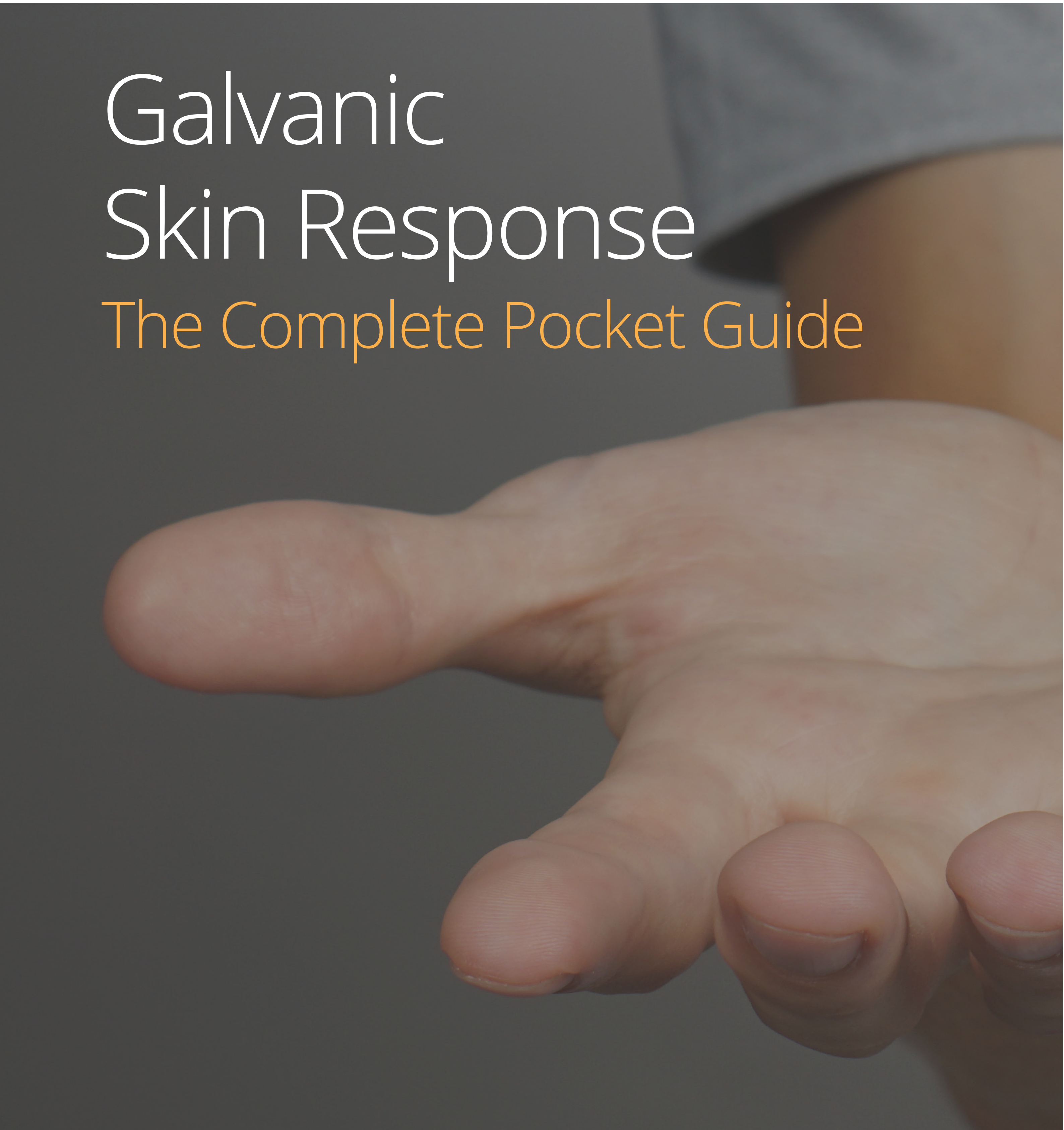
# Galvanic Skin Response

## The Complete Pocket Guide



iMotions – Biometric Research, Simplified

**GSR**

**Pocket Guide**

# The pocket guide

Typically known from the Hollywood's golden era of suspense noir gangster films, for many of us GSR is strongly linked to criminals sitting in a shady backyard room hooked up to a polygraph.

In real life (and actual research), however, there is much more to GSR methodology than outmoded polygraph testing.
Dare to tap into the unconscious and learn what triggers emotional behavior: Why is it that some things more than others make us chuckle or give us the creeps, drive us up the wall or let us jump for joy?

What exactly is GSR? How can it be measured and what does it tell us?

We have the answers. The following pages are packed with everything you need to know to get a solid grasp of GSR data collection and analysis and are full of hands-on advice and our best practices.

Embrace them, dance around them, make friends with them - they will get you on the right track with GSR in no time. Ready to go? Ready to go!

## What's inside?


### THE BASICS ... AND BEYOND

*What is GSR?* ........ 05

*Skin & sweat* ........ 06

*GSR & emotional arousal* ........ 09

*Application fields of GSR* ........ 10

### GET STARTED WITH GSR

*GSR sensors* ........ 13

*Sensor placement* ........ 14

*Respondent instructions* ........ 16

*GSR devices* ........ 18

### GSR DATA EXPLAINED

*The raw GSR signal* ........ 21

*Collecting GSR data* ........ 23

*Analyzing GSR data* ........ 25

*GSR reloaded: Adding biometric sensors* ........ 29

*GSR done right with iMotions software* ........ 31

# THE BASICS

# What is GSR?

Are you smitten by images of cute kittens or newborn babies? Are you frightened to the core when you watch horror movies? Don't worry, we won't spill the beans.

And what about those big hairy spiders – do they give you the creeps? Do you catch yourself desperately wanting to buy that shiny pair of shoes you just saw in the cheery television ad?

Is your mouth watering just thinking about that yummy piece of chocolate cake that you're going to treat yourself with today at lunch? We get you.

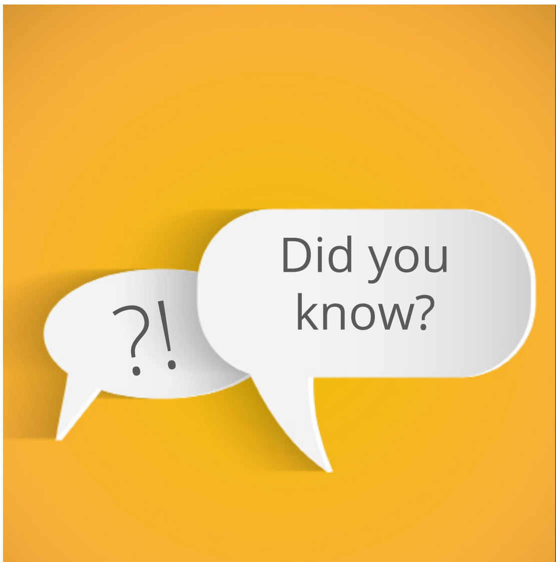
Our skin is an open book

## The skin tells everything

Our skin reveals a lot of information on how we feel when we're exposed to emotionally loaded images, videos, events, or other kinds of stimuli – both positive ("aww, how cute!") and negative ("yikes!"). No matter whether we are stressed, nervous, fearful, psyched up, stoked, baffled, or surprised - whenever we are emotionally aroused, the electrical conductivity of our skin subtly changes.

One of the most sensitive measures for emotional arousal is **Galvanic Skin Response (GSR)**, also referred to as **Electrodermal Activity (EDA)** or **Skin Conductance (SC)**.

GSR originates from the autonomic activation of sweat glands in the skin. The sweating on hands and feet is triggered by emotional stimulation: Whenever we are emotionally aroused, the GSR data shows distinctive patterns that are visible with bare eyes and that can be quantified statistically.




### What makes GSR such a valuable biometric signal in assessing emotional behavior?

With GSR, you can tap into unconscious behavior that is not under cognitive control. Skin conductivity is solely modulated by autonomic sympathetic activity that drives bodily processes, cognitive and emotional states as well as cognition on an entirely subconscious level. We simply cannot consciously control the level of skin conductivity. Exactly this circumstance renders GSR the perfect marker for emotional arousal as it offers undiluted insights into physiological and psychological processes of a person.

# Skin & sweat

To understand how GSR works, take a quick step back and have a look at the physiological characteristics of the largest organ of the human body - the skin.

Our skin functions as the principal interface between organism and environment. Together with other organs, it is responsible for bodily processes such as the immune system, thermo-regulation, and sensory-motor exploration:

1 **Immune System**
As protective barrier, the skin separates our body from the environment and its threats - mechanical impacts and pressure, variations in temperature, micro-organisms, radiation, and chemical agents.

2 **Thermoregulation**
The skin controls body temperature by regulating sweat emission, piloerection ("goosebumps"), and peripheral blood circulation.

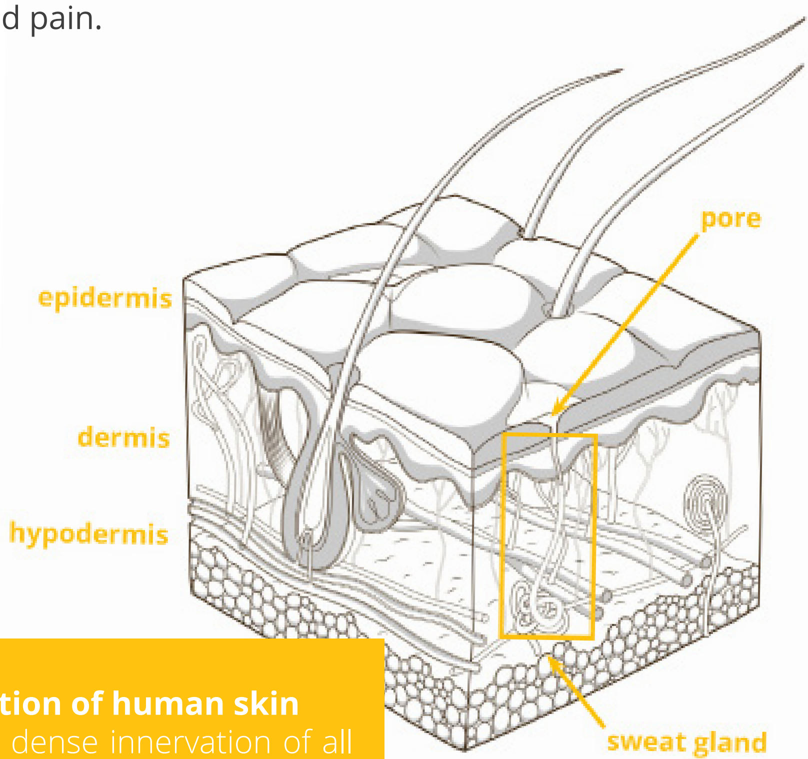
3 **Sensing and Perception**
The skin is an organ of perception. It contains an extensive network of nerve cells that detect and relay changes in the environment based on the activity of receptors for temperature, pressure, and pain.

Consistent with this complexity of function, the skin has three primary layers:

1 Epidermis (outmost protective layer)

2 Dermis (cushion for the body from stress and strain)

3 Hypodermis (anchor to bones and muscles)




**A cross-section of human skin**
showing the dense innervation of all skin layers with nerve cells and sweat glands

Our body has about three million sweat glands. The density of sweat glands varies markedly across the body, the highest being on the forehead and cheeks, the palms and fingers as well as on the sole of the feet.

Whenever sweat glands are triggered and become more active, they secrete moisture through pores towards the skin surface. By changing the balance of positive and negative ions in the secreted fluid, electrical current flows more readily, resulting in measurable changes in skin conductance (increased skin conductance = decreased skin resistance).

This change in skin conductance is generally termed **Galvanic Skin Response (GSR)**.


### Galvanic Skin Response (GSR)

Galvanic Skin Response reflects the variation in the electrical characteristics of the skin.

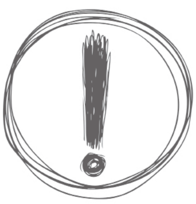
GSR is also known as **Skin Conductance (SC), Electrodermal Activity (EDA), Electrodermal Response (EDR),** and **Psychogalvanic Reflex (PGR).**

GSR activity is typically measured in “micro-Siemens (µS)” or “micro-Mho (µM)”.

While the primary purpose of sweat emission is thermoregulation, sweating on hands and feet is also triggered whenever we’re emotionally aroused.

## Emotional sweating?

Yes, you heard right.

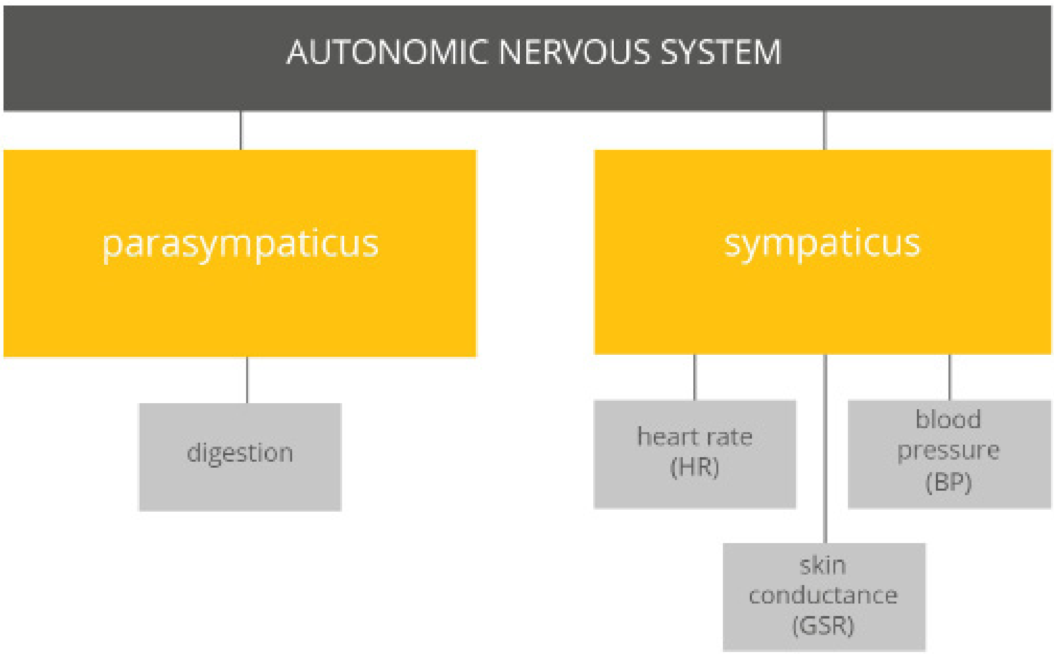


Like other vegetative autoregulatory processes (body temperature, heart rate, blood pressure, gut motility, etc.) sweat secretion **cannot be controlled consciously**. Rather, it is driven and balanced by our autonomic nervous system in order to meet behavioral demands (to prepare and execute energetic movement, for example).

Most broadly, the autonomic nervous system can be separated into the following two subdivisions:

**The sympathetic nervous system**
represents a rapid response mobilizing system, facilitating immediate motor action (“fight or flight”). Increased sympathetic activity is associated with bodily indicators of “autonomic arousal” such as increased heart rate, blood pressure, and sweating.

**The parasympathetic nervous system**
regulates slowly changing processes associated with „resting and digesting“ or „feeding and breeding“.




## Recap

Sweat secretion and the associated changes in skin conductance are **unconscious processes** that are solely under sympathetic control and reflect **changes in arousal**.

# GSR & emotional arousal

So far, so good: Emotional experiences trigger **changes in autonomic arousal** quite impressively. Now what does that mean exactly?

Exposure to fear-inducing stimuli (an angry face, the sight of a creepy spider etc.) induce emotional arousal, causing an increase in sweat secretion and, ultimately, measurable electrodermal activity.

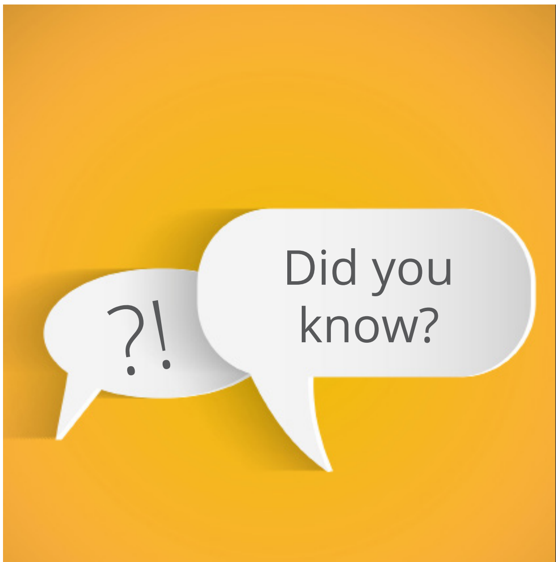
In emotional situations, **bodily processes are triggered automatically**: The heart beats faster, the pulse rises, hands become sweaty. To put it bluntly: While we are physiologically or psychologically aroused (in fear, extreme joy or under stress), we start to sweat.

In case you were thinking sweat running down in streams, let's give the all-clear here: We don't need to be sweat-flooded in order to see differences in electrodermal activity (factually, the sweating doesn't even need to be visible).

GSR reflects emotional arousal

Besides emotional stimulus properties, recent findings indicate that skin conductance is also sensitive towards **other aspects of a stimulus**.

Are we familiar with the stimulus or are we encountering it for the first time? Is the stimulus threatening or rewarding? Do we associate the stimulus with wins or losses, love or hate, anticipation and outcome, memory recall or cognitive work? Against this backdrop, changes in skin conductance might also reflect **motivational and attentional processing**.




### Don't sweat it! Or should you?

You surely know how your hands feel cold and all clammy when you're terrified. Just imagine an "all or nothing" exam situation for which you are super ill prepared. We've all been there, haven't we?

Take a minute and recall that moment of defeat in the auditorium.

See? Just thinking about it gives you the chills and sweaty hands!

# Application fields of GSR

*"By 1972, more than 1,500 articles on GSR had been published in professional publications, and nowadays GSR is regarded as the most popular method for investigating human psychophysiological phenomena." Boucsein (2014)*

With GSR, the impact of **any emotionally arousing** content, product or service can be tested - actual physical objects, videos, images, sounds, odors, food probes and other sensory stimuli as well as thought experiments and mental images.

Paired with the fact that GSR responses are extremely **easy to measure**, possible applications cover a fascinating variety of fields in academic and commercial research.

There is a wide variety of GSR applications

## Psychological Research

Psychological studies utilize GSR to identify how humans respond emotionally towards various stimuli and how these responses are affected by stimulus properties (color, shape, duration of presentation), personality characteristics (extraverts vs. introverts), social expectancies ("men are not afraid of the dark!"), and the interaction of cultural aspects and individual learning histories. Think of this: A terrifying encounter with the neighbor's vicious dog in your childhood certainly triggers autonomic arousal and increased sweating when you come face to face with dogs in later life (perhaps even an image of a dog is enough to give you the creeps).

## Clinical Research & Psychotherapy

Clinical populations such as patients suffering from eating disorders, phobias or post-traumatic stress disorder (PTSD) show heightened fear responses and emotional arousal to trauma reminders. Also, autonomic responses towards threatening stimuli typically do not subside even in the presence of safety reminders. Over the course of a cognitive-behavioral therapy, however, GSR can be monitored during exposure or relaxation trainings in order to provide a quantitative measure of the physiological arousal of the patient and assess the severity of the disease as well as the success of the therapeutic intervention.

## Consumer Neuroscience & Marketing

Evaluating consumer preferences is a critical element of marketing. GSR can be measured to track emotional arousal towards products with high consumer interest, however only subtle differences in performance and quality. For example, shopping preferences and decisions in cosmetics are primarily based on affective and subconscious processes. With the help of GSR recordings, these processes can be examined in more detail in order to enhance products, assess market segments or identify target audiences and buyer ersonas.

## Media & Ad Testing

In media research, campaign material such as TV ads, trailers, and full-length shows can be shown to individual participants or focus groups while monitoring their emotional arousal via GSR measurements. Identifying key frames in the stimulus material or isolating scenes that “just don’t work” (where supposedly emotional content was shown but the audience did not respond) are just two of the many approaches to utilizing GSR for evaluation purposes.

## Usability Testing & UX Design

Using software should be a pleasant experience. Hence, frustration and confusion levels should be kept as low as possible. Monitoring GSR can provide unfiltered insights into stress levels of users during the interaction with new website content, user interfaces, and online forms. How emotionally satisfying is the navigation? Whenever visitors encounter road blocks or get lost in complex sub-menus, you might certainly see increased stress levels reflected in stereotypic GSR activation patterns.

IMOTIONS®
BIOMETRIC RESEARCH PLATFORM

# GET STARTED

# GSR sensors

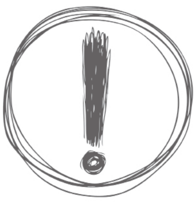
Let‘s get practical with some good news: The observation of electrodermal phenomena requires **only very basic equipment**. However, there are a few things to keep in mind when it comes to choosing the right gear and applying it correctly.

We‘re here to help.

With minimal preparation times and cleanup, skin conductivity is recorded **non-invasively** using two electrodes placed on the skin. This renders GSR measurements a lot more **comfortable for respondents** compared to other methods such as fMRI or EEG, where longer preparation and calibration phases are quite common (and sometimes a true hassle).

Generally, GSR sensors have a 1 $cm^2$ measurement site made of Ag/AgCl (silver/silver-chloride) and are placed either in reusable snap-on Velcro straps or in a patch sticker. While the former can be applied as-is, the patch sticker requires the use of conductive gel in order to improve the conductivity between skin and electrode.

## The logic behind GSR is very simple:

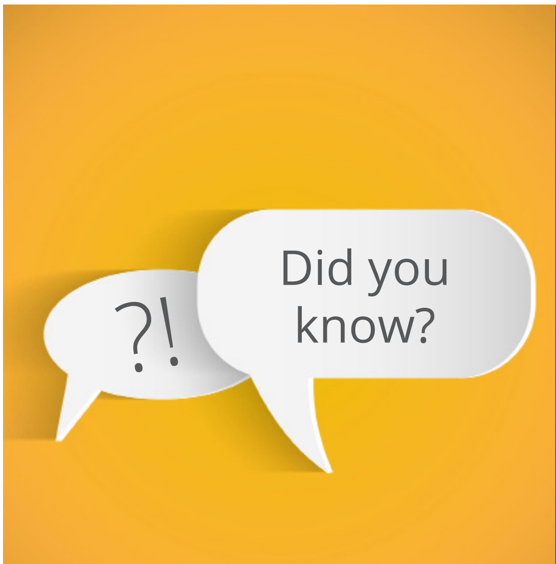


1 Place two electrodes on emotionally sensitive body locations

2 Apply a constant low voltage

3 Measure the electrical current between the two electrodes

4 Report the associated skin conductance




### What about the sampling rate?

Although GSR data might be acquired with arbitrary sampling rates (up to 2000 Hz), very low sampling rates are sufficient.

We suggest sampling rates from 1 to 10 Hz, however keep in mind that higher sampling rates might be necessary if the same device collects GSR and other physiological parameters such as (optical) heart rate, for example.

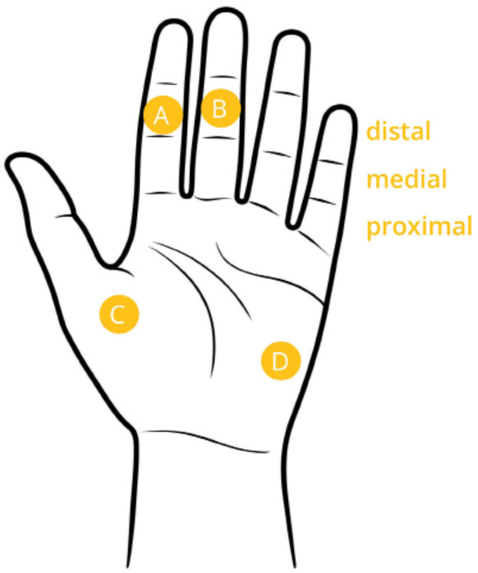
# Sensor placement

While sweat glands are present on almost all parts of the body, certain areas respond more strongly to emotional stimulation. Particularly, **the palms of the hands**, **fingers** and **foot soles** are sensitive recording sites.

Which location should you choose for your recording? Have a look at our recommendations dependent on your stimulus material and the task at hand:

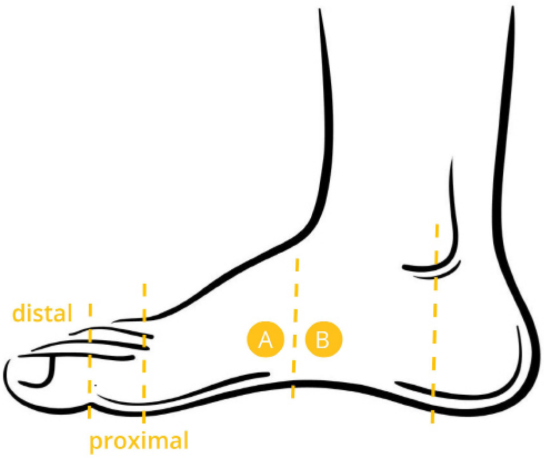
1

**Record from fingers**...
if your respondents' hands are static (when passively watching images or videos, for example). Researchers typically record from the nondominant hand such that respondents are still able to use their dominant hand during task performance (clicking the mouse or pressing a button while responding to on-screen stimuli, for example). Velcro strap electrodes can be placed on the index (A) and middle finger (B).




2

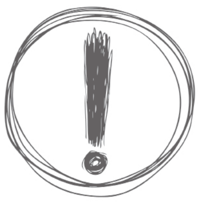
**Record from the palm**...
if your respondents have to use both hands (when using the mouse or the keyboard to fill out survey forms or handling software interfaces, for example). In this scenario, use electrode stickers instead in order to ensure proper and stable electrode placement (C and D).




3

**Record from the feet**...
if respondents have to use both of their hands quite extensively (when manipulating and interacting with actual objects in real-life environments, for example). In this case, attach the sensors to the inner side of the foot (A and B). As the soles are strongly affected by pressure while standing or walking, make sure to place the sensors on a medial site on the inner side of the foot (ideally the extensor of the big toe's base joint). While placing the sensors, your respondents should be seated in a comfy position.

## Sensor placement - expert tips



Here comes even more hands-on advice.
Check out our smart hacks for optimal sensor connectivity:

1 To guarantee accurate biometric measurements, the sensors need to be **connected to the skin at all times** throughout the experiment. Ensure the sensors are placed snugly on the palm or foot without being too firm as this deteriorates data quality.

2 Consider using **adhesive electrode pads** that are already filled with conductive gel in order to reduce preparation time and to avoid electrode movement.

3 Spare yourself unpleasant surprises and be **consistent with sensor placement across all respondents**. Use the same recording site for the entire study, and do not switch locations during or between recordings.

4 Normally you don't need to pretreat recording sites. However, if a respondent has extremely oily skin, you might be better off **cleaning the skin surface** at the recording site with an alcohol swab (70% isopropanol, available at drug stores) in order to improve sensor stability. By contrast, recordings from respondents with very dry hands (elderly or clinical populations, for example) might be improved by applying some skin moisturizer or hand balm.

# Respondent instructions

While GSR sensors are easy to setup and connect, there are a couple of **muscular artifacts** you should steer clear of. Why? Because they can significantly deteriorate the quality of your data. Not too cool.

So first things first. To minimize annoying artifacts right from the outset, take a few extra minutes and **instruct your respondents properly**. Here is what you can tell them to make them smile (and your data shine):

Instruct respondents properly to minimize artifacts

1 **Breathe normally**

Your respondents should breathe normally during the recording. Why's that? Excessive inhalation and exhalation (or holding their breath) result in strong drifts in the GSR data. These could easily be misinterpreted as changes in emotional arousal. The best way to make your respondents aware of this circumstance is by showing them in a live view of the data how breathing alters the signal. Of course, we are only human - chances are we *will* hold our breath when we're exposed to emotionally arousing stimuli (no matter how detailed and insistent the instruction is). To be on the safe side, we recommend recording breathing activity together with GSR using a respiration belt or similar devices.

2 **Keep limb movements to a minimum**

Movements, particularly of those body parts where the GSR sensors are attached, can heavily affect data quality. One essential element is to make your respondents aware of the negative effects - show them the stream of raw GSR data while waving heavily or making a fist. The key is to make your respondents feel at ease, so in stationary setups it might make sense to give them enough time to find a comfortable arm/hand position. When you record GSR in a shelf test study or other life-like scenarios where your respondents are walking around freely, you can either instruct them to keep hand movements at a minimum, attach a small rigid body to the fingers where the Velcro strap electrodes have been attached, or place the electrodes at the inner foot soles, thereby avoiding movement artifacts completely.

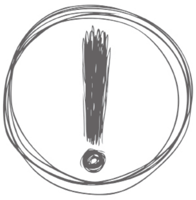
3 **Try not to talk**

Talking should be avoided during GSR recordings as it elicits slow variations in the signal that do not reflect emotional arousal.

4 **Sit comfortably during stationary studies in lab environments**

Your respondents should feel comfortable at all times. That's probably the number one rule in biometric research. After all, human behavior studies wouldn't be possible without respondents and their willingness to donate their spare time. It goes without saying that people should feel at ease and as comfortable as possible throughout the study for the sake of their well-being (and your own happiness).

## Seating comfort during studies



How exactly can you provide optimal seating comfort during studies?
Here are our sure-fire tips:

1 Use a simple, comfortable chair. Adjust the chair height to make sure your respondents are seated comfortably in a **natural position** with feet flat on the ground (use a footrest if necessary) and thighs parallel with the floor to avoid pressure points. Try to avoid swivel chairs and chairs with wheels as they invite participants to sway, rotate, and move around during data collection. Not so good.

2 Adjust the height and/or depth of the lumbar support to provide comfortable **lower back support**. Most often it takes as little as offering a soft cushion for enhanced seating comfort or reclining slightly to take pressure off the lower back. Be attentive and ask your respondents if they feel comfortable, especially if your study is designed to run several hours. Keep in mind that happy respondents are a prerequisite for optimal data quality.

# GSR devices

In case you are imagining bulky equipment, think again. In fact, GSR devices are quite the opposite.

They typically consist of **two electrodes**, an **amplifier** (to boost signal amplitude), and a **digitizer** (to transfer the analog raw signal into binary data streams). Wireless GSR devices further contain data transmission modules for communication with the recording computer (using the Bluetooth protocol, for example). While some devices allow arbitrary sensor placements in any of the locations we have already mentioned, other devices have GSR electrodes rigidly mounted in wristbands or elastic straps.

There is **“no one fits all“ solution** - which sensor to pick in order to obtain the most appropriate GSR data depends on your research question and the specific requirements of your study.

However, irrespective of which GSR sensor you go for, it is always good advice to **assess the quality of the GSR signal** in the live viewer before you start the recording.

You can even examine the data together with the respondent in order to check for potential issues and visualize the impact of breathing, movements, and talking.

*Empatica E4 Wristband*

*Shimmer3 GSR+ (GSR, PPG)*


*BIOPAC MP150 + EDA100C*

Here's our handy checklist for the rather technical aspects of data collection:

1

**Have you attached the GSR electrodes?**

Make sure that the sensors are properly attached to the fingers, hand or foot.

2

**Have you wired up all cables correctly?**

Check that the electrode cables are not dangling loosely but are properly plugged into the correct sockets of your GSR device.

3

**Is the GSR device up and running?**

You wouldn't believe how many experiments have been started with the GSR sensors still turned off. Spare yourself the hassle and make sure that the device is set to "on" and configured correctly.

4

**Is the GSR device properly connected?**

GSR devices are either plugged in directly or are connected wirelessly, so always test if the connection has been established. Check if the Bluetooth dongle is properly plugged in and receives incoming data. As Bluetooth technology is a short-range wireless connection between two devices, be aware of the following:

1 **Reception range**
Even if the transmitting GSR device and the Bluetooth receiver are in direct line of sight, try to stay in the recommended reception range (approximately 5 meters) as the connection will be lost otherwise.

2 **Obstruction**
Bluetooth signals cannot pass through water, human tissue or concrete. This implies that the connection is dropped whenever respondents walk into neighboring rooms or occlude the sensor with their hand or body (we actually consist of 80% water).

## The important three Ps: pretest, pretest, pretest!

Don't skimp.
You can save yourself a lot of trouble and worries if you take your time and set up the study environment properly instead of trying to correct for a sloppy framework afterwards.

Always run a pretest to check data quality and ensure that all is working properly.

Remember:
There is no substitute for clean data!

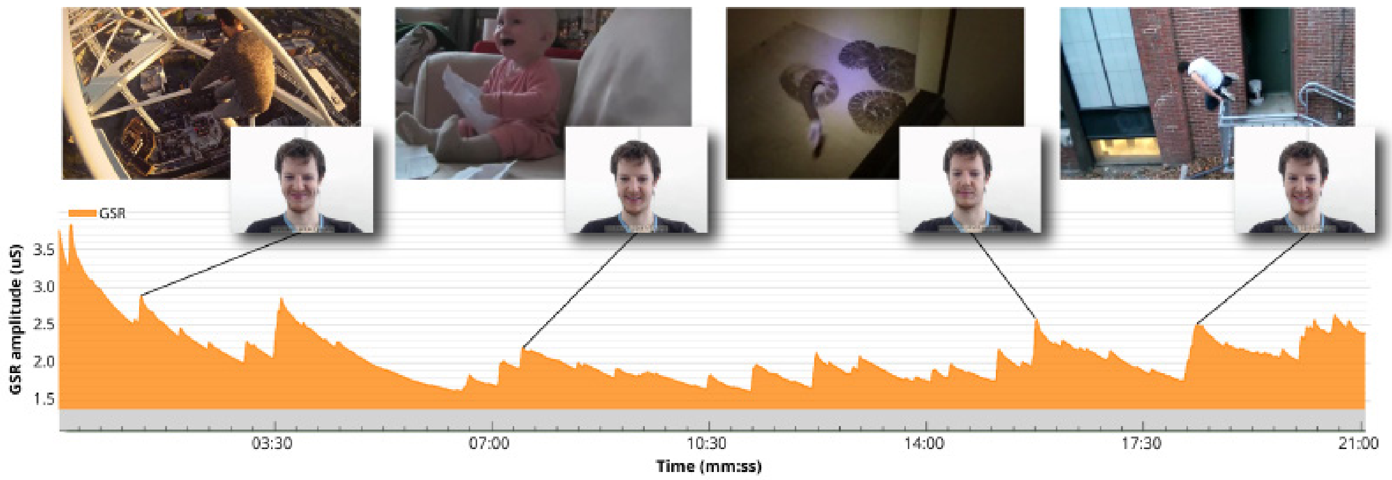
# GSR DATA EXPLAINED

# The raw GSR signal

Now that we know all the basic hacks for optimal sensor placement, respondent instruction, and best practices for data collection, it's about time to get even smarter and have a close look at the characteristics of the actual raw GSR signal.

Ready to jumo right in? Here we go.

The data below shows the GSR signal during a 20-minute video screening. The primary research question was: **Which are the emotionally arousing scenes in the video?** Respondents were seated comfortably in front of the monitor with GSR sensors attached to the index and middle finger of the non-dominant hand. We've also used a face camera to track facial expressions.




The GSR signal consists of two main components: SCL and SCR. Let's explain.

1

## Skin Conductance Level (SCL)

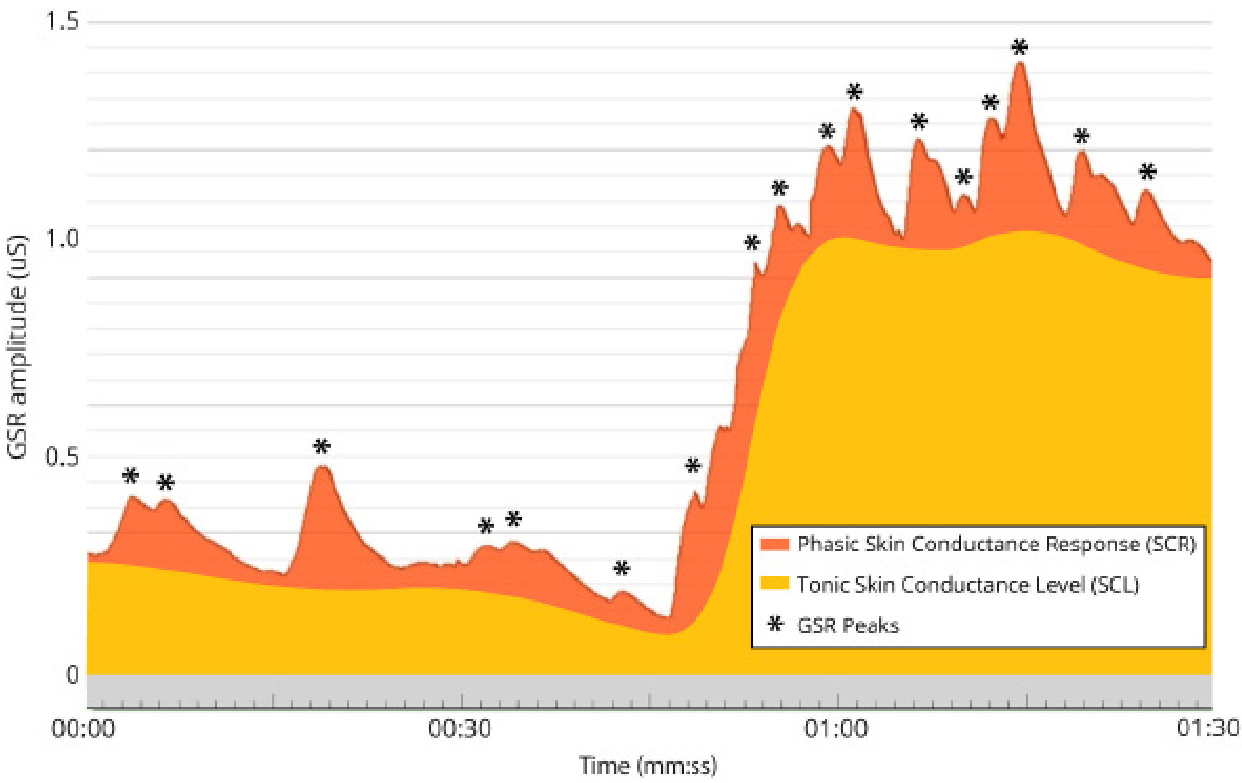
The **tonic level**, known as skin conductance level (SCL), slowly varies and changes slightly on a time scale of tens of seconds to minutes. The rising and declining SCL is constantly changing within an individual respondent, depending on their hydration, skin dryness, or autonomic regulation. The tonic level can also differ markedly across individuals. This has led some researchers to conclude that the actual tonic level on its own is not that informative.

2

## Skin Conductance Response (SCR)

The **phasic response** rides on top of the tonic changes and shows significantly faster alterations. Variations in the phasic component are visible as "GSR bursts" or "GSR peaks". The phasic response is also labeled skin conductance response (SCR) as it is sensitive to specific emotionally arousing stimulus events (event-related SCRs, ER-SCRs). These bursts occur between 1-5 seconds after the onset of emotional stimuli. By contrast, non-specific skin conductance responses (NS-SCRs) happen spontaneously in the body at a rate of 1-3 per minute and are not a consequence of any eliciting stimulus.

# The raw GSR signal



# Collecting GSR data

## GSR quality assessment

Systematic research on individual differences in GSR activity has identified two very distinct groups of respondents:

1. **"Electrodermal labiles"**
This group shows an increased number of non-specific skin conductance responses (NS-SCRs) throughout a recording. If confronted with emotional stimuli, their SCRs rise only very slowly. Electrodermal labiles have been found to exhibit superior performance in sustaining attention to external stimuli and in rapid response execution. Think pilots, air traffic controllers and gun-fighting cowboys.

2. **"Electrodermal stabiles"**
This group has a reduced number of non-specific skin conductance responses and/or fast-spiking GSR peaks. Stabiles show superior performance in any kind of task involving short-term memory and attentional focusing where distractions have to be blended out. Good examples are blackjack players, fast food employees or researchers doing behavioral coding.

## Optimal stimulus setup

In order to evaluate the individual GSR characteristics of your respondents, their GSR activity should be collected during a baseline period.

The ideal baseline period should be **at least 2-4 minutes long** and placed **at the beginning** of your actual data recording. Collecting a baseline also helps identify recording issues caused by dry skin or environmental conditions, allowing you to take countermeasures - providing further instructions or optimizing GSR sensor placement, for example.

### Neutral baseline
In this condition, no stimuli are presented. Respondents sit comfortably in a relaxed position, potentially with their eyes closed. The recorded GSR activity reflects the spontaneous variability of the signal, consisting only of the tonic level and non-specific skin conductance responses (NS-SCR) only.

### Baseline with variable stimuli
This condition contains stimuli with varying emotional content - a video with scenes that elicit positive and negative emotions, for example. The variable baseline is considered to "max out" a respondent's GSR data, comprising the full spectrum of GSR responses towards variable emotional content. You could show very calming scenes (nature, landscapes), which are interrupted by scenes that trigger strong GSR responses (life-threatening, sexually arousing or happy scenarios).

After collecting a baseline as recommended, you are certainly ready to start a recording in the desired test environment with the right respondents containing the stimulus set of interest.

Sounds like you made it to research heaven. Err, hold on a minute - there is one last thing we forgot to work through: How should stimuli be presented?

Let’s find out.

## Stimulus presentation

As GSR peaks occur within **1-5 seconds after** the onset of a stimulus, you certainly want to present any material long enough for respondents to process its content.

This holds true for all sensory modalities: vision, hearing, taste, smell, and touch. Further, it might be useful to place **“cool-off” stimuli** of appropriate duration between the stimuli of interest in order to allow the GSR signal to return to baseline.

Think of it this way: If you present emotionally loaded images in very quick succession (in 1 second intervals, for example), you will most likely see a ramping up of GSR peaks, making it hard to distinguish which peak was triggered by the first, second, or third stimulus. Not exactly what you were shooting for.

Therefore, try to keep recording conditions **clean and structured**: Present functional stimuli long enough and use intermediate stimuli so that the GSR signal for all respondents can “cool off” and start from baseline levels for the next stimulus.


**Pics, pics, pics!**

The International Affective Picture System (IAPS) is a database that has been specifically designed for emotion and attention research, comprising about 1,000 standardized color photographs, which have been rated based on their emotional content.
The IAPS is widely used in several fields of academic and commercial research. Access to the database is restricted and requires submitting an official request.

http://csea.phhp.ufl.edu/media/requestform.html

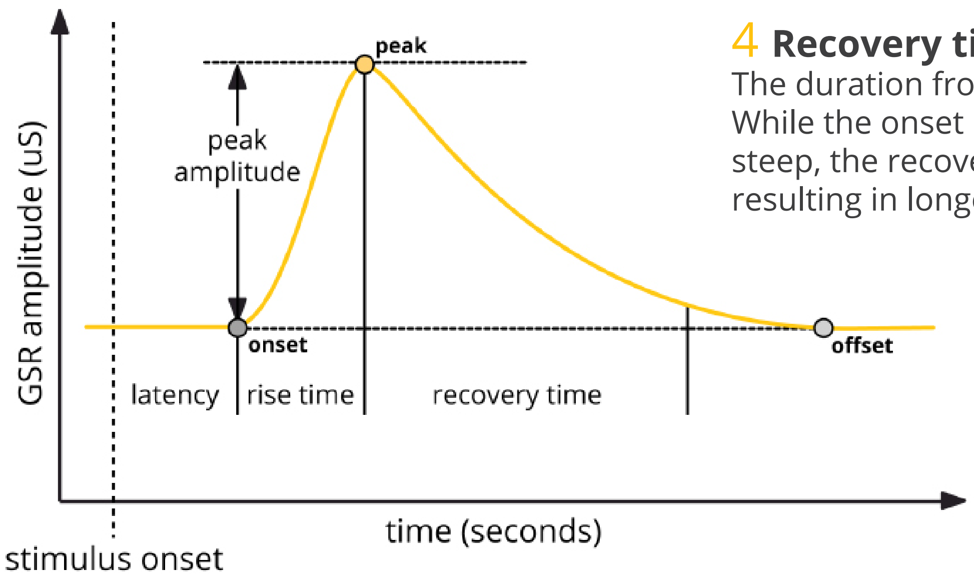
# Analyzing GSR data

Kudos to you.

You have come a long, long way - from sensor placement and GSR quality assessment to stimulus setup and presentation.

Let's glimpse at GSR data analysis - because that's where the true fun (and your enlightenment) starts.

When analyzing GSR data, focus primarily on the **event-related SCRs** as they can be interpreted as direct measures of arousal and engagement of your respondents. Individual SCRs can be characterized by the following four metrics:

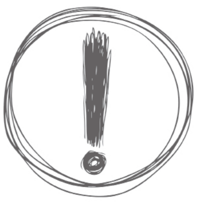



### 1 Latency
The duration from stimulus onset to the onset of the phasic burst. Typically, ER-SCRs arise 1-5 seconds after stimulus onset. The onset is generally set to the time point where the GSR curve exceeds a minimum amplitude criterion (0.01 or 0.05 µS, respectively). GSR changes that occur before this period are typically defined as NS-SCRs and are not considered as being generated by the experimental manipulation.

### 2 Peak amplitude
The amplitude difference between onset and peak.

### 3 Rise time
The duration from onset to peak.

### 4 Recovery time
The duration from peak to 100% recovery. While the onset of an SCR can be quite steep, the recovery is typically flatter, resulting in longer recovery times.



Admittedly, our illustration above is a simplification as the raw GSR signal is not completely flat before or after a peak. Instead, it varies due to individual differences in the tonic GSR level or due to noise stemming from movement or respiration artifacts.

Also, several GSR peaks can occur in direct succession, resulting in an adding up (or "ramping up") of the GSR signal instead of returning back to base levels. This phenomenon makes the analysis of the recovery time following peaks much more difficult compared to the analysis of onset- and peak-related latency and amplitude measures.

Because of this, the raw GSR data is usually processed as following:

1 **Downsampling**
This procedure reduces the number of samples per second. The GSR signal is often sampled at a much higher sampling rate than actually required. You can therefore downsample the data without a significant risk of losing important aspects of the signal. If your GSR data was collected at 100 Hz (100 samples per second), you can safely downsample it to 10 Hz (10 samples per second) or even less.

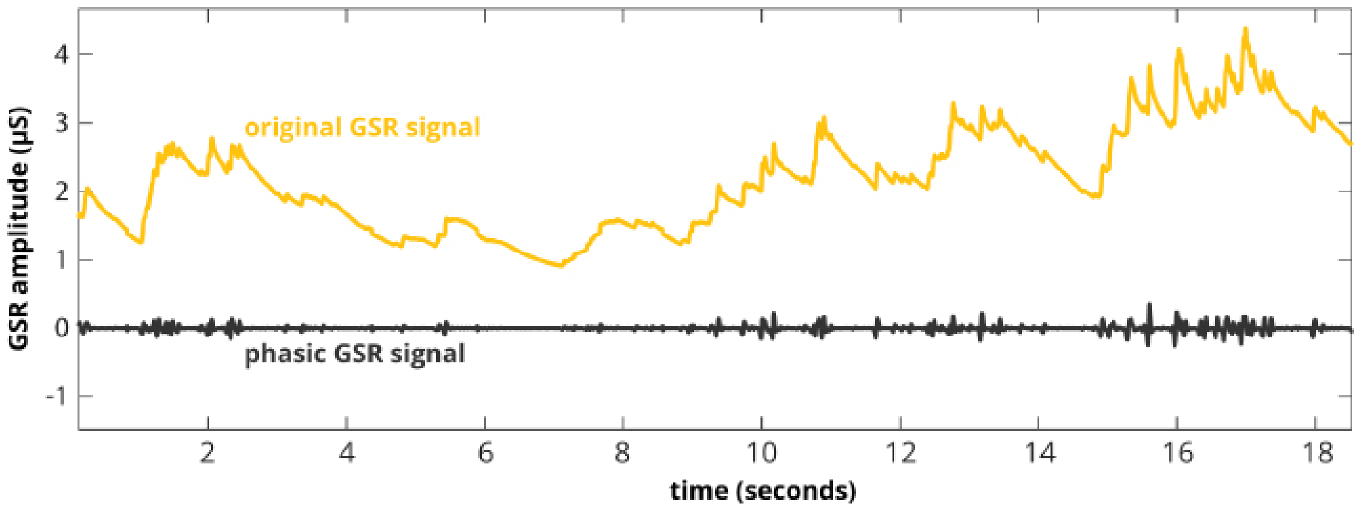
2 **Filtering**
With a filter you can "smooth" the GSR curve in order to **remove the tonic component** of the signal which is unrelated to arousal or high-amplitude "spikes" generated by movement. A median filter accomplishes this, leaving you with only the phasic signal.

You can apply a basic median filter in three steps:

1 Go through the data sample by sample.

2 For each sample, compute the median GSR score of the surrounding samples based on a +/-4 second time interval centered on the current sample.

3 Subtract the average from the current sample. The result is the phasic data.



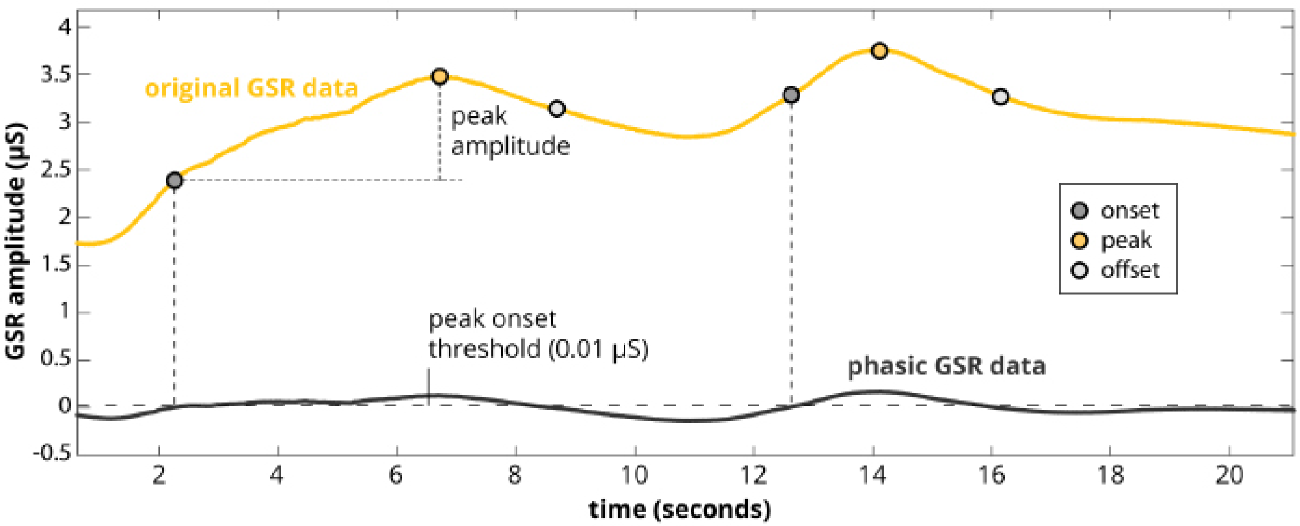
## 3 Onset and peak detection

Sure, you can scroll through the data and identify obvious GSR peaks manually. This was in fact how GSR data was originally performed. However, this can become a rather tedious process if your recording session covers several hours of varying stimuli, and your respondent pool comprises several hundred participants and segmentation groups.

Therefore, you might want to use algorithms and procedures that allow for **automatic detection** as well as report of onsets and peaks in a recording as follows:

1 Find peak onsets (> 0.01 μS) and offsets (< 0 μS) in the phasic data.

2 In the original, unfiltered GSR data find the maximum GSR value within each pair of onsets and offsets. These are the GSR peaks. The GSR peak amplitude is the amplitude at the peak minus the amplitude at onset.




After you have completed all of these steps, you can analyze any of the following GSR metrics with respect to differences between stimuli, respondents, and groups ... or just compare them within respondents across repeated presentations over time. Your call:

## 1 Number of GSR peaks

This metric tells you how many GSR peaks occurred during a recording condition. You can get the number for each respondent and compute an average number of GSR peaks across respondents. To give you an idea: If a video advertisement triggered more GSR peaks in your male respondent group compared to the female group (assuming that both groups showed comparable baseline activity), the material most likely contained gender-specific emotional cues that triggered GSR responses preferentially in men compared to women. In case this effect is not desired, it is a clear call to action to edit the video in order to address the female audience as well.

## 2 Average GSR peak amplitude and magnitude

If you present the same stimulus several times, you can compute the average GSR amplitude. For this measure, null responses (where the respondent showed no GSR peak at all) are simply ignored. In order to also reflect these, some authors additionally report the GSR magnitude, which includes null responses.

Congrats! You now have access to all GSR peaks of one respondent for any tested stimulus. Since the GSR peaks across your respondents might vary in latency and/or amplitude, the aggregation cannot be a simple averaging of all GSR waveforms across respondents.

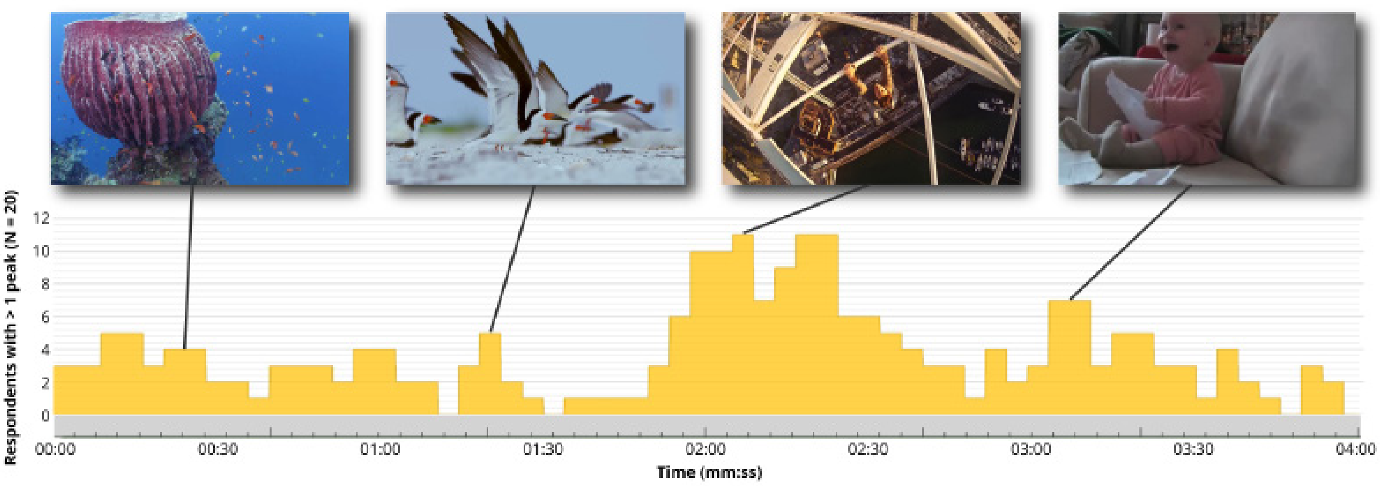
Instead, you have to accomplish GSR **aggregation based on binarization of the signal**. Here‘s how:

1 Break the continuous data of each respondent during the selected stimulus period into intervals with a certain window length (5 seconds, for example) and window overlap (1 second. for example).

2 Assign a value of 1 (“true“) to intervals that contain at least one GSR peak. Assign a value of 0 (“false“) to intervals that contain no GSR peak. Instead of the actual GSR peak amplitudes, the binary values 0 or 1 are used.

3 Sum up the binary scores for a bin across all respondents. Here‘s an example: If you collected GSR data from 10 respondents and all of them had at least one GSR peak in a certain interval, the aggregated value for this interval is 10. If none of your respondents had a GSR peak in the interval, the aggregated value for this interval is 0.

The resulting curve is a visualization of the consistency of your respondents‘ autonomic arousal elicited by the provided stimulus material. The aggregated result relates directly to the emotional arousal of the audience, (in our example, 11 out of 20 respondents had a GSR peak in the time interval 02:00 - 02:20--).



# GSR reloaded: Adding biometric sensors

What we know so far: Skin conductance offers tremendously valuable insights into our subconscious arousal when we're confronted with emotionally loaded stimulus material.

However, solely based on GSR we can't extract whether the arousal was due to positive or negative stimulus content. Why? The GSR peaks look completely identical. Both positive and negative stimuli can result in an increase in arousal triggering GSR peaks.

Complement GSR with other biometric sensors to paint the full picture

In other words: While GSR is an ideal measure to track emotional arousal, it is not able to reveal the emotional *valence*, that is, the quality of the emotions. The true power of GSR unfolds as it is **combined with other sources of data** to measure complex dependent variables and paint the full picture of emotional behavior.

The following 5 biometric sensors are a perfect complement to GSR recordings. Which metrics can be extracted from the different systems?

Let's see.

## Eye tracking

Eye tracking is the recording of eye position (gaze point) and movement on a 2D screen or in 3D environments based on the optical tracking of corneal reflections. Eye tracking reflects visual attention as it objectively monitors where, when, and what respondents look at. Furthermore, eye tracking devices can record the dilation and constriction of the pupil, which has been found to correlate with emotional arousal and cognitive workload. Eye tracking therefore can be used to validate and complement GSR measurements.

## Facial expression analysis

Facial expression analysis is a non-intrusive method to assess both emotions (subtle movements in face muscles, mostly subconscious) and feelings (accompanied by clearly noticeable changes in facial expression). While facial expressions can measure the valence of an emotion/feeling, they can't measure the associated arousal.

## EEG

Electroencephalography is a neuroimaging technique that measures electrical activity on the scalp. EEG tells which parts of the brain are active during task performance or stimulus exposure. It analyzes brain dynamics of engagement (arousal), motivation, frustration, cognitive workload and other metrics associated with stimulus processing, action preparation, and execution. EEG tracks stimulus-related processes much faster compared to other biometrics sensors.

## EMG

Electromyographic sensors monitor the electric energy generated by bodily movements (e.g., of the face, hands or fingers). Use EMG to monitor muscular responses to any type of stimulus material; it can extract even subtle activation patterns associated with consciously controlled hand/finger movements (such as the startle reflex). In addition, facial EMG can be used to track smiles and frowns in order to infer a subject's emotional state.

## ECG

Track heart rate, or pulse, from ECG electrodes or optical sensors (PPG) to get insights into respondents' physical state, anxiety and stress levels (arousal), and how changes in physiological state relate to their actions and decisions.


### The whole is more than the sum of its parts

Each biometric sensor reveals a specific aspect of human cognition, emotion, and behavior.

Depending on your individual research question, consider combining GSR with two or more additional biosensors in order to gain meaningful insights into the intricate relationships between the autonomic regulation of emotional arousal, valence, cognition, attention, and motivation.

# GSR done right with iMotions software

Let‘s recap.

1 While GSR is straightforward to measure, the analysis and interpretation of the collected data is a bit more challenging due to the fact that electrodermal activity occurs as part of a complex set of responses mediated by the autonomic nervous system.

2 GSR data reflects emotional arousal. To identify how arousal, valence, motivation and cognition interact in response to physical or psychological stimuli, it becomes necessary to complement GSR with other biosensors.

Before you can kick off your GSR research, you definitely need to think about which recording and data analysis software to use. Usually, separate software is required for data acquisition and data processing. Although some manufacturers offer integrated solutions, you will most likely have to export the raw data to a dedicated analysis platform for data inspection and further processing.

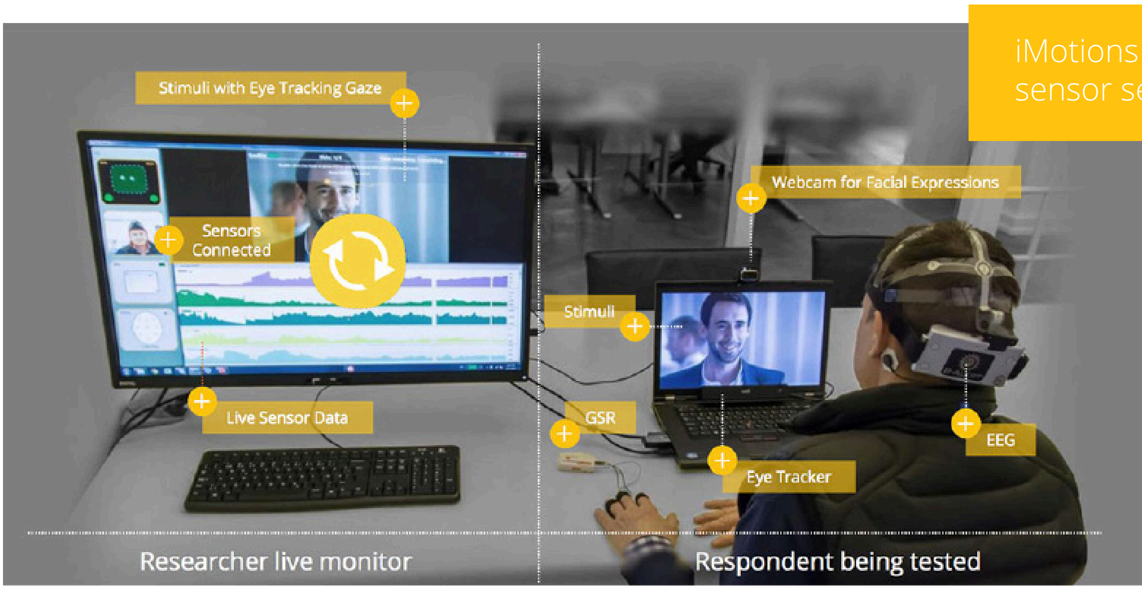
So which software solution allows you to integrate any type of stimulus with GSR and other biometric sensors without having to piece everything together? “

iMotions Biometric Research Platform is an easy to use software solution for study design, multisensor calibration, data collection, and analysis.

Out of the box, iMotions supports **over 50 leading biometric sensors** including GSR, eye tracking, EEG, ECG/EMG and facial expression analysis along with survey technologies for multimodal human behavior research.

IMOTIONS®

BIOMETRIC RESEARCH PLATFORM




iMotions multi-modal sensor setup

## What‘s in it for you?

From start to finish, iMotions has got you covered:

**Get the most from GSR and multi-sensor research**

1. Run your multimodal study on **one single computer.**

2. Forget about complex setups: iMotions requires **minimal technical skills** and effort for **easy experimental setup** and data acquisition.

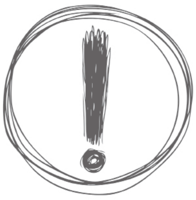
3. Get **real-time feedback** on calibration quality for highest measurement accuracy.

4. Draw on unlimited resources: **Plug & play any biometric sensor** and **synchronize it with any type of stimulus** (images, videos, websites, screen recordings, surveys, real-life objects, you name it).

5. Receive **immediate feedback on data quality** throughout the recording across respondents.

6. Worried about data synchronization? Don’t be. **iMotions takes care of the synchronization of data streams across all sensors**, so you can work on what really matters.

iMotions introduces **individual GSR peak detection** and **innovative aggregation procedures**:



1 You can use this innovative GSR aggregation procedure to get insights into the consistency of your respondents‘ autonomc arousal elicited by the provided stimulus material.

2 Working with time windows, iMotions can pool together GSR peaks that are happening approximately at the same time.

3 iMotions can count the number of respondents that had “a response“ (at least one GSR peak) in a time window. The aggregated result relates directly to the audience.

## Ready to elevate your research?

Learn how to launch your GSR study at full speed at www.imotions.com

# Further reading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