
EEG Training User Guide

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1 Introduction To Neurofeedback With MBTT

This guide describes how to use the Mind-Body Training Tools (MBTT) EEG training suite for EEG neurofeedback. It covers all aspects of EEG neurofeedback training, from setting up your training protocol, to running a training session, to analysing your results (generating reports).

In MBTT you can select from a range of protocols. Protocols are covered in more depth later, but for now let's say the protocol represents the trainer's decision of what specific EEG parameter to train. Many protocols available to users follow a standard form. There is also a number of “special” protocols – an example is the alpha-theta crossover application. This guide covers only standard-form protocols. Special protocols have their own user guides.

EEG neurofeedback is a form of brain training – training the brain at the physiological level. There are a great many forms of neurofeedback, and neurofeedback is by no means a simple or straightforward process. This reflects the complexity inherent in EEG (brain waves). MBTT offers a lot of flexibility in how you can practice neurofeedback, but it is not a comprehensive neurofeedback tool.

This document assumes you have a basic understanding of what EEG is and how it is measured and quantified. Hardware set-up, including sensor placements, is not covered.

It assumes that you've installed the software, and carried out some initial set-up tasks. If you haven't done so yet, see the Installation and Set-up Guide.

As the Installation and Set-up Guide makes clear, the MBTT software consists of a set of applications built with BioEra (a third-party visual design tool for processing and displaying physiological data in real time) together with a separate program called the Platform application which is your starting point for running training sessions.

The remainder of section 1 describes the software in principal terms, without getting into the details of operating controls. Later sections go into these details: section 2 covers protocols, section 3 running actual training sessions, section 4 assessing training using reports, and section 5 managing data.

1.1 Overview of the Training Process

In any form of EEG neurofeedback, the practitioner must choose and configure what we can call a training protocol: this means *what*, *where* and *how* to train the brain.

- **What** – meaning what aspect of EEG, or what parameter within the EEG, e.g. theta amplitude (theta being an EEG frequency band, approx. 3-7 Hz). Also whether to train an increase or decrease in the selected parameter.
- **Where** – the practitioner must decide what site(s) on the scalp to measure EEG from. (EEG varies across the scalp.) Part of this decision involves deciding how many channels to train with. A channel is a single measurement of EEG. If you want to record EEG from two points on the scalp, you need two channels. You must also decide on montage (monopolar or bipolar placement or the sensors).
- **How** – the practitioner must decide how to present feedback to the trainee – e.g. as a simple graph, or as a sound, etc. Should the trainee have eyes open or closed?

Section 2 covers how to create and configure protocols in MBTT EEG Training. Then section 3 looks at how to run a training session.

EEG neurofeedback typically requires multiple sessions – ranging from 10 to 100 or more. Over the course of training the protocol may be adjusted or switched completely.

The MBTT EEG training tools are designed to present the complex process of neurofeedback training as simply as possible, but without taking away any of the key decisions from the user.

The selection of an appropriate protocol is key to successful neurofeedback. This document doesn't attempt to explain how to make the decision – really, professional neurofeedback practitioner training is required for that – but it's worth mentioning MBTT's EEG assessment tools. These are a separate module of MBTT for EEG assessment, having its own user guide. The EEG assessment module is designed to facilitate protocol selection.

Besides assessment at the outset and during the course of neurofeedback training, the practitioner will likely want to assess progress over training sessions. The MBTT EEG training module offers various reports to meet this need. Report generation is covered in section 4.

1.2 The Training Protocol

When you work with MBTT EEG training tools, the first thing you need to do is select or create a protocol. Here I'm using “protocol” to refer to named entities within the software: protocols can be created, edited, and saved for later use. So far as the software is concerned, the protocol encapsulates the practitioner's choice of EEG parameter, the number of channels, and something known as thresholds. A threshold is a way of representing more specific targets – e.g. you might want to train alpha up, but how much alpha constitutes success? The thresholds are the software controls that allow the trainer to make that decision. Thresholds are explained more fully in section 1.2.5 below.

The choice of training sites is not explicitly represented in the software, since it doesn't need to do anything differently, whether you train at one site or another (it does however offer the chance to record the sites used). Likewise, the decision of eyes open or closed is not represented in the software (though of course it is still relevant to the practitioner).

Montage also is not represented explicitly. Montage means how you place the sensors: using two electrodes on the scalp is known as a bipolar montage, while one on the scalp and one on the ear is a monopolar montage. You can use a protocol with either montage, and as far as the software is concerned it works the same way, though of course there are important conceptual differences in what the training is actually doing, and the recorded EEG will look different.

MBTT EEG Training has a standard form of protocol. The software offers users a lot of freedom for selecting, creating and modifying protocols, but this flexibility is not unlimited. With a standard-form protocol, there is one single feedback parameter. You can train one single channel, or more than one (two and four-channel training is also possible) but in this case the same EEG parameter (e.g. alpha amplitude) is computed for each channel, and the channels are then averaged.

(To complicate the picture, some of the standard-form protocols calculate a parameter based on two channels – coherence is an example. But still, there is one single feedback parameter.)

1.2.1 Two-Parameter Training

In neurofeedback it's conceivable that you'd want to train with more than one feedback parameter at the same time – e.g. you might want to train up SMR amplitude in the right hemisphere, and beta amplitude in the right hemisphere. In MBTT this is not possible using the basic standard-form protocol, but you can create a more advanced form of protocol offering two feedback parameters. These advanced protocols are covered in a separate user guide. I recommend you familiarise yourself with the more basic standard-form protocols first, as the more advanced protocols build on some of the features you'll learn about here.

Again, there is a small number of non-standard protocols available – these are covered in their own user guides. I anticipate developing more special protocols in the future. Again I recommend you familiarise yourself with the more basic standard-form protocols first.

1.2.2 Feedback Parameters

To repeat, the standard-form protocols available in MBTT EEG Training offer you the chance to train with one main parameter at a time. (There are also secondary training parameters known as inhibits – these are covered in section 2.5.3 below.)

The main parameter can be:

- Amplitude of a (user-defined) frequency band such as theta.
- The ratio of two EEG band amplitudes (e.g. theta to beta).
- The sum of two band amplitudes (e.g. 2-7 Hz plus 16-28 Hz). This can be thought of as training a broad frequency range with a window in the middle.
- The percentage of the EEG within a specific band e.g. alpha – as calculated by a mathematical method called Fourier analysis or FFT, which is different to the standard method of digital filtering.
- Coherence – coherence is a parameter describing the relationship between two brain regions – its calculation therefore requires two channels of EEG.
- Others besides.

1.2.2.1 Amplitudes

The simplest kind of training involves an amplitude of a frequency band. Generally when people speak of training theta, they mean training theta *amplitude* (either up or down). The software calculates such an amplitude based on the output of a digital filter, which is an oscillating signal. MBTT EEG Training software calculates a peak-to-peak measure of amplitude, which means the “distance” from one peak in the signal to following trough. This amplitude is calculated twice per cycle of the oscillation, and then averaged over a time interval (which may be set by the user). Other software may use different methods, e.g. RMS amplitude. It means that the numbers produced by different neurofeedback software products may not be directly comparable. Of course what matters for training purposes is relative change.

1.2.3 Filters

A filter is a means of separating out some particular fraction from a mixture or composite. EEG filtering is just the same. EEG is a complex oscillation – the frequency is not fixed but varying moment to moment. You can think of general EEG as a mixture of many component oscillations, each having its own frequency. Over time, these components wax and wane in terms of their “size” or amplitude. When you direct a stream of EEG data to a digital filter, the filter lets through component waves of a certain frequency, and blocks others from passing. It's like a sieve, which lets through small particles and catches large particles. Another analogy is coloured glass, which lets through light of a particular colour (or frequency). Normal white light (e.g. daylight) is actually a mixture of different colours or frequencies. Other colours are blocked by coloured glass.

The digital filters used in neurofeedback are typically “bandpass” filters which block frequencies both above and below their set range. So a theta filter, for example, would block frequencies above 7 or 8 Hz, as well as below 4 Hz.

Once the EEG signal has been filtered, it's then an easy matter to determine its amplitude. Amplitude is always calculated as an average over a window of time – e.g. 1 second, or 5 seconds.

The band amplitude calculated in this way is probably the simplest and most commonly used feedback parameter. You can present it as feedback in various ways, e.g. as a simple bar graph that goes up and down over time, as your EEG band component waxes and wanes.

Of course you don't have to restrict your filters to named bands like alpha or theta – you can choose to train either broad ranges or narrow ranges.

1.2.3.1 Fourier Analysis

Digital filtering is probably the most common method of calculating band amplitudes in neurofeedback. But it's not the only method. Another is Fourier Analysis, or the use of a tool called a Fast Fourier Transform or FFT. I'm not going to explain this method – my point here is that it's a completely different mathematical process. You can expect the results of the two methods to be similar (i.e. correlate closely with each other) – e.g. alpha derived from a digital filter varies in the same way as alpha derived from FFT, but they aren't going to be exactly the same.

1.2.4 **Secondary Parameters – Inhibits**

In a typical neurofeedback protocol, you select a main parameter that you want to either enhance or inhibit – e.g. you might decide to enhance theta amplitude (i.e. train it upwards).

Whilst your main interest might be in this parameter, you may have a secondary concern with other aspects of the EEG. For example you might want to enhance theta but keep delta relatively low, or more commonly, keep beta or high beta relatively low.

In MBTT EEG Training, the protocol represents one main parameter, but optionally can include one or two secondary parameters which you typically want to keep low. These are called inhibits.

Inhibit parameters can only be band amplitudes – you can't use ratios or coherence, for instance.

1.2.4.1 EEG Artefact

Of course not every change detectable as EEG comes from brain state changes – they can be artefact. Artefact in the EEG signal is undesirable in neurofeedback because it muddies the waters of training, and can swamp the “real” feedback of interest, which is to do with brain state change.

The main sources of artefact are:

- Movements – especially of the sensors and cables
- Eye movements including eye blinks – which typically show up as large spikes of low-frequency EEG
- Muscle tension – which shows up in the higher frequency range of EEG, also known as EMG.

Inhibit parameters can be selected to represent artefact. For example, muscle tension shows up as high beta or gamma activity. Using inhibits in this way aims to prevent the rewarding of artefact.

1.2.5 **Number of Channels**

In complex EEG neurofeedback protocols, the practitioner can train different parameters at different sites on the scalp. In MBTT EEG training, standard-form protocols are more restrictive. Whilst you can train with 1, 2 or 4 channels of EEG, you must track the same parameter from each channel – i.e. there is only one feedback parameter.

If you do opt to train with more than 1 channel, the channels are combined into one single parameter by averaging. In the live training application there is no way to distinguish what is happening at different sites (though you can look at the individual channels later in reports).

Please note, MBTT EEG training includes more advanced (non-standard) protocols for training different EEG parameters in different channels (such as SMR up in channel 1, and beta up in channel 2).

1.2.6 Thresholds

Thresholds are a way of translating your selected feedback parameter into more specific targets.

For example, suppose you want to present feedback in the form of a bell-ring, or some other discrete event. How high (or low) should your feedback parameter come before the bell rings? If you're training upwards, you'd need to set a level which, whenever your parameter exceeds it, the software triggers the bell-ring. This level is the threshold.

In MBTT EEG Training, there is a threshold control (or more accurately, a set of controls) for the main feedback parameter, and there can be others for the inhibit parameters if you've chosen to employ them. Figure 1 below shows the main threshold controls.

Central to the threshold is the bar chart you see on the right in figure 1, which represents the main feedback parameter (with a light green trace). You'll see there are two levels, represented as magenta bars or limits in the chart. (Please note, the two parts of figure 1 are not shown to the same scale. Figure 12 in section 3.4 shows the threshold controls in the context of the whole control window.)

Setting the threshold levels appropriately is key to the success of neurofeedback training session. You need to set the levels so as to maximise learning – not so high as to make success too difficult, nor so low as to make it too easy.

I will explain more about how thresholds work, and how you can set the threshold levels, after discussing types of feedback (section 1.2.7.1 below).

1.2.7 Training Periods

Within a training session it's often desirable to break the training up into blocks, with rests for the trainee in between. The MBTT software allows you to do this, whilst still monitoring the EEG throughout. The blocks are known as training periods.

Using training periods means you don't have to stop or pause the flow of EEG data, when you want to take a break from active training. You specify the duration of a training period first, and then press a button to begin. Feedback is only active during training periods. Rest periods can last as long as you like, and you can change the training period duration before any one (they don't have to be the same length).

1.2.8 Presenting Feedback

In principle there are many different ways you could present the changing parameter to the trainee as feedback. Perhaps the simplest, conceptually speaking, would be as a bar graph – the height of the bar goes up when the parameter rises, and down when the parameter falls. Or instead of a simple vertical bar, you could have a “dial” like the speedometer of a car. These are examples of visual feedback, but you could also give auditory feedback (which would be essential if you want to train eyes closed). In this case you could present a tone which rises and falls in pitch, with the feedback parameter.



Figure 1 – Main parameter threshold controls

1.2.8.1 Types of Feedback: Proportional and Discrete

The examples I've just given above are types of proportional or continuously-varying feedback, where the feedback varies smoothly over a range, rather than simply being on or off.

Another form of feedback is to have a clearly defined event, such as a bell-ring, as I mentioned earlier – e.g. when theta amplitude goes above your threshold level, the software rings a bell. The signal crossing a threshold level is like scoring a point in training, and the bell sound is like a reward for scoring a point. This is a form of discrete feedback.

Another form of discrete feedback is stop-go feedback – e.g. a video plays when the feedback parameter is above threshold, and stops when the feedback parameter is below threshold.

In MBTT EEG Training, you can choose from a number of different feedback screens, some of which are points-based, while others are proportional. This choice of feedback screen is independent of your selected protocol (assuming you're working with a standard-form protocol).

Points-based and proportional feedback have their own advantages and disadvantages.

Points-based feedback fits more closely with the operant conditioning model of natural learning which psychology research has demonstrated so clearly with animals (e.g. a pigeon pecks a lever and gets a food reward – these are discrete events). Points-based feedback allows the brain to take mini-breaks between points (called refractory periods). This may be more consistent with real-world learning. Some have argued points-based feedback is the most efficient way for the brain to learn in neurofeedback.

Sometimes neurofeedback is done as an automatic learning procedure, with very little in the way of conscious effort or control needed, other than to sit still etc. In fact many practitioners believe the conscious mind plays almost no role in the neurofeedback learning process.

On the other hand, real-world skills acquisition (e.g. learning to play tennis) does give a role to the conscious mind. The trainee must have the intent to perform the tasks involved, or must be motivated, and must pay attention to the task. (The actual learning is still automatic.) It's my personal belief that the conscious mind can play a role in neurofeedback, in terms of paying attention and holding intent. Further, I would say that proportional feedback is often preferable for conscious awareness, and facilitates paying attention.

1.2.8.2 Feedback Latency

Feedback latency is an important concept in neurofeedback. It's the time gap between the actual change in brain state (e.g. the brain produces a burst of alpha rhythm) and the representation of this event in the software, as feedback (e.g. a bell-ring). Some latency is inevitable but in principle the latency should be as small as possible, to optimise efficiency of learning in the brain.

One source of latency is averaging of the feedback parameter. Suppose you're training amplitude – amplitude is calculated for each single cycle of the EEG oscillation, and there is a lot of variability across cycles, so some averaging is needed so that the feedback signal doesn't appear chaotic. More averaging (i.e. averaging over a longer time period) means the feedback signal varies more smoothly, making it appear more meaningful, at the cost of being slower to respond to actual brain state changes (i.e. greater feedback latency). In practice, 0.5 seconds of averaging seems to be standard in the neurofeedback world.

Points-based feedback allows you to use a lower average when the software calculates the feedback parameter, and therefore may give lower latency.

1.2.8.3 Thresholds Revisited: Threshold Ratio

For points-based feedback, it's easy to grasp that you set a level for the scoring of a point. But the threshold is also relevant to proportional feedback, because it effectively defines the range over

which the feedback varies. This is essentially why there are two threshold levels (seen as small magenta bars, back in figure 1).

Let me give another example of proportional feedback, one which I personally like to use. You can have the software play a soundtrack with variable volume. Suppose you are training to enhance alpha (i.e. increase alpha amplitude). When the alpha signal rises, as it crosses the lower threshold, the sound first becomes audible, but at a very low volume. As the alpha signal rises further, the volume increases, up to a maximum at the point where the signal meets the upper threshold level. In other words, the two levels define the range over which the feedback varies.

The software calculates a “threshold ratio”. This is a number which is zero at the lower level, and one at the upper level. Expressing the ratio as a formula:

$$\text{Threshold Ratio} = \frac{(\text{Current Reading} - \text{Lower Level})}{(\text{Upper Level} - \text{Lower Level})}$$

Understanding what threshold ratio is, is helpful in grasping how particular feedback screens work.

1.2.8.4 Reward Versus Aversive Feedback

In the natural world, learning happens when there is some incentive involved. A pigeon learns to peck a lever when doing so is rewarded with food. If it instead received an electric shock, it would learn *not* to peck the lever. (Both are examples of *operant conditioning*.)

In neurofeedback, you may wish to train the brain either to avoid some particular state (which is deemed problematic), or you might train it towards some other state, judged advantageous.

For example, excessive theta in the front part of the head is thought to be detrimental to focus. So when theta rises too high, you give feedback which serves as a kind of warning to the brain not to go into that state. You could use an unpleasant sound as feedback, where excessive theta causes the sound to play.

Another example: alpha (at least towards the back of the brain) is associated with relaxation, so you might want to *reward* high levels of alpha, for example with pleasant music.

Most neurofeedback trainers teach that reward feedback is much preferable to aversive feedback. However MBTT EEG Training allows you to offer both reward and aversive feedback.

(It could be argued that feedback can be both rewarding and aversive at the same time. For example, suppose the medium of feedback is a video that plays when the brain is in a desirable state, and stops otherwise. Is the brain learning from the reward (= video playing) or from the video stopping which could be seen as aversive?)

Some feedback screens in MBTT EEG Training allow both reward and aversive feedback – e.g. a reward soundtrack plays when the feedback parameter is in the desired zone, and a different, aversive soundtrack plays when the feedback goes to an unwanted place.

1.2.9 **Trainer & Trainee Screens**

Neurofeedback is often done in a context of a trainer or practitioner, and another individual as the trainee, but individuals can also train themselves. MBTT EEG Training is designed to cater for both.

To run a training session, you'll start up a training application which has two windows. Conceptually, one is the practitioner's window, and contains controls to configure the protocol, etc. This window is known as the control screen. For example it contains the threshold controls, and training period controls. The second window is designed for the trainee to view, when the training is live – i.e. it contains direct feedback elements. It's known as the feedback screen.

It can be helpful to use a dual monitor computer system, with one window on each monitor, but not essential. Both windows can fit on a wide screen monitor with full HD resolution. Clearly, in eyes-closed training you'd favour audio feedback, and it wouldn't be so important to see the feedback screen.

If you're training yourself, obviously both windows are for you.

1.3 Overview Of MBTT EEG Training Software

As stated elsewhere, Mind-Body Training Tools consists of a set of applications built using BioEra, plus the Platform application, which manages and launches the training applications, and manages the data they generate. So the Platform application is the starting point.

Each MBTT module has its own tab in the Platform app, and EEG Training is no exception. The EEG training tab is shown in figure 2 below.

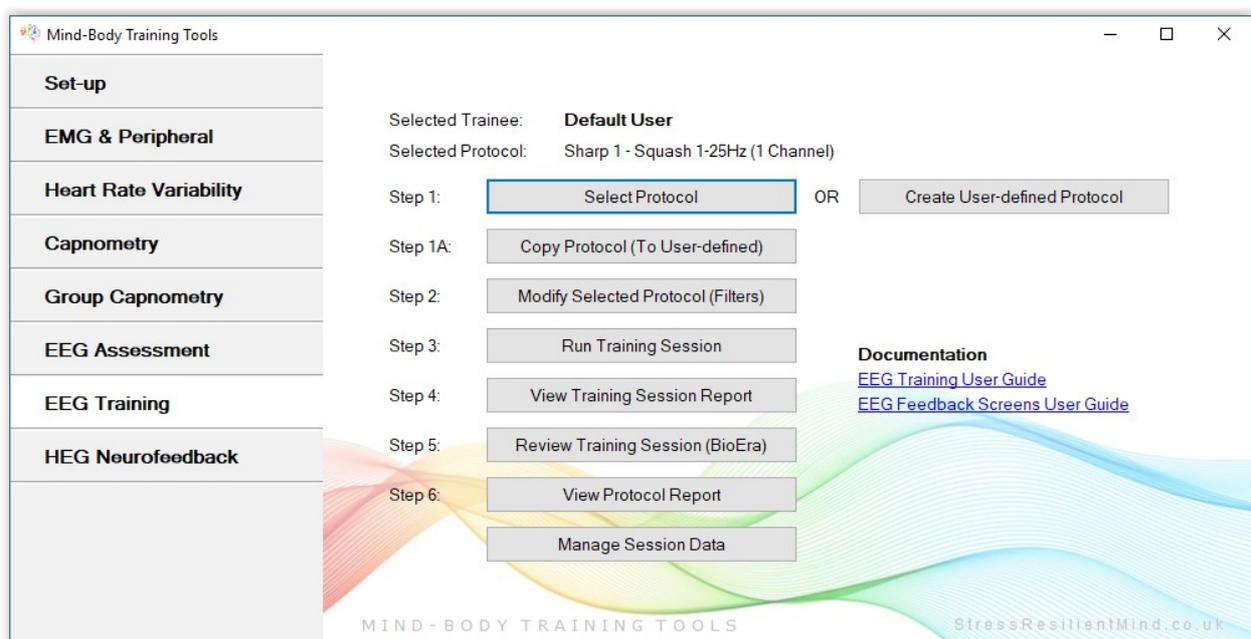


Figure 2 – EEG Training tab of the Mind-Body Training Tools Platform application

The controls are designed to follow the conceptual steps involved in EEG neurofeedback training:

1. Select or create a training protocol.
2. If necessary adjust the protocol settings.
3. Launch a training session.
4. Assess the training session by reviewing the data it generated.

These steps are covered in detail, in the next few sections.

2 Setting Up Training Protocols

The first step in training is to choose a protocol. Recall that in the software, protocols exist as named entities. You need to either select a pre-existing protocol or create a new one (either from scratch or by copying and then modifying a pre-existing protocol). There are buttons in the Platform application for each of these functions. The settings of any protocol are saved by the software.

2.1 Review of Protocols in MBTT

Recall from section 1 that the protocol encapsulates the practitioner's choice of what aspect of EEG to train. Each named protocol stores:

- details of the EEG parameter chosen, typically in the form of one or more filters
- number of channels to use in training
- inhibit thresholds used (if any)
- settings associated with thresholds, including threshold levels and averaging.

2.2 Preconfigured Protocols

Probably the easiest way to get started with the software is to select one of the preconfigured protocols that are set up when you first install MBTT.

When you click the Select Protocol button in the Platform (labelled step 1 in figure 2), the protocol selection dialog appears. It is shown in figure 3 below.

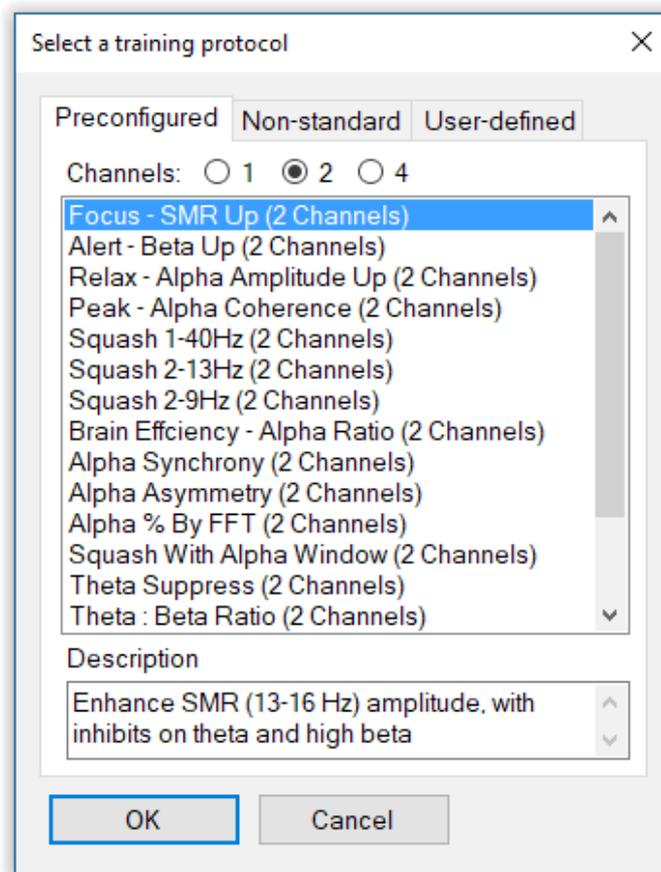


Figure 3 – Protocol selection dialog

As you see, the protocols are grouped under three tabs.

The first tab is for preconfigured protocols following the standard form. For the most part these are relatively commonly used protocols, such as up-training SMR. See section 2.2.1 below for a list of preconfigured protocols.

The second tab is for non-standard protocols such as the MBTT alpha-theta crossover protocol. These are not covered in this guide, but have their own documentation.

The third tab is for protocols you've created and saved yourself – so when you first run the software this list is empty. See section 2.4 below for how to create your own protocols.

To select a preconfigured protocol, simply click on the one you want from the list in the first tab, and press OK.

Once you've selected any protocol, its name is displayed at the top of the Platform application's EEG training tab, just below the selected user name.

Most preconfigured protocols train amplitude, but some involve ratios or other measures.

2.2.1 List of Preconfigured Protocols

The following is a list of the (standard-form) preconfigured protocols available in MBTT. Unless otherwise stated, the parameter is the amplitude of the given frequency band. Also, a protocol does not use inhibits unless explicitly stated.

The majority of the protocols listed have 1, 2 and 4 channel versions available. Recall that the multi-channel protocols mostly just take an average of the same parameter for each channel – though there are some exceptions to this rule, e.g. coherence.

Please note the names of the first four, viz. focus, alert, relax, and peak, are adopted from a list of standard protocols given by Thomas Collura in his book “Technical Foundations of Neurofeedback”.

I've generally used the following frequency ranges for the named bands: theta – 3-7 Hz; alpha – 8-12 Hz; beta – 16-25 Hz; high beta – 28-40 Hz. You can of course adjust these to your liking.

- **Focus – SMR (13-16 Hz) Up**

This protocol employs two inhibits, for the theta and high beta (28-40 Hz) ranges.

- **Alert – Beta (16-25 Hz) Up**

Also employs two inhibits, for theta and high beta.

- **Relax – Alpha (8-12 Hz) Up**

Again two protocols are used: 1-6 Hz and then high beta.

- **Peak – Alpha Coherence Up**

Please note, coherence, being a relationship between two sites, requires two channels (so no one-channel version is possible). There is a four-channel version of this protocol, which uses the average of three coherence calculations (channels 1 & 2, 1 & 3, and 1 & 4).

- **Sharp 1 – Squash 1-25 Hz (Down)**

- **Sharp 2 – Squash 2-13 Hz (Down)**

- **Sharp 3 – Squash 1-9 Hz (Down)**

- **Brain Efficiency – Ratio of Fast:Slow Alpha**

The ratio between fast alpha (10.5-12 Hz) and slow alpha (8-9.5 Hz) is effectively a measure

of dominant alpha frequency, which is thought to correlate with “brain efficiency” (e.g. see Dr Paul Swingle's book, “Adding Neurotherapy to Your Practice”).

- **Alpha Synchrony**

Like coherence, synchrony is a measure of the relationship between two sites, hence this protocol does not exist in one-channel form. Two sites have high synchrony when they are phase-locked and the phase difference is very low. The synchrony protocol is designed to be at least relatively independent of amplitude (i.e. the focus is much more the phase relationship).

- **Alpha Asymmetry**

This protocol measures the percentage difference in alpha amplitude between two channels, i.e. channel 1 minus channel 2, as a percentage of the average of the two. I anticipate you'll use left and right hemisphere placements, e.g. F4 and F3. Since you would typically want alpha to be greater on the right side, channel 1 would be on the right and channel 2 the left, and you would train upwards.

The four-channel version takes the average of two differences, i.e. channel 1 minus channel 2 and channel 3 minus channel 4.

- **Alpha Percentage by FFT**

The large majority of protocols listed here use standard band filters to calculate their parameter. This protocol differs in that it uses a Fast Fourier Transform (FFT) to calculate the component in the alpha range, which is expressed as a percentage.

- **Squash with Alpha Window**

In this protocol, a broad frequency range is suppressed (trained down) except the alpha range (8-12 Hz) is excluded. The parameter is thus the sum of two bands: 2-8 Hz and 13-28 Hz).

- **Theta (3-7 Hz) Down**

- **Theta to Beta Ratio (Up or Down)**

- **Theta (3-7 Hz) Up**

This protocol employs two inhibits (delta and high beta).

- **Ratio of Alpha to 1-7 Hz**

This protocol is designed for training alpha, or keeping alpha amplitude high while avoiding increases in lower frequencies (1-7 Hz) which happen when the trainee drifts towards sleep. It is thus a kind of relaxed alertness protocol.

- **Gamma : EMG Ratio**

Some neurofeedback practitioners advocate training gamma amplitude up. This is potentially problematic because the gamma frequency range overlaps with the muscle tension or EMG frequency range. Simply rewarding gamma could in practice amount to training increased muscle tension. This protocol is designed for training gamma up and at the same time avoiding the pitfall of rewarding muscle tension.

Besides these standard-form protocols, the software comes with preconfigured special protocols such as the alpha-theta application, which are described in separate documents.

2.3 Modifying Protocols

Once selected, you can modify any standard-form protocol, including the preconfigured protocols. In the first place this means you can adjust the settings of the filters used, e.g. you can change the frequency range. However you cannot change the number or type of filter used – e.g. you cannot change a simple amplitude protocol to a ratio protocol or a coherence protocol. Also, you cannot change the number of inhibit thresholds a protocol has.

Although you can change any protocol, you may decide it is better to take a copy of an existing protocol first, and then edit that – that way you preserve the settings of the original.

To modify a protocol, you must first select it, and then click the button in the Platform application, labelled “step 2” in figure 2. This launches a BioEra application specifically designed to only access filter properties. It contains four buttons, as you see in figure 4 below.

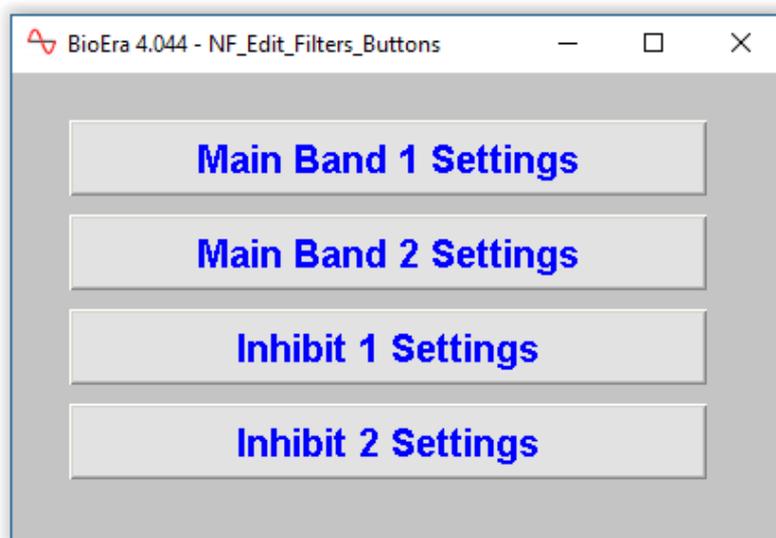


Figure 4 – The BioEra application for modifying protocols (filters)

Each of these buttons opens another dialog for setting properties of the relevant filter. Not all buttons are active – for instance if your protocol doesn't use inhibits, neither of the bottom two buttons will do anything when clicked.

There are two buttons for the main parameter; the second is only active if your protocol involves two frequency bands, i.e. if it is a ratio or a sum of two bands protocol.

Figure 5 below shows a typical BioEra filter properties dialog (i.e. a basic bandpass filter). You can adjust the frequency range, but there are a lot of other settings besides. These are beyond the scope of this document. For a full explanation you'd need a fairly advanced training in neurofeedback.

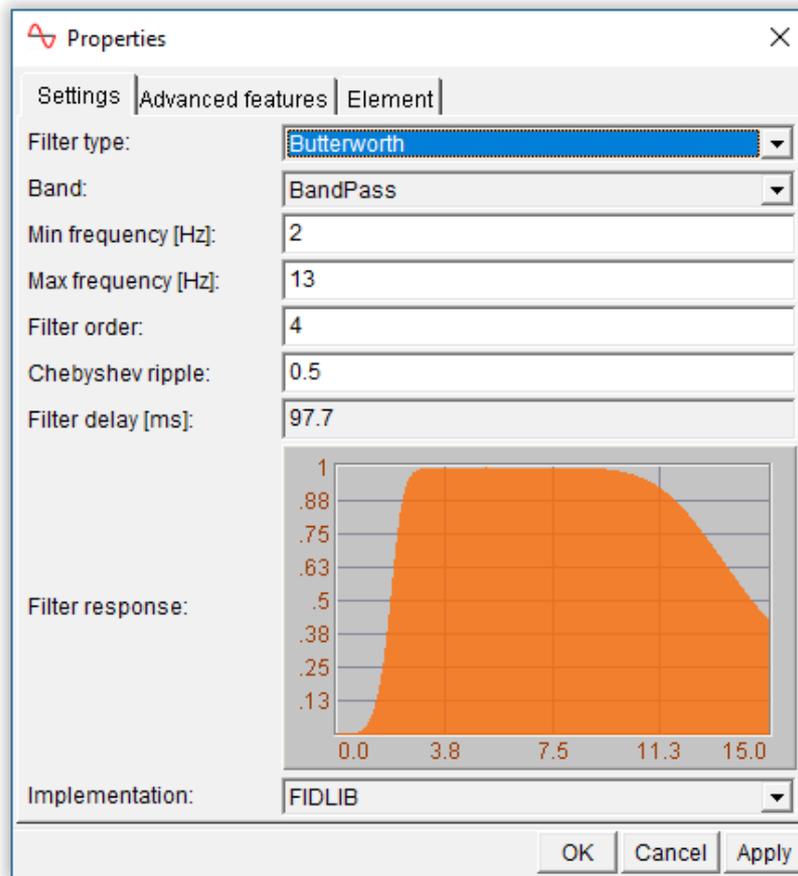


Figure 5 – The BioEra Edit Filter Dialog

Digital filtering necessarily takes some time – i.e. it adds to the feedback latency (mentioned in section 1 above). An estimate of the filter delay is given – though to see this updated after making changes you will have to close and re-open the dialog. In general, the “tighter” the filter, the longer the delay introduced. A looser filter lets through more EEG activity outside its frequency range. You can get an impression of how tight or accurate the filter is by looking at the graph in the dialog.

In summary, there is a trade-off between speed and accuracy of the filter. The properties in the dialog, such as filter type, will affect both the delay and the accuracy of the filter. Please note, you may have to close and then re-open the filter properties dialog for the delay calculation to update properly.

2.4 Creating a New Training Protocol

You can create new protocols in two ways: first, you can take a copy of an existing protocol, and second, you can create one from scratch.

You can create as many protocols as you like. If you're a practitioner, you may want to create individualised protocols for each client. Even if you're using the same general protocol you might want to create individual copies so that you can save threshold levels (remember these are saved between sessions). That said, it's usually better to update your threshold levels frequently and at each session.

Once you have created a new protocol by either method, the new protocol automatically is the selected protocol.

2.4.1 Copying An Existing Protocol

Probably the simplest way to create a new protocol is to select a pre-existing protocol that is similar in form to what you want, then take a copy of it, then modify its settings as described above.

To copy the currently selected protocol, click the button labelled “Step 1A” in the Platform application (see figure 2). A dialog window will appear, in which you can enter a name for the new protocol, plus names for the parameters (e.g. “alpha amplitude” for the main feedback parameter).

You can adjust the settings of the new protocol as described in section 2.3 above.

2.4.2 Creating a New Protocol

You can also create a new protocol from scratch, selecting the form of filters involved, e.g. a simple band amplitude or a ratio of two frequency bands.

Click the button in the Platform, to the right of “step 1” (see figure 2). A dialog will appear, as shown in figure 6 below. This dialog should be largely self-explanatory.

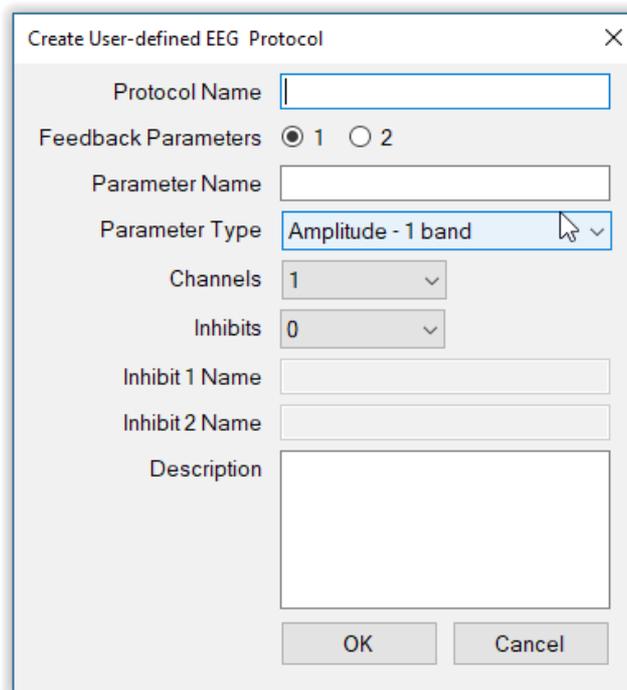


Figure 6 – Create new protocol dialog (MBTT Platform)

First you need to enter a name for your new protocol.

Next, you can choose to use one single feedback parameter or two. Selecting two is a more advanced form of neurofeedback. It means having two feedback channels at the same time, e.g. two different sounds. Protocols using two feedback parameters are covered in a separate user guide. The standard-form protocols described here employ one feedback channel. If you're new to neurofeedback I would certainly recommend starting with the standard-form protocols. Please note, with standard-form protocols you can still combine more than one EEG parameter into the feedback parameter (e.g. you can train theta amplitude plus beta amplitude – only you wouldn't be able to distinguish the two components).

Next you need to enter a name for your feedback parameter (e.g. alpha amplitude), and then select the form of this parameter, from the following list:

- Amplitude of a single frequency band (e.g. alpha)
- Amplitude – sum of two frequency bands (e.g. theta + beta)
- Ratio of two band amplitudes
- Percentage of amplitude in a given frequency band, based on FFT (the above are calculated based on digital filtering)
- Programmable – when selected, this option creates a BioEra design that you can edit yourself in whatever way that you will, giving you a high degree of freedom to develop your own training protocols. The only restriction is that your design must calculate a single parameter. This editable BioEra design file is called “NF_Protocol_[n]Ch” where [n] is the number of channels you selected. This design can be opened in BioEra (it is not password-protected like the other BioEra design files). You need to be familiar with graphical programming in BioEra (not covered in this guide), and thus this option is for advanced users.

Protocol files are stored in under the “base folder”, which you set up once when you first install the MBTT software. See the Software Installation & Set-up Guide for more details. You can't create named protocols until you've set up this folder. If you want to copy protocols between computers, you can do so by accessing this location (they are in a sub-folder called “Protocols”).

2.5 Working With Thresholds

To fully define a protocol, you need to set its threshold properties. You can't access the controls to set these properties, until you start a training session, which is covered in section 3 below. However the function of the controls is described here.

The threshold controls consist of the set of drop-down lists and buttons, found at the bottom of the control screen, and shown in figure 7 below, together with the vertical bar chart found at the right-hand side of the control screen (also shown in figure 7).

At first sight there are rather a lot of controls. My design intent was to give users maximum control and flexibility in setting up thresholds. However, when you're new to the software you'll want to avoid getting overwhelmed by all the detail, so please note that many of the controls can be left at their default settings, to get you started.

The key element of the threshold is the bar chart (figure 7) which shows the variation of the main feedback parameter (the light green bar moves up and down during a training session).

In figure 7 you see two horizontal magenta bars or limits, which show the actual threshold levels. To repeat, these two levels define the specific behaviour of the feedback. Of course the position of these bars can be changed, e.g. they can be dragged with the mouse – this is covered in section 2.5.2 below. The levels are also

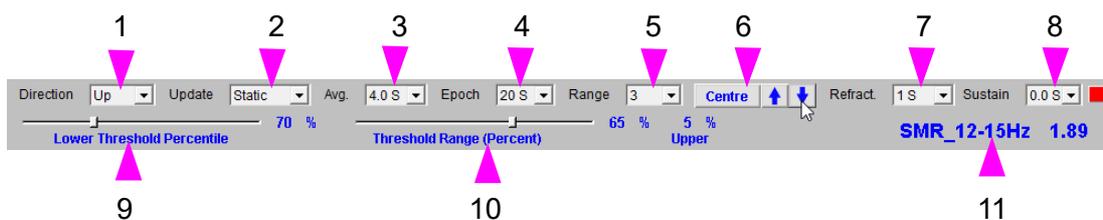


Figure 7 – Main parameter threshold controls, within the standard BioEra training app

displayed as dotted lines in the parameter display (see section 3.3.5 below). Setting the levels in the right places, is key to the success of neurofeedback.

How the levels control the feedback depends whether you're working with proportional or discrete / points-based feedback. If the latter, then points are scored when the training parameter exceeds the upper level, assuming you're training UP. (If you're training DOWN, the parameter must dip below the lower level to score a point.)

If you're working with proportional feedback, then the two levels define the range over which the feedback varies. The feedback is maximum at the upper level and minimum at the lower level. E.g. if you're using audio feedback with variable volume, the feedback sound is loudest and quietest when the feedback parameter is at the threshold levels.

The set of controls associated with the threshold help to control specific behaviour of the feedback, mainly by controlling how the two threshold levels are set. The following table explains what they do. (The controls are listed in approximate order of importance.)

Control	Description
Direction	Sets whether you want to train your main parameter up (enhancing it) or down (suppressing it). Clearly this is a fundamental setting for your protocol.
Update	Sets how the threshold levels are to be updated (see section 2.5.2 below).
Average	The time period over which the feedback parameter is averaged, before it is fed through to the threshold. Using a longer average period will result in a smoother graph but will be less sensitive to short-term variations, and there will be a greater latency. A shorter average period is probably more suitable for points-based training, a little longer for proportional feedback.
Epoch	Sets the time period over which the threshold levels are calculated, when using automatic updating. This will make more sense, once you understand how to change or update the threshold levels, which is covered section 2.5.2 below.
Range	Sets the scale or range of the bar chart, and works in combination with adjacent buttons – see section 2.5.1 below.
Refractory Period	This control is relevant to points-based training only. After a point is scored, there is a period during which another point cannot be scored – this is the refractory period, during which the brain can take mini-break. It is useful for optimising learning, or learning efficiency.
Sustain	This control is also relevant to points-based training only. You can specify a period of time that the parameter must stay above the threshold level (or below if you're training down) before a point is registered. Clearly this makes scoring a point harder. It may be appropriate later in training.
Centre Button	When this button is clicked, the displayed range shown by the bar chart is shifted either up or down, so that the current value or the feedback parameter falls right in the centre of the bar chart. Use this if the signal has moved off the top or the bottom of the chart.
Up, Down Buttons	These work a little like the centre button, in that the displayed range of the threshold bar chart is shifted by a set increment, either up or down depending which arrow you clicked.

2.5.1 Adjusting The Bar Chart Range

The scale or range of the bar chart is controlled by three buttons, in addition to the “Range” drop-down control listed above. The three buttons are labelled 6 in figure 7 above. They shift the trace up and down within the chart, while keeping the range constant. Clicking “Centre”, as you might expect, centres the trace within the chart, based on the average over the last 20 seconds. The up and down arrows move the trace higher and lower while keeping the scale fixed.

These controls also set the range of the main parameter display, described in section 3.4.7 below.

2.5.2 Updating Threshold Levels

Again, setting the threshold levels in an appropriate place is key to training. Neurofeedback training should offer a balanced challenge level – not so hard that you rarely achieve reward feedback (and training becomes subjectively frustrating or stressful) and not so easy that you get so much reward as to make it pretty meaningless.

The simplest way to set the threshold levels is “by hand”, meaning you can drag the magenta levels with your mouse to where you want them. You'll want a little time to see how your parameter naturally varies, before setting the levels. Seeing the levels in relation to the parameter trend (see section 3.3.5 below) will help you judge.

Please note there is a known problem with the software: holding your mouse button down while dragging the sliders for too long can cause the application to stop (you can restart it but you lose the earlier data). To avoid this problem you can click on the point where you want to place the slider control, and you can fine tune it with the left and right keys on your keyboard.

Alternatively you can have the software set the threshold levels. To do this, the software relies on the concept of percentile ranges.

2.5.2.1 Percentiles and Percentile Range

Suppose you follow the variation of your training parameter over a period of time, say 1 minute. In that time there will have been a maximum and minimum for the parameter, which define the range of variation of the parameter. We can divide this range up into percentiles or one-hundredth parts. The 20th percentile is roughly speaking, the point in the parameter range above which the parameter spent 20% of the time (and clearly it was therefore below for 80% of the time.)

To be strictly precise, the software orders all the readings received during the time period from minimum to maximum – let's say during this time the software received 1,000 readings or samples. The 20th percentile is the reading that comes 20% or the way down the list of readings in order – in this case the 200th reading.

So the 75th percentile is the point above which the parameter spent 75% of the time (returning to the looser but easier way of speaking). This point is going to be much closer to the minimum than the 20th percentile. The 1st percentile is going to be very close to the maximum, while the 99th is going to be very close to the minimum.

If you set your lower threshold level at the 75th percentile and the upper at the 20th percentile, it means that the parameter was below the lower for 25% of the time, above the upper for 20% of the time, and somewhere in between for 55% of the time.

Of course this is true for the minute over which the percentiles were calculated, but may not be true for the next minute (especially if training successfully influences brain state).

2.5.2.2 Automatic Updates

You can have the software automatically calculate the threshold levels based on your setting the upper and lower percentiles. There are two slider controls by which you can set the levels to given percentiles of your choice. The first sets the lower level percentile (75 in my example). The second sets the percentile range, or the difference between the upper and lower levels. In my example the range is 55 %. The percentile of the upper level is the lower plus the range. The sliders are labelled 9 and 10 in figure 7.

The period of time over which the percentiles are calculated is known as the epoch, and it is set using a drop-down list control listed in the table above.

You can opt either to have the levels move continuously, based on a moving window of time (epoch), or have the levels static, and only update when you specifically choose to. The drop-down list control 2 in figure 7 makes this setting. If you select “static”, then the levels remain fixed until you click the “Update” button (14 in figure 7) at which point the levels jump to the percentiles as calculated over the epoch up until the button click. Also, in “static” mode you can drag the levels “by hand” (using your mouse) as described earlier.

2.5.3 Inhibit Threshold Controls

Inhibit thresholds work in a similar way to the main parameter threshold. Their purpose is also related to controlling exactly when and how feedback is delivered, but they have a slightly different function to the main parameter threshold, and their controls are simpler. Not all protocols use inhibit thresholds. Those that do, can have one or two inhibit thresholds.

This will be a good point at which to summarise the role of inhibits.

- They represent secondary EEG parameters – aspects of EEG you want to keep within bounds but not as significant as your main parameter.
- They can represent artefacts, and so can be used to prevent the rewarding of e.g. muscles tightening up.
- Inhibit parameters are always held low rather than trained up – in this respect they are quite different from the main parameter.
- There is only one threshold level for inhibits. When the inhibit parameter is below this level, feedback works as normal. If it's above, then the rewards are curtailed in some way.
- Inhibit parameters are mainly relevant when you are training the main parameter up – they are often not needed when down-training the main parameter. They are useful when you want to enhance *only* your selected parameter and not everything in the EEG.
- In points-based training, you cannot score a point if either of your inhibit parameters exceed the upper threshold level.

Figure 8 below shows a set of inhibit controls. They are analogous to the main threshold controls, though arranged differently, and some are missing.

You can set the single threshold level (labelled 1 in figure 8) in the same way as for

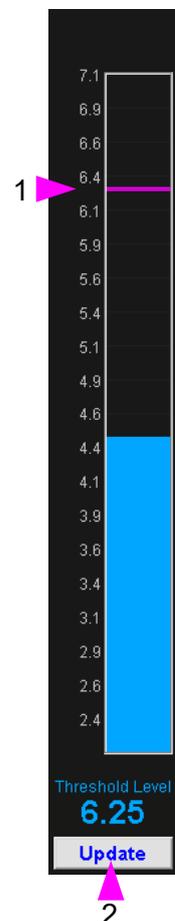


Figure 8 – Inhibit protocol controls

main parameter thresholds.

- The threshold can vary dynamically or can be static.
- If static, you can set it manually by dragging the bar with your mouse.
- Or you can update it by clicking the update button (2 in figure 8) – in this case the new level will be calculated based on the threshold control settings.

The following points summarise how inhibit thresholds differ from main parameter thresholds.

- There is no direction of training control, since inhibits are always held down.
- There are no refractory period or sustain controls, since inhibits are not used for scoring points.
- There is only one slider control, which sets the percentile for the single threshold level. (There is no percentile range slider control.)

3 Running a Training Session

The complete sequence of steps for running an EEG neurofeedback training session is:

1. Make sure you have correctly set your device type, from the Platform application's set-up tab. This setting is remembered and doesn't need to be done every time.
2. Make sure you have selected the appropriate user from the Platform's set-up tab. If you're a practitioner you'll probably want to create a named user for each of your clients so that you can keep their data separate.
3. Select the protocol you're going to train with, as described in section 2 above.
4. Open the training session dialog (described in section 3.1 below) by clicking the button for “step 3” in the Platform app's EEG training tab (figure 2 above).
5. Check impedance (related to the quality of your EEG hook-up).
6. (Optionally) open the EEG inspection application, as an additional check on the quality of your hook-up.
7. Select what feedback screen you'd like to use from the options available (see section 3.4).
8. Launch the BioEra EEG training application, and start the flow of data.
9. Set the threshold controls appropriately.
10. Begin a training period.

3.1 The Training Session Dialog

Clicking on the button for “step 3” in the Platform application opens up the EEG training session dialog, shown in figure 9 below.

The labels 1 to 6 in figure 9 indicate the steps you'll take:

- First check impedances (if available – depends on your device) – button 1 in figure 9.
- Optionally inspect the EEG signal to further insure the quality of your hook-up – button 2 in figure 9.
- Select a feedback screen (from the list, 3 in figure 9, noting the description given in text box 4 in figure 9).
- Optionally enter the site you're training at (in the text box labelled 5 in figure 9).
- Finally click button 6 to launch the BioEra training app.

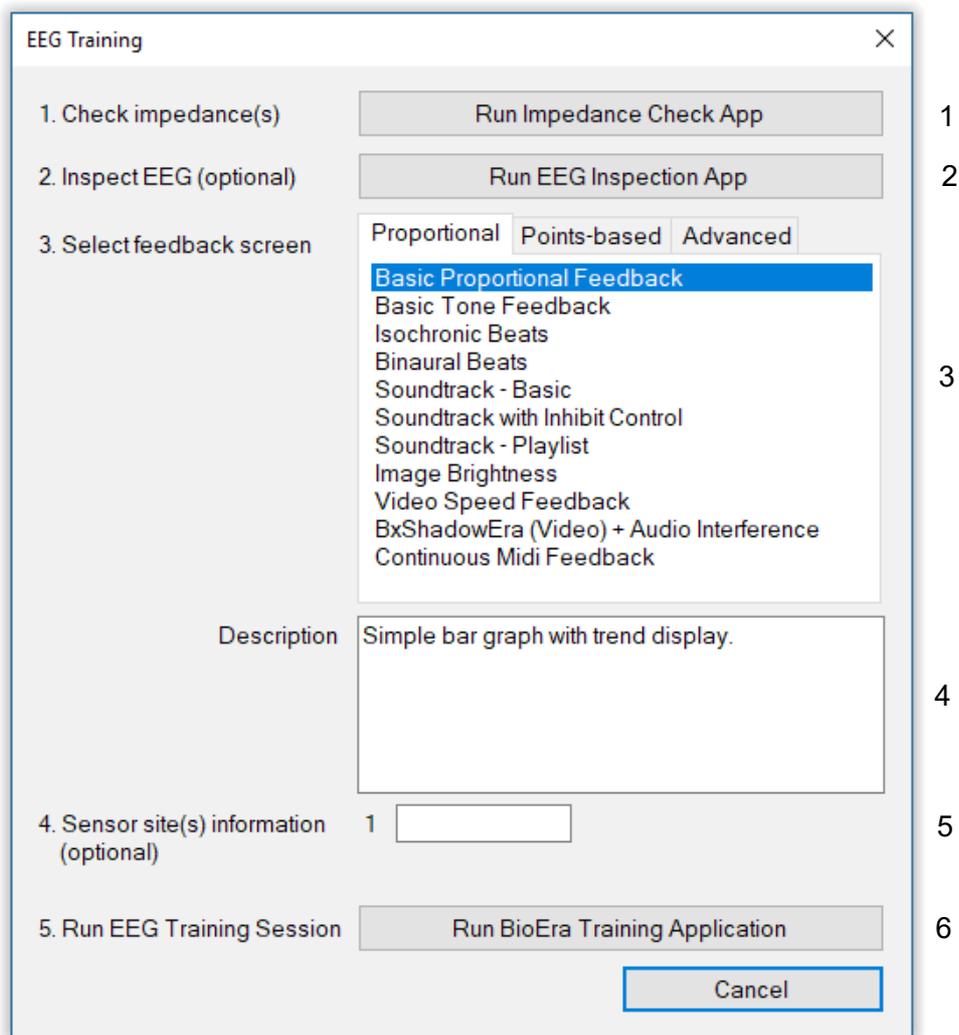


Figure 9 – Run EEG training session dialog

3.2 Checking Impedances

To check your impedances using software, click the button at the top of the training session dialog, labelled 1 in figure 9.

Checking impedances is a way of ensuring the quality of your EEG hook-ups. A more detailed explanation of impedance is beyond the scope of this document.

Please note, what happens here depends on what type of amplifier you are using. Not every device has software impedance checking available, in which case the button will be inactive.

Figure 10 below shows the (BioEra-based) impedance check application for the Physiocom GP series of amplifier.

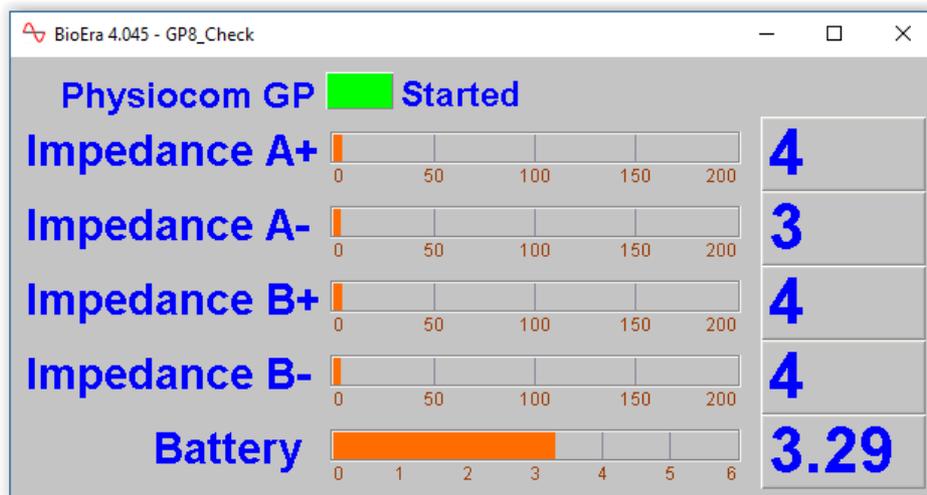


Figure 10 – The BioEra impedance check application
(for the Physiocom GP series of amplifiers)

3.3 Inspecting EEG

You can further check the quality of your sensor hook-ups by inspecting the raw EEG in a separate BioEra app, as shown in figure 11 below. The three charts show raw EEG, then EEG filtered between 1 and 40 Hz, then at the bottom a spectral analysis.

Drop-down list controls set the vertical and horizontal ranges of these charts. If you're using a multi-channel protocol you can inspect each channel separately by changing the setting of another drop-down list control at the top.

Further discussion of EEG quality is beyond the scope of this guide.

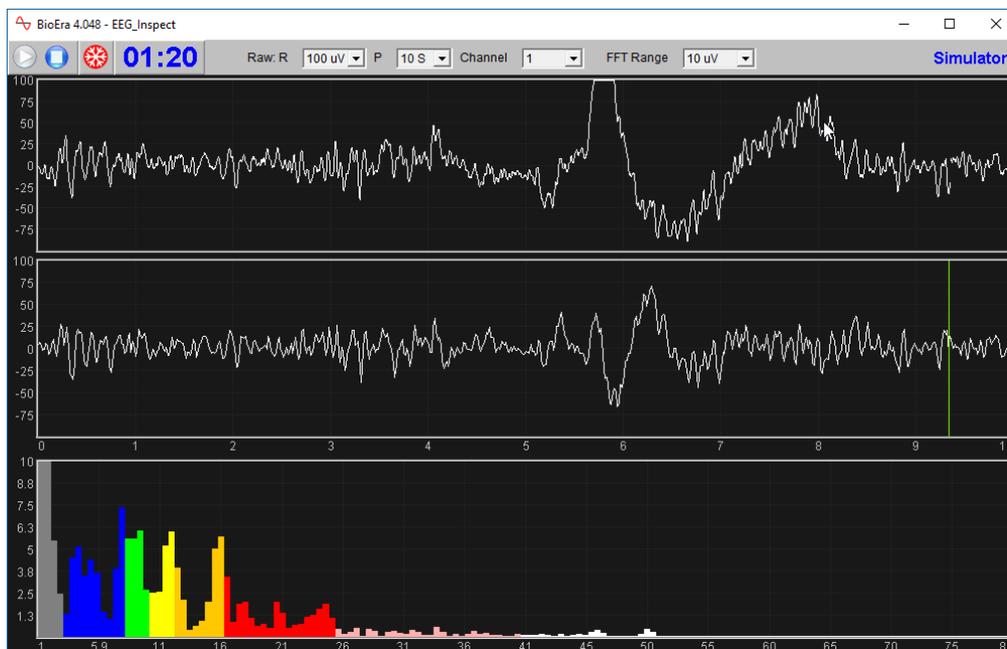


Figure 11 – The BioEra EEG inspection application

3.4 Standard Training Application

Clicking the button labelled 6 in figure 9 launches the BioEra application for EEG training. This application is the mainstay of neurofeedback training. It has two windows, the control screen and the feedback screen. Figure 12 below shows the control screen, in this case for a one-channel protocol. (If you're using more than one channel there are minor differences.)

This section describes the charts and controls in the control screen of the standard-form EEG training application. The other window, the feedback screen, is described in section 3.5.

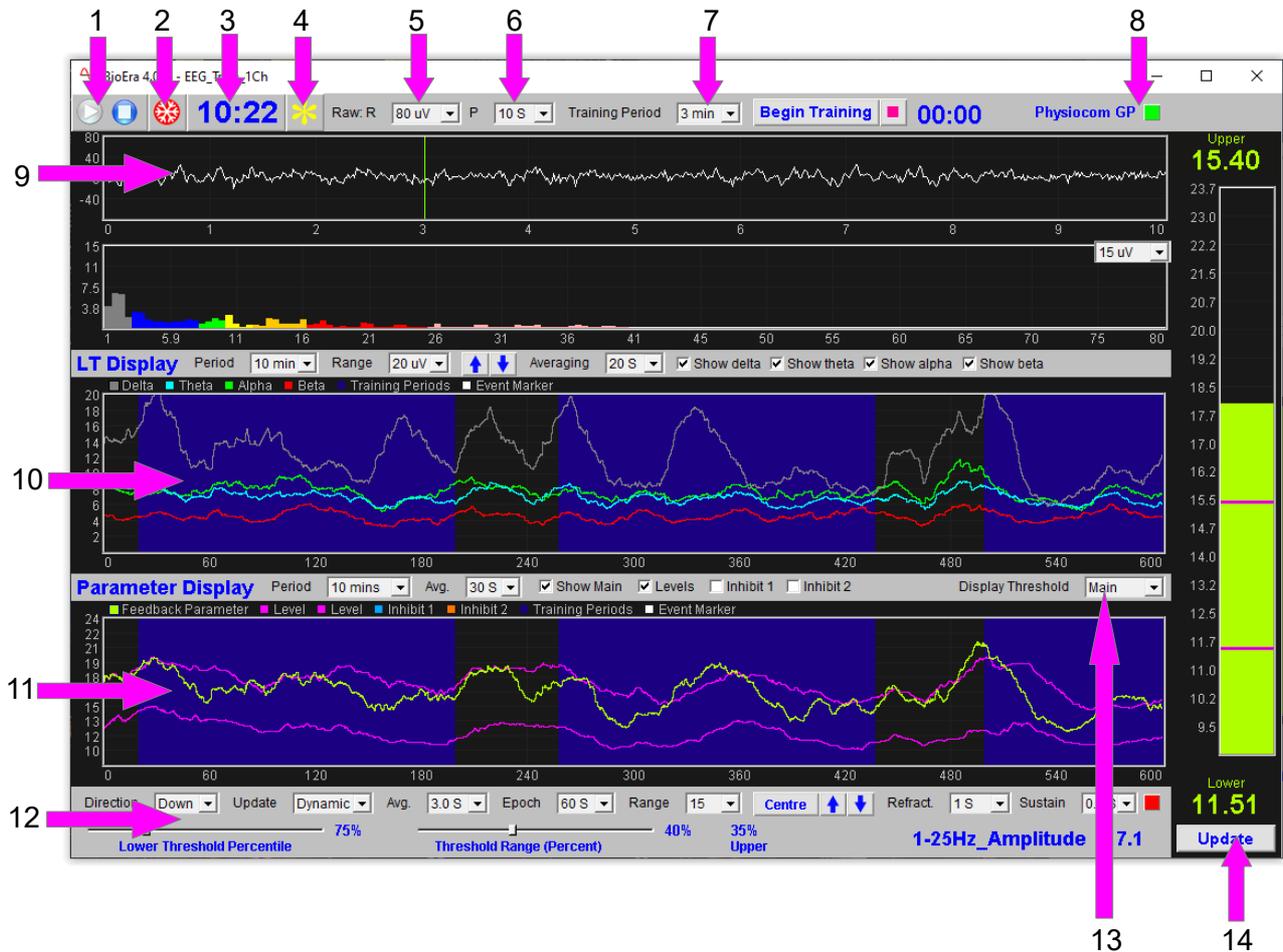


Figure 12 – BioEra EEG Training application control window

3.4.1 Play, Stop and Freeze

These button controls, 1 and 2 in figure 12, should be fairly self-explanatory – pressing Play opens the flow of EEG data through the application.

If you press Stop and then Play again, you'll overwrite the session data for the first period (and thus it won't show up in any session report you might generate later). To avoid this, close the application down after pressing Stop, then restart it.

The freeze button (2 in figure 12) pauses the displays in the application. Pressing the button again, un-freezes the displays. Note that while the charts are frozen, data processing is still going on in the software, and also being written to the session file just the same. Freeze periods are not represented in session reports.

Next to these buttons you'll see the session time display (3 in figure 12).

3.4.2 Event Marker

The EEG training application includes a simple event marker. This can be useful particularly for practitioners. If something happens during training, you can mark it in the software, and then discuss it with the trainee later.

Clicking the event marker button (4 in figure 12) causes a vertical line to be shown in the parameter display, and also in the session report graph (see section 4.3 below). Pressing the escape button on your keyboard has the same effect.

When you mark an event, a dialog will appear, allowing you to add a short note. Notes are later shown in session reports. You don't need to enter a note; hitting return or clicking 'ok' will close the dialog.

3.4.3 Training Period Controls

Training periods were described in section 1.2.6 above – to repeat, they are a way of breaking training up into shorter blocks, between which the trainee can take rests. You can also make protocol adjustments, i.e. move the threshold levels (though in fact you can do this at any time during a session).



Figure 13 – Training period controls & timer display

Figure 13 above shows the training period controls, which are found right at the top of the control screen, 7 in figure 12.

The drop-down list control sets the duration of training periods.

The “Begin Training” button, when pressed, obviously starts a new training period, and if pressed during a training period it resets the time of the training period to zero, making the current training period longer. A numeric display shows the elapsed time of the current training period.

If you want to end a training period before its full term, you can press the button marked with a red square.

The displays and audio elements in the feedback screen only become active during training periods (i.e. after you press the begin button).

3.4.4 Device Status & Properties

In the top right corner of the control window you'll see the name of the device you're using as the source of the EEG signal (8 in figure 12). For some devices, there is a button which, when clicked, opens a dialog through which you can set some properties for the device or its port.

There is also a small status indicator lamp. Green (as you see in figure 12) means the device is started, red means it is not. If this indicator does not turn green when you press play, please check it is connected properly to your computer.

3.4.5 Raw Signal Display

The chart(s) at the top of the control screen show the raw channel signal(s) (9 in figure 12). The actual appearance depends on how many channels you're using. In figure 12 there is only one channel. Figure 14 below shows what a four-channel protocol looks like.

No matter the number of channels, there are two drop-down list controls, 5 and 6 in figure 12, which set the vertical scale and the horizontal scale (or time period) of the raw EEG displays.

In the case of one- and two-channel protocols, a spectral analysis is also shown (having its own range control in the top right corner).

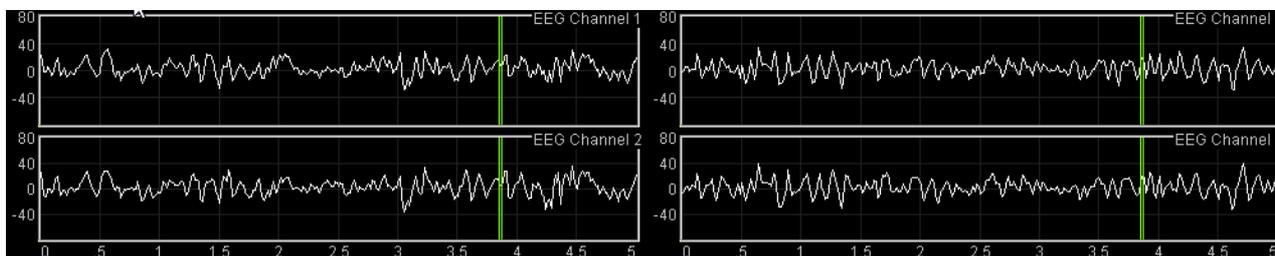


Figure 14 – Raw signal displays – four channel version

3.4.6 Long Term Display

Figure 15 below shows the variation of the standard EEG frequency bands over the longer term. Delta, theta, alpha and beta bands can be displayed. As for the parameter display, training periods are shown as blue blocks (three are shown in figure 15).

Check-box controls (5 to 8 in figure 15) set which of the bands (delta, theta, etc.) to display.

This chart has drop-down list controls (1 and 2 in figure 15) to set the vertical and horizontal (time) ranges. Up and down buttons (3 in figure 15) shift the traces up and down, so that you can centre them in the chart while keeping the scale the same.

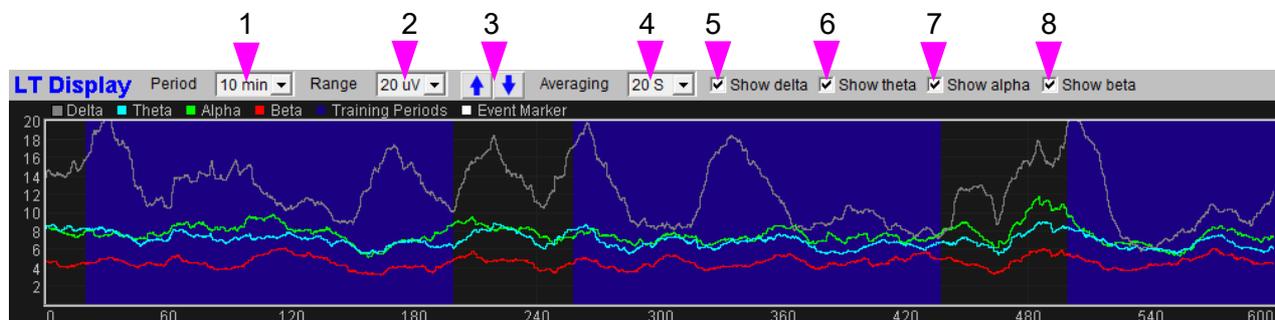


Figure 15 – Long term display

The long-term display can only show one channel of EEG data at a time. If you're using a two- or four-channel protocol, you can switch the display to other channels using a drop-down list control above the chart (not shown in figure 15, but found at the right hand end of the chart).

The averaging control (4 in figure 15) sets the amount of smoothing that is applied to each of the frequency band traces. A setting of 20 seconds, as you see in figure 15, means that the trace is a moving average of the last 20 seconds' worth of data. Setting a lower average means the trace will be more variable (or “spikier” in appearance).

Please note this average setting is applied only to the traces in the long-term display; it does not affect feedback (or latency).

3.4.7 Main Feedback Parameter Display

Next down is the main feedback parameter display. This shows the trend of the training parameter over the most recent few minutes or so. Figure 16 below shows this display and its controls.



Figure 16 – Parameter display

Training periods are shown in this chart as blue blocks – you can see three such in figure 16.

The drop-down list control 1 in figure 16 sets the time period or horizontal scale for this chart.

If your protocol uses inhibits, you can opt to display the inhibit parameter(s) too in this display. The check-box controls above the chart (2, 4 and 5 in figure 16) can be used to set which traces to display.

You can also opt to display the threshold levels. In figure 16 the main feedback parameter's threshold levels are shown as magenta traces – you can see that they are varying dynamically (see section 2.5 above for a discussion of how threshold levels are set). Seeing them displayed in this chart helps you judge if they are set appropriately. Inhibit threshold levels are shown as dotted lines (the variation is not shown for these).

The vertical scale (range) for this chart is the same as the bar chart for the threshold, i.e. set by the 'Range' drop-down list, plus 'Centre', Up and Down buttons, within the threshold, and described in section 2.5.1 above. This is true for each parameter displayed (main feedback, plus inhibits). Because each parameter has its own independent threshold bar chart, there are independent ranges for each the the trend display. To switch which range is displayed at the left side of the chart, click on the coloured squares above the chart.

The averaging control (2 in figure 16) sets the amount of smoothing that is applied to each trace. A setting of 30 seconds, as you see in figure 16, means that the trace is a moving average of the last 30 seconds' worth of data. Setting a lower average means the trace will be more variable (or “spikier” in appearance). Please note this average setting is applied only to the traces in this display; it does not affect feedback (or latency).

3.4.8 Threshold Controls

At the bottom of the control screen you'll find the threshold controls. These have already been discussed in section 2.5 above.

If you're using inhibits, then you have a choice of which threshold to display. You can show the main parameter or either of the two inhibit thresholds. This decision is made using a drop-down list control, found above the parameter display (section 3.4.7 above) at the right hand side (see 13 in figure 12, also 7 in figure 16). Changing this setting hides one set of controls plus bar chart, and makes visible another set.

3.5 Feedback Screens

Before you launch a training session using the BioEra app, in the training session dialog (figure 9, step 3) you are required to select a feedback screen. Your selection determines what you'll see in the app's feedback screen. The different options give you ways of presenting feedback in different forms, e.g. as audio feedback or as simple graphical feedback.

Feedback screens are grouped into three list: (i) continuous feedback, (ii) points-based feedback, and (iii) more advanced screens or screens containing elements of both. The lists are presented in a tab control (one list per tab).

Full details of the feedback screens are given in a separate document: the MBTT EEG Training Feedback Screens Guide.

A sample feedback screen is shown in figure 17 below – this one offers audio feedback via soundtracks whose volumes vary with the feedback parameter.

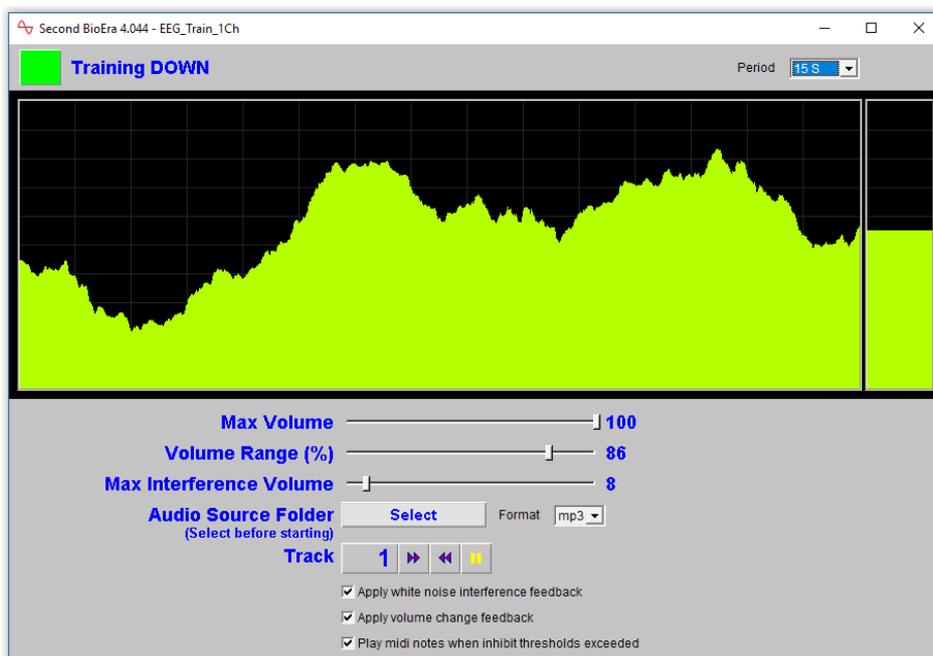


Figure 17 – Sample feedback screen

4 Assessing Training & Progress: Reports

During a training session, the BioEra EEG training application writes data which can later be used to generate reports. It creates two files: (i) a session file which is readable by BioEra (saved in .xdf format), and (ii) a summary data file recording the main feedback parameter (saved as a text file).

After a training session you can view the data in two ways. First, you can create an MBTT session report (in html format, and viewed in a web browser). Second, you can view the .xdf session file in a BioEra report app.

The MBTT html report focuses on the main training parameter, shows the training periods clearly, and can be copied or emailed to anyone even if they don't have MBTT software. MBTT session reports are covered in section 4.3 below. The BioEra report has the advantage that it can show the standard EEG bands (theta, alpha, etc.). BioEra reports are described in section 4.4.

You can also generate a protocol report, which allows you to compare all sessions run using a single protocol. This report is also generated in html format. Protocol reports are covered in section 4.5 below.

4.1 The Summary Data File

The summary data file is in simple text format, and has the file extension “.txt”.

There is one line of text per *training epoch*. (This term has no other significance beyond that data is written once per epoch.) The duration of a training epoch is set using a drop-down list control in the control screen of the BioEra EEG training application. This control is labelled 'Data Epoch' and was mentioned earlier in section 3.4.6.

The items of data recorded are:

- session time
- the main feedback parameter, averaged over the training epoch,
- inhibit parameters, also averaged over the training epoch,
- training period start and end points
- “events” marked using the event marker (see section 3.4.2 above).

4.2 File Storage

The data files are automatically given a name incorporating the session date and a session number, and stored within the Mind-Body Training Tools base folder. Figure 18 shows the folder structure. You can access the files directly using the Manage Data functionality described below in section 5 below.

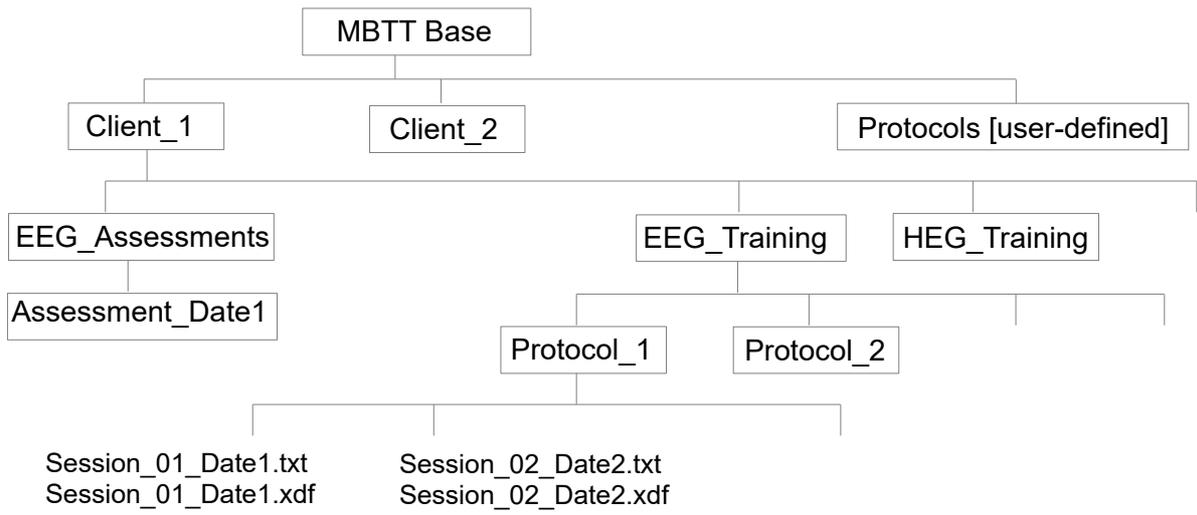


Figure 18 – Application data directory tree

4.3 Generating MBTT Session Reports

To create a session summary report, from the EEG Training tab of the Platform application (figure 2 above), click the button, 'View Training Session Report' (step 4). First you'll be prompted to select a session from those stored for your currently selected protocol. Then you'll see an options dialog appear (see section 4.3.1 below). When you click 'OK' the report will be generated and opened automatically in your computer's default browser (please note, just because the report opens in a browser, does not mean it is on the internet – it is stored locally on your computer).

If a report already exists for the selected session, MBTT will offer to either open the existing report or re-generate the report (perhaps with different options).

MBTT session reports can be printed using your browser's print functionality, can be copied to another computer, and can be emailed (see section 5 below).

4.3.1 Report Options

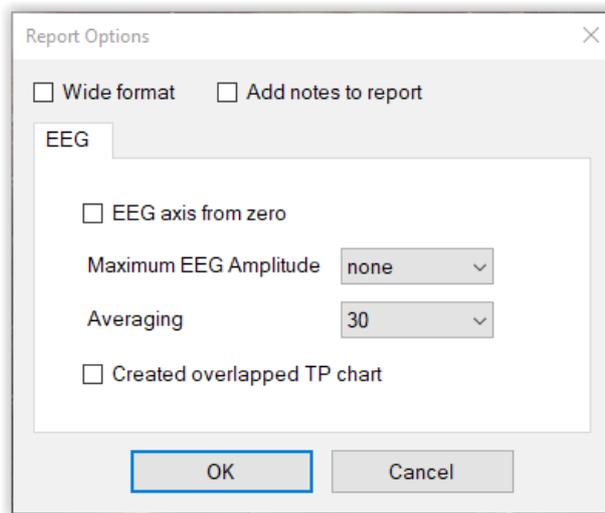


Figure 19 – Training session report options

Figure 19 above shows the training session report options dialog.

- 'Wide format' – checking this box will create a wider version of the summary charts. If you wish to print a report in landscape form this option is probably warranted.
- 'Add notes to report' – checking this box opens a further dialog allowing you to type some notes on a session, for future reference. If you regenerate a report, the original notes are preserved.
- 'EEG axis from zero' – when checked the vertical axis starts from zero. When it is unchecked, the vertical range is scaled so that the actual data range fits the space. This may give a misleading sense of how variable the data was.
- When you select a maximum EEG amplitude, the software assumes that any parameter values above this are artefact and excludes this data from the report calculations (and chart generation).
- 'Averaging' sets the amount of smoothing applied to the traces. A setting of 30 seconds means any point on a trace represents a moving average of 30 seconds' worth of data. Setting a lower averaging means the trace will be much more variable or “spikier” in appearance.

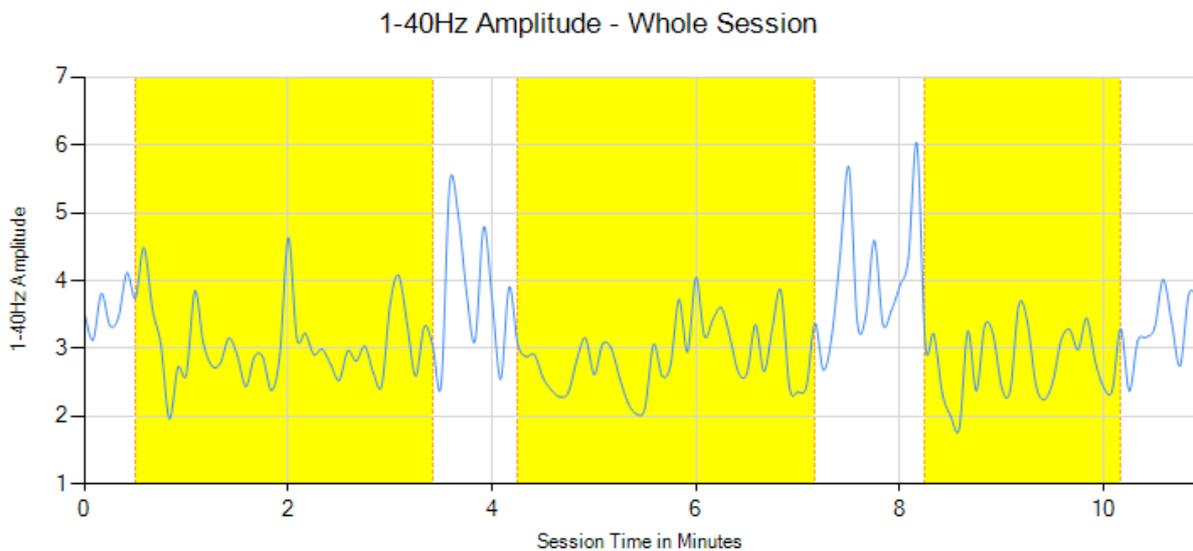
4.3.2 Sample Session Report

EEG Training Session Report

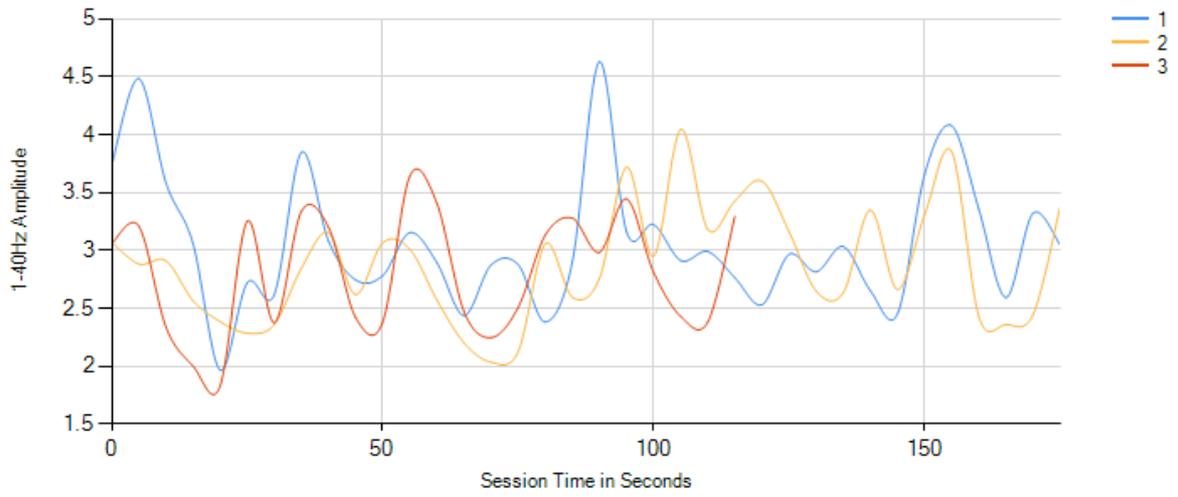
Trainee name:	Default User
Session date:	08/02/2018 12:48:12
Protocol:	1-40Hz Squash (1 Channel)
Training Parameter:	1-40Hz Amplitude
Sensor sites:	F3-F4

1-40Hz Amplitude Summary Data by Training Period

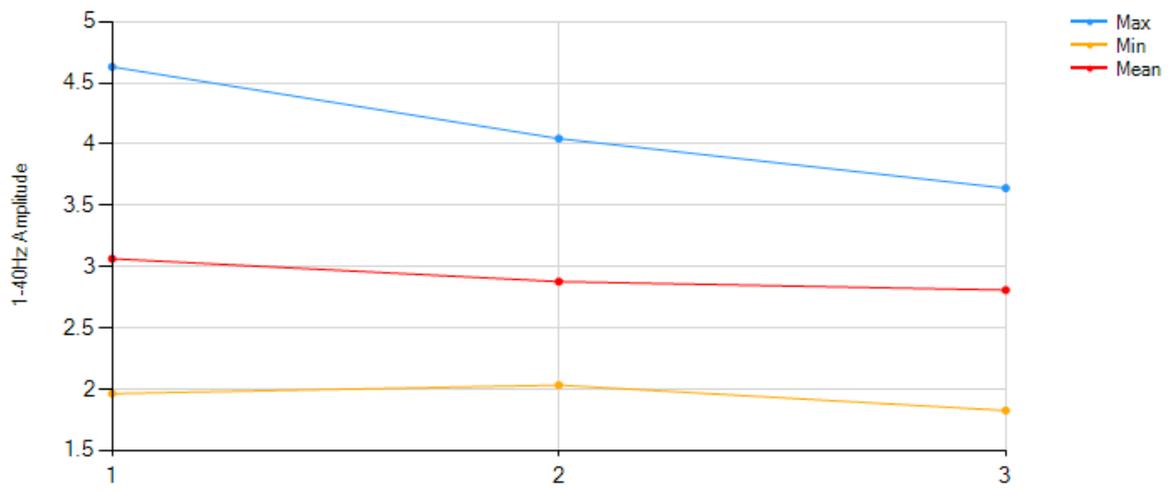
TP	Duration	Mean	Max	Min
1	180	3.06	4.63	1.96
2	180	2.88	4.04	2.03
3	120	2.81	3.64	1.83
All TP	-	2.93	4.63	1.83
Non-TP	-	3.73	6.02	2.37



1-40Hz Amplitude - by Training Period (Overlapped)



Training Period Progression



4.4 Reviewing Training Sessions in BioEra

To review a training session in the BioEra session review application, from the EEG Training tab of the Platform application (figure 2), click the button, 'Review Training Session - BioEra' (step 5). You'll be prompted to select a session from those stored for your currently selected protocol. The BioEra session review application will then start. Figure 20 below shows what it looks like.

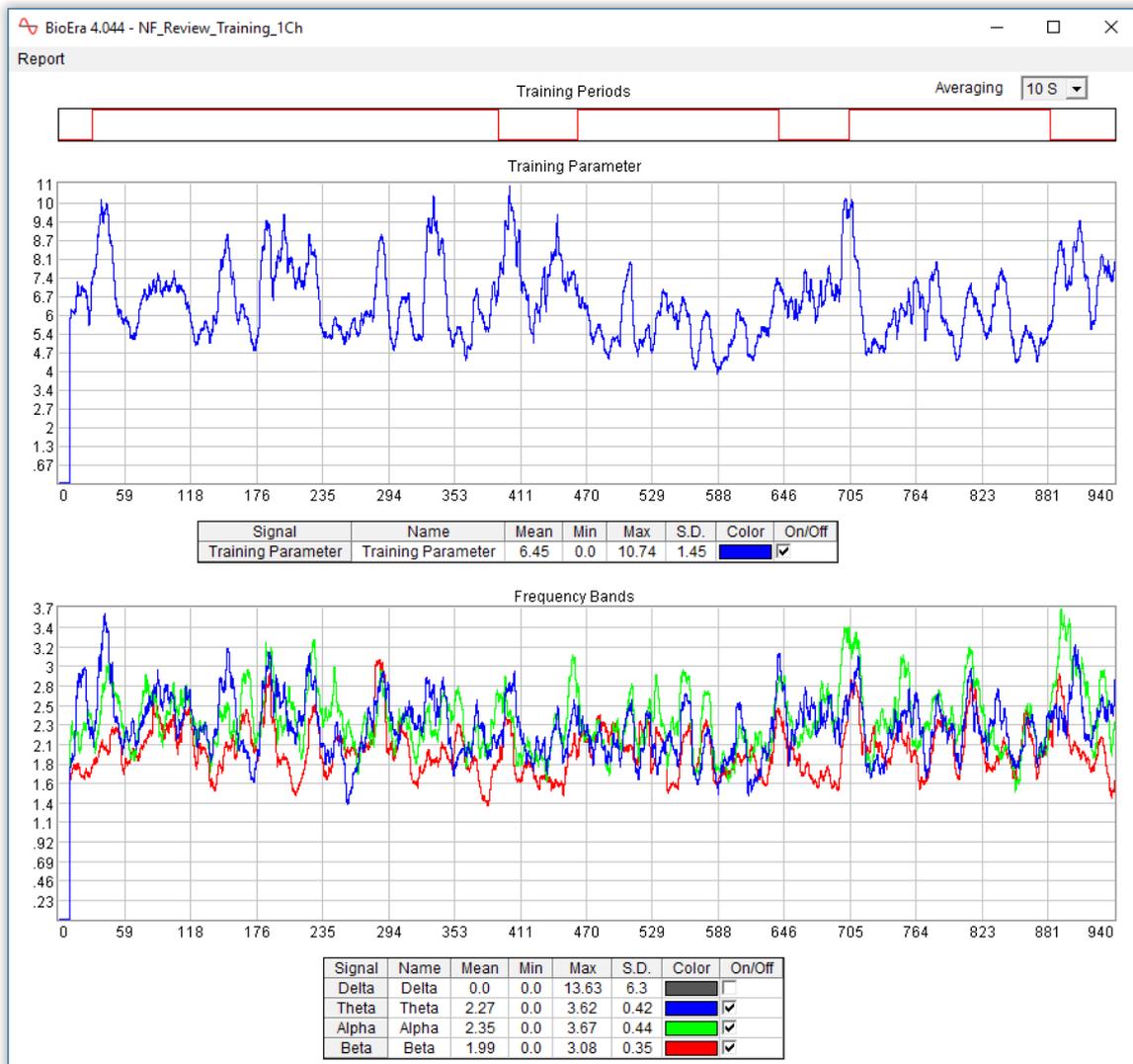


Figure 20 – BioEra session review application

The BioEra report differs from the MBTT session report in that besides the main training parameter, it shows the standard EEG frequency bands, delta (1-4 Hz), theta (3-7 Hz), alpha (8-12 Hz) and beta (16-25 Hz), over the course of the session.

The tables below each chart show session summary data and check box controls allow you to show and hide individual traces.

You can zoom in onto particular regions of the charts by dragging your mouse over an area of interest. Doing so only changes one chart, which means you lose the relationship to the other two charts. Right-clicking over the chart will bring up a menu – e.g. “show all” allows you to zoom back out to the full session.

The BioEra report can only show one channel of EEG data at a time. If you've used a two- or four-channel protocol, you can select which channel to view in the report using a drop-down list control found in the top left corner of the display.

If your protocol uses a calculation based on two channels at once, such as a coherence or synchrony protocol, the report will not work, and the main parameter chart will either show zero throughout the session, or something erroneous. Simple amplitude protocols or ratio protocols, should be fine.

You can also set the level of averaging used, via a drop-down list control in the top right corner. Using a longer averaging period results in smoother traces, but showing less “detail”.

You can print the report via the “Report” menu in the top left corner, but please be aware of the limitations of the print function. You will probably have to re-size the window of the BioEra report app, so that the report fits the page. I suggest using the page set-up and print preview functions, and make sure the charts fit within the dotted box which is the print area. Alternatively it may be easier to take a screenshot and save this as an image file. There are freeware programs that can capture a selected region of your screen, e.g. Gadwin Printscreen.

Please note that the training application doesn't start writing to the xdf file until 15 seconds after you pressed 'play'. This is to allow the signal to settle.

4.5 Generating Protocol Reports

A protocol report allows you to view together all the sessions run using a given protocol, so that you can see the trainee's progress over time.

To create a protocol report, from the EEG Training tab of the Platform application (shown in figure 1 above), click the button, 'View Protocol Report' (step 6). You'll see an options dialog appear – which is similar to that for the session report (see section 4.3.1 above). This dialog is shown in figure 21 below.

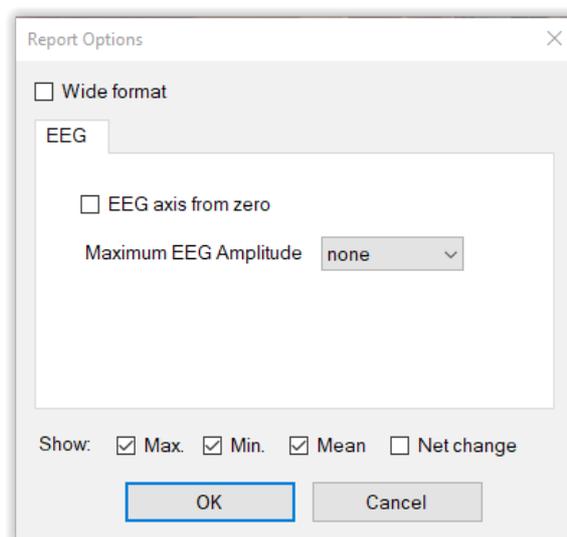


Figure 21 – Training protocol report options

You can opt to view up to four line plots showing maximum per session, minimum per session, average (mean) per session, and net change per session, with one point per session. (This will make more sense if you view the sample report chart shown in section 4.5.1 below.)

When you click 'OK' the report will be generated and opened automatically in your computer's

default browser.

In my experience the protocol report doesn't necessarily show a change over time. This doesn't necessarily mean that training has been ineffective.

4.5.1 Sample Protocol Report

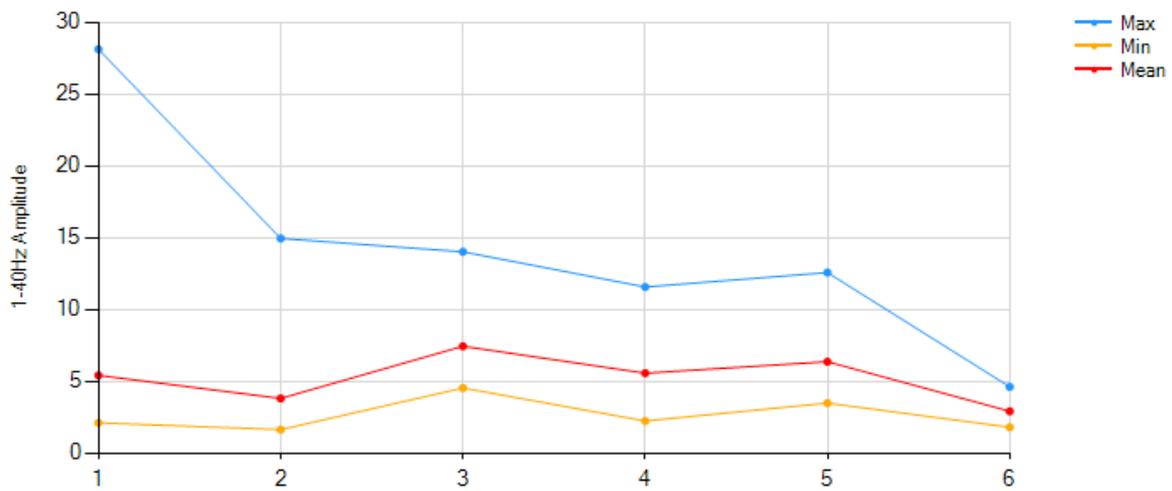
EEG Training Protocol Report

Protocol	1-25Hz Squash (1 Channel)
Training Parameter:	1-25Hz Amplitude
Trainee Name	Default User

1-25Hz Amplitude Summary Data

Session Date	Num. T.P.	Mean	Max	Min
18/01/2018 12:02:49	4	5.43	28.12	2.13
18/01/2018 16:11:33	5	3.83	14.96	1.66
24/01/2018 16:31:06	5	7.46	14.03	4.55
31/01/2018 12:03:40	6	5.59	11.58	2.26
01/02/2018 12:33:31	6	6.38	12.58	3.50
08/02/2018 12:48:12	3	2.93	4.63	1.83

Protocol Analysis - 1 Point Per Session



Session Averages

Parameter	Mean	Max	Min
1-25Hz Amplitude	5.27	14.32	2.65

5 Managing Data

With EEG neurofeedback training it is quite easy to amass a lot of data over time. MBTT allows you to manage data.

Clicking on the button “Manage Session Data”, at the bottom of the EEG training tab of the Platform application (see figure 2 above) opens a dialog for managing data (shown in figure 22 below).

In this dialog you'll see a list of sessions for the currently selected protocol. You can select one or several sessions (to select more than one, use Ctrl-click).

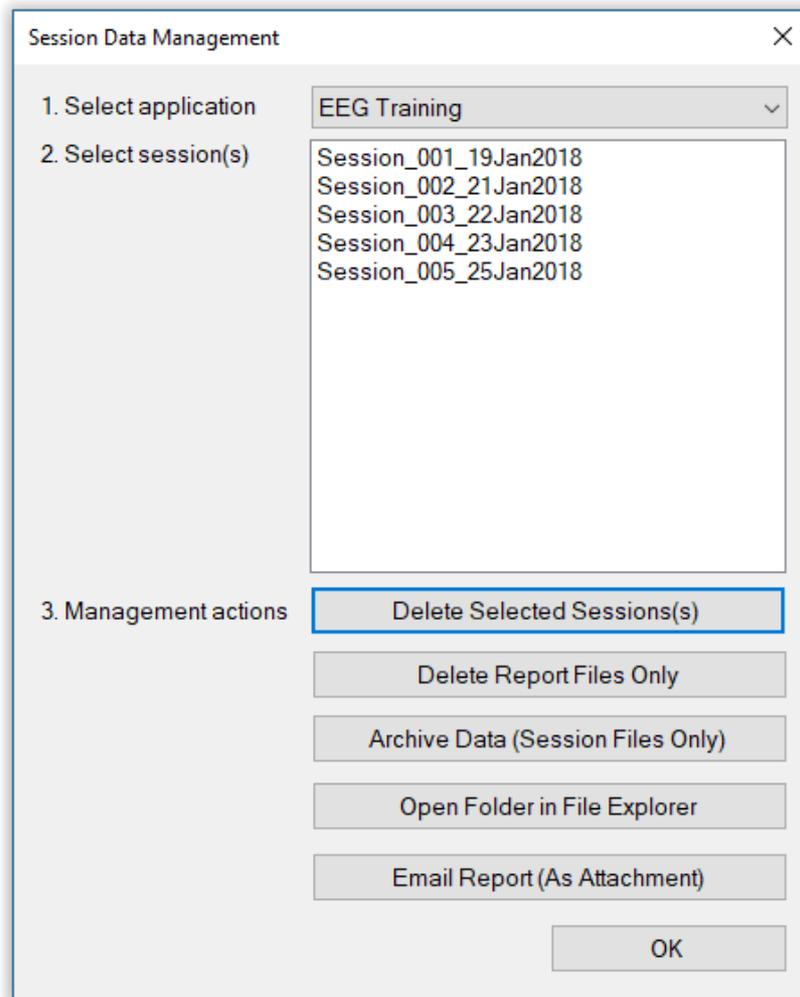


Figure 22 – Data management dialog

Management actions you can perform include:

- Delete Session(s) – this will delete all files associated with the selected sessions
- Delete Report Files Only – this will delete all files associated with the session, except the summary text file and the session xdf file – i.e. html files and their associated image files. You can always regenerate report files later.
- Archive Data – this firstly deletes all report files associated with the selected session(s), as

per the previous function (i.e. excluding the text file and the xdf file) and secondly moves the summary text file and the xdf file into a sub-folder called “_archive”. Doing so means these sessions will not appear in the session lists, e.g. when you want to create a session report.

- Open Folder in (Windows) File Explorer – this may be useful occasionally, e.g. if you want to restore an archived session file, you have to manually move it back out of the “_archive” folder.
- Email report – this compresses all files associated with the selected session into a zip file, and emails this as an attachment. This can be useful e.g. if you are a practitioner and want to send your client a report, or if you are working with a coach and want to email details of your progress. You can only email one session or report at a time with this function.

When you email a report you'll see a further dialog like that shown in figure 23 below. Besides entering the recipient address, you'll be required to enter your own (sender) address, plus details of your email server. These latter are remembered by the software for next time you want to send a report. Your mail server address typically has the form *mail.your-domain.com*, if you have your own domain with a hosting provider. If you use an email provider such as gmail or yahoo mail, you can probably find the information you need by googling e.g. “gmail smtp server”.

The image shows a dialog box titled "Email Report" with a close button (X) in the top right corner. The dialog contains the following fields and controls:

- Recipient Address:** An empty text input field.
- Sender Address:** A text input field containing "your_email@domain.com".
- Mail Host (SMTP Server):** A text input field containing "mail.your-domain.com".
- Port (on SMTP Server):** A text input field containing "25".
- Sender Email Password:** A text input field containing ten black dots (password masked).
- Message (optional):** A large, empty text area for entering a message.
- Enable SSL:** An unchecked checkbox.
- CC Sender:** An unchecked checkbox.
- Buttons:** "Send" and "Cancel" buttons at the bottom.

Figure 23 – Email report dialog