



PsychLab

Skin Conductance

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PRECISION INSTRUMENTS

PsychLab provides for high resolution skin conductance measurement to produce publishable data. The system accommodates a wide variety of experiments including those involving showing of

pictures, playing sounds, and recording synchronized video in computer file. fMRI applications are also supported.

SC Basics

Skin conductance (SC) is measured with 8mm diameter silver/silver chloride electrodes positioned on the medial phalanx of the index and middle fingers held in position by double sided sticky electrode collars. SC response (SCR) provides an indication of arousal.

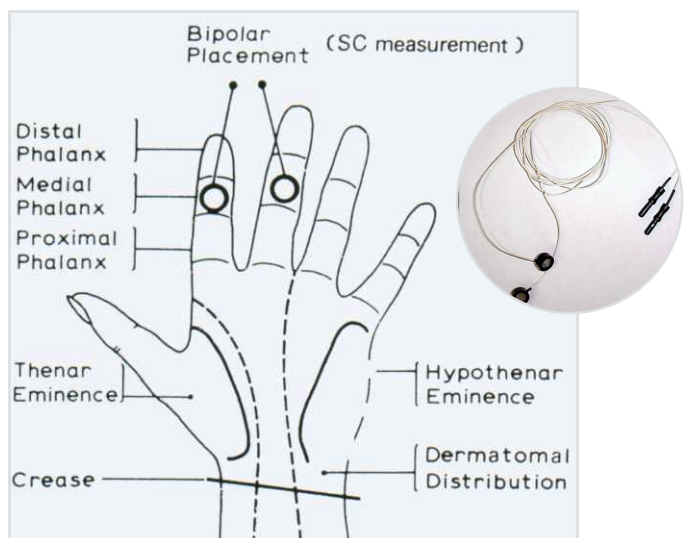
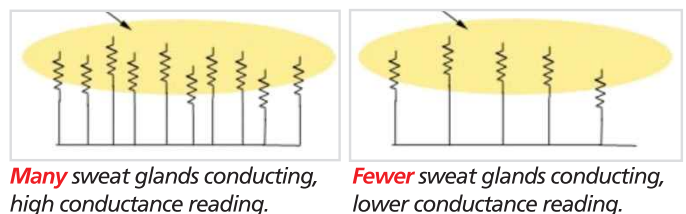
Skin Conductance is also known as Galvanic Skin Response (GSR) or Electrodermal activity (EDA), but Skin Conductance is the correct term. It is based in the primitive 'fight or flight' response, whereby the body prepares itself for the exertion needed to deal with a perceived threat by increasing sweat activity to cool itself. At low levels, this happens all the time, as the mind experiences thoughts and emotion.

The reason for using the conductance measure which is the reciprocal of resistance lies in the understood model for skin conductivity. As perspiration increases, more sweat glands begin to conduct electricity in a given area of skin. This is opposed to the incorrect model whereby there is a constant number of sweat glands per skin area, and the conductivity of each gland varies. The former model is one of a varying number of parallel resistances, the latter equivalent to varying series resistance. The electrical formula for calculating parallel resistance is: $1/(\text{total resistance}) = 1/(\text{resistance1}) + 1/(\text{resistance2})$ etc. where each resistance is a discrete sweat gland. However if measured as conductance the simplified formula is: $\text{total conductance} = \text{conductance1} + \text{conductance2}$ etc. Thus it makes sense to use units of conductance (micro Siemens) rather than its reciprocal resistance (Meg Ohms). To measure SC, a very small voltage is applied across the electrodes (0.5V). By measuring the current that flows, conductance can be determined.

Sensitive response to thoughts is only found at two places on the body, the hand and foot. Two sites on the hand are normally used, medial phalange of the fingers, or palm. The site used on the feet (rarely) is at the heel. See Martin & Venables, Handbook of Psychophysiology, 1979.



Area of skin under electrode



There is a delay between stimulus and SC response, usually considered to be a minimum of 0.8 seconds. For this reason studies which look at discrete responses apply a time window in the analysis such that responses are only accepted if the onset lies between 0.8 (or 1) second and usually 4 seconds after the stimulus. Later than that and it will be considered a non-specific response (NSR) also called a spontaneous response (SR); not a stimulus elicited response. The abbreviations SR and NSR are correct terms for use in publications. Responses are also screened by their amplitude, normally a minimum response amplitude of 0.02 micro Siemens is required.

Designing the experiment

PsychLab measuring software allows other measures to be mixed with SC. User programmed events can be scheduled as required while data acquisition proceeds, including stimulator control. It accommodates auditory and visual stimulation. Pictures may be shown using intelligent script to design picture order, timing, and so on. For picture or movie presentation, a second monitor is normally required, using windows 'extended desktop' mode which allows two computer monitors to display different things under control of one program. Pseudo random and true random functions are available. Orienting response, habituation, conditioning and other studies may be performed with this highly flexible, user programmable software. Our stimulators include tone, noise or click and electric shock.



A classic SCR (SC Response) to a discrete stimulus is shown in the red trace, with its characteristic onset, rise time, peak, and exponential decay, sometimes measured as 'half recovery time'.



LEFT: Experimenter room

BELOW: Experiment set-up with stimulus screen for viewing pictures or movie clips.



SC recording with MRI



A long shielded input cable is used allowing SC to be recorded in the adverse magnetic environment. Conventional silver/silver chloride electrodes have been found not to interfere

with MRI performance when placed at the distance of the hand of the subject. The SC amplifier is positioned outside the faraday cage. Please ask for further details about this application.

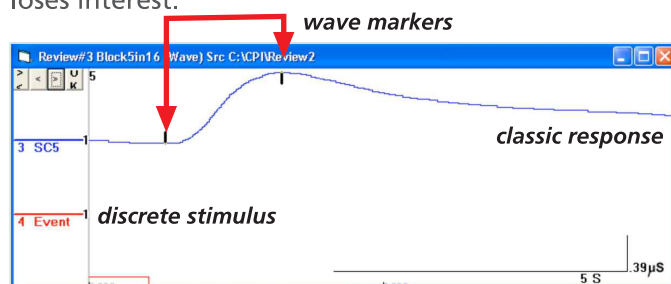


LEFT: Auditory stimulator

BELOW: Pain stimulus shocker

Designing an experiment with Specific Responses

This is the event related type of experiment, where there are clearly defined discrete stimuli which may elicit SC responses. Normally the stimulus will be repeated for a number of trials, with randomized or pseudo random variation of interval between trials. It is important when designing the experiment to leave sufficient time between stimuli, so that each discrete response can be windowed and quantified. An SCR typically takes 4 or 5 seconds to complete, and onset may be up to 4 seconds from stimulus onset. Experiments may be designed with as short as 8 seconds between stimuli, but to be comfortable, 12 – 15 seconds is better. There is often a compromise that must be made to avoid the experiment becoming so long that the subject loses interest.



The intelligent macro script facility in PsychLab data analysis allows sophisticated procedures to be implemented which in addition to windowing and

Trial	dom	event	subject	group	SCLevel	SRlatency	PLatcy	SRamptd	NSR	PreNSR	PstNSR	Habit	AvgSCL	Key
043	001	040	82091	00000	05.586	3.0920	4.1900	00.5913	000	00.7103	00.0000	0	05.492	000
044	002	040	82091	00000	04.752	2.8410	5.2390	00.6382	000	00.0000	00.0000	0	04.989	000
045	003	040	82091	00000	05.097	2.7950	4.2430	00.5764	000	00.0000	00.0000	0	05.263	000
046	004	040	82091	00000	04.866	2.6090	6.2070	00.4269	000	00.0000	00.0000	0	05.043	000
047	005	040	82091	00000	04.837	2.6330	6.1310	00.9556	001	00.0000	00.2407	0	05.337	000
048	006	040	82091	00000	05.106	1.0920	3.5900	00.5852	001	00.0000	00.9804	0	05.564	000
049	007	040	82091	00000	05.134	1.4140	3.1120	00.9628	000	00.0000	00.0000	0	05.466	000
050	008	040	82091	00000	05.312	2.8980	5.0460	00.0607	000	00.0000	00.0000	0	05.386	000
051	001	030	82091	00000	05.626	2.8180	4.7660	01.2833	001	00.0000	00.1801	0	06.309	000
052	002	030	82091	00000	05.384	2.9190	4.7170	01.0361	001	00.0000	00.2388	0	05.875	000
053	003	030	82091	00000	05.455	3.1550	4.8030	00.8434	001	00.0000	00.4185	0	05.861	000
054	004	030	82091	00000	05.484	1.6050	3.1530	00.0931	002	00.0000	01.2543	0	05.988	000
055	005	030	82091	00000	05.587	3.0100	4.5080	00.6878	000	00.0443	00.0000	0	05.815	000
056	006	030	82091	00000	05.438	2.9280	4.8760	00.2655	001	00.0000	00.3517	0	05.709	000
057	007	030	82091	00000	05.528	3.0660	6.1140	00.8274	001	00.0000	00.0233	0	05.806	000

scoring SR can identify habituation trial and also produce information about second or late responses and those that occur before the response window. In the example result data shown, the third from right column shows habituation, if it occurred. Trials in the data are in groups of 8, such a group of trials is called a domain. The 3rd column from left shows trial grouping. Habituation occurred in trial 6 of type 60 domain. This is a very complex example of specific response SC analysis.

PsychLab Wave detection system is used in many published studies. It was first implemented in 1986.

The following information is produced:

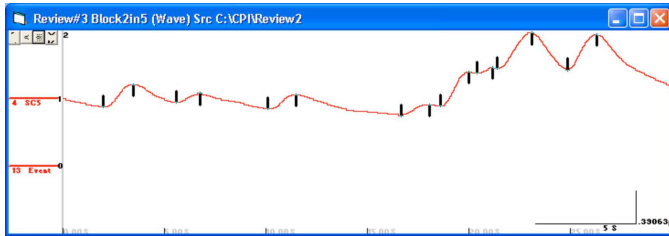
- 1) Onset level of each wave.
- 2) Onset latency (from block stimulus event) for each wave.
- 3) Amplitude of each wave.
- 4) Total amplitude of all waves in each channel.
- 5) Count of waves in each channel.
- 6) Peak latency of each wave.

Non-Specific response experiments

Generally studies involving picture stimulus are dealt with in the non-specific category, because response to pictures may not be immediate. Other types of experiment in this category are emotion work, drug trials, and any procedure where there is not a specific stimulus. Non-specific response experiment usually will have some way of identifying different stages in the procedure, whether that be an interview, presentation of movie clip, and so on.

The method used for NSR SC analysis is to collect total responses that occur in different stages of the procedure.

In the case of picture presentation, responses are counted while the picture is shown. It is helpful when comparing response count in different stages if they are counted in a uniform time epoch, therefore each stage of the procedure might be broken up into as many time epochs as fit that stage, if it is of indeterminate duration. Data are then produced for each stage, using the wave algorithm to count responses and also quantify total response amplitude. The latter is not frequently used in published research, but arguably provides more sensitive data.



Wave detection may be used for both SC Specific Response (SR) and Non-specific Response (NSR) detection. With SR, normally the amplitude of the first wave detected in the defined time window is produced, and possibly latency of onset.

The table shows typical format for NSR data, where each line is the data for one 30 second time epoch. The

1	0	10	.4539986	2
2	0	10	1.277996	6
3	0	10	1.550003	7
4	0	10	.3560009	4
5	0	10	.2640018	3
6	0	10	.2899971	4
7	0	10	.6019974	6
8	0	10	.302002	3
9	0	10	.6080017	4
10	0	10	.2559986	2
11	0	20	0	0
12	0	20	2.799988E-02	1

rightmost column is the count of responses, the next is total response amplitude in that time epoch.

Details of the PsychLab SC instrument

The amplifier shown combines the SC5 Skin Conductance unit and an EKG amplifier for measuring Heart Rate. It connects directly with the computer USB and requires no external power supply.

The SC5 device uses a high resolution 24 bit digital converter to ensure full accuracy. Skin conductance has a range up to 100 micro Siemens, and within that range it is necessary to be able to resolve very small responses. The standard criterion for a skin conductance response is 0.02 micro Siemens, and to properly detect such a response it should be resolved to at least 0.002. With 24 bit accuracy SC5 easily achieves this, and can show responses below levels previously considered viable. SC5 uses the preferred constant voltage method (0.5V).

The SC5 24 bit accuracy A-D converter runs at a fixed internal sample rate of 80Hz, however the cycle sample rate for the SC-EKG unit may be set to a higher rate if required, in which case samples will be padded with identical readings. The 24 bit ADC digitizes SC immediately at the point where it is measured, minimising the possibility of interference or error. The circuit is self-calibrating, using known high precision resistances which are automatically switched in circuit by reed relays, which themselves exhibit very low contact resistance and thus minimize error. Calibration occurs when the unit is first powered up. When calibration is complete, the 24 bit code accurately represents SC



PsychLab Skin Conductance EKG

measured between the red and black input terminals. The green terminal is provided only for cable shield ground, if an extended input cable is required. PSYCHLAB directly conveys the 24 bit value to the host computer.

When SC5 is used with PSYCHLAB software, convenient automatic evaluation of phasic SCR is available both in the stimulus - response paradigm (specific response, SR), and in the non-specific response paradigm (NSR). In the former, the phasic response can be analysed for onset level, onset latency, amplitude and peak latency. In the latter, SCR may be counted (and evaluated for total amplitude if required) in given time periods, allowing performance to be compared in baseline and stimulation phases of the experiment.

SC5 measures directly in conductance, using DC coupling with constant voltage electrode excitation. The high resolution of SC5 allows SCRs lower than 0.01 micro-Siemens to be magnified in software and adequately resolved.

The PSYLAB SC range of instruments originate in 1979 and comply with the recommendations of Lykken and Venables. Further useful information, including recommendation of electrode type, conductive paste etc. may be found in pages 4 – 62 of “Techniques in Psychophysiology”; Martin & Venables (published by Wiley, 1980).

SC5 Specifications:

Measurement Units	micro-Siemens
Absolute accuracy	+/- 0.1 micro Siemens
Relative accuracy	5.96e-6 micro Siemens
Frequency response	DC - 10 Hz
Subject excitation	0.5V DC
Range	0 - 100 micro Siemens