Biofeedback via Skin Temperature Measurement

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Characteristics of the Signal:

The temperature at the surface of the skin changes accordingly to the circulation of blood through body tissue. The arterioles which cross through the tissue, are surrounded by fibres of smooth muscles and are controlled by the sympathetic nervous system.
During a state of increased exertion, exitement and stress, the muscles are forced to contract, causing a stenosis of vasculature. This leads to a reduction of skin temperature, since the blood circulation of the tissue is reduced.
Fluctuations in temperature are rather dull, therefore the skin temperature is suitable for observing long-term processes.

Conduction Technique:

With the help of a very sensitive thermal sensor the skin temperature is measured in direct contact to the surface of the skin. The skin temperature is measured in degree Celsius and displayed accurately with 2 digits after decimal point.

Suitable areas of conduction represent the fingers or the forearm.

A rubber band, hook-and-loop fastener, or a simple glue strip are used for the application of the sensor. It is important that the sensor is in stable and confirmed contact to the surface of the skin.

The recorded, measured values also depend on the temperature of the surrounding environment, therefore it is wise to measure under constant conditions. The user should take approx. 5 minutes for acclimation to the surrounding temperature, so that his organism can get used to the room temperature.

Possible Areas of Application:

The skin temperature feedback is almost solely used for relaxation purposes. It is easy to apply and easy to learn. Thereby a high rate of success and enhancement of overall well-being is achieved.

An especially effective and commonly used method of training is the „training of hand- warming“, as the most simple form of biofeedback. A sensor is attached to a finger (index-finger or middle-finger). This training is recommended for users who often have cold hands and feet.

The training of hand-warming is also used for specific disturbances such as migrem, hypertension and circulatory disorders.

The Training of Hand-warming:

During the training of hand-warming the user receives a feedback of the temperature in his fingers. Thereby, he can raise the temperature selectively, to increase the blood circulation in his hands.
Autogenic training also knows a similar type of training the so called „warmth-exercise“.

After a phase of acclimation the temperature can rise up to 3,5° C due to the hand-warming training.

The objective of a hand-warming training lies in the aim to control one's own skin temperature and thereby also gain control over the blood circulation of external extremities. The user is supposed to learn to estimate the skin temperature correctly.

The biosensors of our hands convey an imprecise sense of the skin temperature and merely allow a differentiation between hot, warm, cool and cold. The precise feedback of an accurate temperature sensor gives the user much more sophisticated information about the momentary temperature and thus the blood circulation.

In the event of mental exposure and stress the sympathetic nervous system has a high level of agitation which causes a reduction of the temperature in our fingers and a reduction of blood circulation. Evolutionary this is quite reasonable because tension and excitement originally served as a means of preparation for an attack or escape. Thereby a lot of blood circulates in the working musculature, generated through the stenosis of vasculature in the hands, feet and the forearm.

Execution of the Hand-warming Training:
(A user and an instructor are required)

1. Establish favorable surrounding conditions

- a quiet room (turn off cell phone and phone)
- comfortable room temperature of about 20-22 ℃
- suitable seating possibility
- comfortable clothing

2. Attaching the sensor

The sensor is attached to a finger via rubber band, tape or hook-and-loop fastener. The exact location is irrelevant but it is important to always chose the same location in order to maintain comparability of measured values.

3. Selection of feedback

As a form of feedback both an optical and an acoustic signal are recommended. The advantage of an acoustic signal is that is can be realized with closed eyes. Many users like closing their eyes out of relaxation purposes.

A visual feedback is given by an animation which is portrayed on a monitor. For example, a sunrise can be animated and adapted to the augmentation of the skin temperature. An increasing skin temperature thus makes the sun rise on the monitor.

In addition to that, display of a thermometer is suitable revealing the current temperature in absolut digits.

4. The First Phase during Training (with instructor)

In comparison to other forms of biofeedback training, remarkable results can be made in a short period of time. Often, 6 to 10 sessions are enough. The length of a single session always depends on the user's ability to concentrate, but should not exceed a range of 15 minutes. If the user suffers from strong cerebral fatigue, it is recommended to rather increase the amount of training sessions and at the same time reduce the length of each session.

4.1 Recording a Baseline:

Each training sessions starts with a 5 minute baseline measurement. During this part of the session the user is not yet provided with a feedback of his skin temperature which is only accessable to the instructor. The baseline serves as a mechanism for adaptation of the temperature sensor to the temperature in the fingers. The user is not yet supposed to relax, but to simply sit still and upright. At the point where the temperature of the sensor arrives at a stable point the actual training starts.

4.2 Relaxing for 10 Minutes

Now the user tries to relax for 10 minutes but still is neglected a feedback. The instructor observes and tests if the user can already increase his skin temperature during the relaxation period without gaining a feedback. The user then reports if he was able to relax and estimates the change of his skin temperature.

4.3 Observing the Feedback

Now the user is supplied with an optic and an acoustical feedback for the first time in order for him to get used to the process. He should only observe his skin temperature and then he can try to influence his temperature willingly in some sort of way. For this „Try out training" a time limit is not to be included.

4.4 Ending the First Session and Homework

The first session is now over. As a homework for the next session the user should consider his skin temperature several times per day. He can also create a protocoll in which he writes down notes about wether his hands feel cold or warm during different activities throughout the day.

5. The Second Phase During Training

5.1 Targeted Relaxtion

After the homework has been discussed and evaluated the user is able to see a temperature signal and how it looks during a stressed as well as a relaxed state. Then another baseline is recorded for 5 minutes and the user should try to relax in order to raise his skin temperature. The strategy he choses to accomplish this is up to him.
If the user does not succeed within 5 minutes he can be supported. He can imagine lying in the sun or in the sauna, or putting his hands in warm water etc. But there are also acoustic suggestions to be made. The user is supposed to say words like: „ My right hand is warm"; „My left hand is warm", etc.

5.2 Ending the Session an Homework

The user should now try to repeat whatever method was successful in raising his skin temperature. He is supposed to do this twice daily until the next session. Of course he does not have a feedback while practicing at home. He should rather observe if his hands feel warmer after a certain period of time. Regular training is the key to success.

When the second phase of training was successful (there can be several sessions during this phase) and the homework also has the desired outcome, the third phase of training can begin.

5. The Third Phase of Training

6.1 Relaxation without any Feedback

Up to now the user should have learned to raise his skin temperature to 31-35 °C. Now it is tested if this can also be acc omplished without any feedback. During the course of the session (don't forget the baseline) phases with and without feedback (approx. 2 minutes) are alternated. You first start without any feedback and the instructor later turnst he feedback on.

The more a user can constantly keep his skin temperature above 30 °C the less feedback he should obtain. 36° C are def inetely possible.

6.2 Ending the Session and Homework

Also during this phase the user receives the homework to repeat the training twice daily.

When the user is able to constantly raise his skin temperature without any feedback during the third phase and maintain a high training level, he can progress to the fourth and last phase of training.

7. The Fourth Phase of Training

7.1 Relaxation and Stress Recovery

After the regular baseline the user should raise his skin temperature and keep it at a high level (considerabely over 30 ℃). Now a phase of stress induction is commenced. The instructor confronts the user with problems creates a hectic environment, or thinks of another situation of mental stress for the user. The individual limits of the user should not be exceeded. After a certain period of stress, a recovery phase of atleast three minutes is required, before the next stress phase can begin.

The user should learn to maintain a high level of training even when he is confronted with different scenarios of stress. During phases of imposition the user should obtain feedback of his skin temperature. During the phases of relaxation, feedback is not provided.

If the user successfully maintains a high skin temperature, even during phases of pressure and stress he has reached the goal of the hand-warming training.

Chart-Overview of the Phases of Training

Phase	**Account**
1. Observing and experimenting	Record a baseline, Relaxation without feedback, first confrontation with feedback, observation only, homework
2. Targeted Relaxation	Record a baseline, specific relaxation with feedback, homework
3. Relaxation also without feedback	Record a baseline, targeted relaxation with and without feedback (transfer of learning), homework
4. Relaxation and stress recovery	Record a baseline, targeted relaxation without feedback, create situations of pressure without feedback.