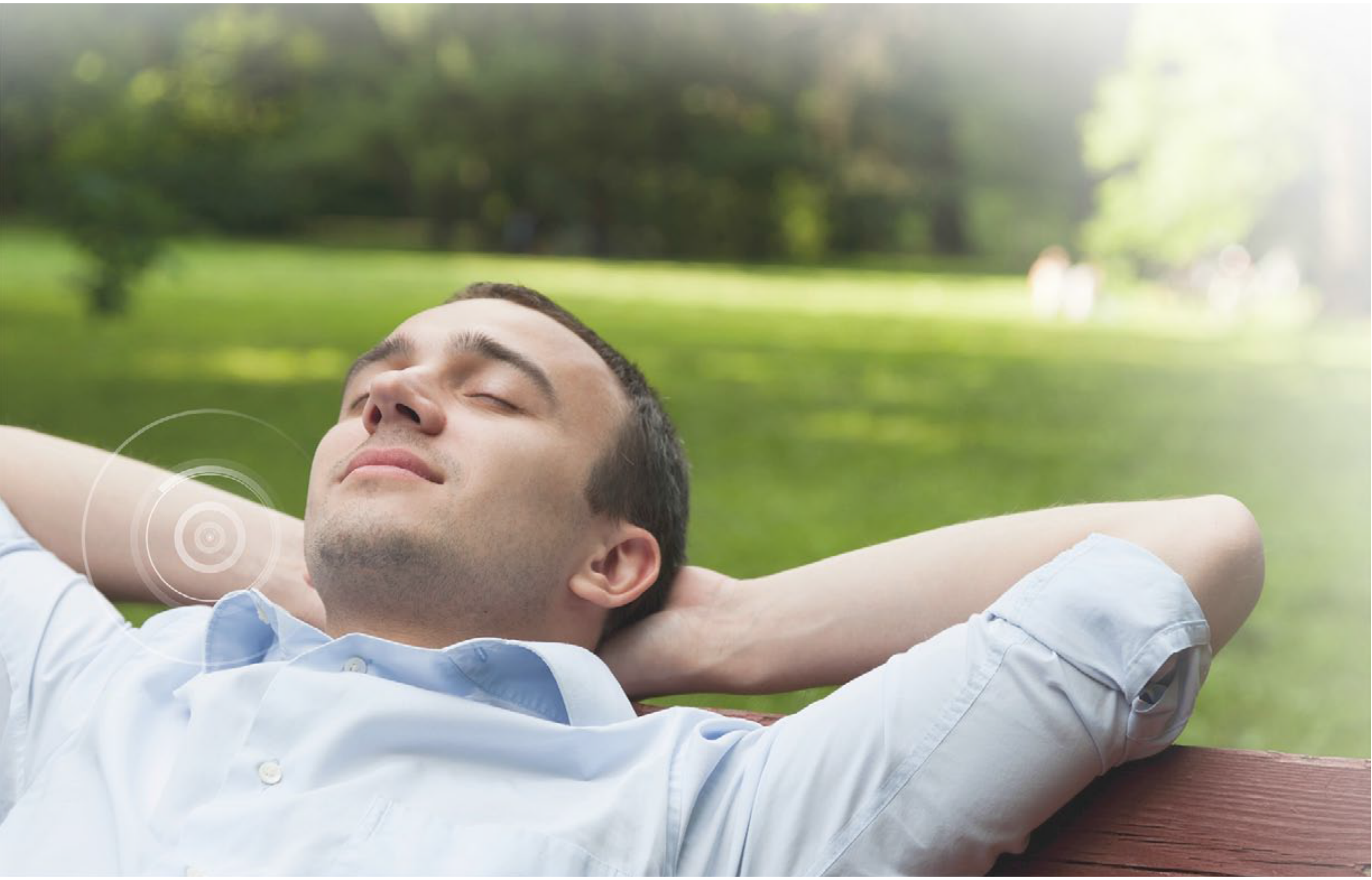
Enabling Accurate and Reliable Stress-level Measurements with NeuroSky ECG Technologies

NeuroSky®
Body and Mind. Quantified.

Studies have shown that prolonged periods of stress can lead to a variety of serious conditions, and that managing stress can play a key role in preventing an individual's health from further deteriorating. The ability to measure and track stress over time can help people identify situations and behaviors that may cause stress. Armed with stress-tracking trend information, individuals can make insightful lifestyle choices for achieving healthier, more balanced and less stressed lives. Fortunately, stress can be accurately measured using mHealth solutions enabled by NeuroSky's ECG biosensors and tracking biometrics. NeuroSky ECG technologies provide an objective method for measuring stress and presenting the results in a way that is easily understood by users.



Billions in Healthcare and Productivity Costs

Stress is a major health issue and costs the economy billions of dollars every year. According to the American Institute of Stress, "it is hard to think of any disease in which stress cannot play an aggravating role." In fact, the Institute reports that up to 90 percent of doctor's visits are stress related, and clinical studies have shown that stress is a major cause of cardiovascular disease, depression, and substance abuse. Workplace stress in the United States costs more than $300 billion each year in healthcare expenses, missed work, employee turnover, legal costs, workers' compensation, and insurance[1] and workers who report they are stressed incur healthcare costs 46 percent higher than other employees.[2]

What is Stress and How it Happens

As defined by Hans Selye in 1936, physiological stress is "the non-specific response...to any demand for change." In other words, stress doesn't just "happen," but rather, it is a reaction our bodies have to specific events and emotions. To understand its significance, it is important to consider how our Autonomic Nervous System (ANS) manages stress and recovery.

ANS controls functions like heart rate, respiration, and digestion that normally occur unconsciously. The system keeps our bodies in a regulated, balanced state by automatically cycling between the two branches of ANS: the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS).

SNS represents the body's "Fight or Flight" response, which can be triggered by a variety of stressors. States of excitement and emotions such as anger and fear activate SNS. Although the source may vary (external or internal, short or long term, physical or mental), the body responds by activating the SNS and releasing neurotransmitters and hormones that dilate pupils, increase heart rate and blood pressure, and activate sweat secretion as well as releasing more of a hormone called Cortisol in the bloodstream. In contrast, non-essential functions such as the digestive and immune systems slow down.

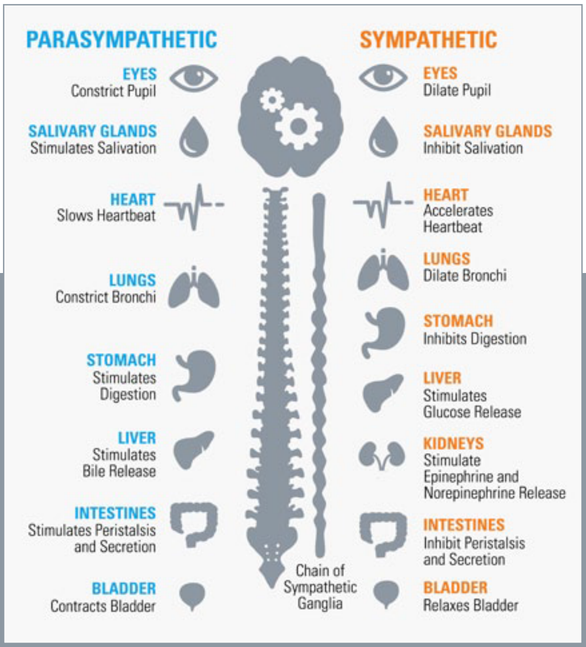


Figure 1: The Autonomic Nervous System (ANS) consists of the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS)

PNS, on the other hand, activates the "Recuperate and Renew" response mode. When PNS is active, it lowers the heart rate, breathing rate, blood pressure, reduces the level of Cortisol and more.

Ideally, SNS and PNS balance each other, allowing the body to react to stressors (SNS) and recover quickly (PNS) when they are no longer present. However, in our modern lives we are frequently faced with stressful emotions like anger and fear for prolonged periods, which keeps SNS active a long time. As a result, PNS often does not get an opportunity to be active, and ANS gets off kilter, diminishing the body's ability to recover.

While not entirely avoidable, stress is manageable. To manage stress, you first have to be able to objectively measure it, and then control it by making lifestyle choices that avoid or minimize the behaviors and factors associated with stress.

Quantifying Stress with NeuroSky's ECG Biosensors and Biometric Algorithms

Numerous scientific studies ([6-15]) concluded that HR (Heart Rate) and HRV (Heart Rate Variability) derived from ECG are strong markers of stress. Key derivatives of HRV, such as the high frequency (HF 0.15 Hz – 0.40 Hz) and low frequency (LF 0.04 Hz – 0.15 Hz) components of HRV and the ratio LF/HF, have been widely shown to be indicators of stress levels.

Since NeuroSky ECG-based biosensors can calculate HR and HRV very accurately using short duration measurements, they enable NeuroSky's stress algorithm to interpret ECG data into a reliable and meaningful indicator of stress.

More importantly, since the HF and LF components of HRV are critical elements of Stress algorithms, it is essential that HF and LF can be accurately calculated. ECG signal provides a very sharp R-peak which can be precisely located so that the R-R interval and hence HRV as well as HF/LF components of HRV can be very accurately calculated form short duration (around 30 seconds) ECG measurements. Other technologies like optical (PPG) sensing only provide an approximate R peak location which means that HRV and especially HF component of HRV cannot be accurately computed from short duration measurements. It may require measurement of 5 minutes or more to get the error rate due to inaccurate R peaks location from PPG measurements to acceptable levels. ECG based Stress measurements are clearly more accurate and can be obtained from shorter duration measurements than those done by optical (PPG) technology.

NeuroSky Stress Algorithm Validation

As mentioned earlier, Cortisol measurement in the bloodstream or saliva provides a reliable marker for Stress. NeuroSky's stress algorithm has been rigorously validated using standardized experiments, including the Trier Social Stress Test (TSST, [13, 14]), which consists of delivering a public speech and doing mental arithmetic calculation after the speech. Cortisol measurements are done at various stages as indicators of stress. Before the test, the stress level may be low, while it increases when preparing for the speech. During the speech and mental calculation, stress is significantly elevated, and gradually falls after the test to a point lower than before the test. With NeuroSky's algorithm, a typical stress-level trend during a TSST experiment correlates very closely to this behavior.

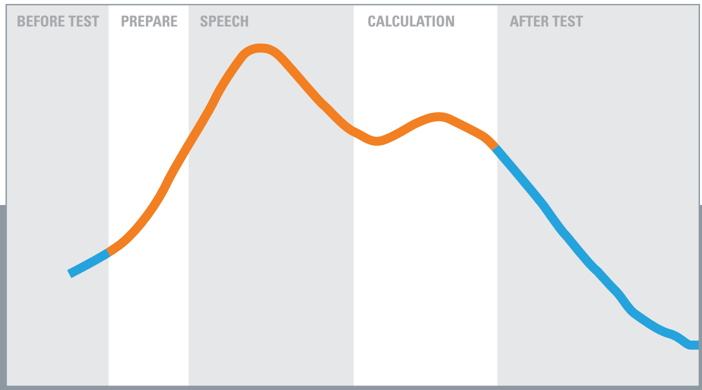
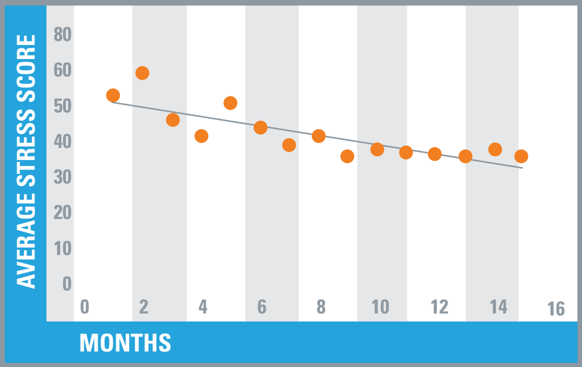


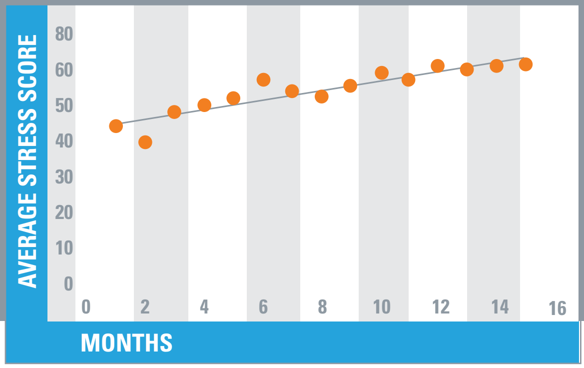
Figure 2: A typical stress response during a TSST experiment

Meaningful and Interpretable Data for mHealth Solutions

NeuroSky's stress algorithm provides insightful data via numerical values (1 to 100) relative to a user's baseline, so that an increase or decrease in stress can be easily tracked. In order for the algorithm to function properly, users specify profile information like Age and Gender, and then record their first reading when they are in a low/no stress situation (e.g., upon waking in the morning). The algorithm adapts intelligently, to establish a true, usable baseline after the first few readings. The table on the right is an example for communicating accurate messages to a user based on his or her stress reading.

SCORE	INTERPRETATION
1-20	Low to No Stress
21-40	Minimal Stress
41-60	Moderate Stress
61-80	Stressed
81-100	Highly Stressed





Individual stress readings can be recorded over time to illustrate long-term trends, as shown in charts below. For example: a downward trend line would appear for someone following a program of proven physiological stress management techniques (e.g., exercise, sleep, diet, eliminating environmental stressors, and other behavioral changes). On the other hand, a person whose stress is getting worse would show an upward trend, which, if prolonged, would indicate the need for implementing a stress reduction program.

Important Considerations for OEM/ODM Companies

As noted earlier, the cost of stress to the economy is in the hundreds of billions of dollars and an effective solution that can address this market by providing an easy to use device and ecosystem to measure and track stress would certainly be of interest to large OEM/ODM companies.

There are several “free” stress measurement Apps available on iOS and Android devices that primarily use the phone’s camera to optically sense changes in blood flow and compute HR/HRV and Stress based on these readings. Some of the Apps require a companion wearable device that uses optical sensors to measure heart rate and HRV and compute stress based on those measurements.

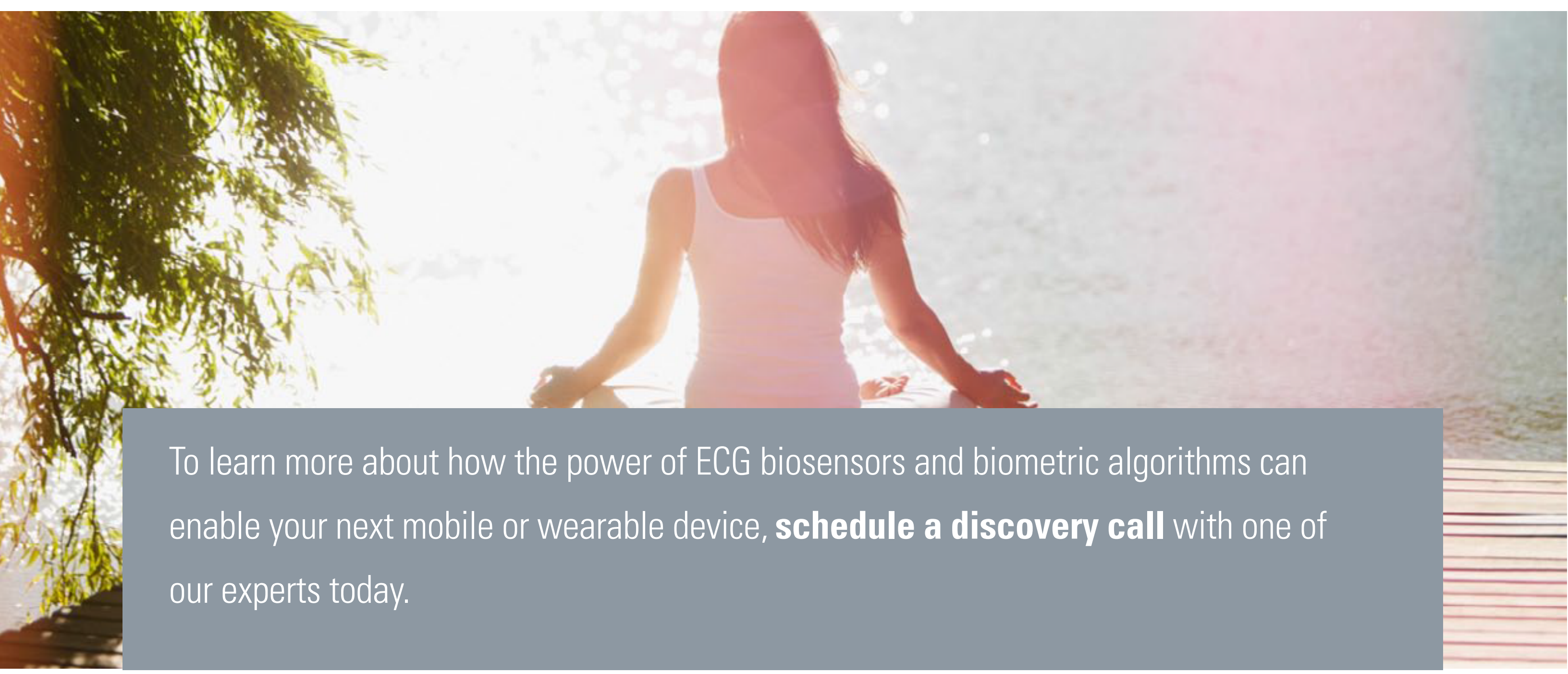
While this may be adequate for the casual user who may want to look at “Stress” readings out of curiosity, it does not have the accuracy or the scientific validation required to be considered by enterprise customers interested in offering accurate stress tracking over long term in a meaningful way for their user base.

OEM/ODM companies looking to add Stress measurement capability to their products in order to sell in to the enterprise market can do so by leveraging the ease of integration provided by NeuroSky ECG biosensors as well as NeuroSky’s scientifically validated Stress algorithm that works in conjunction with these bio-sensors. This capability would enable OEM/ODM companies to market their products to enterprise customers such as mobile carriers, insurance companies and healthcare institutions.

Stress is a part of our everyday lives, and prolonged periods of high levels of stress have been linked to various diseases and unhealthy conditions.

Fortunately, physiological stress can be accurately measured by easy-to-use mHealth wearables, devices, and apps enabled by NeuroSky's ECG biosensors and tracking biometrics. It is well understood that HR and HRV are highly correlated markers for stress. NeuroSky ECG biosensors provide an objective method for measuring these parameters. And our biometric algorithm enhances the value of stress data by applying the latest research insights encapsulated in the algorithm and presenting the results in a fashion that is easily understood by individual users.

The ability to measure and track long-term trends allows individuals to identify situations, behaviors, and lifestyle choices that may affect their level of stress. Armed with this knowledge, individuals can make the right choices for successfully managing stress and achieving a healthier balance in their lives.



To learn more about how the power of ECG biosensors and biometric algorithms can enable your next mobile or wearable device, **schedule a discovery call** with one of our experts today.

Email: publish@neurosky.com www.neurosky.com

Reference

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