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Review Article

A Brief Introduction and Review on Galvanic Skin Response

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ABSTRACT

The Galvanic Skin Response (GSR) is defined as a change in the electrical properties of the skin. The signal can be used for capturing the autonomic nerve responses as a parameter of the sweat gland function. The response appears as an increase in the electrical conductance of the skin (a decrease in resistance) across the palms of the hands or soles of the feet. The PGR (psychogalvanic reflex) is mediated by the sympathetic division of the autonomic nervous system. The PGR is essentially involuntary, although people can be taught to control it somewhat via biofeedback training. As a detector of emotion, the response often has served as one of the indicators in the lie detector, along with blood pressure, pulse, and respiration.

The galvanic skin resistance (GSR) is an accessible & sensitive index of peripheral sympathetic nervous activity, reflecting peripheral autonomic change. This test has a potential therapeutic value as GSR biofeedback in assessing seizure frequency in patients with drug resistant epilepsy.

Keywords: Galvanic skin resistance, Psychogalvanic reflex, Electrodermal activity.

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INTRODUCTION

The Galvanic Skin Response (GSR) is defined as a change in the electrical properties of the skin. The signal can be used for capturing the autonomic nerve responses as a parameter of the sweat gland function. Psychogalvanic reflex (PGR), also called galvanic skin response (GSR), a change in the electrical properties of the body (probably of the skin) following noxious stimulation, stimulation that produces emotional reaction, and, to some extent, stimulation that attracts the subject's attention and leads to an aroused alertness. The response appears as an increase in the electrical conductance of the skin (a decrease in resistance) across the palms of the hands or soles of the feet. It appears about two seconds after stimulation, as by a pinprick or threat of injury; it rises to a maximum after two to ten seconds and subsides at about the same rate.

The PGR is mediated by the sympathetic division of the autonomic nervous system. It is a part of the general arousal or activation pattern of physiological responses that mobilizes and fits the person for effective reaction in an emergency. In addition, parts of the brain's premotor cerebral cortex appear to have a role in producing it. The consensus is that the PGR is associated with activation of the sweat glands by the postganglionic sympathetic fibers but that the perspiration actually secreted does not produce the characteristic decrease in skin resistance by acting as an electrolytic conductor. A more sensitive indicator of minimal emotional arousal than are other physiological responses, the PGR has figured extensively in studies of emotion and emotional learning. It can help to uncover complexes of emotional sensitivities when used with word-association tests or interviews; by observing when the response occurs, the skilled worker can deduce which stimuli evoke emotional disturbance. The PGR is essentially involuntary, although people can be taught to control it somewhat via biofeedback training. As a detector of emotion, the response often has served as one of the indicators in the lie detector, along with blood pressure, pulse, and respiration.

GSR is the electrical resistance recorded between two electrodes placed on the hand with a feeble electric current running between them. A change in autonomic tone, largely sympathetic, results in alteration of GSR. For example, following sympathetic stimulation, there is a slight increase in sweating, and this slight increase is enough to lower the skin resistance since the sweat contains water and electrolytes, both of which increase the conductivity of skin. Thus a fall in GSR indicates a rise in sympathetic tone.

A review on GSR discloses three principal theories which purport to account for the phenomenon.

(1) Muscular activity: GSR is the direct display of bio-electric changes in muscle. Evidence indicates that there is a relationship which is not causal.

(2) Vascular changes: GSR is the electrical activity attendant on vasodilatation or vasoconstriction. The evidence here is persuasive but still favors correlation rather than causation.

(3) Secretory changes: GSR is the pre-secretory electrical activity of the sweat glands. The evidence seems to select this theory as the best of the three, although the actual mechanics is, as yet, unknown.[1]

The galvanic skin resistance (GSR) is an accessible & sensitive index of peripheral sympathetic nervous activity, reflecting peripheral autonomic change. This test has a potential therapeutic value as GSR biofeedback in assessing seizure frequency in patients with drug resistant epilepsy. The GSR has also been used to judge the autonomic neuro-cardial disturbances taking place in diabetics, chronic alcoholics & in patients with Parkinsonism. So the estimation of GSR may be of use to unravel any significant alterations in the sympathetic tone during pregnancy.[2]

Haemodynamic studies during pregnancy suggest that autonomic nervous activity in the early stages of pregnancy is in fact different from the pre-pregnant state.[3] The integrity of peripheral sympathetic cholinergic functions can be assessed electrically by measuring the activity of sweat glands. The sweat secretion is accompanied by a change in skin conductance due to sweat electrolytes. Lack of changes in skin potential in response to such stimuli may thus serve as an index of sympathetic neuropathy.[4] Significantly decreased mean value for GSR in the third trimester indicates increased sympathetic activity in the third trimester of pregnancy. This is in agreement with a similar study where skin conductance (SCL) measured was found to be increased in pregnant subjects.[5]

It has also been shown that normal pregnancy (third trimester) is associated with an increase in resting peripheral sympathetic neural discharge having vaso-constrictor properties. The significant increase in sympathetic activity in the third trimester of pregnancy can be related to the hormonal changes in pregnancy such as elevated levels of gestational hormones and activation of rennin-angiotensin system (angiotensin II).[6] However, aortocaval compression caused by progressively enlarging gravid uterus which compromises venous return and cardiac output, has been speculated as a key mechanism leading to a shift in autonomic nervous activity towards a higher sympathetic modulation.[7] So we propose that GSR may be a potent means to elucidate the variations in sympathetic tone in pregnancy.

As regards Galvanic Skin Response (GSR), there are several studies which propose different methods of detecting stress levels by measuring skin conductance.[8] The study described has the objective of detecting sweat levels for the diagnosis of sudomotor dysfunction that can help in the diagnosis of diabetes.[9] There are other medical applications based on skin conductance, such as epilepsy control: sweaty hands may be a warning signal of an epileptic attack as support of the diagnosis and treatment of bipolar disorder patients.[10,11] By combining the sweat of the hands with the temperature of the skin, it is possible to develop a truth meter; as when the person is lying, his hands are colder and skin resistance is lower.[12] There are two methodologies for measuring GSR, the exosomatic and the endosomatic methods. The exosomatic method can either use a direct current (DC) or alternating current (AC) through a circuit consisting of a galvanometer, electric battery and subject to measure changes in EDA; however DC currents are used more often than AC currents.[13] In contrast the second method, the endosomatic method, uses a subject and galvanometer circuit to measure changes in resting electromotive force, or voltage of the skin.[13] Of all the methods - (1) endosomatic and (2) exosomatic with either DC or AC- it is exosomatic DC that is most commonly used.[14] Using the two methods, two processes of EDA can be measured; phasic and tonic. Phasic processes, referred to as responses or electrodermal responses (EDR), are more event related and have shorter time courses. These responses are usually the result of eliciting stimuli, but can also be non-specific with unidentified origins and are reported in terms of amplitude (magnitude of response) and frequency (number of responses). Tonic processes, referred to as levels or electrodermal levels (EDL), consist of longer time courses and are slower to change and are usually described in terms of amplitude. Exosomatic DC, the most frequently used method, has two types of measurement and terms in which GSR can be reported -Skin Conductance (SC) and Skin Resistance (SR). It is important to note that an increase in conductance equals a decrease in resistance and vice versa. For both SC and SR there are both phasic and tonic processes hence Skin Conductance Response (SCR) and Skin Conductance Level (SCL) as well as Skin Resistance Response (SRR) and Skin Resistance Level (SRL) are all measures of GSR. The endosomatic method conversely has only one measurement -Skin Potential (SP), and again can be reported as a phasic (Skin Potential Response, SPR) or a tonic process (Skin Potential Level, SPL). GSR continues to be one of the most frequently used methods in psychophysiology and is considered the gold-standard.[15]

A significant increase was observed in the GSR reading on standing in the pranayama group; this was not seen with the non-pranayama group. It indicates a decrease in the sympathetic tone while performing routine daily activities. The fact that this change was observed following the practice of pranayama for a short span of 7 days suggests that a decrease in sympathetic tone might be the earliest change amongst the various physiological changes seen following a regular practice of pranayama. No such change was seen in the non-pranayama group. This difference in GSR between the two groups seen during standing phase was significant, thus indicating the early-onset benefits of pranayama.[16]

There is much clinical evidence to suggest that the activity of autonomic nervous system varies with age. The values for the Cold pressor response and the Hand grip test showed progressive increase with age and GSR showed decrease with age suggesting increase sympathetic activity with age.[17] It was hypothesized that there was a significant positive effect of prayer and meditation (Om chanting) on galvanic skin response (GSR). The results revealed a significant increase in GSR values as an effect of prayer and meditation which suggested the psychophysiological relaxation. Practicing prayer and meditation increases the galvanic skin response and hence decreases the stress level of the individual.[18]

Studies examining GSR in Mood Disorders examined studies that recruited only patients with mood disorders with the aim of identifying a GSR profile. It was hypothesized that mood disorder patients would have a GSR profile with small, if any, GSR responses to stimuli and low levels of electrodermal activity (EDA) during baseline. In conclusion, using results from both studies, mood disorder patients' GSR profile appeared to be characterized by increased EDA (decreased skin resistance) with increased emotional activity, including manic phases, and decreased EDA (increased skin resistance) with decreased emotional activity, including depressive phases. This pattern of EDA response to emotional activity appears similar to our understanding of and expectations from healthy control, therefore mood disorder patients respond similarly to healthy control in terms of type of emotional activity experienced. With the presence of a GSR profile for mood disorder patients' clinicians may utilize GSR as a diagnostic aid but also help to monitor their patient's emotional experiences. A GSR profile would also potentially aid in establishing the effectiveness of pharmacotherapy as well as help identify the most suitable medication for a patient with a specific mood disorder. In terms of comorbidity, a GSR profile helps understanding why certain disorders have a higher rate of comorbidity than others. GSR would also aid in the defining and categorization of various disorders. As benefits to patient populations a GSR profile may aid in establishing the level of genetic predisposition in family members as well as expanding their understanding of the disorders. In terms of researchers a GSR profile opens up a variety of further avenues for research. Exploration of underlying reasons for gender over representation in certain disorders becomes possible due to the different GSR patterns of men and women.[19]

WORKING PRINCIPAL

In order to measure the electrical resistance, a constant voltage needs to be applied and the skin conductance can be calculated with the help of Ohm's Law by measuring the current flow. A Galvanic Skin Response Amplifier applies a small voltage through the skin which cannot be perceived by humans, but can be detected through amplification. The GSR is a combination of operational amplifiers, high-pass filters, low-pass filters, *arduino uno, band-pass* filters and led lights. It measures the conductance of the skin. Stress produce sweat and is been measure through copper electrodes. The data can be seen through the graph by using GUI software inside the computers. If there is no computer, the LED light will be as our output.

In the more common method measuring the skin conductance using an external electrical stimuli (as opposed to the lesser used method of detecting an internally generated voltage on the skin) an initial base level called the Skin Conductance Level (SCL) is established. Each person has a different SCL ranging from 10 – 50 µS. The devices which measure a galvanic skin response are often referred to as feedback instruments, in part because of how this response is generated or detected. If this response is measured "actively," then a gentle electric current is passed through the body of the test subject to measure conductivity. A passive test measures the current that is generated by the person's body itself. The feedback from this is what constitutes the measured galvanic skin response.

Fig 1: Shows a typical setup for measuring GSR. The sensor is just a 9V LEGO motor wire and some aluminum foil wrapped around your fingers with tape. A small current is generated in a pocket size amplifier which is able to sense fluctuations upto a few microsiemens.

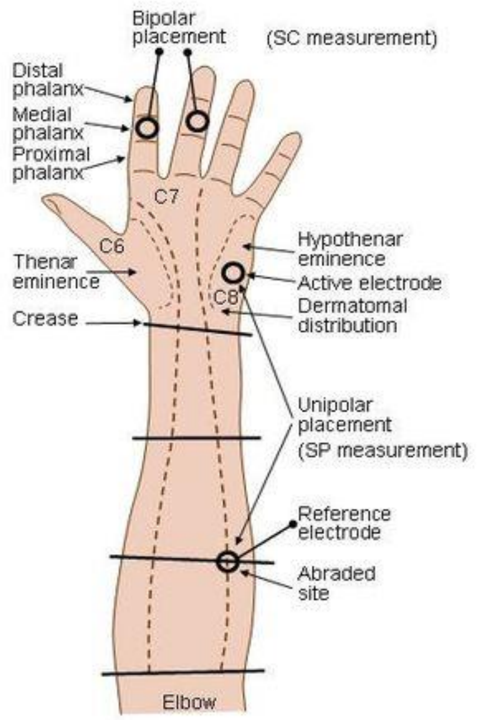

Fig 2: Set-up/location for placement of electrodes

Fig 3: A simple LEGO setup for a lie detector test

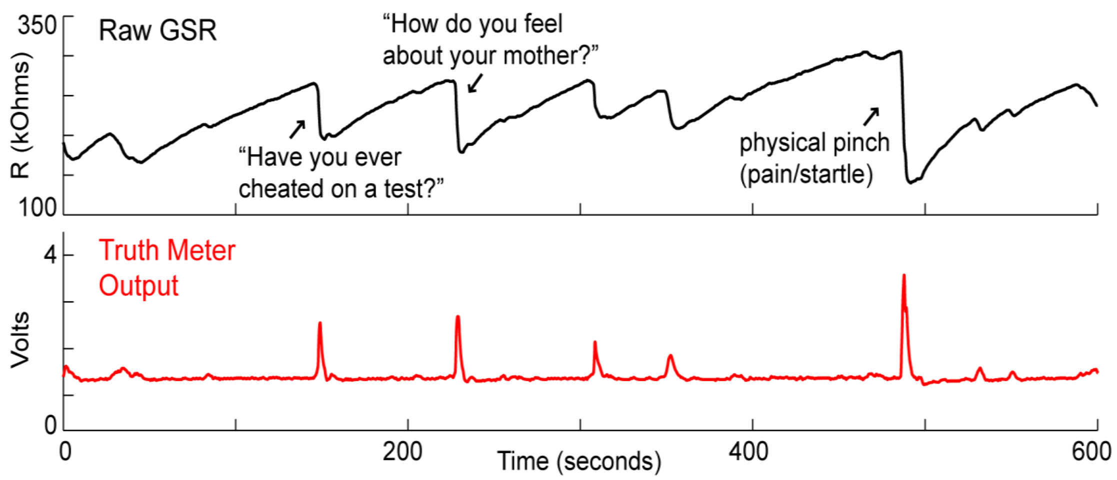

Fig 4: Graphical presentation of GSR

EDA (Electro-dermal activity) is best measured at palmar sites. Suggested locations for electrode placement are given in Figure 2. In general, the electrodes used are of the Ag/AgCl type which are recessed from the skin and require the use of a suitable electrode paste. Since this is a reversible type of electrode, polarization and bias potentials are minimized. This is obviously of importance since such contributions introduce artifact in the SP and SC determinations. There is also a half-cell potential under each electrode, but if these are similar and overlie identical chloride concentrations their effects are equal and cancel. For this reason an electrode paste with NaCl at the concentration of sweat (approximately 0.3% NaCl) is to be preferred. As described in Figure 2, the reference site should be abraded, a procedure that may possibly remove the corneum and introduce much reduced contact resistance. The site itself, on the forearm, is selected to be a neutral (nonactive) location so that only good contact is required. Although the removal of the corneum at the active site would interfere with the examination of the system there, no such requirement needs to be imposed at the reference site, since it should be nonactive.

APPLICATION

Measuring the galvanic skin response can also be an important element of certain psychotherapy treatments, as well as behavioral therapy. There is a connection between stress and anxiety levels to the response of the skin to electricity.

The most well-known use for measuring this response is as a part of a polygraph or "lie detector" test. Various parameters of the body's reaction (of which GSR is one) are recorded when a person lies. Knowingly stating a falsehood is, in a physiological sense, stressful and unnatural. A change in the electrical conductivity of the skin, as well as changes in breathing, heartbeat, and perspiration, is one of the body's responses to the stress of lying. Fig 3 shows the set up for such a "Galvanic Skin

Response Sensor" developed by LEGO-enthusiast Michael Gasperi. A set of foil-lined velcro strips attached by 9V wire to an RCX control brick, Gasperi's lie detector works on the principal that people sweat more when they're fibbing, causing a change in the skin's electrical resistance which the sensor picks up. Fig.4 is typical graphical presentation of GSR.

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