Biofeedback and Neurofeedback

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President
Thought Technology Ltd
**What is biofeedback & neurofeedback?**

- **Biofeedback** refers to therapies that monitor and display an individual’s physiological activity to treat symptoms and improve performance.
- Biofeedback and neurofeedback are evidence-based approaches to enhancing personal awareness and control over body and mind.
- Neurofeedback is a subset of biofeedback in which brainwave (EEG) activity is monitored.
What is biofeedback/neurofeedback?

<table>
<thead>
<tr>
<th>Biofeedback Modality</th>
<th>Source</th>
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<tbody>
<tr>
<td>Electrodermal (EDR)</td>
<td>Eccrine sweat glands</td>
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<tr>
<td>Electroencephalographic (EEG)</td>
<td>Cortical action potentials</td>
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<tr>
<td>Electromyographic (EMG)</td>
<td>Skeletal muscle depolarization</td>
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<tr>
<td>Heart rate variability (HRV)</td>
<td>Variability in the interbeat interval</td>
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<tr>
<td>Photoplethysmographic (PPG)</td>
<td>Peripheral blood flow</td>
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<tr>
<td>Respiratory (RESP)</td>
<td>Abdominal and chest movement</td>
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<tr>
<td>Temperature (TEMP)</td>
<td>Peripheral blood flow</td>
</tr>
<tr>
<td>Non-physiologic Sensors:</td>
<td>Force, angle, sound level, etc</td>
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</table>
An electrodermograph monitors eccrine sweat gland activity detected by sensors placed on the fingers or palm – measured as skin conductance.
In *skin conductance*, an electrodermograph imposes an imperceptible current across the skin and measures how easily it travels through the skin.

When anxiety raises the level of sweat in a sweat duct, conductance increases. Skin conductance is measured in microsiemens (millionths of a Siemen).
In 1974, I designed the GSR1 and later in 1976 as part of Thought Technology, the GSR2 – the first truly portable skin conductance biofeedback devices.
An *electroencephalograph* uses precious metal electrodes to detect a voltage between at least two electrodes located on the scalp.
Electroencephalographic biofeedback

*EEG biofeedback*, which is also called *neurofeedback*, monitors both slow and fast cortical potentials.

The goal of training is to normalize or enhance each patient’s EEG pattern during specific activities.

Training may up-train specific frequency bands and down-train others.
Neurotherapists use EEG biofeedback when treating:

- addiction
- attention deficit hyperactivity disorder (ADHD)
- learning disability
- migraine
- tonic-clonic seizures

1 Gilbert & Moss, 2003
2 Yucha & Gilbert, 2004
The electromyograph (EMG) uses surface electrodes to detect muscle action potentials from underlying skeletal muscles.

Two to three precious metal electrodes, designated *active* and *reference*, are needed to measure the EMG signal.
Clinicians place 3 electrode over a target muscle.
The EMG signal is measured in microvolts (millionths of a volt).
The goal of training may be to reduce or increase surface EMG (SEMG) activity, or to restore left-right symmetry during static postures and movement.
Electromyographic biofeedback

Biofeedback therapists use EMG biofeedback when treating:

- chronic pain
- bruxism
- essential hypertension
- headache (migraine and tension)
- paralysis or muscle weakness (stroke or injury)
- temporomandibular joint dysfunction

1 Gilbert & Moss, 2003
2 Yucha & Gilbert, 2004
Both the *electrocardiograph* and the *photoplethysmograph* monitor the interbeat interval between adjacent R-waves to measure heart rate & heart rate variability (HRV). Users learn to control HR & parameters of HRV.
The goal of training is to increase heart rate variability as measured by SDNN, pNN50, and HR Max – HR Min, and to increase signal power in the low-frequency range of the EKG.
Biofeedback therapists use heart rate variability biofeedback to treat:

- anxiety
- asthma
- hypertension
- unexplained abdominal pain \(^1,^2\)

\(^1\) Gilbert & Moss, 2003
\(^2\) Yucha & Gilbert, 2004
Respiratory biofeedback

A sensor responsive to stretching uses a flexible sensor band that is placed around the chest, abdomen, or both to monitor breathing mechanics, and respiration amplitude and rate.
Respiratory biofeedback

The goals of respiratory biofeedback are to correct dysfunctional breathing patterns and behaviors, and to learn to breathe abdominally from 5-7 breaths per minute.

EZ-Air is a free breathing training program available for PC’s at www.bfe.org
A *feedback thermometer* detects skin temperature with a thermistor (temperature-sensitive resistor) that is usually attached to a finger or toe.
Increased sympathetic activation associated with anxiety and hyper-vigilance can produce vasoconstriction and hand-cooling.

In temperature biofeedback, a patient watches temperature displays with at least one-tenth of a degree resolution that are updated every few seconds.
How does biofeedback work?

Whenever we provide a human being with feedback about a biological process, that information enables the individual to:

- increase awareness of the process
- gain conscious control of the process
### Conditions

<table>
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<tbody>
<tr>
<td>Anxiety</td>
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<tr>
<td>ADHD</td>
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<tr>
<td>Headache - Adult</td>
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<tr>
<td>Hypertension</td>
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<tr>
<td>Temporomandibular disorders (TMD)</td>
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<tr>
<td>Urinary incontinence</td>
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</table>
Pelvic Floor SEMG biofeedback is effective in 70-85% of patients with stable physiology, who have Stress or Urge Incontinence.
Anxiety

Five Main Categories of Anxiety Disorders:

- Phobia
- Panic Disorder
- Generalized Anxiety Disorder
- Stress Disorders (Posttraumatic Stress Disorder and Acute Stress Disorder)
- Obsessive-Compulsive Disorder

Excessive anxiety and worry are core features of Generalized Anxiety Disorder.
3-10 percent of school-age children, are diagnosed with Attention Deficit Hyperactivity Disorder (ADHD).

From 15-70% of diagnosed children receive stimulant medication.

While CNS stimulants generally improve ADHD symptoms clinicians have been concerned about stimulants’ long-term effects on developing brains.
Neurophysiological research reports electrical *under-activity* over frontal and central areas of the cortex in the majority of individuals with ADHD.

Neurofeedback treatment protocols have developed as strategies to retrain and normalize brain function in children and adults with this abnormal cortical pattern.
About 75% of the studied patients improved. Neurofeedback appears to be superior to no treatment and comparable to stimulant medication. Patients require at least 20 sessions, and as many as 50 sessions, to produce clinical improvement.
ADHD
Almost 60% of American adults can be classified with prehypertension or hypertension.

The treatments that produced the greatest blood pressure reductions were ranked as follows:

- stress management
- SEMG biofeedback
- temperature biofeedback
## Exciting new biofeedback applications

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<td>Constraint-induced rehabilitation for stroke</td>
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<tr>
<td>EEG biofeedback for Asperger’s syndrome</td>
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<tr>
<td>EEG biofeedback for traumatic brain injury</td>
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<tr>
<td>fMRI biofeedback for chronic pain</td>
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<tr>
<td>Slow cortical potential biofeedback for migraine</td>
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Biofeedback and neurofeedback are promising evidence-based therapies. Biofeedback and neurofeedback protocols have been rigorously evaluated and many have demonstrated clinical efficacy with a small side-effect profile.
Non-Medical Applications of Biofeedback

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<td>Sports</td>
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<tr>
<td>Multimedia Presentations</td>
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<tr>
<td>Games</td>
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<tr>
<td>Peak Performance</td>
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<tr>
<td>Ergonomics</td>
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Many individual athletes and teams use biofeedback/neurofeedback to:

- Train themselves to visualize specific actions in their sport, while at the same time controlling key physiological parameters indicating ideal activity, or
- Monitor themselves while performing the sport (ex. Golf, archery, biathlon) & control their physiology during the activity
TUTTI I SEGRETI DI MILAN LAB

Preparazione personalizzata, prevenzione degli infortuni, supporto psicologico: tutto monitorato e computerizzato. Qui nasce il calciatore del Duemilano. E qui, per la prima volta, hanno aperto lo porto...

CALCIO E SCIENZA A MILANELLO

Si analizza lo stato psicologico dell’atleta con l’aiuto della Mindroom, la “stanza della mente” che consente ai calciatori di combattere lo stress.
Biofeedback and neurofeedback continue to be used in creative and artistic ways:

- Monitoring actors while interacting with the audience (Jeremy, Jordan and Mitchel’s project)
- Performing music
  - Steve Mann’s Deconcert to create Brain music from 30 subjects
  - The use in musical instruments to affect quality of sound
Jeremy and colleagues (Mitchell and Jordan) are monitoring an actor using Bluetooth telemetry during a one-woman show.

- The audience can see physiological changes through a variety of lights, sounds and graphics.
Brain Music - DeConcert

- Steve Mann hooked up 30 people to EEG to produce a ‘brain concert’, called DeConcert
Games

- Games can be controlled by physiology, or used as feedback for training – ex. BioGraph Infiniti
What is the Ideal Multimedia Experience?

- The immersion of one’s senses into a computerized environment
- The better the multimedia content and presentation, and of course the hardware, the less one is aware of the virtual world
- The end result is total immersion into the rapidly developing world of virtual reality.
“...Using Virtual Reality, airplane phobics, for example, put on a set of special glasses with headphones that generate the three dimensional experience of actually being in a plane, going down the runway, taking off, cruising through turbulence, and landing, all while receiving biofeedback information”
Thought Technology
Hardware & Software

ProComp
INFINITI
Features

High Sampling Rates
- 2 channels of 2048 samples/sec
- 6 channels of 256 samples/sec

2 channels of raw SEMG
Up to 8 channels of EEG
Automatic sensor recognition
Features

- USB connection for secure data monitoring
- Bluetooth wireless CF
- Internal user activated re-calibration
- Ability to save data directly to Compact Flash memory card for real life assessments
- Integrated impedance checking
Features:

High Sampling Rates
- 2 channels of 2048 samples/sec
- 3 channels of 256 samples/sec

2 channels of raw SEMG
Up to 5 channels of EEG
Automatic sensor recognition
ProComp 2™ is a compact, powerful, 2 channel version of ProComp Infiniti encoder with:

• 13 bit resolution
• 256 samples/second or 32 samples/sec on each input.
• One built-in EEG sensor - requires only an electrode lead for EEG monitoring and biofeedback.
ProComp2 can be easily worn on a head band or shirt collar.

Connects to a PC through a light-weight fiber-optic cable.

Can use any two ProComp sensors (EEG, EKG, EMG, SC, Temp, BVP, Respiration, Force, Goniometry, Voltage & more)
GSR2
Home Trainer

The GSR2 is the world’s best selling biofeedback instrument with over 500,000 GSR2’s unitas sold since 1976.

It provides proportional tone pitch feedback to changes in stress levels.

It can also be used with a temperature sensor to teach hand and foot warming.
BioGraph® Infiniti Software Platform

Thought Technology’s BioGraph Infiniti™ software platform has been carefully designed to meet current and future needs for biofeedback and psychophysiology:

1. Flexibility
2. Reliability
3. Modular Design
   - A selection of specialized Application Suites
   - Powerful Application Developer Tools
Choose up to 5 Screens...
and Switch Between them During a Session

Allowing you to train clients on progressively challenging tasks
Multimedia Biofeedback

Exciting Threshold
Dependant Fractals and Animations
Immediate and Discrete Feedback

Delivers physiological feedback in many creative ways with engaging animations
Create a Symphony of the Brain

Listen to Midi-Splitter sound feedback where different brain waves individually control different musical instruments.

Keep all three instruments playing!
Combine and Synchronize Live Video and Feedback

View posture or performance of any activity, such as muscle reactions in real time - or post-session.
A modified "histogram" instrument allows you to plot 1 to 8 epoch statistics on a real-time trend graph. The graph instrument can show lines or bars and the epoch duration can be modified on the fly. The same instrument can be used in review mode for a quick assessment.
Multi-Condition DVD Feedback

The DVD feedback instrument allows users to control up to 4 independent playback actions from feedback conditions. Actions include Playback ON/OFF, Sound Low/High, Image Zoom In/Out and Image Size Grow/Shrink. The instrument also allows the user to click DVD menu items and select different DVD chapters while recording.
Auto-scaling and auto-offset functions are implemented on display instruments. Several choices of auto and manual thresholding are available.
Demonstrate a Client’s Learning Curve from Session to Session

Your client’s progress can be validated with printed session statistics and trend reports for both open and scripted sessions to enhance case management, as well as to facilitate reimbursement.
Integrated Impedance Checking

Enhance the quality of your EEG recordings with high quality, low impedance electrode connections to your clients.
Application Developers Tools

For Expert Users: The Application Developer Tools allow you to develop your own feedback, review screens, and scripted sessions with:

- Channel Editor
- Screen Editor
- Script Editor
Instantly Edit Screens

Simply click “Edit Screen” while running a client session, to change any screen setting.
Change Virtual Channel Settings on the Fly

Simply press ‘Pause’ during a session to modify any parameter, such as smoothing, bandpass, statistical thresholds, etc.
Connect BioGraph Infiniti Instruments to External Programs, such as Flash-based games

BioGraph Infiniti includes a control instrument which provides information on:
• Threshold levels (above/below)
• Signal levels
• Boolean values