EmoGraphy Skin Conductance Developments in ambulatory hardware and software

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Philips: committed to innovation

- Intellectual Property & Standards provides world class IP solutions
- Committed to Open Innovation
 - Track record in Standardization
 - Technology licensing turns ideas into opportunities for third parties
- Today's topic:
 EmoGraphy Skin
 Conductance

Est. **1891**

Headquarters in Amsterdam, Netherlands

104,000+

Employees worldwide in 100+ countries

€ 24.2 billion Sales in 2015

Portfolio ∽70% B2B

\$10.3 billion

Brand value in 2014

7% of sales invested in R&D
76,000 patent rights, 47,000 trademarks,
91,000 design rights



Emotional fitness: Health of body & mind

Emotional fitness increases resilience and enhances quality of life





Meaningful consumer concepts

for short term daily stress

EmoState manages mental balance

SleepReady provides sleep preparation





EmoState: essential for healthy lifestyle and optimal daily performance

- Humans are increasingly unaware of bodily signals
 - EmoGraphy raises awareness of emotional state
 - EmoGraphy measures emotional Intensity continuously
- Prediction algorithm signals possible threshold crossings
- Manage daily stress by coaching advice



 Over stimulated: decrease cognitive performance (strategic thinking, memory, etc.)

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    <u>Under stimulated:</u>
enhanced perception of
effort, reduced endurance
of mental activity
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IDS

The body's biological response to a stressor

- Stressor triggers a fast neural path and a slow hormonal path
- Cortisol and Skin Conductance are both direct results of the same stressor



Fast Response (e.g. seconds)

Cortisol is the stress hormone

- Cortisol is released by the adrenal cortex to help the body deal with stressors
- Increases blood pressure and blood glucose levels for immediate energy distribution to muscles and brains at the expense of processes not needed for immediate survival
- Increases vigilance and emotional memory
- Cortisol is the most accurate measure of stress¹





Sympathetic system triggers fight-or-flight



- Sympathetic nervous system stimulates "fight-or-flight" response to stressors
- Sympathetic nervous system inhibits "rest-and-digest" functions
- All responses are mediated by adrenalin and noradrenalin, *except* sweating (triggered by acetylcholine release)



Sweat glands are direct coupled to stress Clean indicator of sympathetic activity

 Sympathetic nervous system stimulates fight-or-flight response to stressors

- Sweat glands (circle) are the only organs singularly coupled to the sympathetic nervous system
- Other organs (e.g. heart) are coupled to both the sympathetic and parasympathetic nervous system



Cortisol and skin conductance responses are both direct results of the same stressor and are thus related



EmoGraphy Meaningful info from Skin Conductance



- EmotionIntensity: current excitement level measures direct stress effects
- High dynamic range of SC provides more detailed insights into current level of excitement
- EmoState: upcoming emotional state over/under stimulated, or balanced
- Predicted EmoState (60 minutes ahead)
- Time to Recovery

Individual cortisol responses accumulated into *Emotion Induced Cortisol*

• EmoGraphy algorithm calculates Emotion Induced Cortisol (EIC) from skin conductance peak heights and skin conductance level rise in a given time period



Skin conductance trace with Emotion Induced Cortisol (EIC) caused by the emotional stressors

Cortisol response to emotional stressor peaks ~30 min. after SC peak is detected

Subsequent cortisol responses overlap resulting in a larger cortisol level variation



SleepReady: energy for the next day

- Continuous measurement of excitement level during the day determines "emotional tiredness"
- Proper sleep preparation has big impact on sleep onset latency and sleep effectiveness
- Provide timely advice on wind-down process before bed time





Accurate, robust and meaningful measurements

• **Robust:** micro climate

- Micro climate ensures conductivity irrespective of the environmental conditions
- Skin conductance signal measured by changes in saline concentration (instead of changes in amount of sweat)
- Detection of non-responsive state preventing false positives
- Accuracy: affordable sensor design with high resolution
 - Sensor design's high resolution combined with a high dynamic range allows measurements on variety of skin, personality types and environmental conditions
 - Motion robust: fast sampling rate (up to 160Hz) allows motion artifacts to be filtered out
 - Bi-polar DC measurement for minimal mains noise
- Meaningful: calculate cortisol changes
 - Translate skin conductance signal in an estimated cortisol change
 - Optimal brain performance by avoiding under and over stimulation



License offering

- License products are
 - Sensor reference design + embedded software library
 - Rules based coaching module and coaching messages
 (optional and only in combination with embedded SW lib)



