Skin Temperature
Software Application User Guide

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1 Introduction

This guide introduces the Skin Temperature (ST) biofeedback application, part of the Mind-Body Training Tools suite. This set of applications is designed to develop skills in mind-body awareness and self-regulation, particularly in a context of mindfulness and meditation practice.

The guide has two purposes: firstly to say something about what variation in skin temperature actually means, and secondly to teach you how to use the software – though it is more of a reference than a tutorial. Other training material is available on the StressResilientMind.co.uk website.

In brief, skin temperature changes are mediated by the Autonomic Nervous System (ANS), which is a major effector of the physiological expression of emotions. Skin temperature biofeedback offers firstly a context for learning about this aspect of the mind-body connection, and secondly a means of developing a more favourable balance between the two branches of the ANS (the sympathetic and parasympathetic nervous systems).

In keeping with others in the suite, the ST application was designed to support *your* aims, not to supplant them. Achieving high skin temperature is not necessarily the most important thing. Biofeedback should enhance or expand your subjective awareness rather than detract from it.

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

The application works with several devices. For an up to date list of supported hardware, please see the StressResilientMind.co.uk website.
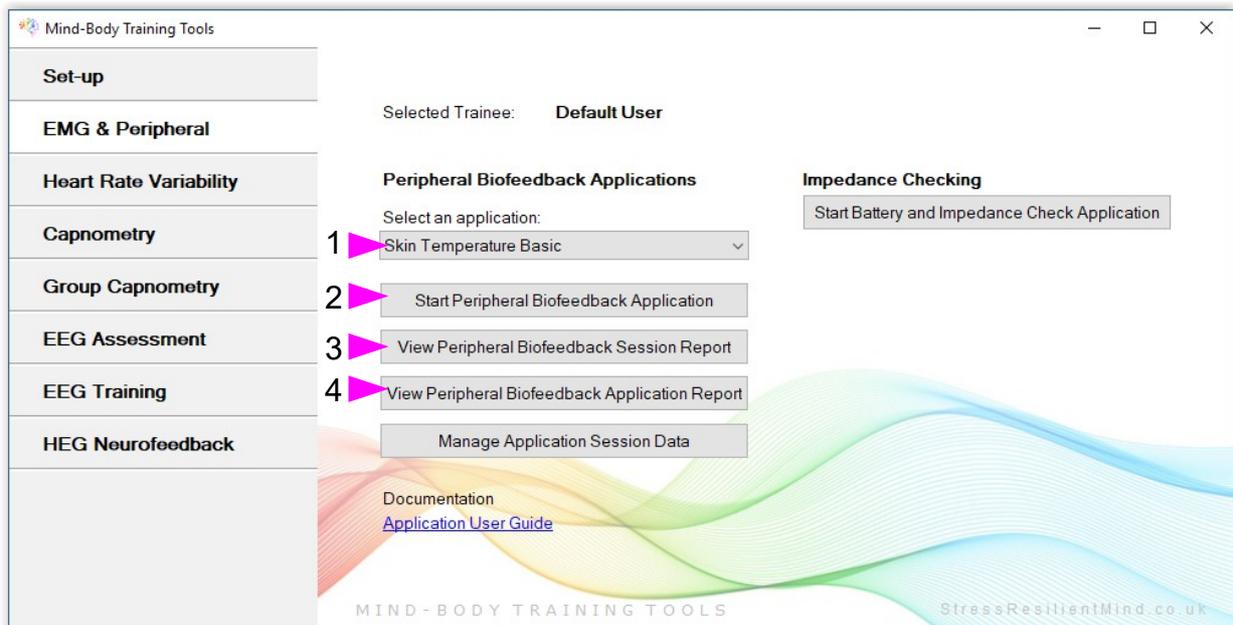
2 Launching the Application

Figure 1 – EMG & Peripheral (biofeedback) Tab of the Platform Application

Figure 1 above shows the EMG & Peripheral tab of the Platform. First you need to select the "Skin Temperature Basic" application from the drop-down list control (labelled 1). Then click the button to launch the app (labelled 2). Make sure you have your BioEra licence key (dongle) inserted into a USB socket. After a few seconds a new window will appear on your screen.

2.1 Hardware Set-up

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

Before you start the application you configure the device set-up options, accessible by clicking a button in the Set-up tab of the Platform. In the dialog, select the type of amplifier (biofeedback device) you are using, in the **skin temperature source control**. Note, all the source settings are remembered the next time you start the Platform.

Figure 2 – Amplifier status

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

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

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

3 About Skin Temperature Biofeedback

Skin temperature biofeedback has a long history of use in relaxation training, and a considerable body of experimental evidence supporting its efficacy. This section explains how skin temperature relates to relaxation.

3.1 The Physiological Basis of Skin Temperature Biofeedback

The standard location for the sensor in skin temperature biofeedback is one of the fingers. Temperature changes here are mediated by changes in blood flow. An increased volume of warm blood flowing in the peripheral vessels warms the skin tissue. Peripheral blood flow is in turn controlled by the Autonomic Nervous System (ANS).

3.1.1 The Autonomic Nervous System

The ANS is a part of the nervous system that governs many of our automatic and visceral responses. It has two branches, known as the sympathetic and parasympathetic nervous systems. These have opposite effects on the body, rather like the accelerator and brake in a car. The sympathetic increases the body's arousal level (it's the accelerator) while the parasympathetic lowers arousal (it's the brake). Some examples of effects of sympathetic arousal include increased heart rate and blood pressure, increased blood sugar levels, and a directing of the blood more towards the muscles. It's preparing the body for action – it's associated with the so-called "fight or flight" or stress response. Conversely the parasympathetic NS has effects such as lowering heart rate, blood pressure and blood sugar, and diverting blood more towards the digestive organs (it's known as the "rest and digest" response).

Many of our blood vessels have tiny muscles in their walls, which are under the control of the sympathetic NS. It is by contracting these muscles that the sympathetic NS is able to raise blood pressure and alter the pattern of blood flow.

3.1.2 Influences on the ANS

The question now is, what causes the ANS to activate either the sympathetic or the parasympathetic nervous systems?

The major influences of interest are emotions. The sympathetic or "fight or flight" response happens when we feel stressed – anxious, frustrated or angry. The parasympathetic response is an aspect of more positive emotion. We could sum it up as the relaxation response, which is of course what we are attempting to train in skin temperature biofeedback.

Another influence is body temperature regulation. The body needs to keep its temperature stable, and regulating peripheral blood flow via the ANS is a means of achieving this. For example if you go into a hot room, the body can increase its rate of heat loss by directing blood towards the surface of the skin. However we're not really interested in this. In fact, for skin temperature biofeedback we need a stable and ambient environment, so that we can assume that the temperature changes are indeed a reflection of emotional influences.

It's worth mentioning that draughts of air over the sensor can also cause changes in the feedback, and since they are nothing to do with relaxation they will invalidate the feedback as a means of learning to relax. So for skin temperature biofeedback you need to find a room with a stable and ambient temperature and without any draughts.

3.2 Rate of Change of Temperature

The temperature itself is of little value since we can't infer much about the state of the ANS. Rather, it is *changes* in temperature that count. If skin temperature falls, it is reasonable to infer that the there was a sympathetic response, and similarly if the temperature is rising we can infer that the parasympathetic is dominant. For this reason it is useful to calculate the *rate of change of temperature*. Much of the feedback in the application is actually based on this calculation – for example see section 4.3 below.

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

A zero rate of change means that the temperature is stable or unchanging, and that the ANS is maintaining a balance. This state doesn't tend to last very long!

When the sympathetic NS is activated, the rate of change is less than zero, or negative. (The temperature is falling.) The greater the magnitude of the rate of change, the stronger the activation.

When the parasympathetic is dominant, the rate of change is above zero (the temperature is increasing).

4 User Interface

This section explains the charts and controls of the application's user interface, and how to configure the feedback. Figure 3 below shows the application's window.

You can select either Celcius or Fahrenheit as the unit of temperature, using the drop-down list control labelled 1 in figure 4. This control affects *all the displays in the interface*.
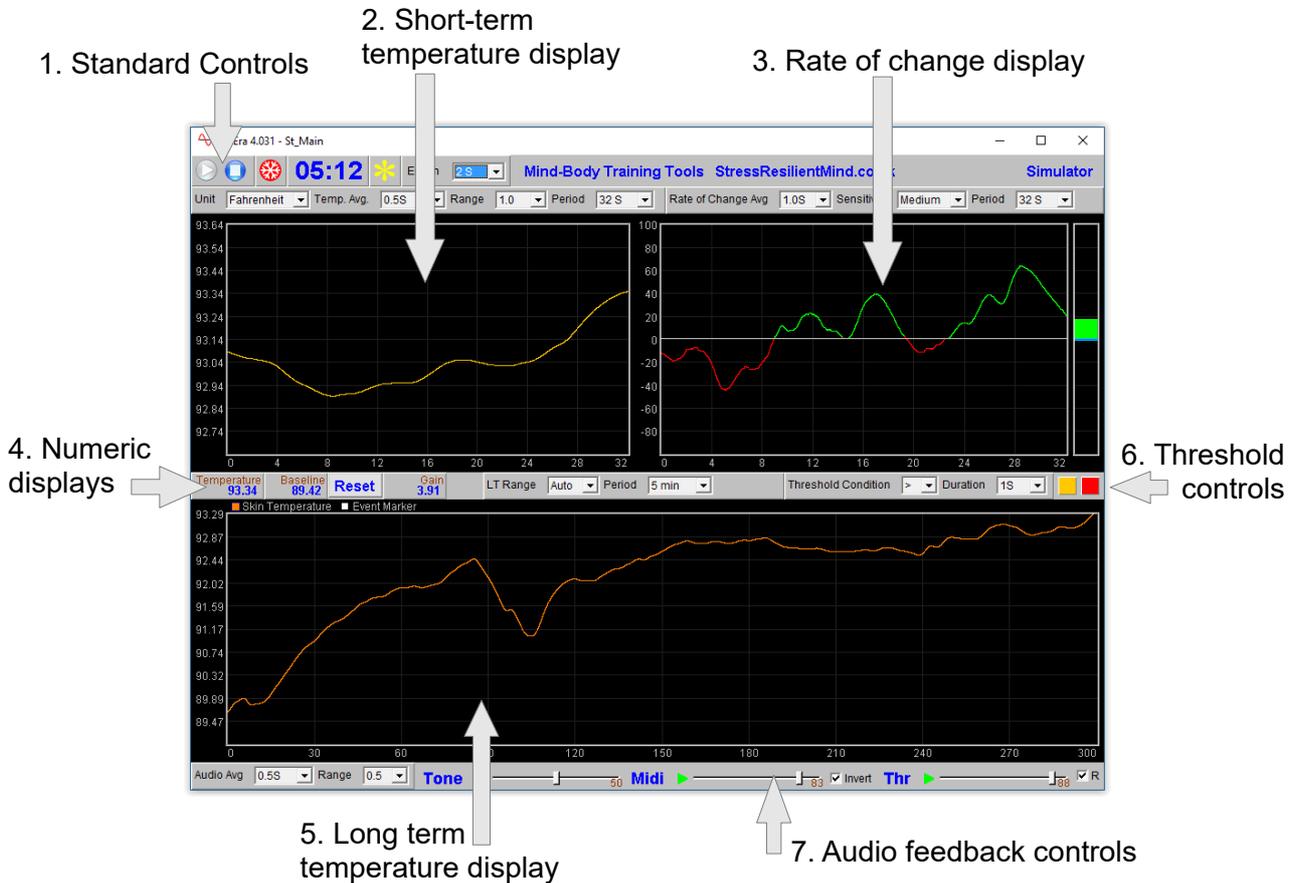

Figure 3 – User interface

4.1 Standard Controls (Start / Stop, etc.)

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

The 'Epoch' control sets the time period at which data is written to the session data file. This data file is used to generate session reports, which are described in section 5 below. Choosing a lower time period generates more data. For example, if you select 2 seconds, then the application will write the temperature to the session data file once every two seconds.

The button marked with a red asterisk is a simple event marker. You can use it to mark adventitious happenings and changes in session conditions (e.g. you turn on or off breath pacing). It is particularly useful for coaches and therapists. Events thus marked are represented in the long term chart (see section 4.5 below) by a vertical white line. They are also recorded in the session data file and are shown in session report charts (as dotted vertical lines) (see section 5).

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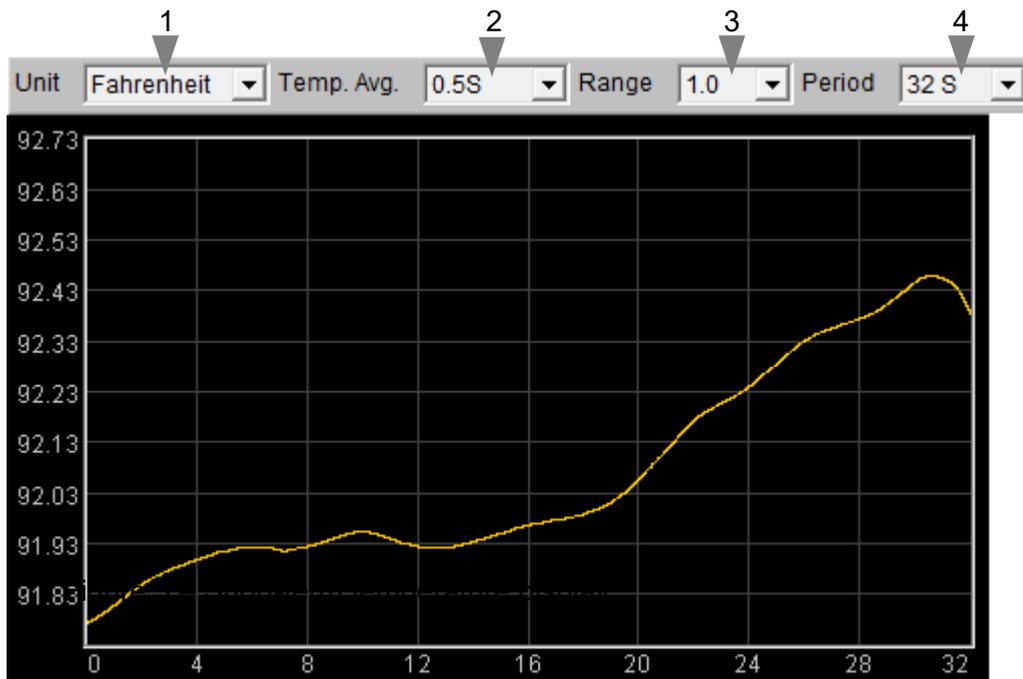
4.2 Short-term Temperature Display

Figure 4 – Short-term temperature display

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

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

Unit
Select either Fahrenheit or Celcius as the unit of temperature. This applies to all the displays, not just the short-term temperature chart.

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

I suggest a setting of 0.5 seconds will be adequate for most users.

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

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

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

Period
This controls the length of time it takes for the traces to traverse the whole chart from right to left – or in other words the horizontal range. Note that *increasing* the period after processing has started can have unpredictable consequences, so I recommend you make your selection before pressing play.

4.3 Rate of Change Display

Figure 5 – Rate of change of temperature display

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

Since the goal of training is to increase or at least maintain the temperature, you should aim to keep this graph "in the green" as much as possible.

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

These charts also show the threshold level (blue bar and blue dotted line). See section 4.6 below for more details.

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

Rate of Change Avg	Controls the level of smoothing of the signal. With a shorter average you will see all the fine-grained changes. With a longer average these are smoothed out, but the signal will be slower in responding to change.
	I suggest a setting of 1.0 seconds as a starting point.
Sensitivity	Controls the vertical scale or range of the display. With a higher sensitivity setting, the range will be smaller, so changes will appear more prominently.
	The zero line is always fixed in the centre of the chart.
	If the trace tends to disappear off the top or bottom of the chart, choose a lower

sensitivity. Conversely if the trace is bunched tightly around the zero line, choose a higher sensitivity.

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

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

4.4 Numeric Displays

The numeric displays show the following data:

Temperature   Current temperature

Baseline   The temperature at the beginning of the session, or more accurately 30 seconds into the session (to allow a settling period).

You may reset the baseline to the current temperature at any time, by pressing the 'Reset' button.

Gain   Current temperature minus the baseline. This allows you to assess the overall change achieved in your session.

4.5 Long-term Display

Figure 6 – Long-term temperature display

The long-term display (figure 6) shows the variation of temperature over a longer time scale (up to 30 minutes). The two drop-down lists (1 and 2 in figure 6) control the horizontal and vertical ranges.

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

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

are constantly changing.

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

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

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

4.6 Threshold Display and Controls

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

(Controls for threshold-based audio feedback are covered in section 4.7 below.)

There is a single threshold in the skin temperature application, shown in figure 7 below. It offers just two conditions, "above" and "below", so is simpler than most other applications.
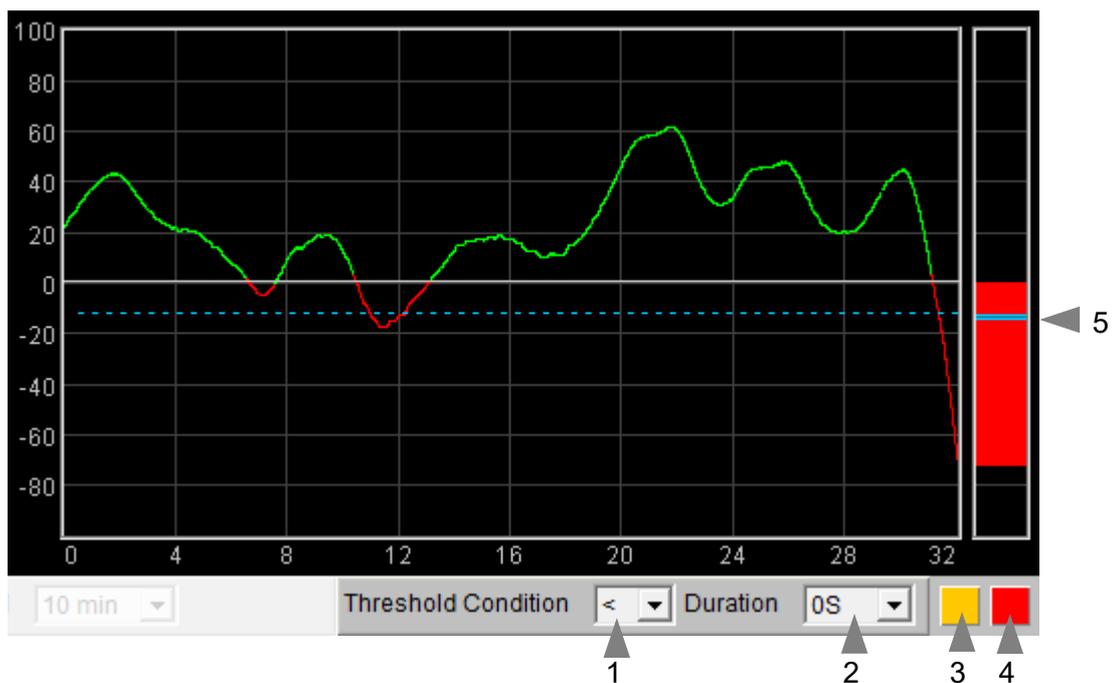

Figure 7 – Threshold display and controls

The range of the threshold's bar graph is controlled by the "sensitivity" drop-down list control which sets the range of the rate of change display, described in section 4.3 above. In other words, the bar graph and the rate of change display, being adjacent to each other, will always be matched in terms of range.

There is a duration control available for this threshold (see the Guide to Audio and Threshold-based Feedback).

4.7 Audio Feedback

Again, please read the Guide to Audio and Threshold-based Feedback to gain a fuller understanding of the audio feedback controls, which are shown in figure 8 below.
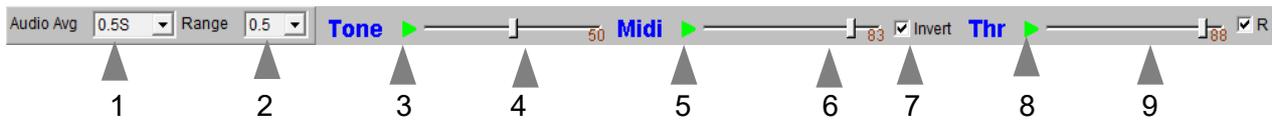

Figure 8 – Audio feedback controls

In the skin temperature application three forms of audio feedback are available: simple tone, midi, and threshold. For the most part audio feedback works as it does in other applications, but there are some features particular to this application:

- Audio feedback has it's own averaging control, distinct from the application's main average (but working in the same way), and labelled 1 in figure 8.

- Tone and midi feedback have their own range control (shown as 2 in figure 8) distinct from the range controls for the short-term and long-term displays.

- Both tone and midi feedback have an "auto-centre" feature, meaning that when the change in temperature is sufficiently large to take the pitch outside of its range, the pitch is reset to the middle of the range, in effect recalibrating the feedback.

- There is an additional control, a check-box labelled "Invert", 9 in figure 8 above, which flips the mapping for both tone and midi feedback such that when the temperature signal rises, the pitch falls (deepens). This may be preferable for some users, because a deeper pitch is more aesthetically pleasing, so a greater degree of relaxation should produce a deeper pitch.

- The threshold has a "duration" control, already mentioned in section 4.5 above, and in consequence there are two lamps, the left lights up (amber) on the initial threshold-cross, while the right lights up (red) only after the "duration" period.

5 Session Reports

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

Note that the temperature data in the session data file is averaged according to the setting of the short-term temperature display (control 2 in figure 4) and is in either Fahrenheit or Celcius, according to your setting in the application (control 1 in figure 4).

To generate and open a session report, click the button labelled 3 in figure 1. A dialog window opens in which you can select various options (see figure 9 below).

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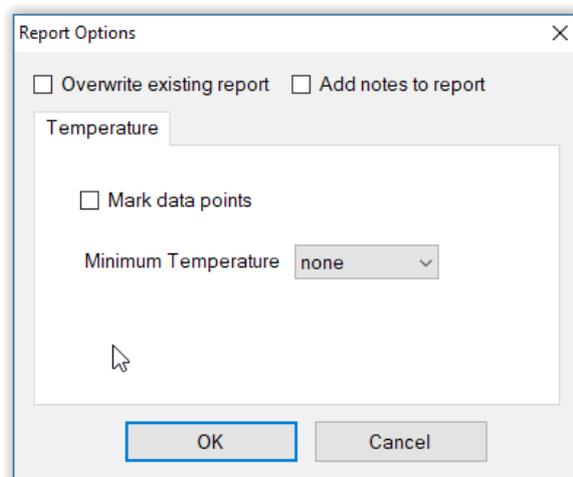

Figure 9 – Report options

5.1 Report Options

Most of the options should be self-explanatory.

If you change your mind about options on seeing your report, you can regenerate the report by clicking the report button (3 in figure 1), then checking 'Overwrite existing report' (top left in the dialog).

Setting a minimum temperature is a basic way of excluding "artefacts", for example if you moved during the session, so that the flow of air over the sensor caused cooling. Data points falling below the minimum value are excluded.

5.2 Adding Notes to a Report

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

You may wish to add notes after having first seen the report. In this case, simply click the button (3 in figure 1) again, and check the Add notes option. This will regenerate the report with your added notes.

5.3 Sample Session Report

Training Session Report

Training Application	Skin Temperature
User Name	Default User
Session Date	31/03/12 14:44
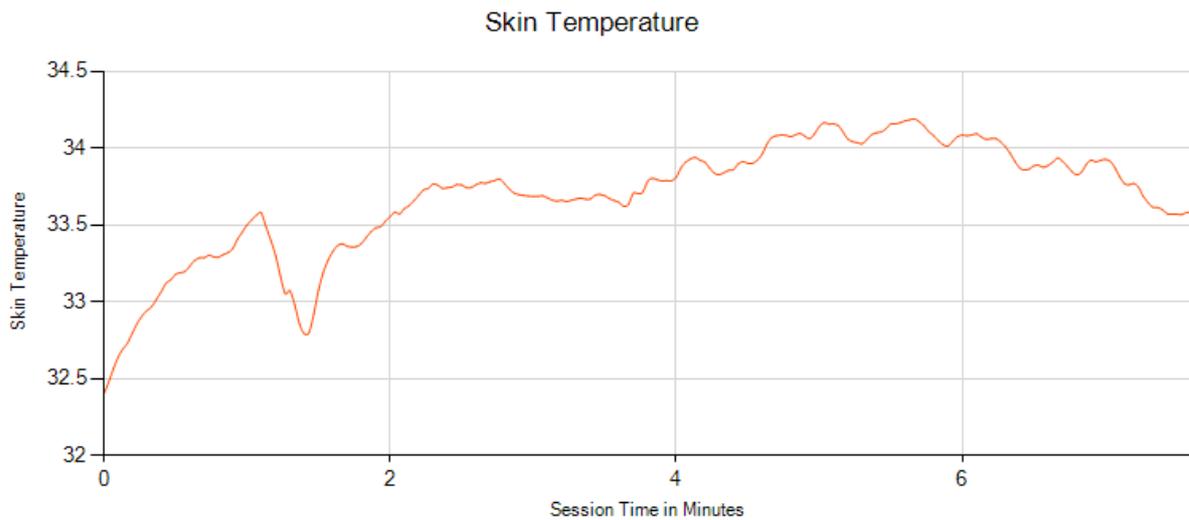
Skin Temperature Summary Data

Parameter	Value
Starting Temperature	32.4
End Temperature	33.6
Max Temperature	34.2
Net Temperature Gain	1.2

6 Application Report

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

To generate and open an application report, click the button labelled 4 in figure 1. A dialog window opens in which you can select various options (see figure 10).

As with session reports, the software creates the application report in html format. It will be opened using your computer's default web browser, e.g. Google Chrome. (Note that a live internet connection is not needed.) The html file is saved, so you can for example email it to someone. See the Installation and Set-up Guide for details of file storage.
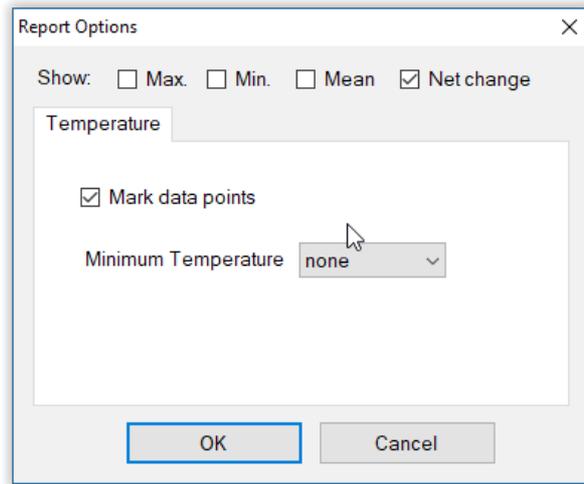
Figure 10 – Report options

6.1 Report Options

The application report options dialog is an adapted version of the session report options dialog. Many of the options are the same, and should be self-explanatory. See section 5.1 above.

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