EEG Training User Guide: Alpha-theta Crossover Protocol

Contents

1 Introduction to Alpha-theta Training

This guide describes how to use the Mind-Body Training Tools (MBTT) EEG training application for alpha-theta EEG neurofeedback. It does not explain how to do alpha-theta training, only how to use the software – for the former you'd need professional training. Nonetheless in this introduction I present a background summary of alpha-theta training.

Many of the features of the MBTT alpha-theta application are the same as those used in the MBTT standard-form protocol EEG training. Therefore I recommend you read the main MBTT EEG Training User Guide first, as here I will assume prior knowledge of the MBTT standard EEG training, and do not explain the common features in any great depth.

1.1 Alpha-theta Training

Alpha-theta training is also known as "deep states" training. Some of the first neurofeedback pioneers found that rewarding alpha and theta at the back of the head facilitated access into deep states or "twilight" states, which in turn supported their healing work.

Alpha-theta training became the mainstay of the Peniston & Kulkosky protocol for working in two clinical areas in particular: PTSD and addiction (alcoholism). Alpha-theta training is used more widely by therapists working with anxiety and other emotional disorders.

It is difficult but not impossible to train yourself using the alpha-theta application, however caution is urged, most especially if you have a history of trauma or other mental health issues, because alpha-theta work may trigger emotional abreactions. If you wish to use the application therapeutically, you should find a trained and qualified practitioner.

I developed the MBTT alpha-theta application based on my understanding of alpha-theta work, but I do not claim it is in any sense "sanctioned" or approved as a therapeutic or medical application. I am not myself a qualified psychologist or medical doctor.

In the course of alpha-theta training, the trainee enters a very relaxed, trance-like state, progressively going "deeper" in some sense.

EEG is measured from the back of the head, either occipitally or parietally. Alpha-theta training is always done eyes-closed.

The initial "goal" is to develop strong alpha. As the state deepens, theta amplitude builds up. At some point, a particular event may happen, which is that theta amplitude may exceed alpha amplitude. This is known as crossover – the alpha and theta traces cross over in the software charts. The alpha-theta crossover is seen as particularly favourable, though arguably not essential to the success of the work. In terms of the EEG, the ratio of alpha amplitude to theta amplitude drops from above 1 (which is normal at the back of the head in the eyes-closed state) to less than 1.

Some people think that what is actually happening in the crossover, is not simply that alpha is falling and theta rising, but that the frequency or speed of the alpha rhythm is dropping down into the upper range of the theta band. For this reason it can be useful to track the amplitude of the narrow band in this crossover region, about 7 to 8 Hz.

The deep states sought after in alpha-theta training are not the same as dozing off to sleep. There is still an awareness, albeit different from everyday consciousness. In the sleep state, delta amplitude tends to come up, as theta does, whereas in true deep states delta does not climb so high. Therefore it is useful for the practitioner to track delta amplitude, and for the software to warn of excessive delta, to hopefully prevent the trainee falling asleep.

It would be somewhat pointless for neurofeedback software to reward the alpha-theta crossover (i.e. alpha:theta ratio dropping below 1) if there is not a good level of either or both of alpha and theta. Often in the eyes-open state, theta is greater than alpha (ratio < 1) but this is clearly different from

deep states.

1.2 EEG Parameters

The application keeps track of six EEG parameters:

- Alpha (8-12 Hz) amplitude
- Theta (4-8 Hz) amplitude
- Alpha to theta ratio (of amplitudes)
- 7-8 Hz amplitude
- Combined alpha + theta (4-12 Hz) amplitude
- Delta amplitude.

1.3 Audio Feedback

Because alpha-theta training is done eyes-closed, feedback (for the trainee) is auditory. The MBTT alpha-theta application delivers feedback by playing up to three soundtracks at variable volume, with volume tracking selected EEG parameters.

The feedback is highly configurable – e.g. you can select the parameter to feed back for each of the three soundtracks.

For example the default configuration is:

Soundtrack 1: Alpha amplitude

Soundtrack 2: Theta amplitude

Soundtrack 3: Alpha / theta ratio

Another option could be i) combined alpha + theta amplitude, ii) 7-8 Hz amplitude, iii) alpha / theta ratio.

Please note, suitable media files are not provided with MBTT software for reasons of copyright. Appropriate soundtracks are however easy to obtain, and in section 3.3.1 below I offer some suggestions on what to use and how to purchase it.

1.4 Threshold Controls

For any of the soundtracks, we need to define the range of the EEG parameter that the volume varies over. This is achieved using threshold controls. In the MBTT alpha-theta application there are five thresholds, one for each of the EEG parameters listed above, except for delta which has a much simpler threshold control (see section 3.4 below for more details of the latter).

These thresholds work much like the thresholds in the MBTT standard-form application. See the main EEG Training User Guide for a fuller explanation.

In summary, each threshold sets two levels, an upper and a lower, which define the limits of variation. For example, if you are rewarding alpha amplitude, the lower level is the point at which the sound first becomes audible (below this it is silent) and the upper level is the point maximum volume is reached. The volume increases smoothly, going from lower to upper levels.

The user can of course set the levels, and as with most neurofeedback, appropriate setting is key to the success of training.

The volume mapping can be inverted, so that the soundtrack gets louder as the parameter drops lower. This makes sense if e.g. you want to reward the crossover – you want the soundtrack to play

when the alpha / theta ratio is < 1. You would set both levels close to 1.0.

Clearly, of the five thresholds, the only ones that are relevant (at any one time) are those that you select as the basis of the soundtrack feedback (which is at most three of the five).

1.5 Two-track & Three-track Versions

There are two versions of the training application available, differing only in the number of soundtracks they offer. The main application offers three (of course you can decide to only use two or even one if you like). The second version is simpler, having only two soundtracks (at most). It may give better audio performance, if you happen to be using an older, slower computer.

1.6 Calculation of Amplitudes

This is a technical note to explain how the software calculates amplitudes. Different neurofeedback software products may use slightly different methods and so numbers may not be directly comparable.

The alpha-theta application uses digital bandpass filters, one for each of the main parameters. The software then takes the magnitude of the filter's output. (This output is oscillating between positive and negative values and would otherwise average out to zero.) Then this magnitude is averaged over a period of a few seconds.

This amplitude calculation is different from the peak-to-peak amplitude, and even from zero-to-peak amplitude (it is approximately 0.64 x peak amplitude, or 0.32 x peak-to-peak amplitude). It also differs very slightly from RMS amplitude.

In training, where relative change is much more important than actual numbers, this note is not really significant.

2 The MBTT Platform Application

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 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 1 below.
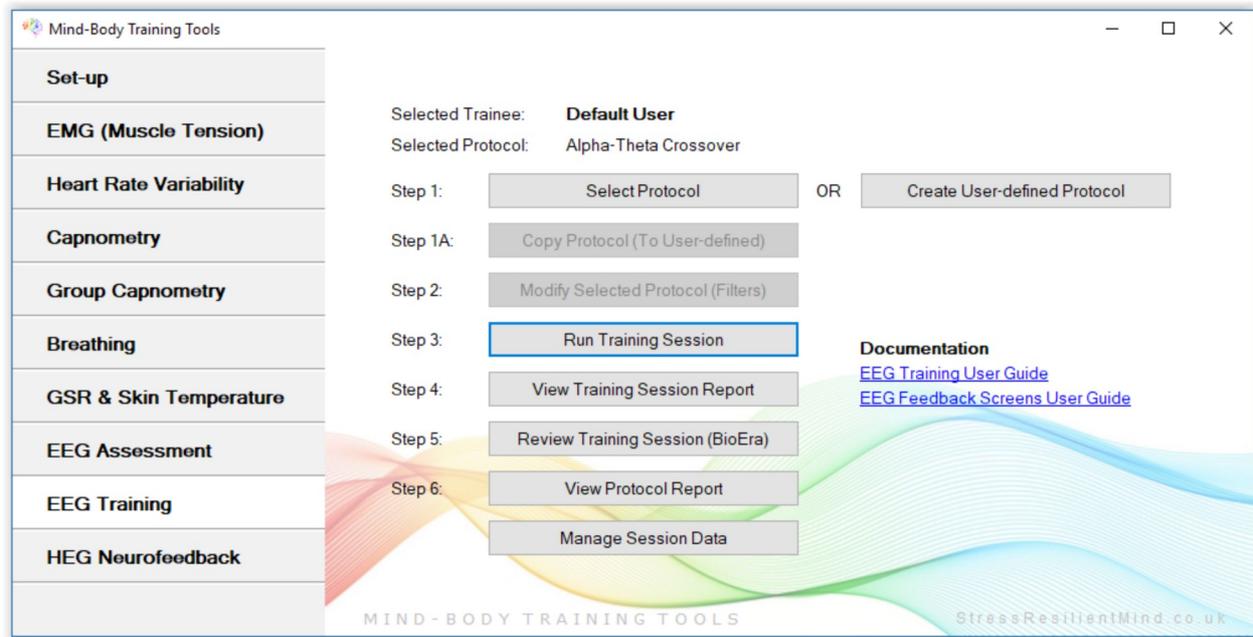

Figure 1 – EEG Training tab of the Mind-Body Training Tools Platform application

To run an alpha-theta training session, first you need to select the alpha-theta crossover protocol, by clicking on the button "Select Protocol" (Step 1). This opens up a dialog window showing lists of protocols organised under three tabs. The alpha-theta crossover protocol is listed under the "non-standard" tab. Select it there, then click ok to close the dialog.

In figure 1 above, the alpha-theta protocol has already been selected – you can see it is named as the selected protocol.

At this point, you can either run a new session or view data from previous alpha-theta sessions (i.e. create reports). The buttons for steps 4 onwards are for report generation and data management, and these functions are covered in section 4 below.

You can't edit the protocol in the same way as for standard-form protocols, but the alpha-theta protocol is very flexible and you can modify just about anything you need to from within the training application itself.

2.1 Running A Live Training Session

To launch a live training session, click the button "Run Training Session" (step 3). This opens another dialog window, shown below in figure 2.
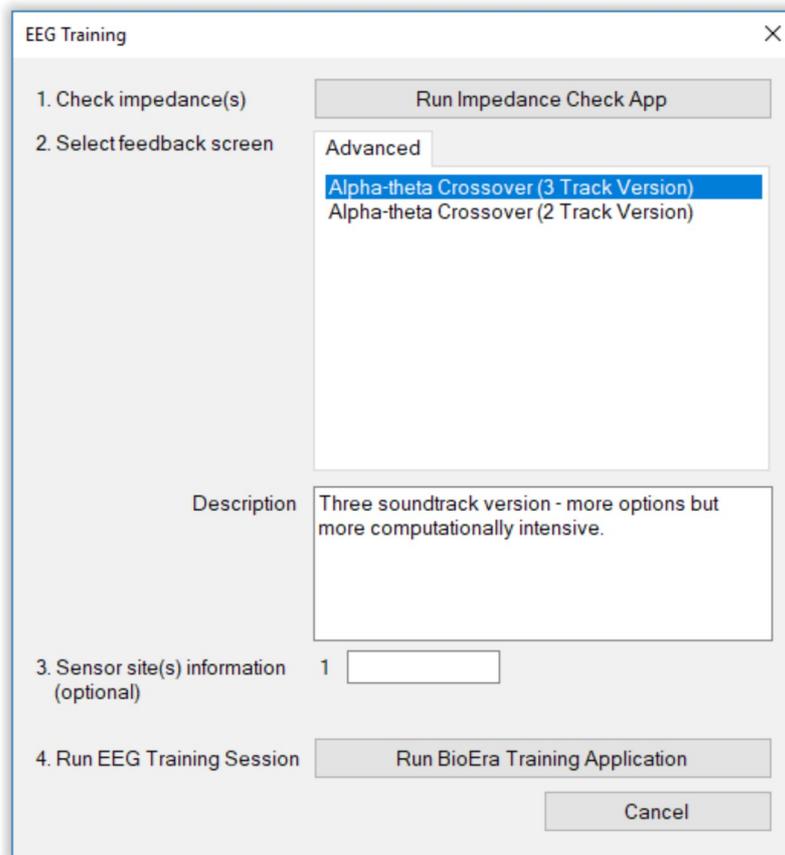

Figure 2 – Run training session dialog

It is strongly recommended that you check the quality of your EEG hook-up by testing impedance – click the button "Run Impedance Check App" at the top of the dialog, step 1.

Explaining impedance checking is beyond the scope of this guide, but it should be said that this function in MBTT is dependent on what type of amplifier you are using. Not every amplifier has an impedance checking tool built into MBTT, but you should still check impedance using another means.

As mentioned earlier there are two versions of the alpha-theta training application. They are substantially the same but differ in terms of the number of soundtracks available for feedback.

Select the version you want to use in the tabbed box, at step 2.

You can optionally record the site on the scalp you're recording from. This does not affect the software operation, but it is recorded and shown in reports.

Click the button "Run BioEra Training Application" (step 4) to launch the live training session. This app is described in detail in the following section.

3 The BioEra Training Application

As stated in other documentation, live biofeedback and neurofeedback work is done using a third-party software called BioEra. The alpha-theta training app is built as a BioEra design. This app has two windows, one devoted to thresholds (the thresholds screen) and the other (the control screen) for everything else.

3.1 Control Screen

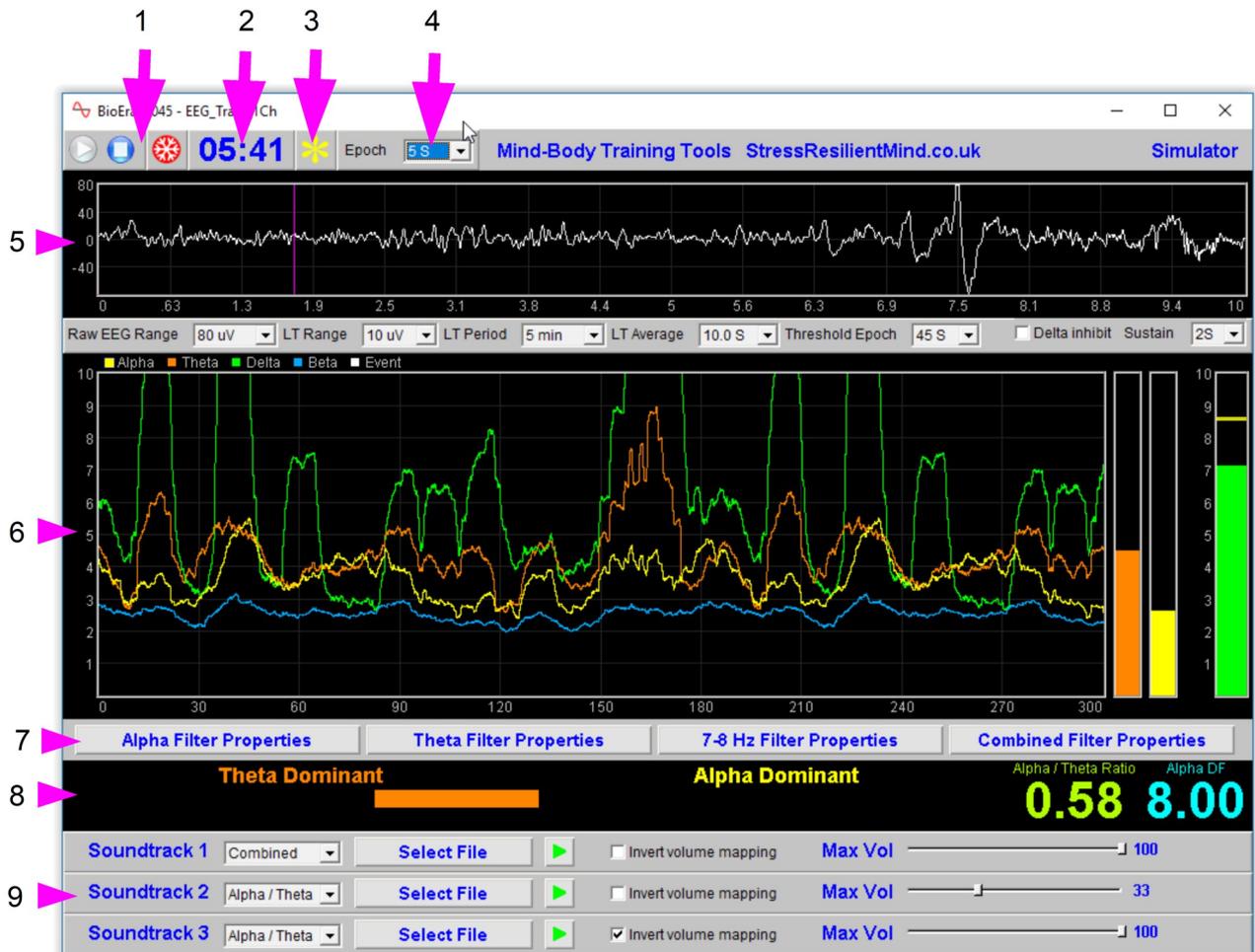Figure 3 below shows the control screen window for the alpha-theta training application.

Figure 3 – Control screen of the alpha-theta training application

3.1.1   Controls Common To Standard-form EEG Training

The following controls are explained more fully in the main EEG Training User Guide:

- Start, stop, freeze buttons (1 in figure 3)

- Session time display (2 in figure 3)

- Event marker (3 in figure 3)

- Data epoch (drop down list – 4 in figure 3) – sets how often data is written for the session summary report

3.1.2   Raw EEG Display

The uppermost chart (5 in figure 3) shows the raw EEG – it is always useful to see this, in part to know that you have a clean EEG.

A drop-down list controls set the range (vertical scale) of this chart.

3.1.3   Main Trend Display

The largest chart, in the centre of the control screen, (6 in figure 3) shows the variation of the main parameters (e.g. alpha and theta amplitude) over time. Beta amplitude is also shown for reference.

Drop-down list controls can set the time range (horizontal scale), the EEG range (vertical scale), plus the level of averaging or smoothing used in the chart. (Note this latter is a different setting to what is used in the thresholds, and for audio feedback.)

To the right of the trend display are three bar charts, showing the current levels of alpha (yellow) theta (orange) and delta (green). These three have the same vertical scale as the trend display. The delta chart also serves as the basis of the delta threshold, described in section 3.4 below.

3.1.4   Filter Controls

You can set the properties for the filters used to calculate most of the parameters listed in section 1.1. above. Filters are described in more detail in the main EEG Training User Guide. The main settings are the upper and lower frequency cut-offs, but there are others besides.

There are buttons (7 in figure 3) which open up a filter properties dialog.

For example you could make the crossover a little easier to achieve by extending the theta range higher and narrowing the alpha range.

3.1.5   Alpha / Theta Ratio Bar Display

A simple bar graph (8 in figure 3) shows clearly when crossover has happened (or not). If alpha is dominant (ratio > 1) a yellow bar shows, to the right of centre. If theta is dominant, an orange bar shows to the left of centre.

The actual ratio is shown numerically in an adjacent display (to the right), as is the alpha dominant frequency.

3.2 Thresholds Screen

Figure 4 below shows the second window of the BioEra training application, i.e. the thresholds screen.

Figure 4 – Thresholds screen

There are five sets of controls. Each set I refer to as a threshold control. There is one threshold control for each of the EEG parameters: alpha amplitude, theta amplitude, combined (theta +alpha) amplitude, 7-8 Hz amplitude, and alpha / theta ratio.

Each of the five is identical in form, except for the last one (alpha-theta ratio) which is described separately in section 3.2.1.1 below.

3.2.1 Threshold Controls

To repeat what was said in the introduction, the main purpose of a threshold is to define the range of the EEG parameter over which feedback is given, and in the alpha-theta application this means the volume range of the soundtracks. The upper and lower levels define the limits of the volume variation (silence and full volume).

The thresholds here are much the same as the standard-form protocol threshold described in the main EEG Training User Guide. I refer you there for a fuller description.
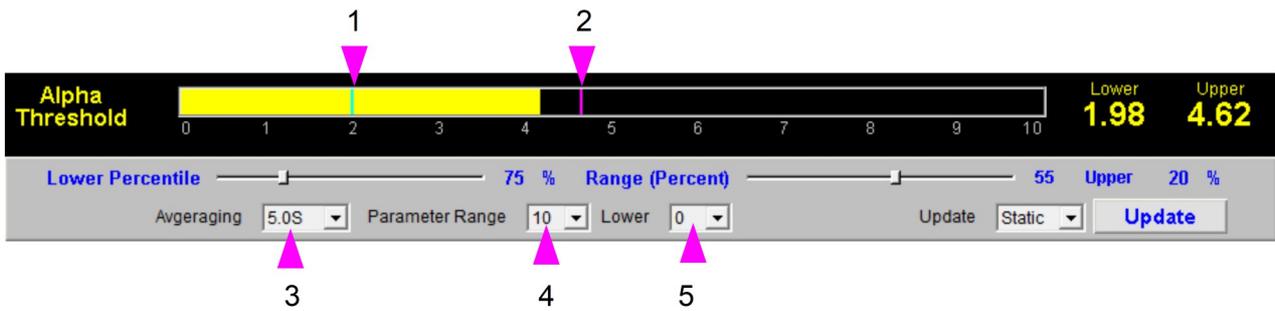
Figure 5 below shows one threshold.

Figure 5 – One of the five thresholds

The levels can be moved or updated, either automatically or "by hand" (dragging them with your mouse). Automatic updating of threshold levels using percentile ranges is described in the EEG Training User Guide.

There is a (drop-down list) control (3 in figure 5) that sets the amount of averaging or smoothing of the threshold parameter. Since the threshold output is channelled directly into the audio feedback, this setting is therefore significant for the smoothness and responsiveness of the audio feedback.

Other drop down lists (4 and 5 in figure 5) control the range or scale of the chart.

3.2.1.1 Alpha / Theta Ratio Conditional Parameter

The alpha-theta ratio threshold (shown in figure 6 below) is different, in having one extra (drop-down list) control (labelled 1 in figure 6). This sets a "conditional parameter".
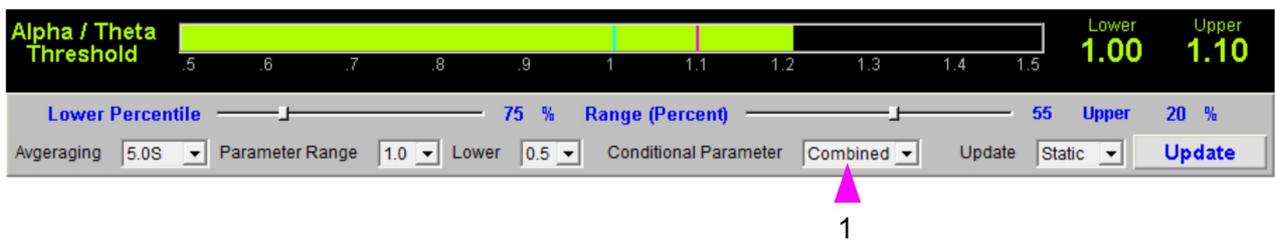

Figure 6 – Alpha-theta ratio threshold

The purpose of this relates to a point made back in section 1: there is little point in rewarding the crossover (ratio dropping below 1) if there is very little of either alpha or theta activity to begin with. The conditional parameter control allows you to stipulate that one of the other parameters must be above threshold before rewarding changes in the alpha-theta ratio. For example, you could set the conditional parameter to be the combined (alpha + theta) amplitude. Then the software will only play the reward sound for the crossover when there is sufficient combined alpha and theta activity.

When the conditional parameter is above its upper threshold, the crossover reward is "normal" or at its full level. If it is below the lower threshold, there is no reward for crossover. If it is between the two, the reward is somewhat diminished.)

Technically, the software calculates the volume of the crossover soundtrack as the product of the two threshold ratios (i.e. the alpha/theta and the conditional parameter thresholds). The concept of threshold ratio has not been mentioned here, but is mentioned in the main EEG Training User Guide.

3.3 Audio Feedback

As described in the introduction, alpha-theta training, being eyes-closed training, relies on audio feedback, and in the MBTT software it takes the form of three independent soundtracks.

The controls for these are found at the bottom of the control screen, and are shown again in figure 7 below.
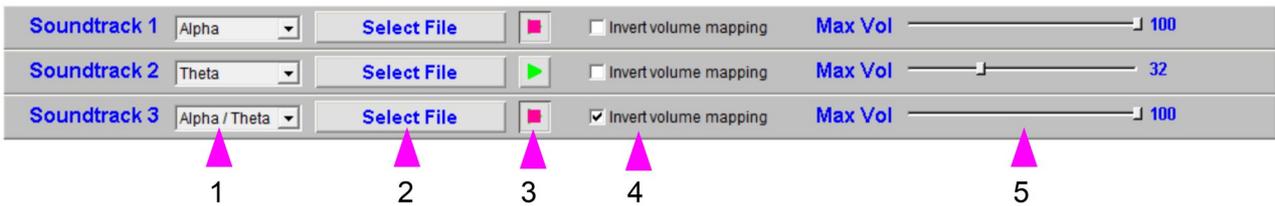

Figure 7 – Audio (soundtracks) controls

Each soundtrack has an identical set of controls, one set per box as you see in figure 7 (i.e. each box controls one soundtrack).

Each soundtrack can be turned on or off independently using a button control (3 in figure 7, where you see that two soundtracks are turned on and one is left off).

A drop-down list control (1 in figure 7) selects the EEG parameter on which to base feedback (i.e. one of the five main threshold parameters as described in section 7 above.

A button control (2 in figure 7) opens a dialog for you to select a media file to use (see section 7 below). The selection is remembered by the software for the next session you run.

A checkbox control (4 in figure 7) enables you to flip the volume mapping, so that the sound plays louder, the lower the parameter drops. Practically speaking, you'd probably want to apply this feature only for the alpha / theta ratio parameter, so that you can reward it dropping low (as in the crossover).

Each soundtrack has a relative volume slider control (5 in figure 7). These can be useful in setting the relative balance between tracks (sometimes one media file is naturally louder or quieter than another).

3.3.1   Media Files

Audio files are not included with MBTT software for reasons of copyright. You need to obtain suitable material for yourself. You can purchase this easily from online retailers such as Amazon or Apple (iTunes).

I have found that nature sounds work well with neurofeedback. For example I've used the application myself with a "dawn chorus" soundtrack for alpha feedback, then a babbling stream soundtrack for theta feedback, then a music track to reward alpha-theta crossover.

I think the best sort of music is gentle, relaxing, perhaps even bland and generic. At your favourite music retailer, search on "music for relaxation" or "music for sleep" or "music for hypnosis" or even "angel music".

You should probably only use one music track at a time, as two or more at the same time are likely to be unaesthetic, but nature soundtracks can easily be combined to pleasant effect. I suggest useful soundtracks are: flowing water, waves on a sea shore, birds singing, garden sounds, rainforest sounds. Another factor to consider is that soundtracks should ideally have relatively steady volume. In this respect waves on a sea shore may not be ideal.

The software requires audio files to be in .wav format. However, downloadable audio files are typically provided in .mp3 format, in which case you will need to convert them. Software for conversion is readily available, including some online converters (just google something like "convert mp3 to wav"). Personally I've used a freeware product called *Audacity*, which I have found very helpful, not just for conversion but for sound editing more generally. Downloaded soundtracks typically have a fade-in and fade-out at the start and end, which is unhelpful for neurofeedback. I recommend using Audacity to edit these out.

3.4 Delta Threshold

In the introduction I mentioned that deep states are distinct from dozing off to sleep. Actually it is often quite easy for the alpha-theta trainee to fall asleep, and this is not of course conducive to the success of training. In the hope of preventing this, the training application has the delta threshold. The main distinguishing feature of sleep as opposed to deep states is the level of delta activity.

The delta threshold is much simpler than the other thresholds. The chart and controls are found on the control screen (to the right of the trend display) and there is only one threshold level. See figure 8 below.
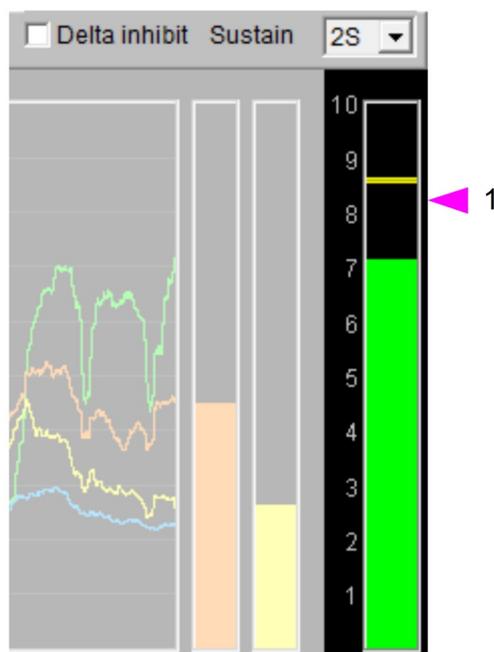

Figure 8 – Delta threshold and controls

The idea is that when delta exceeds this threshold level, the software plays a midi note to alert the trainee. The midi note repeats every 3 seconds for as long as delta exceeds the threshold level.

You can of course move the threshold level, which is labelled 1 in figure 8. The only way is to move it "by hand" (i.e. drag it with your mouse). There is little point in using percentiles because you can't know how much delta corresponds to falling asleep until it happens, and you'd rather avoid that in the first place. The only way to judge delta is by experience.

The range of the threshold bar graph is always set to be the same as the main trend display.

You can enable or disable the midi feedback using the checkbox control at the top left of figure 8 ("Delta inhibit").

The drop-down list control "Sustain" can be used to set a period of time that delta must exceed the threshold level for, before the feedback sounds.

4 Reports & Data Management

As with the standard-form protocols, MBTT software allows you to manage the data generated by training sessions over time. The report and data management functionality is almost exactly the same, for the alpha-theta application, and I again refer you to the main EEG Training User Guide. Here I will give a very brief summary and comment on the minor differences.

4.1 Reports

You can view reports for individual session, or all sessions over time for the currently selected user.

There are two types of individual session reports: html summary reports (based on a text data file written by the training application) and BioEra-viewable reports based on a .xdf session file.

The html report can track four parameters: alpha amplitude, theta amplitude, alpha theta ratio and 7-8 Hz amplitude.

The BioEra report shows the standard EEG bands – delta, theta, alpha and beta. It has at least a couple of advantages: first, you can zoom in to particular areas of the chart (by dragging your mouse over areas of interest) and second, you can show or hide individual traces such as delta.

4.2 Data Management

You can use the data management functions to delete or archive training sessions, and to email reports to other people, e.g. if you are a coach or therapist working with clients.