HEG: Comments

Introduction

The intent of this paper is to convey my observations and opinions on HEG as a modality. I make no claims to being an authority on the subject and none of this is backed up by research. My experience has been limited to personal use, working with Mary's stroke recovery, and observations of people who have tried it at our exhibit booths.

The Technology

Two types of HEG measurement are currently in use.

1. Passive infrared measurements which depends upon the heat radiated by the underlying tissue. This method is used by Jeff Carmen.

2. Active near infrared spectroscopy which passes two colors of light (red/infrared) through the underlying tissue and measures the ratio of the red to infrared return. This method is used by Hershel Tommim in the "Thinking Cap".

Each type is measuring a unique characteristic of the tissue.

The passive infrared type (Carmen) measures changes in radiated heat which can be affected by a number of factors. Blood flow brings core body heat to the affected area so an increase in flow should result in an increase in radiated heat. Metabolic activity also produces heat and could locally increase temperature. In this case, increased blood flow could actually conduct heat away from the tissue if local temperatures exceed blood temperature. Since the changes in passive infrared depend upon heat flow in and out of the head, the response time would be expected to be long.

Active near infrared spectroscopy (Thinking Cap) measures changes in the relative absorption of red and infrared light by the underlying tissue. The light traverses several centimeters of brain tissue as well as the scalp and skull. The ratio of red to infrared light is affected by changes in blood flow and/or perfusion in ways which are not totally understood. However, the ratio seems to increase with brain activity.

As with any modality there is always the opportunity for contamination by artifacts or collateral inputs. My experience to date has been limited to the Thinking Cap approach so I can only comment on this system.

1. Effect of 60Hz interference from direct electrical pickup or modulated light sources. This produces a pumping effect in the readings. External light sources can be shielded from the sensor area. Direct electrical pickup is not generally a problem.

2. Effects of small skin blemishes or hair. Since the red and infrared light sources are separated by a small finite distance, a small obstruction can affect one source more than the other which changes the ratio. For the most part the problem can be avoided by checking carefully for any obstruction under the sensor.

3. Positional changes of the subject. This changes cranial blood pressure and affects perfusion. It can be controlled by observing the subject.

Some of these effects are not large and only become noticeable when used with the high resolution and fast sample rates in the F1000 implementation.

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Observations

The following are some of my observations from use of the Thinking Cap HEG.

1. Small changes in HEG can occur fairly rapidly. A change of 1% in 5 seconds is not uncommon. Increases seem to take place in bursts.

2. HEG has a near optimum response time for subject motivation. It is not as transient as EEG nor so slow as finger temperature. Taking advantage of this characteristic requires a high resolution and smooth response. I display a bar graph showing +/- 4% from reference. The bar re-references on reaching either limit. Early experiments with +/- 20%, and +/- 10% ranges showed them to be more difficult for both initial learners, and for experienced subjects when reaching the higher levels. I have increased the Thinking Cap sample rate to 4X it's normal rate to increase smoothness of response. This also seems to enhance learning.

3. I find a strong left/right component to the modality. At Fp1 increasing the HEG is enhanced by a state of mental readiness or focus. Engaging in interaction with another is possible without decreasing the level. At Fp2 increasing the HEG requires more of a feeling or emotional readiness state. External interaction will usually bring about a decrease in readings.

4. The type of feedback display is important and needs to be selected to match the placement. For the Fp2 placement I am using an expanding "doughnut" which gives the feeling of "opening". This is used together with a bar graph and digital display. At Fp1 the best display seems to be the bargraph and digits. The doughnut gives the wrong feeling to the feedback in this case. In some cases, reversing the polarity of the doughnut having it contract with increasing HEG will work at Fp1. The problem is that this tends to confuse the subject when I go to Fp2 and again reverse the polarity. A different display would probably be better.

5. Temperature/EDR (SCR) are very useful in monitoring the subjects response to the session. A dropping temperature or reactive EDR can signal fatigue and/or irritation and give the clinician the option of dealing with it in an appropriate way. These modalities can also alert the clinician to systemic responses such as hot flashes or blushing which can cause the HEG to rapidly increase. It's not clear at this time what effect these responses have on the training result.

Experience

1. I have personally used the HEG on nearly a daily basis for the last 4 months. I take advantage of the right/left selectivity mentioned above to emphasis a desired brain state. A session at Fp1 is useful when I am about to undertake a mental task such as programming. Training at Fp2 requires quieting thought and is very effective before going to bed. I can't say what the long term effect of all this is at this point other than some indication that I have learned the quieting response and am able to use it without feedback. I have used EEG effectively in the past for the same purposes, but am finding the HEG more convenient, pleasant, and effective.

2. After Mary Deits stroke in Feb 99, we primarily used EEG training together with temperature/EDR(SCR) where appropriate. Her progress had been very good, but was beginning to slow. In late September with the advent of having the Thinking Cap available on the F1000 we shifted to HEG. Most work has been done at Fp1 and Fp2 due to the difficulty of working through hair. We have been able to successfully do feedback over the left mastoid

area. Even though the stroke involved the left rear hemisphere, HEG training in the frontal areas has been very helpful. Mary's progress accelerated markedly and has continued to date.

3. I am exploring the simultaneous feedback of EEG and HEG. More on this later.