
HEG Neurofeedback

Software Applications User Guide

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1 Introduction

This guide introduces the Hemoencephalography (HEG) neurofeedback set of applications, part of the Mind-Body Training Tools suite. These applications are designed to develop skills in mind-body awareness and self-regulation, particularly in a context of mindfulness and meditation practice.

The guide has two purposes: firstly to explain what HEG actually is, and secondly to teach you how to use the software – though it is more of a reference than a tutorial. Other training material is available on the StressResilientMind.co.uk website.

HEG is a way of measuring changes in the brain's metabolic activity. There are two forms, known as near infra-red (nIR) and passive infra-red (pIR). They are different measuring techniques, but for training purposes they appear to be substantially the same.

By 'metabolic activity' I mean energy-consuming processes in brain cells. The brain consumes more energy when you engage in mental activities that require focus. HEG neurofeedback is thus a means of training or exercising the brain at a physiological level, with the aim of boosting mental performance and emotional balance. Neurofeedback training seems to induce lasting change – it stimulates *neuroplasticity* in the brain.

Typically the HEG sensor is positioned over the forehead, where it monitors the Prefrontal Cortex (PFC). This region of the brain is heavily involved in *executive function* – described more fully in section 3.3. Thus HEG is a vehicle for training executive function.

There are in fact six versions of the HEG neurofeedback application. They share the same basic set of displays and controls but each offers a different form of feedback. They are described in sections 5 to 10 below.

In keeping with others in the suite, the HEG neurofeedback applications were designed to support *your* aims, not to supplant them. You're training mental function, and training the brain is a useful but slightly indirect way of doing that. Biofeedback should enhance or expand your subjective awareness rather than detract from it – don't get too caught up in the feedback at the expense of your experience of the mind.

The guide assumes that you have read the Software Installation and Set-up Guide, and therefore know how to start the application.

The applications work with several devices. For an up to date list of supported hardware, please see the StressResilientMind.co.uk website.

2 Launching the Applications

The applications are started from the HEG neurofeedback tab of the Platform application – see figure 1 below. The first step is to select one of the six variants.

2.1 Versions of the HEG Application

As stated earlier, there are six versions of the HEG neurofeedback application. They share the same basic set of controls and displays but offer some different feedback modalities. They are described below.

Select one of them using the drop-down list control labelled 1 in figure 1, before pressing button 2 to launch the application. Make sure you have your BioEra licence key (dongle) inserted into a USB socket. After a few seconds a new window (or two, depending on your choice of application) will appear on your screen.

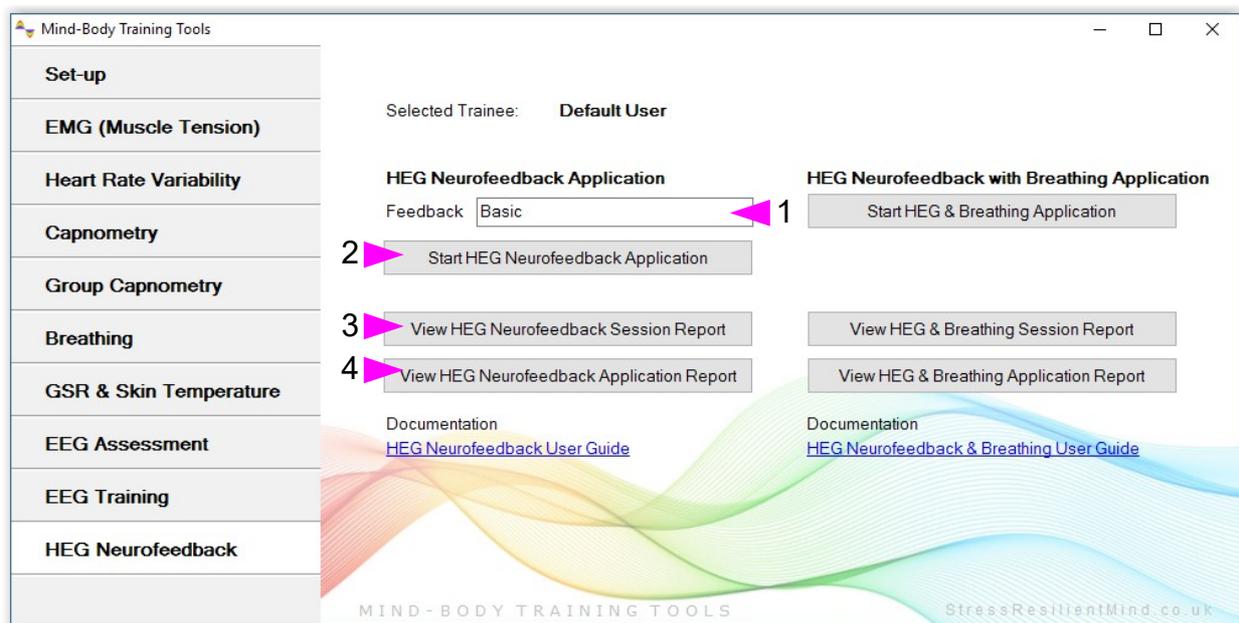


Figure 1 – HEG Neurofeedback Tab of the Platform Application

2.1.1 Basic Application

In this version of the application you are offered some simple audio feedback options:

- Tone – pitch varies with the HEG signal
- Midi – a musical instrument e.g. piano sounds notes, whose pitch varies with the HEG signal.
- Threshold – a bell sounds whenever the HEG signal (or more specifically the rate of change) crosses a threshold.

The application is covered in detail in section 5.

2.1.2 Audio Feedback Applications

In these two apps, the software plays audio files (which might for example be ripped from a CD, e.g. an audio book). Undesired changes in the HEG signal cause the sound to be distorted or masked. These applications are covered in detail in sections 6 and 7.

2.1.3 Video & DVD Feedback

In video feedback, the trainee watches a video while changes in the HEG signal cause the video to play in a different way. The remaining three applications are designed to work with video, but each adjusts video playback in a different way. For example, the video screen may darken when the HEG signal drops, and then recovers its brightness as the HEG signal climbs again.

Ideally for video feedback you'd have a computer with two screens, and with Windows set to "extended desktop" mode, so that you could have the video player on one screen and the biofeedback main window on the other.

Video feedback can be technically challenging, in part because a video depends on a software component called a codec for its playback. For reasons beyond my control, and even beyond the control of the BioEra developers, video playback within BioEra is not entirely reliable – not every video file will work, and others will behave somewhat erratically.

2.1.3.1 BxShadowEra

BxShadowEra is a third-party software product offering a route to video feedback that avoids using BioEra's internal video player, and thus many of the problems with reliability. It can also work with DVDs, games, or any other program you have on your computer, such as a Kindle reader. This means that it can facilitate training in a very wide range of contexts.

The BxShadowEra software creates a simple "overlay" window on the screen, having no content but with variable transparency – i.e. transparency can vary from opaque to completely transparent. This window is called the shadow, because it is more or less dark. Typically the user positions this window over another program such as a video player or DVD player (i.e. another independent software). Its variable transparency then obscures to some extent what you can see in the video player or DVD player.

BioEra can communicate with BxShadowEra, and thus control the transparency. It does this based on the feedback parameter.

In addition, BxShadowEra also adjusts your computer's system volume in a similar way. If the trainee is watching a movie, the volume of the movie will likewise vary with the HEG signal.

BxShadowEra must be purchased independently – it is not included with BioEra or Mind-Body Training Tools. (Please see the StressResilientMind.co.uk website for details on how to access it.) Nonetheless, the HEG module of Mind-Body Training Tools contains applications to work with it.

Section 8.3 below gives details on how to operate BxShadowEra.

2.1.3.2 BxShadowEra + Audio Interference Application

This application is very similar to the Basic application, except that it sends feedback to BxShadowEra, based on the HEG signal. In addition, the application plays white noise (i.e. a hiss) whose volume varies with the HEG signal – this is intended to interfere with a video or DVD the trainee is watching (outside of BioEra).

For more details, see section 8 below.

2.1.3.3 Video (Speed or Brightness Feedback) Application

This application uses BioEra's internal video player. It is able to vary the speed of the video playback. The design intent is to use this application with e.g. simple flight videos rather than movies. The trainee must attempt to move the video forward by adjusting and maintaining their brain state.

Technical issues alluded to above mean that the application won't work with all videos.

For more details, see section 9 below.

2.1.3.4 Video With BxShadowEra Application

This application also uses BioEra's internal video player, but relies on BxShadowEra to deliver feedback. The intention is that BxShadowEra's shadow window is positioned over the internal video player as a means of varying its brightness. Functionally it is similar to the simple BxShadowEra application discussed in section 2.1.3.2 – the main difference being the video player involved. Using the internal video player allows BioEra to pause the video at times, which you would otherwise have to do “by hand”.

This application also generates white noise (hiss) interference.

For more details, see section 9 below.

2.1.4 **Rewarding and Aversive Feedback**

In broad terms, feedback can either reward desired brain state changes, or to “punish” unwanted brain state changes. This just amounts to a minor change in emphasis. Rewarding means the feedback responds positively to increases in the HEG signal, while aversive or punishing feedback means the software creates a negative or undesirable change in response to a decreasing HEG signal.

Applications that use BxShadowEra to obscure a video or DVD appearance are examples of aversive feedback. The application that uses video speed as the feedback parameter is an example of rewarding feedback.

2.2 **Hardware Set-up**

The physical aspects of hardware set-up (how to connect and use your sensors, etc.) are dependent upon the type of amplifier you are using, and are covered in a separate document (Hardware Set-up Guide).

Before you start the application you configure the device set-up options, accessible by clicking a button in the Set-up tab of the Platform. In the dialog, select the type of amplifier (biofeedback device) you are using, in the HEG source control. Note, all the source settings are remembered the next time you start the Platform. (See the Installation and Set-up Guide for further details of device set-up.)

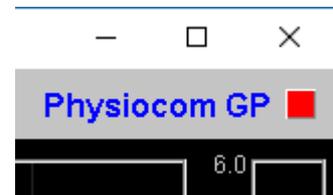


Figure 2 – Amplifier status

One of the device options is 'Simulator'. In simulator mode, you can learn how to use the software without the encumbrance of sensors, leads etc. (The application simply uses recorded data as a source.).

Some of the supported devices present the HEG signal as a temperature. If you're using one of these devices, a drop-down list control allows you to select either Celcius or Fahrenheit.

Once you have started the application, you should see your device selection reflected in the device status display in the top right corner of the main window (see figure 2). The lamp (shown as a red square in figure 2) should change to green when you press the play button. If you do not see this happen, it means that the application has not been able to establish a connection with your device. Check it is plugged in and that the batteries are not flat, etc.

For some devices, you'll see a button rather than just text. Pressing this button opens up a dialog that allows you to adjust settings related to the device, such as COM port. The specifics depend on the device – see the Hardware Set-up Guide for more details.

3 About HEG Neurofeedback

3.1 What Is HEG Neurofeedback?

Neurofeedback is a form of biofeedback in which the physiological signal being measured comes directly from the brain – so it's a form of brain training. Whereas most forms of brain training work with the brain's cognitive performance, neurofeedback works directly with the brain's physiological and metabolic functioning.

There are two forms of HEG sensor, known as nIR (near infra-red) and pIR (passive infra-red). The former was developed by Dr Hershel Toomim and the latter by Dr Jeffrey Carmen. For the purposes of training they seem to be largely equivalent, and the software works with both types. In either case the sensor detects changes in blood flow and metabolic activation (these two being tightly coupled in the brain). The sensor detects activity only in the outer region of the brain (known as the cortex), and only from an area close to the sensor.

A major advantage of HEG neurofeedback is that the signal is particularly simple – it goes up when activation increases, and goes down when activation decreases.

Metabolic activity in brain cells is linked to mental functioning; for example if you concentrate harder, your brain cells (some of them at least) respond by working harder metabolically. So training the brain at the physiological level is a means of boosting mental performance. In HEG neurofeedback we train the signal upwards (not downwards).

3.1.1 Rate of Change of HEG Signal

The absolute value of the HEG signal is of little relevance – we can't infer anything about brain state from it. Rather, it is *changes* in the HEG reading that count. To repeat: when the HEG signal increases we infer the brain became more active. For this reason it is useful to calculate the *rate of change of the HEG signal*. Much of the feedback in the application is actually based on this calculation – for example see section 4.3 below.

The rate of change is equivalent to the slope or gradient of the HEG graph.

A zero rate of change means that the HEG reading is stable or unchanging, and that the brain is maintaining its energy level, without either increasing or decreasing it. This state doesn't tend to last very long!

When the brain is activating, the rate of change is above zero (the HEG signal is increasing) and the higher the rate of change the stronger the activation.

When the brain is becoming less energetically active, the rate of change is less than zero, or negative. (The HEG signal is falling.)

3.2 Sensor Placement

The standard location for the sensor is the centre of the forehead. The region of the brain behind this point is a particularly important area known as the Prefrontal Cortex (PFC). The PFC has been described as the brain's executive control centre. Its functions are discussed in the following section.

You could use any other site on the scalp for HEG neurofeedback, but I advise you to know what you are doing if you decide to move away from the centre of the forehead. It's possible that you could unwittingly train an unhelpful imbalance. Also note that hair blocks the signal – in other words the sensor cannot see through hair.

3.3 Executive Function

To summarise, HEG neurofeedback trains up increased activity in a key brain region, the PFC. More highly evolved in humans than in any other species, the PFC endows us with our uniquely human abilities, traits and intelligences – a set of skills known in neuroscience as executive function, and including:

- The ability to hold the mind steady in its focus.
- Body regulation – by modulating the Autonomic Nervous System (ANS) the PFC influences many of the body's automatic visceral responses.
- Emotional balance – the ability to temper over-arousal and over-stimulation, and to summon and maintain energy and clarity in the absence of external stimulation. Also the ability to modulate emotion-triggering signals coming from other brain regions such as the amygdala (which triggers fear and anger).
- Motivation and emotional drive – the ability to formulate values, goals and purposes.
- The ability to formulate a considered plan of action, and to hold to it in the face of distractions, as well as to update it appropriately. The ability to check impulsiveness.
- Empathy – the ability to appreciate the minds of other people, and to understand how our own behaviour impinges upon them. Ultimately this includes our moral awareness.

PFC functioning has been found to be compromised in several emotional and neurological disorders, including depression and ADHD. HEG neurofeedback can be used therapeutically with these disorders, but you don't have to have a disorder to benefit – HEG neurofeedback is an optimal performance training tool.

Data suggests HEG neurofeedback produces lasting benefits – it's thought that it stimulates structural change in the brain. In other words it stimulates the brain's *neuroplasticity*.

3.4 Working with HEG Neurofeedback

This section gives some guidelines on how to direct and apply the mind in order to increase the HEG signal (measured at the forehead).

Aim to feel intensely awake, alert and present. Imagine that something very significant is about to happen, something that you'll want to remember all your life. The mind is rapt, poised, expectant, with all the senses “peeled”, and yet calm and still.

Your intent is to move the graph upwards. Imagine that you could move it by the power of your intent, as though you had a psychic power. A useful metaphor can be found in the “Star Wars” series of films, in which Jedi knights such as Luke Skywalker learn to channel the mystical “force”.

You need some emotional commitment behind your intent. You have to really want that graph to move upwards. And yet this motivation must remain positive – if it tips over into frustration or self-criticism or “performance anxiety” then this will work against you. Don't be overly attached to the outcome of your exertions. Appreciate that your brain has limitations. The graph will not always head upwards – at times your brain will tire. Take mini-breaks when you need to, then re-engage your intent.

On the other hand, the occasions at which the graph drops are your working ground, or your learning ground. With practice you'll learn to turn them around so that the HEG signal quickly returns to increase.

What kind of influences cause the HEG signal to drop? In my experience there are two main ones:

- The mind becomes bored or fatigued, and drifts into a slothful, low-energy or even sleepy state.
- Negative emotion, perhaps triggered by a passing thought or memory, or perhaps by a negative judgement of your own performance.

In either case, the practice is to rebalance the brain as quickly as possible.

Sometimes the signal begins to fall, but you're not consciously aware of any reason for it (neither of the above two seem to apply). I think it's best to understand these occasions as openings for distraction – if you let the trend continue unchecked for long, the mind will drift into some form of distraction, but if you respond and turn the signal round, no problem.

Responding to mild boredom often isn't easy. Looking at a line on a computer screen is inherently a pretty boring situation. I think this is an important part of the context for training. You have to generate the arousal internally, not rely on the external stimulation. If you were watching a really interesting film, it might be a lot easier to maintain brain activation, but you're probably already good at that and don't need to practise. On the other hand you don't need to focus exclusively on the graph – you can broaden your focus out to include your environment, and other sensory channels besides vision, as long as you can maintain your intent.

Be careful not to over-train. As with physical exercise, there is a window of opportunity for change – not enough effort, and nothing really changes in the longer term, but over-do it and you risk fatiguing the brain and perhaps giving yourself a headache. However there is no reason to think that over-training can cause lasting problems.

In the very early days of training, I suggest no more than five minutes of active training at a time, but you can probably quite quickly build up to 20 minute sessions or longer, though it is reasonable to take rests during this time.

Remember that HEG neurofeedback sessions are about exercising the brain. If brain activation increases but then falls back again – well you've still exercised the brain. Compare it to lifting dumbbells – you have to lower them back again. In other words, achieving a net increase over the course of a HEG training sessions is not the important thing. Don't get overly focused on the numbers. You can assume that if you practise (exercise) regularly, neuroplastic changes will happen in the brain automatically in the longer term.

My design intent has been to support *mind training* (not simply brain training), by enhancing and augmenting your subjective awareness, rather than detracting from it. This is another reason not to get overly focused on the feedback or overly goal-oriented with respect to the feedback. Instead find a way for the feedback to enhance your subjective awareness. In practice this means letting the feedback be more in the background of your broad awareness. Audio feedback is useful in this regard as it allows you to practise without watching the screen.

Keep emotionally positive as much as you can, or at least avoid falling into negative emotions. Getting frustrated when the signal doesn't go up, and getting anxious if it doesn't go up or you think you can't make it go up, are two traps that can cause drops in the signal.

Another point worth making is that, in the context of training it is sometimes enough just to maintain the brain's energy level, without needing to increase metabolic activity. (Of course there is ultimately a ceiling to the HEG signal – it can't keep on increasing for ever more.) In other words, training is about avoiding drops rather than achieving gains.

3.4.1 Training Periods

The mental application involved in HEG neurofeedback is quite intense. As I mentioned, the brain can easily become fatigued, especially in the early days of training. Intense focus is more naturally done in short bursts, inter-spaced with rests.

To facilitate this pattern of working, I incorporated a design feature known as “training periods”. The idea is very straight-forward: you set an interval of time for a burst of training, and when you're ready to begin a training period you press a button to begin it. The system times the period, and at the end of it, the feedback is disengaged. This applies to both visual and auditory feedback. When you feel rested and ready to begin again, you press the button to begin another round of training, at which point the system turns on the feedback again. Thus working with training periods is a kind of “interval training” you may be familiar with in gym work.

You can choose to activate the training periods feature. By default it is turned off. Further details are given in section 4.4 below.

4 User Interface – Common Elements

This section explains the charts and controls of the application's user interface. As discussed earlier, there are six different forms of the application, some of which have two windows (i.e. main and support windows). The six share many features and controls, which are found in the main window (the support windows differ). This section covers these common interface elements, while subsequent sections cover the individual applications in detail.

Figure 3 below shows the Basic application's window. Only the audio controls at the very bottom of the screen are specific to this application. (These are covered in section 5).

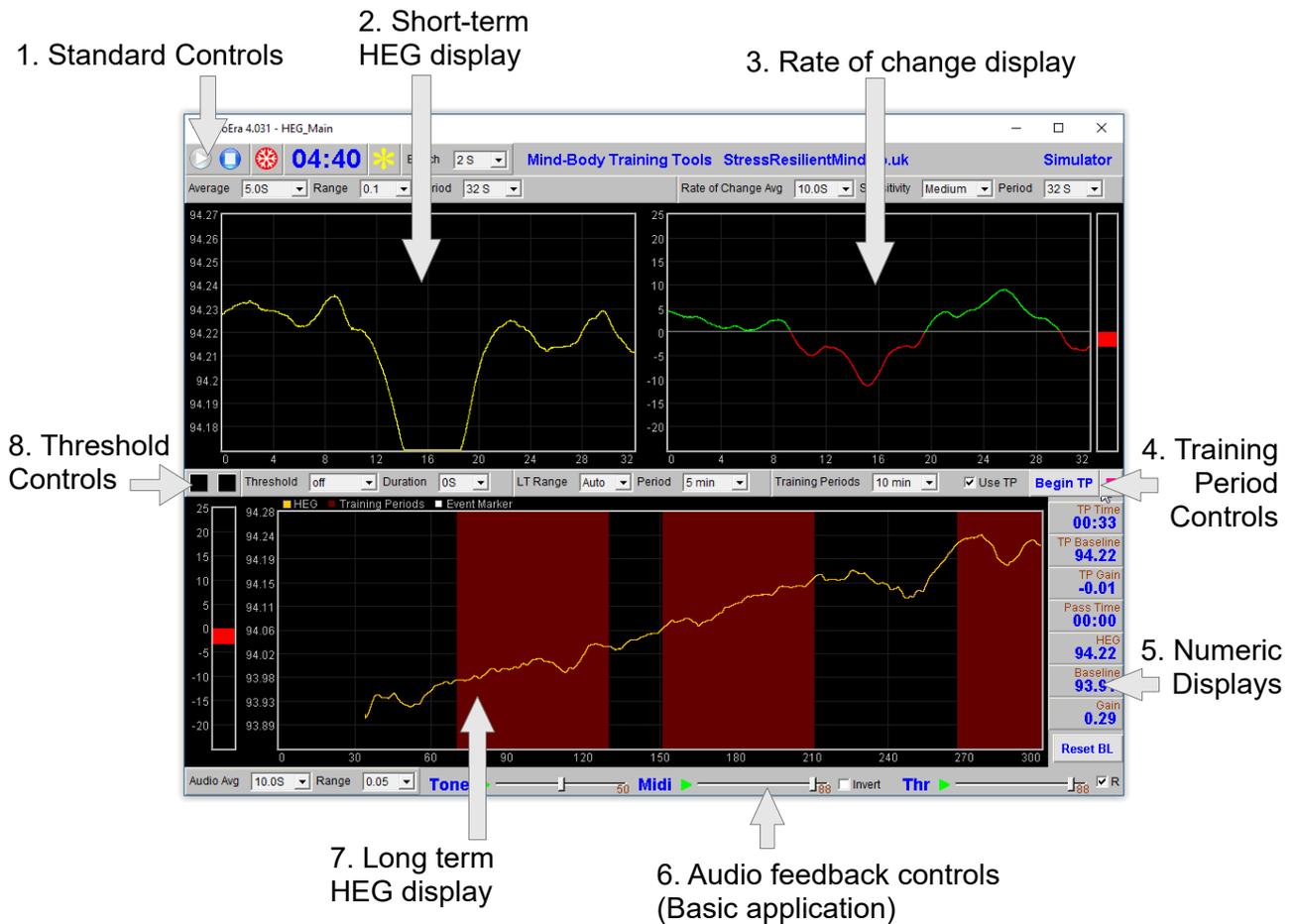


Figure 3 – User interface

4.1 Standard Controls (Start / Stop, etc.)

A set of buttons – Play, Stop and Pause – are the same in all the applications in the suite. They should be self-explanatory.

The 'Epoch' control sets the time period at which data is written to the session data file. This data file is used to generate session reports, which are described in section 11 below. For the HEG application, only HEG data is written. Choosing a lower time period generates more data. For example, if you select 2 seconds, then the application will write HEG readings to the session data file once every two seconds.

The button marked with a red asterisk is a simple event marker. You can use it to mark adventitious happenings and changes in session conditions (e.g. you turn on or off breath pacing). It is particularly useful for coaches and therapists. Events thus marked are represented in the long term

chart (see section 4.1.4 below) by a vertical white line. They are also recorded in the session data file and are shown in session report charts (as dotted vertical lines) (see section 5).

Note that pressing the escape key during a session has the same effect as pressing the red asterisk with your mouse (i.e. it is an alternative).

4.2 Short-term HEG Display



Figure 4 – Short-term HEG display

The chart in figure 4 above shows the progression of the HEG signal over the short term.

The three (sometimes four) drop-down list controls, positioned above the chart and described in the following table, can be used to configure this chart.

Average Controls the level of smoothing of the HEG signal. With a shorter average you will see all the fine-grained changes. With a longer average these are smoothed out, but the signal will be slower in responding to change.

I suggest a setting of 10 seconds as a starting point.

Range Controls the vertical scale of the display, or the difference between the upper and lower limits of the vertical axis.

Note this chart operates in auto-centre mode. The trace will be continually adjusted so that it's (most recent) right hand section displays in the middle of the vertical range. This means that although the scale is fixed, the actual upper and lower limits are constantly changing.

Selecting 'Auto' produces a different behaviour: the system will automatically calculate the best range to best fit the chart based on the variation over the period of the chart. In this case the range will not stay fixed but will vary over the session.

Period This controls the length of time it takes for the trace to traverse the whole chart from right to left – or in other words the horizontal range.

Note that *increasing* the period after processing has started can have unpredictable consequences, so I recommend you make your selection before pressing play.

Unit Only available for some device types. Select either Fahrenheit or Celcius as the unit (of infra-red temperature). This applies to all the displays, not just the short-term HEG chart.

4.3 Rate of Change Display

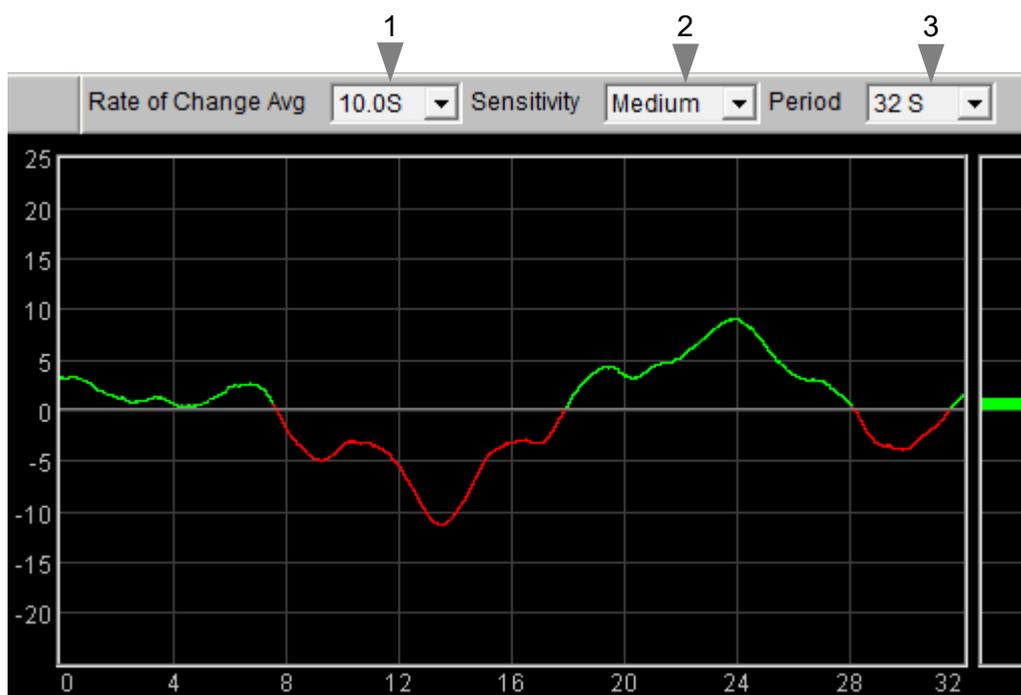


Figure 5 – HEG rate of change display

This chart (figure 5) shows the HEG rate of change, or in other words the gradient or slope of the HEG trace shown in the short-term HEG chart (section 4.2 above). The central horizontal line is zero. When the trace goes above this line, it means the HEG signal is increasing and its colour is green. When the trace falls below the line it means the HEG signal is falling and its colour changes to red. The further away from the zero line, the faster the HEG signal is changing.

Since the goal of training is to increase or at least maintain the HEG reading, you should aim to keep this graph “in the green” as much as you can (but don't expect it to stay there constantly).

The bar graph at the right of the display shows the current rate of change – this chart always has the same scale as the adjacent chart.

The three drop-down list controls, positioned above the chart and described in the following table, can be used to configure this chart.

Rate of Change Avg Controls the level of smoothing of the signal. With a shorter average you will see all the fine-grained changes. With a longer average these are smoothed out, but the signal will be slower in responding to change.

I suggest a setting of 10 seconds as a starting point.

Sensitivity Controls the vertical scale or range of the display. With a higher sensitivity setting, the range will be smaller, so changes will appear more prominently.

The zero line is always fixed in the centre of the chart.

If the trace tends to disappear off the top or bottom of the chart, choose a lower sensitivity. Conversely if the trace is bunched tightly around the zero line, choose a higher sensitivity.

Period This controls the length of time it takes for the traces to traverse the whole chart from right to left – or in other words the horizontal range.

Note that *increasing* the period after processing has started can have unpredictable consequences, so I recommend you make your selection before pressing play.

4.4 Controls for Working with Training Periods

The concept of training periods was introduced in section 3.4.1 as a way of concentrating the effort of training within short bursts. By default, the feature is turned off. This section explains how to activate and use training periods.

Figure 6 shows the controls relating to training periods.

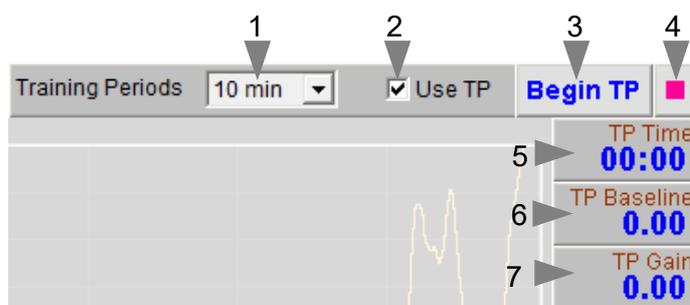


Figure 6 – Training period controls

The check-box, labelled 2 in figure 6, when checked will activate the feature. If you check it while the application is running you'll see that much of the feedback is disengaged. For example the rate of change chart goes to zero, and the short-term HEG trace goes flat. Audio feedback is cut off.

Pressing the button 'Begin TP' (3 in figure 6) begins a timed training period. The feedback becomes active, and the training periods shows as a dark red band in the long term chart (see section 4.6). Pressing it again during a training period has the effect of setting the elapsed time of the training period to zero.

If you want to end a training period early, you can press the button with a red square (4 in figure 6).

Use the drop-down list labelled 1 in figure 6 to set the duration of training periods.

The numeric displays labelled 5, 6, 7, etc. in figure 6 allow you to assess your progress and performance within the training period. They are described in the following table.

- TP Time** Elapsed time since the beginning of the training period
- TP Baseline** The HEG reading at the beginning of the training period.
- TP Gain** Current HEG reading minus the training period baseline.
- Pass Time** The cumulative time for which the threshold condition has been met, since the beginning of the training period. (See section 4.7 for more about the threshold.)

If you want to keep a record of your comparative progress over several training periods, you'll need to write down these values.

4.5 Numeric Displays

The numeric displays show the following data:

- HEG** Current HEG reading
- Baseline** The HEG reading at the beginning of the session, or more precisely 30 seconds into the session (to allow a settling period).
You may reset the baseline to the current HEG reading at any time, by pressing the button, 'Reset BL'.
- Gain** Current HEG reading minus the baseline. This allows you to assess the overall change achieved in your session.

4.6 Long-term Display

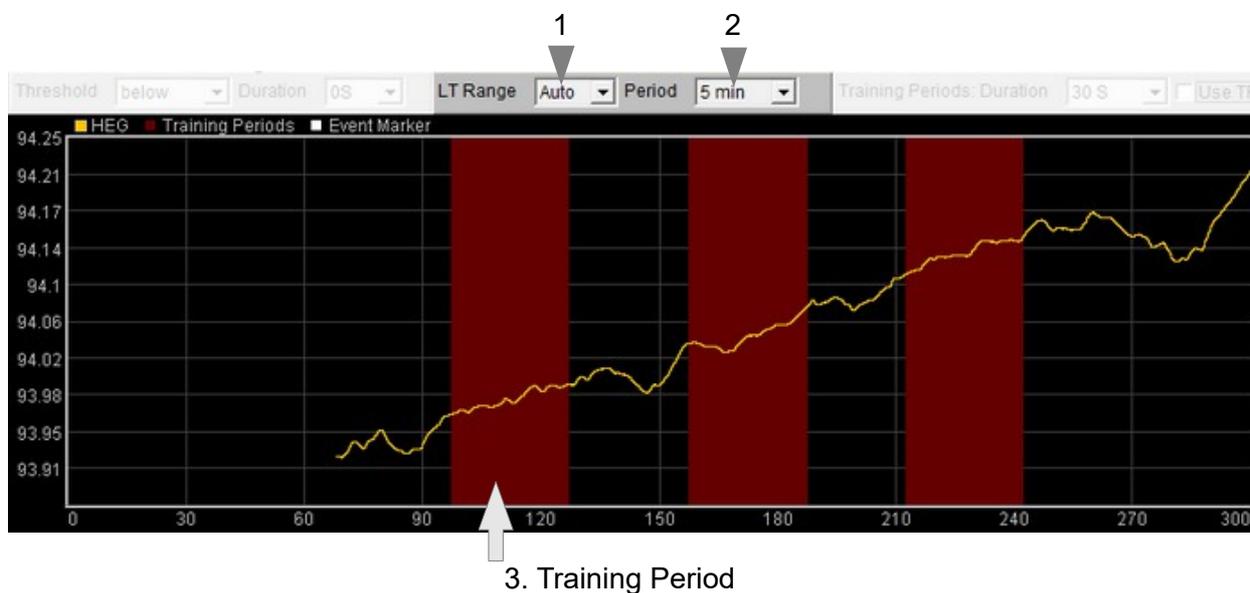


Figure 7 – Long-term HEG display

The long term display (figure 7) shows the variation of the HEG signal over the longer term. Training periods, if you're using them, are shown as dark red bands – you can see three of them in figure 7.

There are two controls associated with the chart, positioned above it (and labelled 1 and 2 in figure 7). They are described in the following table.

LT Range Controls the vertical scale of the main chart, or the difference between the upper and lower limits of the vertical axis.

Note this chart operates in auto-centre mode. The trace will be continually adjusted so that it's (most recent) right hand section displays in the middle of the vertical range. This means that although the scale is fixed, the actual upper and lower limits are constantly changing.

Selecting 'Auto' produces a different behaviour: the system will automatically calculate the best range to best fit the chart based on the variation over the period of the chart. In this case the range will not stay fixed but will vary over the session.

Period Controls the horizontal (time) range – in other words how long it takes the trace to traverse from right to left.

Note that *increasing* the period after processing has started can have unpredictable consequences, so I recommend you make your selection before pressing play.

4.7 Threshold Display and Controls

Threshold-based feedback is designed to follow a consistent pattern throughout all the applications, and therefore it made sense to describe threshold functionality in a single place, viz. The Guide to Audio and Threshold-based Feedback (a separate document). I recommend you read that before trying to make sense of this section.

(Controls for threshold-based audio feedback are covered in section 4.1.8 below.)

In the HEG application, the threshold works on the HEG rate of change. The display and controls are found in the lower left corner of the main window. Some of the controls associated with the rate of change display, also affect the threshold's signal.

As with most applications, four conditions can be applied to the threshold (“above”, “below”, “outside” and “off”). In the Basic application the drop-down list control (1 in figure 8) sets this condition. The other HEG applications (described in sections 5 to 10 below) differ in that this control is absent – the threshold condition is fixed to “outside” meaning there are two threshold levels. The other applications all depend on calculation of the “threshold ratio” (which is described in the Guide to Audio & Threshold-based Feedback).

In the Basic application there is also a duration control, which in effect allows the user to filter out short blips in the signal.

The following table lists the possible threshold conditions, available in the 'condition' control (again, only in the Basic application).

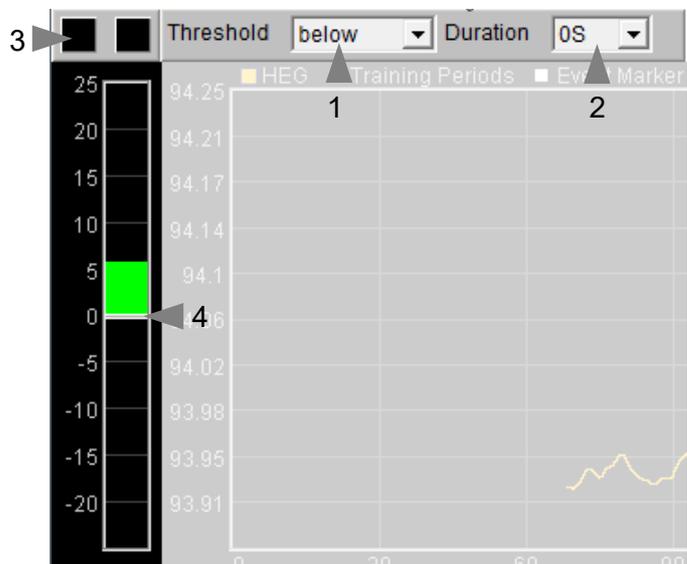


Figure 8 – Threshold display and controls

5 Basic Application Feedback

The Basic version of the HEG application differs from the others in that there are some basic audio feedback options. The controls are found at the very bottom of the application's window. Again, audio feedback functionality is consistent between applications and so is described in one place, i.e. The Guide to Audio and Threshold-based Feedback, which I suggest you read before trying to make sense of this section.

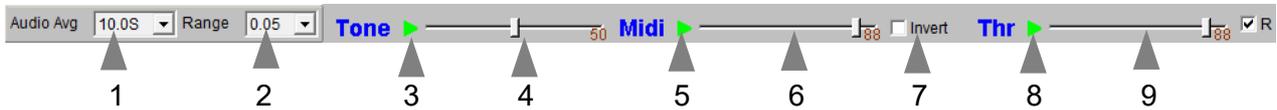


Figure 9 – Audio feedback controls in the Basic application

Figure 9 shows these audio feedback controls. There are three forms of audio feedback available – simple tone, midi and threshold-based. Tone and midi feedback are based on the HEG signal while threshold feedback is based on the HEG rate of change.

For the most part audio feedback works as it does in other applications, but there are some features particular to this application:

- Audio feedback has its own averaging control, distinct from the application's main average (but working in the same way), and labelled 1 in figure 9.
- Tone and midi feedback have their own range control (shown as 2 in figure 9) distinct from the range controls for the displays.
- Both tone and midi feedback have an “auto-centre” feature, meaning that when the change in temperature is sufficiently large to take the pitch outside of its range, the pitch is reset to the middle of the range, in effect recalibrating the feedback.
- There is an additional control, a check-box labelled “Invert”, 9 in figure 8 above, which flips the mapping for both tone and midi feedback such that when the HEG signal rises, the pitch falls (deepens). This may be preferable for some users, because a deeper pitch is more aesthetically pleasing / rewarding.
- The threshold has a “duration” control, already mentioned in section 4.7 above, and in consequence there are two lamps, the left lights up (amber) on the initial threshold-cross, while the right lights up (red) only after the “duration” period.

6 Audio (Basic) Application Feedback

The Audio (Basic) application is very similar to the basic application described above (section 5).

This time, audio feedback takes the form of a sound file being played with variable volume. Feedback is based on HEG rate of change, and so works with the threshold controls described earlier (section 4.7). I recommend you read the Guide to Audio and Threshold-based Feedback, before trying to make sense of this application.

The application's main window is shown in figure 10 below, with the audio controls at the bottom.

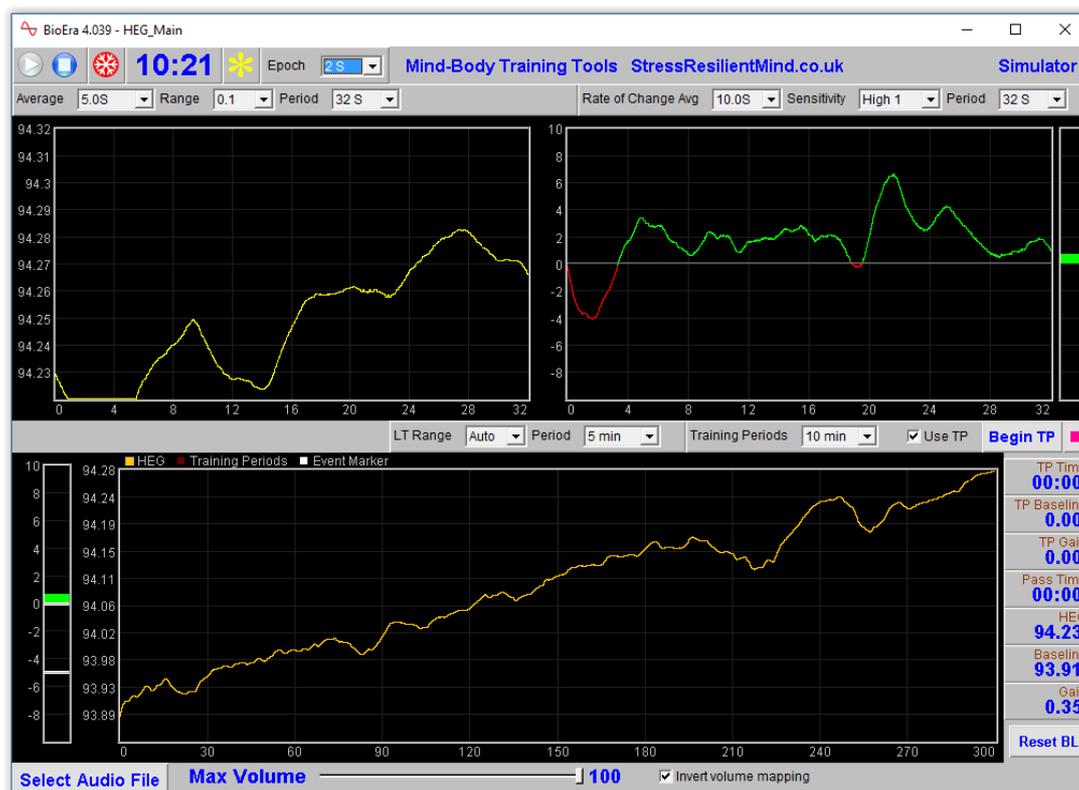


Figure 10 – Main window of the Audio (basic) application

The sound can be used as a reward for an increasing signal, or as a warning for a decreasing signal (if the latter, you'd need to check the “invert volume mapping” checkbox control).

The application works quite well with nature sounds – for example I've used it personally, with a recording of rain and thunder. I use this as a warning for a falling signal – the greater the rate of decrease, the louder the rain sounds. When the signal is increasing there is no sound.

Nature sounds can be bought in mp3 format from well-known providers, but you'll need to convert mp3 files to .wav files, to use them with this application.

The selected sound file is played in a loop – when it finishes it immediately starts again from the beginning.

6.1 Audio Controls

A button allows you to select the audio file to play, and a slider control allows you to set the maximum volume. The only other control is the “invert volume mapping” checkbox already mentioned.

7 Audio (Playlist) Application Feedback

This application, like the Audio (Basic) application, offers HEG feedback in the context of audio tracks playing with variable volume. It's more complex, mainly in that it can play a sequence of tracks in succession. Again, feedback is based on the HEG rate of change. Whenever the HEG signal falls, the audio quality is distorted. The trainee must increase brain activation in order to recover the normal sound. In other words, the feedback is a form of aversive conditioning – the trainee is “punished” for letting brain state drift. The application is designed for use in a concentration exercise, e.g. listen to audio books or other verbal tracks demanding focus.

The application's (single) window looks much the same as that shown in figure 10 above, having only different audio controls right at the bottom. These are shown in figure 11 below.

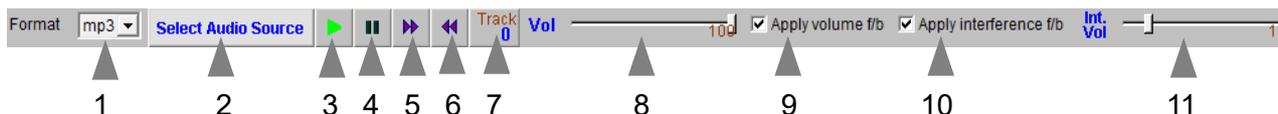


Figure 11 – Feedback controls in the Audio application

The intent is that you can rip sound tracks from a CD into a folder on your system. You then select this folder by pressing the button 'Select Audio Source' (2 in figure 12). The tracks are then played in order (see section 7.1 on file names below). Your CD can be an audio book, which would perhaps demand greater concentration, but it could also be a music CD.

You can opt for one or both of two feedback modalities:

- i. Track volume – the volume of the audio track varies with HEG rate of change. The checkbox, 'Apply volume f/b' (9 in figure 12) activates this modality.
- ii. White noise interference – a hissing sound is played, which obscures the soundtrack, and whose volume varies with the HEG rate of change. The checkbox, 'Apply interference f/b' (10 in figure 12) activates this modality. This works the same way as for the BxShadowEra application described in section 7 below, where it is described more fully.

For both the above feedback modalities, you can set the maximum volume using slider controls (8 and 11 in figure 11).

Press the play button (3 in figure 11) to start the soundtracks. You can pause using button 4, and skip between tracks using buttons 5 and 6. A numeric display (7 in figure 11) shows the current track.

7.1 Audio File Names

The software will look for files in the nominated folder, beginning with a number. The first track should have a name starting with the track number, e.g. “1.wav” or “1_trackname.wav”. The software plays files in the order defined by the number at the start of the filename, e.g. “2.wav” will be played second. Tracks not incorporating numbers are not played. It is therefore important that you name your tracks properly, getting them in the right order.

A sample set of audio tracks is given with the Mind-Body Training Tools software, at this location:

```
[BioEra Root]\design\YBF\Media\Audio_Samples\
```

When you rip tracks from your CD using software such as Windows Media Player, it may add the track number for you, but you may have to add an underscore after it.

7.1.1 Finding Suitable Audio Material

Besides ripping tracks from your CD's, endless material is available online, but please note I am not hereby encouraging or condoning breach of copyright.

7.2 Audio Formats

The application can play files in either .wav format or .mp3 format. You must select the format that matches your files, using the 'Format' drop-down list control (1 in figure 12).

Note, most CD ripping software programs have the option to rip to either of these two formats.

8 BxShadowEra Application Feedback

BxShadowEra is a third party software that allows you to apply feedback in the context of watching videos, DVDs or other software applications such as games. It was described in section 2.1. In summary, BxShadowEra creates an overlay window (the shadow) with variable transparency, that you position in front of your (external to MBTT) video or DVD player. BioEra communicates with BxShadowEra to control the transparency.

The feedback is based on the HEG rate of change. In fact it's based on the HEG threshold ratio. To understand fully what this means, please read the Guide to Audio & Threshold-based Feedback.

In summary, the appearance of the video depends on the HEG rate of change in relation to the two HEG threshold levels. When the signal is at or above the upper limit, the shadow window has full transparency and the video image is unimpeded. When the HEG rate of change drops below this upper limit, the window starts getting darker, reaching a maximum darkness at the lower limit.

(In this application the HEG threshold has no control for the HEG condition – it is fixed at “outside” meaning the two levels are always present – necessary to properly define the threshold ratio.)

The application has a single window, as shown in figure 12 below. Most of the elements in the screen are the same as for the basic application – the controls particular to this application are right at the bottom, and they are described in section 8.2 below.

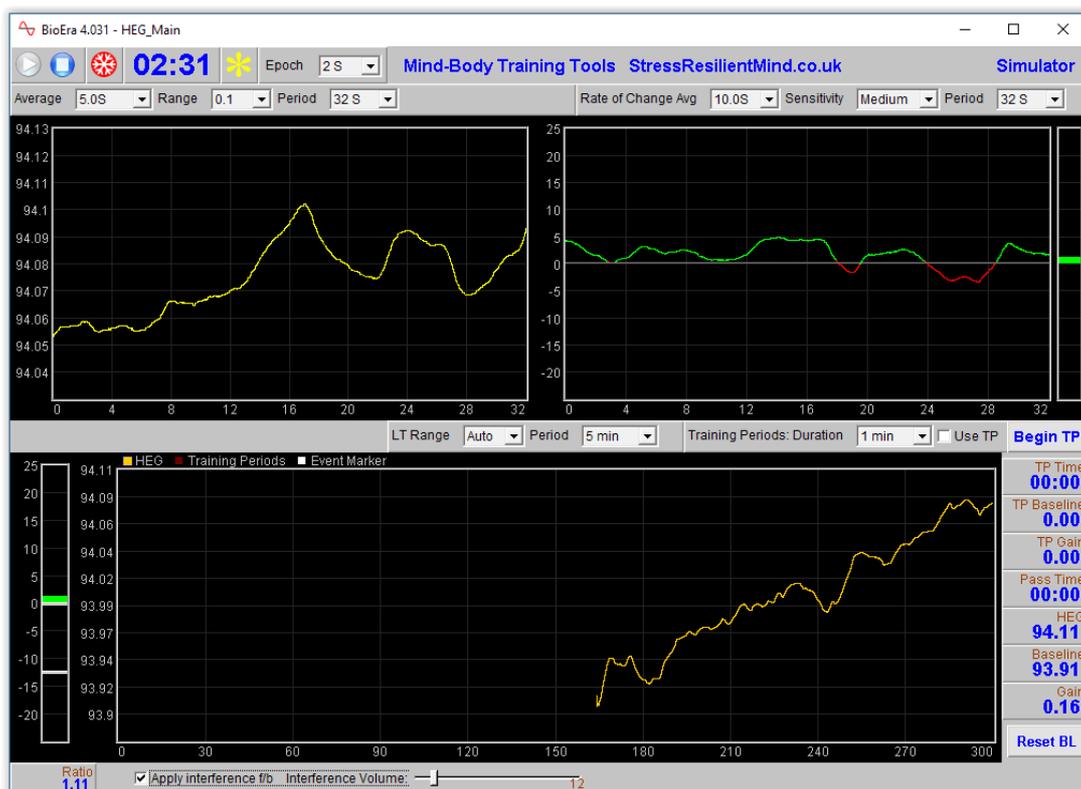


Figure 12 – Main window of the BxShadowEra application

8.1 Threshold Levels

Clearly the settings of the threshold levels is key to the performance of this application.

BxShadowEra delivers aversive feedback, meaning that falls in brain activation (drops in HEG signal) are “punished” with a darkening of the screen..

By default, the upper threshold level is set at zero (rate of change). This means that any positive rate of change gives a clear shadow window, and hence unimpeded video appearance. When the rate of change drops below zero, the shadow / video screen darkens.

Of course you are free to move the threshold levels away from the defaults if you wish.

Changing the sensitivity of the rate of change display, changes the threshold levels, and hence the feedback.

8.2 Audio Interference

Besides feedback via BxShadowEra, this application offers a second means of feedback, viz. audio interference: the software produces a hiss (white noise) with variable volume. If you're watching a movie (e.g. on external video or DVD player software) the hiss will degrade your experience by interfering with the sound (i.e. it's aversive feedback).

It works on a similar principle as the BxShadowEra feedback. That is, feedback is based on the HEG threshold ratio, and when the signal is at or above the upper limit, there is no hiss. The more the HEG rate of change drops below this upper limit, the louder the hiss, reaching a maximum at the lower limit.

Again your positioning of the threshold levels is important.

You can choose to apply this form of feedback or not, using a checkbox control, and you can also control the maximum volume using a slider control. These controls are at the bottom of the application's window, see figure 12 above).

If you don't have BxShadowEra, you can still use this application, simply applying audio interference feedback.

8.3 Configuring BxShadowEra

BxShadowEra has a small number of controls you need to set appropriately.

Start the BxShadowEra application – you should see its window appearing as in figure 13 below.

You must press the button “Enable shadow” before the shadow appears. You can of course move it and resize it as you see fit – until you “fix” it with one of the controls, then this prevents further movement.

Be aware that you can't click on buttons or other controls beneath the shadow window – don't cover your video play button!

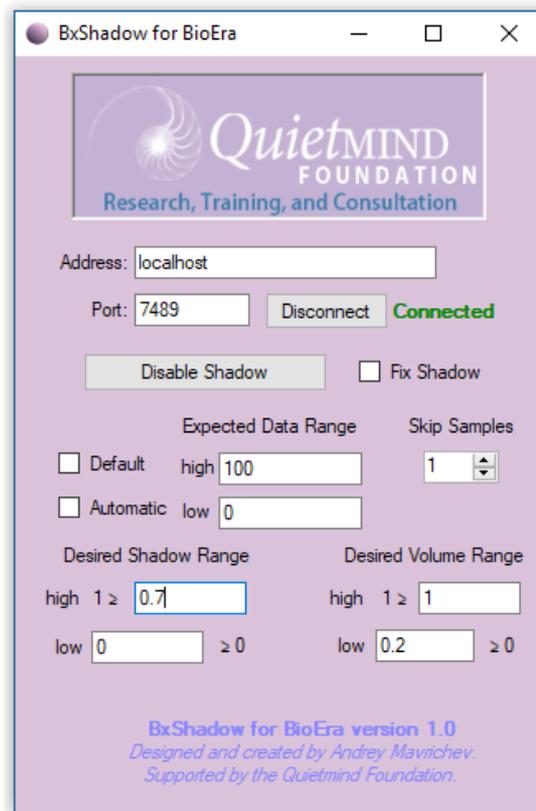


Figure 13 – BxShadowEra application interface

Start the Mind-Body Training Tools BioEra application, and THEN press the button “Connect” - this establishes the communication between the two programs. If the link-up happens as it should, you should see the “connected” message (as in figure 13).

The MBTT application sends a number between 0 and 100 to set the “brightness” or opacity of the shadow window. Make sure to have 0 and 100 entered in the expected data range, as you see in figure 13.

Set the desired shadow range as you see fit. A low of zero gives maximum transparency of the shadow, hence maximum “brightness” - I expect most users will use this setting. At the other extreme, a high of 1 gives a completely opaque shadow, which you may not want. As you see in figure 13 I've used 0.7 and that gives a fairly dark shadow but still with some transparency.

9 Video (Speed or Brightness Feedback) Application

This application presents feedback through the medium of a video, this time using a video player internal to BioEra. This application is therefore prone to the unreliability described in section 2 above.

The application has two windows, the first looking much like that in figure 10 above, having only different controls right at the bottom. The second window contains the video player, and is shown in figure 14 below.

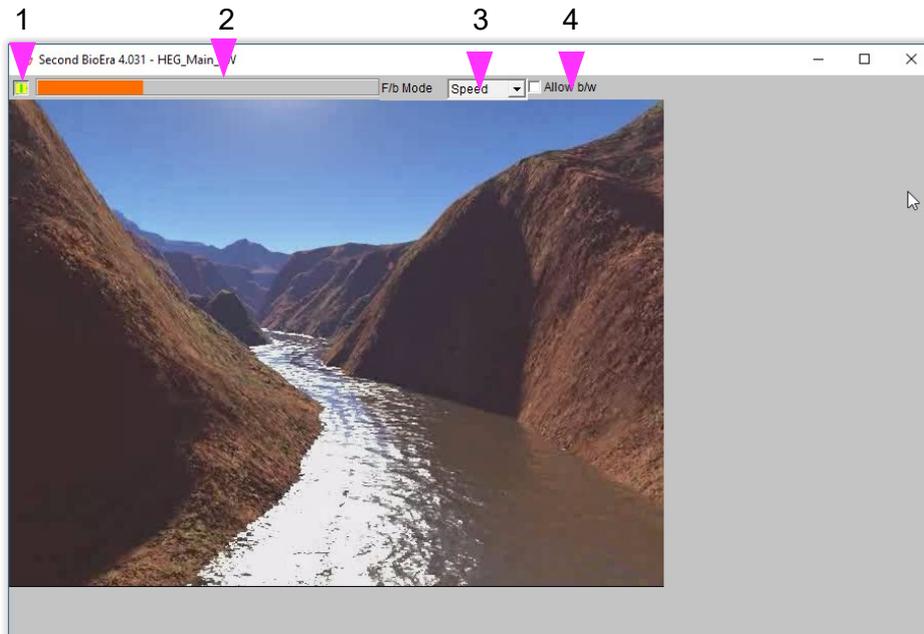


Figure 14 – Video feedback window

As with other HEG applications, the feedback is based on the HEG rate of change, and more specifically on the threshold ratio already mentioned.

9.1 Video Speed Feedback

The most commonly used mode for this application is with speed feedback. In this mode, the video moves forward at a speed determined by the HEG signal. The application works well with flight videos (see section 9.5 below).

Again, positioning of the threshold limits is key. At and above the upper limit, the video plays at a normal speed. Below the lower limit, the video pauses completely, or even moves backwards. In between, the speed varies linearly with the threshold ratio.

This mode of feedback rewards increases in the HEG signal. By default the lower threshold limit is at zero, and the upper is some way above it. The trainee must will the video forward.

9.2 Audio Feedback

Additionally, you can play a sound file whose volume varies with the HEG signal.

When I've used this application myself, I've used a flight video (which doesn't have a soundtrack) and then I've used a separate soundtrack of an aircraft engine. The engine volume is maximum

when the speed is full, and then fades out as the video speed slows.

9.3 Brightness Feedback

Besides the video speed mode described above, you can have BioEra adjust the brightness of the video. This produces similar results as using BxShadowEra as described above. The reliability is often questionable, and depends on the format of the video file and the codec used. The BxShadowEra option may be better / more reliable.

9.4 Application Controls

Figure 15 below shows the controls at the bottom of the application's main window.



Figure 15 – Video feedback controls

You can select both the video and audio files to use, and optionally disable sound feedback, using these controls.

Figure 15 above shows more controls in the video player window:

- You need to start the video manually by pressing the play button (1).
- You can select the mode of feedback as speed or brightness (3).
- In speed mode, you can check (4) to block backward movement, which can be disconcerting for some users, but can also be a useful feedback.
- The bar graph (2) is not a control but simply a representation of the threshold ratio.
- There is a check-box control that allows the video to be resized to the window containing the player (which of course you can resize yourself). Unchecking this option means that the video plays at its encoded dimensions, which in some cases may prove more reliable. Please note, for changes to take effect you need to close down the application and then restart it.

9.5 Video & Audio Files

The application allows you to choose both video files and audio files. As mentioned earlier, the application works well with “flight” videos

A good source of video files are those developed by Jonathan Toomim, and available online at:

<http://sourceforge.net/projects/hegstudio/files/>

Jonathan created these for use with his “HEGStudio” software which works with his Peanut device.

They are simple animated videos of flying over landscapes.

They depend on a particular video codec (software component) called VP6. You need to have it installed on your computer – but you can download it from the internet.

For an aircraft engine sound, you can search the internet or try e.g.

<http://freesound.org/>

<https://www.soundjay.com/propeller-plane-sound-effect.html>

(You need to find an ambient or constant track for it to work.)

9.6 Technical Notes on Video Format

There are several different formats for video files, such as .avi and .mp4. Distinct from the video format is the video codec, a software component used to create video files. For any video to play, regardless of its format, your computer needs to have the right video codec installed. Mind-Body Training Tools software does not include any video codecs, and I cannot offer any technical support for video codecs and formats.

10 Video With BxShadowEra Application

The intent of this application is to work with BxShadowEra (described above) to control the “brightness” of a video screen – the difference from the standard BxShadowEra HEG application being that here the video player is internal to BioEra (and may therefore be less reliable).

The application has two windows, the main one looking much like the other HEG applications, but having a different set of controls at the bottom – these are shown in figure 16 below. The second window shows the video player.

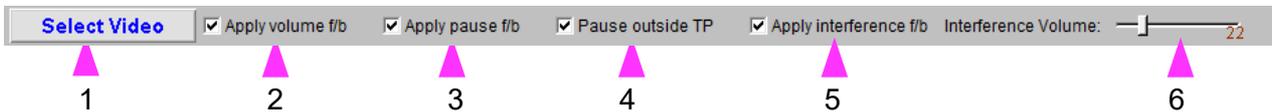


Figure 16 – Video feedback controls

The advantage of this application over the standard BxShadowEra application is that it offers extra control over the video. For example you can:

- opt to pause the video when the HEG rate of change drops below the lower threshold limit (using control 3 in figure 16)
- opt to pause the video outside of training periods (using control 4 in figure 16)
- apply volume feedback (control 2 in figure 16).

Also available in this application is hiss / white noise interference feedback. This works just as it does in the standard BxShadowEra application described above.

As with other HEG applications, the feedback is based on the HEG threshold ratio. Again positioning of the threshold levels is important. Feedback is aversive, so by default the upper level is set at zero, and the software “punishes” falls in the HEG signal.

The second window contains the video player, and is shown in figure 17 below.

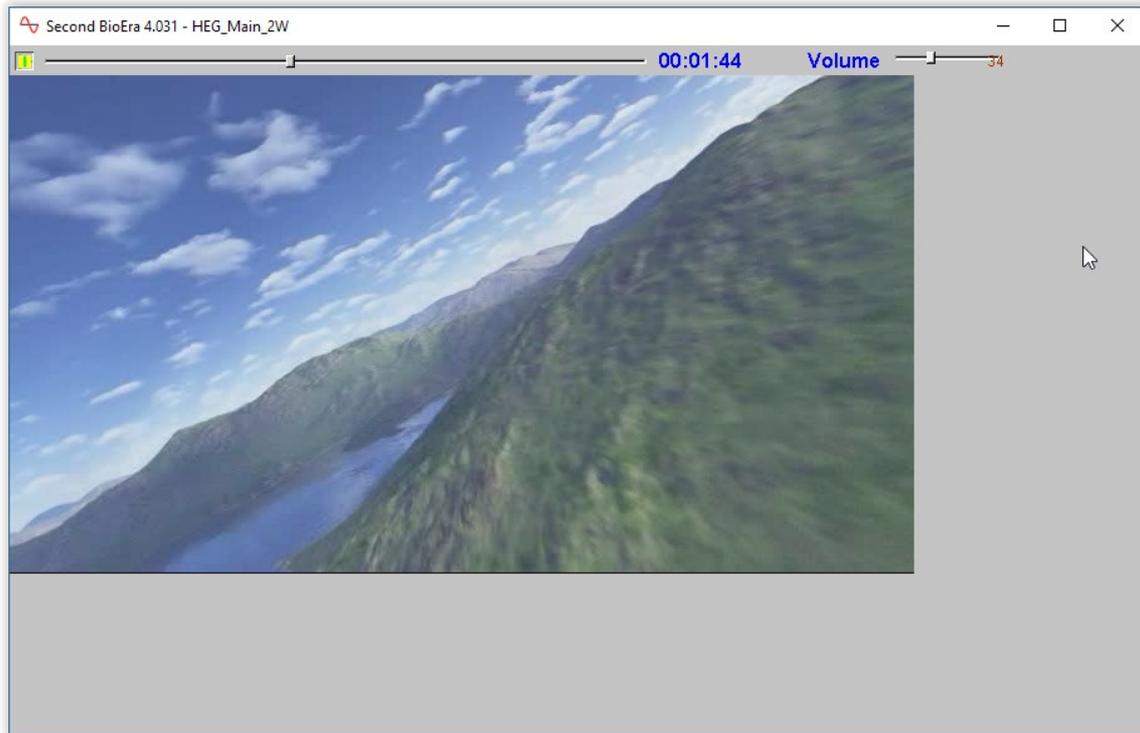


Figure 17 – Video screen

As you see there are some extra controls here:

- A play / pause button for the video
- A slider control which shows the video position but which can be dragged forward or backward to a new point in the video
- A display of the video time
- A slider control setting the volume of the video – if you're using volume feedback, this represents the maximum volume.

11 Session Reports

The application records data so that you can generate a report for your sessions. The report contains summary data and graphs showing the progression of the HEG signal over the whole session.

Note that the HEG data in the session data file is averaged according to the setting of the short-term HEG display (control 1 in figure 4).

To generate and open a session report, click the button labelled 2 in figure 1. A dialog window opens in which you can select various options (see figure 18 below).

The software creates the report in html format. It will be opened using your computer's default web browser, e.g. Google Chrome. (Note that a live internet connection is not needed.) The html file is saved, so you can for example email it to someone. See the Installation and Set-up Guide for details of file storage.

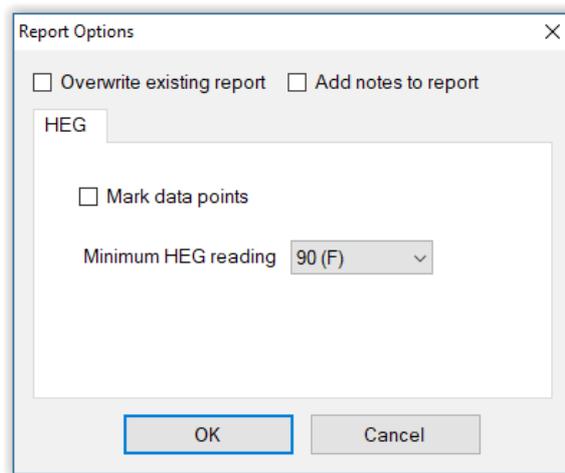


Figure 18 – Report options

11.1 Report Options

Most of the options should be self-explanatory.

If you change your mind about options on seeing your report, you can regenerate the report by clicking the report button (2 in figure 1), then checking 'Overwrite existing report' (top left in the dialog).

Setting a minimum HEG reading is a basic way of excluding “artefacts”, for example if you moved during the session, so that the flow of air over the sensor caused cooling. Data points falling below the minimum value are excluded. Note that typical values of the HEG reading are device dependent.

11.2 Adding Notes to a Report

You can choose to write some notes for your session report. Checking 'Add notes to report' (top right of the dialog) allows you to do this.

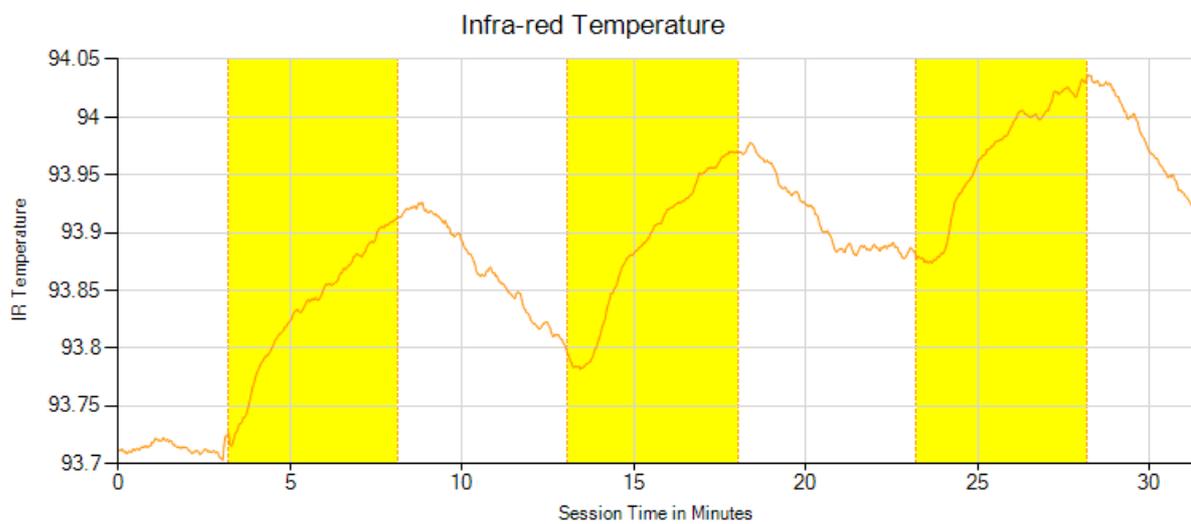
You may wish to add notes after having first seen the report. In this case, simply click the button (2 in figure 1) again, and check the Add notes option. This will regenerate the report with your added notes.

11.3 Sample Session Report

In the graph, the yellow areas represent training periods. You can see clearly that active attention makes a difference – during the training periods the signal consistently rises, and then falls again outside of the training periods.

Training Session Report

Training Application	HEG Neurofeedback
User Name	Default User
Session Date	03/04/12 21:13



HEG Summary Data

Parameter	Value
Starting Reading	93.71
End Reading	93.92
Max Reading	94.04
Net Change	0.21

12 Application Report

An application report summarises all the sessions for the currently selected user, in charts and a table.

To generate and open an application report, click the button labelled 3 in figure 1. A dialog window opens in which you can select various options (see figure 19).

As with session reports, the software creates the application report in html format. It will be opened using your computer's default web browser, e.g. Google Chrome. (Note that a live internet connection is not needed.) The html file is saved, so you can for example email it to someone. See the Installation and Set-up Guide for details of file storage.

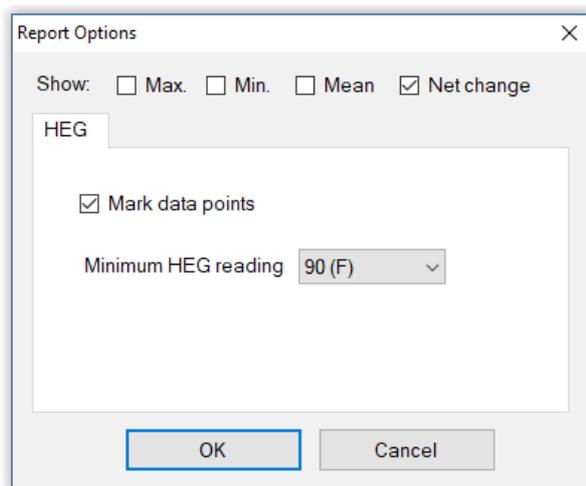


Figure 19 – Report options

12.1 Report Options

The application report options dialog is an adapted version of the session report options dialog. Many of the options are the same, and should be self-explanatory. See section 11.1 above.

As with all of the application reports in the suite, there is a chart for each of the main parameters tracked in the application – in the case of the HEG neurofeedback application that means the HEG reading only. For each chart you can opt for line graphs for the maximum, minimum, mean and net change. The line graphs have one point per session.