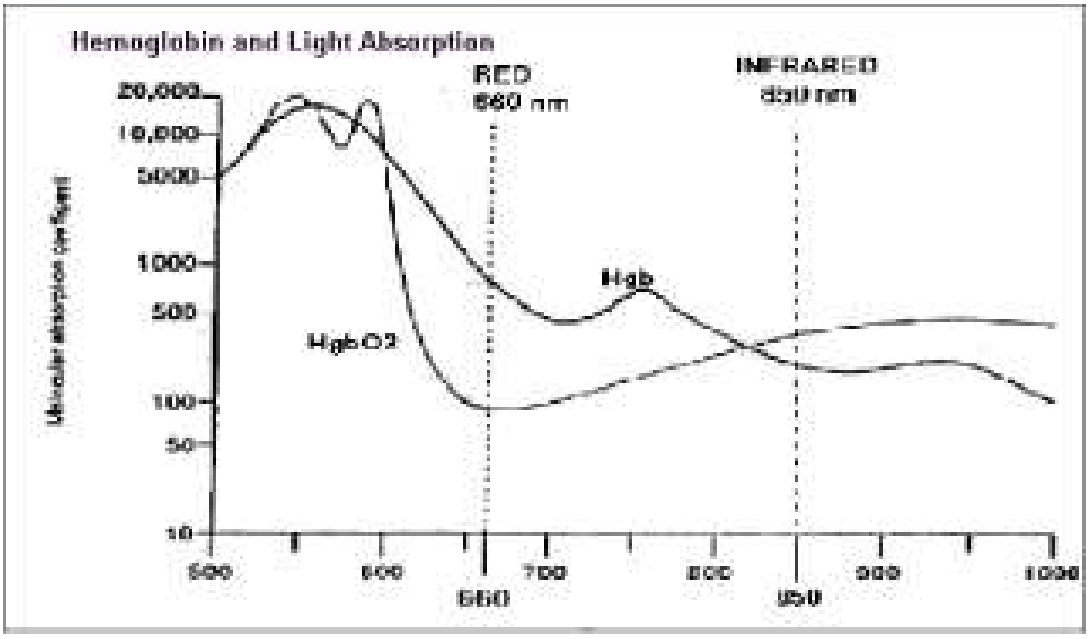

Figure 2 Red light attenuation in oxygen rich and oxygen starved hemoglobin (Elwell 1999)

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.

With both modalities of HEG, there are no electrodes to be applied to the skin, no electrode gels to be used to improve skin contact and no impedance criteria to insure reliable recordings. HEG does not measure electrical activity; therefore, there are no big problems with eye blinking, eye movements, ECG cardiac signals or other muscle source of artifact.

Nevertheless, some care should be exercise when applying HEG biofeedback in order to avoid artifactual readings. Possible known sources of data contamination are:

a) Positional changes of the subject. This changes cranial blood pressure and affects perfusion. It can be controlled by observing the subject.
b) Direct flow of cold air from an air conditioner or extremely high temperatures in the clinic that lead to forehead sweating.
c) Effects of small skin blemishes, inflammation or hair under the HEG sensors.

The actual details of the monitored display used to feedback HEG data can vary slightly depending on the instrument and software application used. However, HEG biofeedback practice is always straightforward for the trainee:

If the user maintains a relaxed but focused state of active concentration, the displayed graph keeps moving upwards, the digital display of data keeps increasing and, (when shown), a movie display keeps playing on. If there is a reduction in active focus by relaxing too much, trying too hard, or becoming tense, frustrated, excited or stressed, the graph reading and digital display drop and by reaching a pre-determined threshold value the movie goes into pause mode and returns to play mode only when the trainee regains active focus and raise the reading above the threshold value. Of course, the threshold difficulty variable is controlled by the neurofeedback therapist and can be made easier or more challenging, depending on the skill level of the trainee.

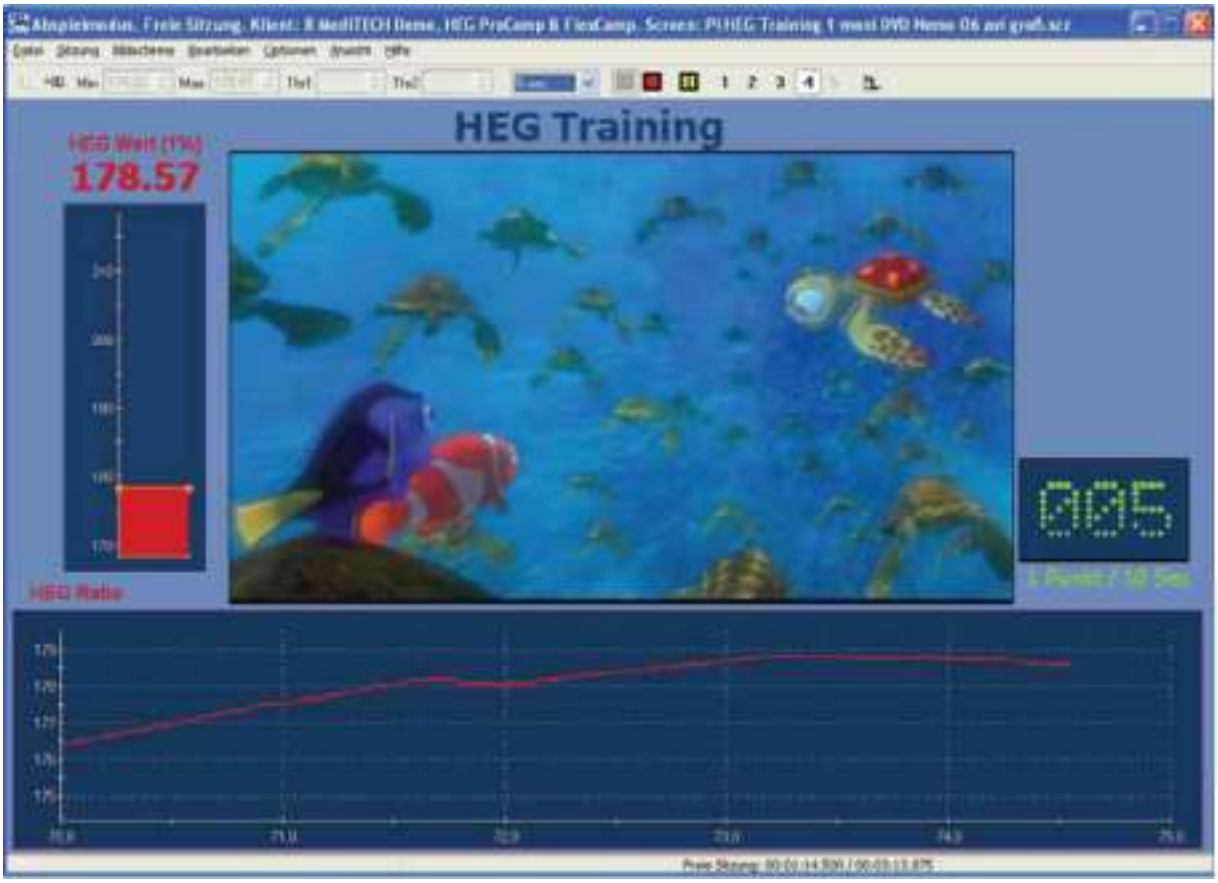

Figure 3 Sample Screen for HEG Biofeedback training

## HEG and Frontal Lobe activation

HEG cannot be easily measured through human hair and is particularly suited to be applied over the forehead, (Fp1, Fpz and Fp2), in order to entrain the prefrontal cortex.

While the pre-frontal cortex represents only 29% of neocortex they mediate some of the most advanced forms of thinking and cognitive activity by human beings. The pre-frontal lobes host the "executive attention networks" and their engagement is required in order to sustain complex thinking, focused concentration, emotional tone and general arousal.

Frontal activation appears to be necessary to succeed in the treatment of many neurobehavioral conditions such as ADD and ADHD. QEEG topographic brain maps and functional MRI images of ADHD patients identify the prefrontal lobes as dysfunctional or even "disconnected" from the rest of the brain through the presence of excessive slow wave activity instead of desirable fast wave activity.

Since the prefrontal lobes mediate so many complex, auto-regulatory brain functions, they would seem to be the best choice of all brain lobes to be the target for HEG training.

## Clinical applications

Although HEG instruments are relatively new devices, increases in brain blood flow via HEG neurofeedback have already shown significant clinical benefits, especially in the areas of migraine, depression and ADHD.

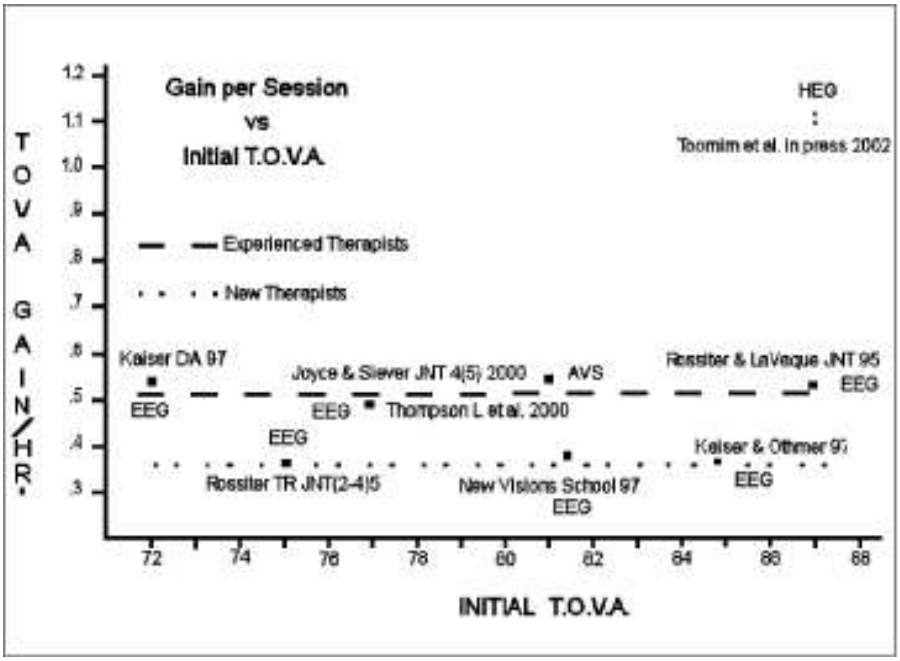


Figure 4 TOVA gains after EEG and HEG biofeedback treatment *(with permission from Hershel Toomim et.al. 2005 )*

In addition, HEG biofeedback has promising clinical potential for many types of learning, perceptual, cognitive, neurological and neurobehavioral disorders, such as ODD, OCD, Tourette's, Asperger's and mild Autism, as well as mild to severe head trauma, closed head injuries and seizure disorders.
It is important to note that HEG does not replace EEG; some therapists claim they work best when both methods are used together. However, HEG appears to often be superior to EEG when the QEEG brain map and/or other clinical indicators suggest a need for prefrontal lobe training.

**Example of temporary frontal activation through HEG biofeedback**
A method for mapping forehead IR emissions by Dr. Ernesto Korenman shows the fast results achieved by HEG biofeedback. The technique is only in his early experimental stage and its clinical significance is currently under discussion. However, these maps may provide useful information about the topographical activation of frontal lobes in general and the effect of HEG training in particular.
Here follows a pre/post IR forehead mapping of a girl (12 years old) diagnosed with dyslexia + ADHD taken before and after 10 minutes over the centre of the forehead (Fpz).

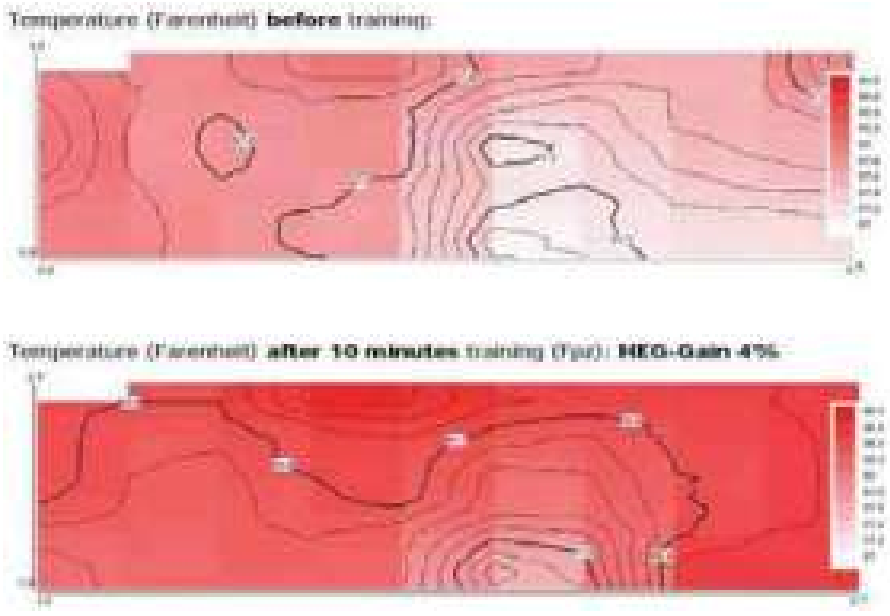


Figure 5 Forehead IR emission maps before and after 10 mins of nIR HEG on Fpz

When applying this methodology prior to consecutive HEG biofeedback training sessions, it proved quite suitable to monitor the long term effects of HEG training and even provide a trend report of forehead IR emission of the patient monitored by the method described prior to each training session over the duration of several months (E Korenman personal communication).

## Table of figures



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