WHY DOES NEUROFEEDBACK WORK?

by Hershel Toomim

I have spent many hours trying to decipher just what we are doing using Neurofeedback.

In fact in the process of trying to find the basis of Neurofeedback. I didn't believe Neurofeedback worked. I started a study. I'd find out if brain blood flow changed with this process. I'd do a blood distribution map, a SPECT, before and after EEG training.

I had everything underway when a radiologist at the chosen SPECT hospital refused to do SPECTs for non-medical reasons. In that study one of the dissertation candidates, Julie Weiner, found Britton Chance's papers on near infrared spectroscopy. Building one was a snap.

In trying to find out what I could do with it, I discovered that cerebral blood flow enhancement is a voluntary function. We do it all the time.

I could increase local cortical blood flow voluntarily. I could exercise my brain! From this Hemoencephalography was born.

WHAT MATTERS?

- Electrode placement?
- Protocols?
- Instruments?
- Frequencies?
- Therapist skills?

I wanted to know what mattered in Neurofeedback. In my search for what matters I found many opinions. I wasn't satisfied until I had a found a physiological change that resulted from the training Attention Deficit Disorder (ADD/ADHD). I studied the published articles on EEG training that used Test of Variables of Attention (TOVA) as the dependent variable. TOVA has a reputation of test retest reliability so that retesting after training should be free from learning effects.

The various papers were not a uniform number of sessions. To make them comparable I calculated and plotted the TOVA point gain for each session as a function of the initial TOVA scores. The result was very strange. The best in the better EEG training group was only 3% above the average for that group. The best in the lower group was only 3% better than the average for its group. The lower group was 70% as good as the upper group.

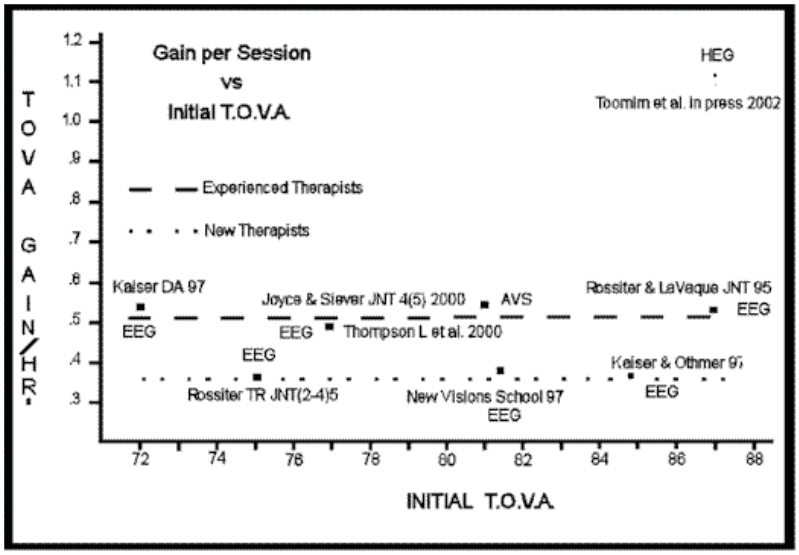
After developing this graph, I entered the results of my use of Hemoencephalography (HEG), blood flow therapy, for 53 subjects. I was happy to learn that HEG worked significantly better than EEG.

Most surprisingly the HEG group was twice as good as the higher EEG group!

I was delighted when my very good friend, Paul Kwong, found the correlation between HEG and TOVA for the forehead placement was about 0.7 and the chance for error, p was less than .001.

I set out to find out why. For one thing I found it followed the same law as EEG on number of sessions although the gain per session was much higher. TOVA gain increased as the number of sessions increased. Also training was at the frontal lobe near the eyebrows while EEG trained near the motor strip at the top of the head

The two EEG groups were differentiated by the experience of the therapists. The inexperienced therapists did 70% as well as the most experienced therapists. The only other reported variable determinant of gain in the EEG groups was the number of sessions.



A surprise was that Audio Visual Training did as well as EEG. I checked and found this paper by Joyce and Seiver had an 18-month follow up. The effect was lasting! Clearly these were unexpected results. There was much that needed an explanation. Now, I had a full plate.

On the graph I had to decide what are the important variables? You can see from the graph that mainly where, what, and how much we trained contributed to the net effect.
HEG clearly outperformed EEG. EEG trained at the top of the head. HEG, blood flow training, trained frontally. This has to account for some of the difference.

WHAT MATTERS?

What we train.

Where we train.

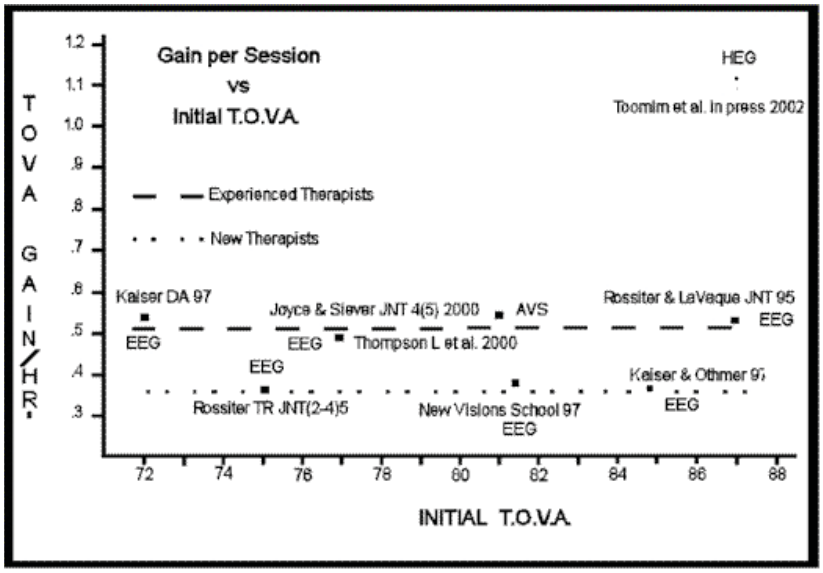
How much we train.

Strangely!

Not much else.

If placement is so important, why has EEG avoided frontal placement?

The problem is eye roll. The eyes are electrically charged spheres. When eyes move they generate large electrical low frequency artifacts. Even the initial TOVA score, that shows how much each group deviated from normal, does not affect the gain from training.



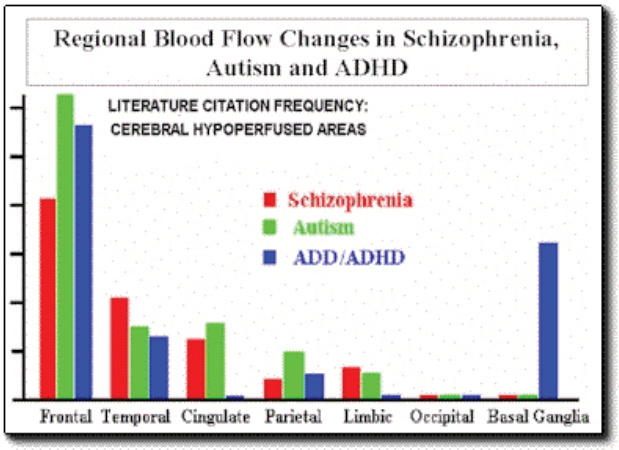
Notice how experienced therapists all gained about ½ of a TOVA point per session. The new and inexperienced therapists gained 1/3 of a point, about 70 percent as much. A good response for ADD/ADHD doesn't seem to require much expertise! However, I can truthfully attest that keeping a child interested in such a boring task as neurofeedback is daunting.

One can make up for that ineptitude with more sessions.

From mouse models, angiogenesis, growth of new capillaries, results from repetitive exercise. Synaptogenesis, development of connections between neurons, results from learning exercises. HEG is in the business of working with hypoperfused, blood starved, brain areas. It is probable EEG is best adapted to correcting dysfunctional learned behaviors like sleeplessness, anxiety, or stress of the competitive over-achiever. HEG, a routine repetitive exercise may be best with developmental disorders such as autism, schizophrenia, unipolar and bipolar depression or ADD/ADHD.

WHERE TRAIN?

The accesible brain module contributing most to dysfunction.



This figure emphasizes the dominance of the frontal cortex in developmental dysfunctions. There should be similar graphs for Bipolar Disorder, Depression, Ageing Dementia, Supranuclear Palsy, Diabetes, Memory Loss, Traumatic Brain Injury, Stroke, Alzheimers, and Parkinson's Diseases. Note these are brain based. They are characterized by depressed blood flow, not learned behavioral disorders.

EEG has a rich literature on correcting behavioral disorders such as anxiety, sleepliness, PTSD. class A behavior. HEG is too young to have developed approaches to these.

HEG is clearly repetitive exercise with a minor learning component. EEG is also a repetitive exercise, it has large body of work illustrating effects on learned behaviors as befits its synaptogenic component.

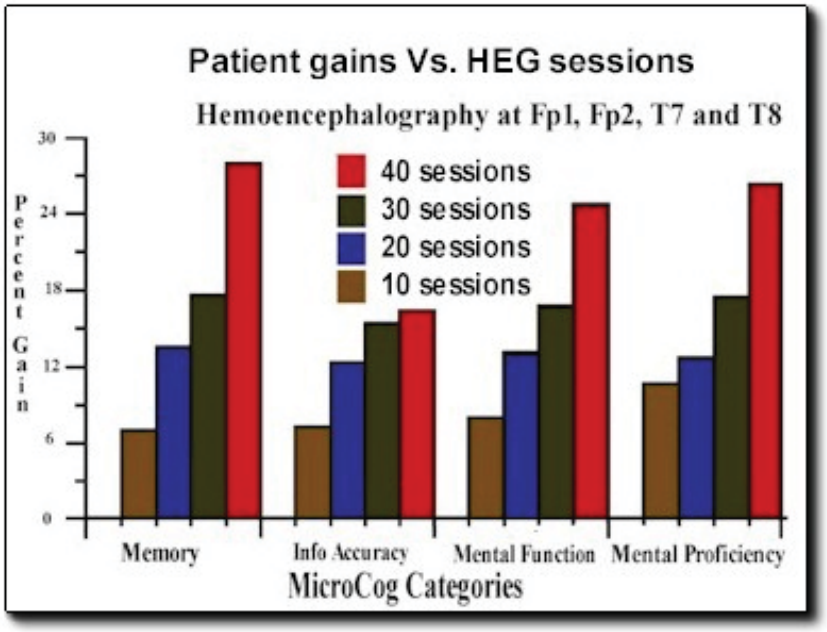
Exercise Repetition makes the difference in angiogenesis as we have seen in the earlier graph. I have always felt that the degree of increase in blood flow had a marked effect on the efficacy of HEG training. Increases relative to awake, idling baseline of 20 % are common. Rarely one finds increases nearing 100 %. I suspect these values are very much larger than the increase due to normal brain use. I am checking this out in my current practice. If so, HEG may well find use as a rehabilitation technique for TBI or stroke.

Repetition of demands develops the brain!

Learning:
Learning = Synaptogenesis
Exercise = Angiogenesis

Neurofeedback is a Brain Exercise

Exercise repetition makes the difference in Angiogenesis and blood flow.

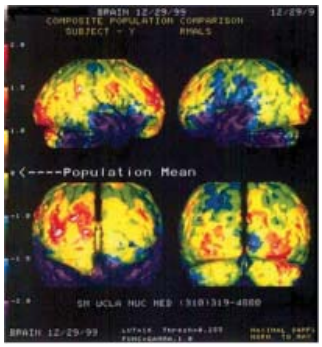


Here we can see the effect of HEG repetition on various brain functions. Note that accuracy is self-limiting and cannot progress much after good accuracy is achieved The other bars show substantial gains up to 40 completed sessions. Saturation has not been a limiting factor. Record keeping has always been a part of my work. Here it is valuable in helping determine where to stop,

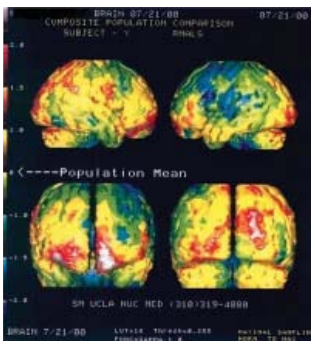
HEG = Blood flow
= Angiogenesis

SPECT
Blood Flow Map
Yellow = Normal Flow.
Blue = Very Low Flow.

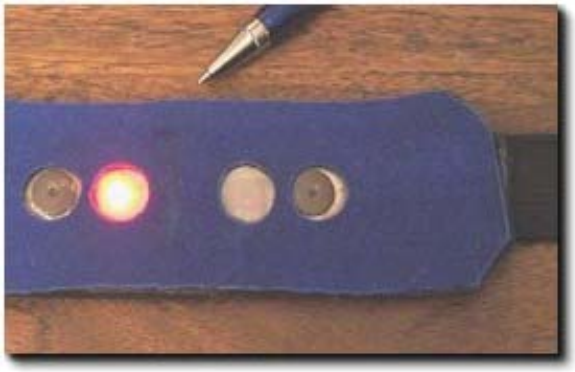
These SPECT brain maps of blood distribution clearly show angiogenesis at work in HEG training in this bipolar patient.



In the SPECT blood distribution maps yellow is normal, red is two standard deviations above normal. Light blue is two standard deviations below normal and dark blue is 4 standard deviations below normal



Here, lower left frontal view, note the dark temporal lobes. Blood flow here is more than two standard deviations below normal. Compare the changes after 23 sessions of HEG



Here we see angiogenesis at work. The temporal lobes are now normal.

Here is the working side of the headband. The two inboard light areas hide the optical receiver on the left. The red and infrared lights are on the right. The two black buttons hold an optional gauze towel in place.

It’s as easy as putting on your hat!