

GSR Analysis Of Hypnotic Analgesia

K. Shankar, M. Manivannan

Biomedical Engineering Group, Department of Applied
Mechanics, Indian Institute of Technology Madras
Chennai India 600036
mani@iitm.ac.in

Peter Fernandez

Psycholab, Porur
Chennai 600116, India

Abstract

This work aims to verify whether Galvanic Skin Response (GSR) can be used as a valid pain indicator and to analyze the changes in GSR during hypnotic analgesic condition. Two types of experiments were conducted namely 'Pain-GSR' (PG) and 'Hypnosis-Pain-GSR' (HPG) experiments for 10 subjects. The experiments were done under pain and no-pain conditions on subjects of both the gender in the age group of 20 to 30 years old. We used 4 iron discs of 1.25 Kg each to create mechanical pain for PG experiment in our laboratory set up. For the HPG experiment, a disposable needle was inserted on subject's skin to create pain. The HPG experiment was conducted in a clinical setup with the help of an experienced hypnotherapist. The experiments were conducted in same ambient conditions of respective setup. The incremental change in conductivity of skin was observed in 'During Pain' stage of PG experiment. In HPG experiment, the conductivity of skin is in same range in 'Pre Pain without Hypnosis' and 'During Pain with Hypnosis' stages. The results of PG experiment show a clear relation between Pain and GSR and there is a scope for measuring pain objectively using GSR. The results of HPG experiment show that the subjects do not feel pain during hypnotic analgesia, and GSR is a true indicator of pain. However before concluding that GSR is a good indicator of pain, it requires a experimental studies with more subjects.

Keywords: Pain, GSR, Hypnosis, Analgesia.

1. Introduction

The onset of the 21st century is an incredibly exciting time in pain research [1]. Information from recent studies in basic pain research is virtually exploding and has revealed numerous novel targets in pain research. Even though the pain is an alert system of our body, the body uses to defend itself from destructive processes that occur from time to time; pain offers challenges to both, physician and sufferer [2]. For the sufferer, it is a hurt. He faces huge challenges in getting relieved from pain. For the physician, it offers great challenges in terms of curing sufferer's pain. In order to cure pain, a physician must know the quantity of sufferer's pain exactly.

Otherwise, the physician may prescribe a wrong dosage of pain killers; it may lead to side effects [3,4]. Therefore, it is essential to measure the pain objectively and we need some quantitative indicator of pain.

Though there are many quantitative indicators of pain in the literature[5], this work aims only to check whether Galvanic Skin Response(GSR) can be used as a valid pain indicator or not. GSR measures the level of autonomic system activity by measuring the electrical resistance of the tissue path between two electrodes applied to the skin. This technique has been extensively used in animal and human research on pain.

We aim also to analyze the changes in GSR during hypnotic analgesic condition. It is well known from literatures that hypnosis has been used as an important pain relieving technique [6]. During hypnosis, changes in the activity of Autonomic Nervous System have been reported [6]. At present there are no convincing studies to show the neurological changes during hypnosis. Since GSR is a good measure of changes in autonomic activity, it has been used in this work to validate hypnotic analgesic condition of subjects.

The term 'pain' in this paper is limited to only for mechanically stimulated pain and not the actual pain. The experiments were done in laboratory set up, not in clinical set up. However the hypnosis experiments were done in actual clinical setup with subjects who were not actually suffering with pain.

2. Methodology

To analyze the relationship between GSR and pain we did 'Pain-GSR' (PG) experiments by measuring GSR while controlled pain stimuli are applied (Fig.3). The physiology says that there would be change in skin resistance due to pain. In majority of cases the GSR is recorded by the change of electrical resistance of the skin to a direct current [7,8]. This change in skin resistance is due to perspiration. For design purpose the skin resistance has been considered as 250 K Ω [8].

In this work a circuit was developed to deliver constant current of 5 μ Ampere. The reason for keeping the current as 5 μ A is to minimize the polarization at the electrodes [7]. A separate power supply circuit, which supplies constant 5 volts, was also designed by using a voltage regulator.

The data were acquired by using Data Acquisition Card (PMD-1208FS DAQ) of Measurement and Computing Corporation (MCC). The signal is acquired at a sampling rate of 256 Hz. The PMD DAQ card does not perform simultaneous A/D conversion on the each channel. Instead, all the channels are multiplexed to a single A/D converter internally. Hence, there is a time lag between different

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channels in the (pseudo) simultaneous sampling. The voltage range of the A/D converter is $\pm 5V$.

2.1. Circuit Description

The circuit (Fig.1), developed for GSR measurement is a simple constant current source circuit with, an op-amp LM741 and $1M\Omega$ resistors. The op-amp is operated in non inverting mode. The constant voltage of 5V is supplied to the non inverting terminal of op-amp through $1M\Omega$ resistor and the inverting terminal is grounded through $1M\Omega$. The 6th pin of op-amp is connected with inverting and non inverting terminal with $1M\Omega$ resistor. The current output is taken out from the non inverting terminal. This current is fed to the body of specific location.

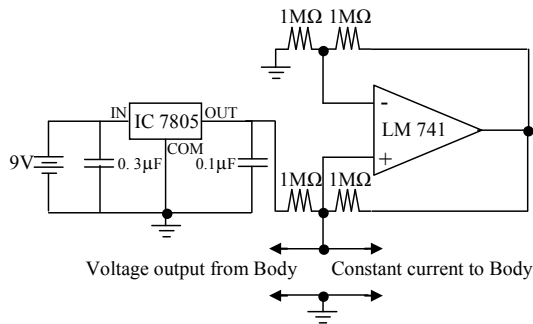


Figure 1: Circuit for GSR measurement.

2.2. Experiment

Two experiments were conducted in this work. They are Pain-GSR (PG) experiment and Hypnosis-Pain-GSR (HPG) experiment. These experiments were performed with 10 subjects. Among these 10 subjects, 3 subjects (2male subjects and 1 female subject) were used for HPG experiment. And remaining 7 (5 male subjects and 2 female subjects) were used for PG experiment. All the subjects were in the age group of 20 to 30 years old.

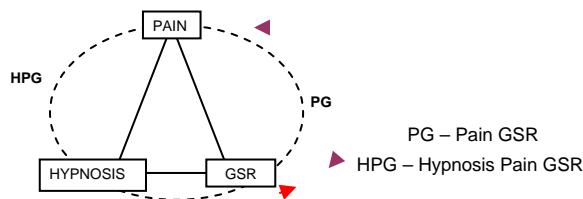


Figure 2: Pain, GSR, Hypnosis and related



Figure 3: Controlled Pain Stimuli for PG experiment

The PG experiment gives the response of GSR during pain and no pain conditions only. This experiment was conducted in our laboratory set up. The same ambient condition was maintained for all the subjects during all the stages of experiment. A mechanical pain stimulus was given to all the subjects.

On the other hand, the HPG experiment gives the response of GSR on pain during hypnotic analgesic and non hypnotic analgesic conditions. This experiment was conducted in clinical environment with the help of an experienced hypnotherapist. For this experiment also the same ambient conditions were maintained for all the subjects during all the stages of experiment.

The output from the circuit is only the voltage from the subject's skin. This voltage output is then converted into conductance by applying Ohm's law. Before making involvement in the experiments, the subjects were well taught about the experiments and they were prepared for the same.

In the PG experiment, the electrodes were placed in the appropriate place, as shown in figure (Fig.4.). This experiment was performed in 3 stages, namely Pre Pain, During Pain and Post Pain stages. In the Pre Pain stage, the readings were taken from the subject when he/she was not given with any pain stimuli. In the During Pain stage, the pain stimulus was given externally to the subject. The pain was created by placing 4 iron discs of 1.25 Kg weight each on right hand fingers. The discs were placed for 10 minutes continuously. And after 10th minute the readings were taken for 10seconds. In the Post Pain stage of experiment the iron discs from fingers were taken out and the subjects were allowed to relax for 5 minutes. After 5 minutes the GSR reading for Post Pain stage was measured for 10 seconds.



Figure 4: Placement of Electrodes

In this work, we choose 8 right-handed subjects between 20 to 35 years of age, among the 8 subjects three are female and 5 are male subjects. The subjects were all volunteers. The EEG data is acquired while the subject is undergoing Hypnosis, who is hypnotized by a psychotherapist for 5 minutes. Shielded electrodes of standard size disc type Ag-AgCl electrodes are used to acquire the EEG signal. Following 10 - 20 convention for electrode placement the first channel electrodes are placed on frontal cortex (F3) and other is on left earlobe (A1). The second channel electrodes are placed on the central cortex (C3) and on the right ear lobe (A2). The third pair of electrodes is placed over the centre of P3, O1 and T5 and the reference at forehead (FPZ).

An analog-to-digital converter PMD-1208FS DAQ This experiment was conducted in 5 stages, namely (i)Pre Pain without Hypnosis, (ii)Pain without Hypnosis, (iii)During

Hypnosis, (iv) During Pain with Hypnosis, (v) After Hypnosis without Pain stages.

In the HPG experiment, the subjects were asked to lie down on the bed. For the first stage of experiment, the readings were taken from the subject before he/she was hypnotized and was not given any pain stimuli. In the second stage of experiment, the hypnotherapist inserted a disposable needle in the right lower arm of the subject. In this stage also, the subject was not hypnotized; therefore he/she must have felt pain in certain level according to their threshold. For the third stage of experiment, the subject was hypnotized. The hypnotization process was for 5 minutes. After completing the 3rd stage of experiment, the subject was in hypnotized condition. As a token of hypnosis, the hypnotist made to feel numbness in the right lower arm of the subject for half an hour. At this condition, the fourth stage of the experiment was conducted on the subject with pain stimuli. The subject was again given pain externally as done in the second stage of the experiment in the same area. In all the above stages the readings were taken for analysis. In the last stage of experiment, the readings were taken from the subject after coming out from the hypnotic condition.



Fig. 5. Pain stimuli given to a subject during HPG experiment.

3. Results and Discussion

The consolidated data from PG experiments of average values of conductivity for each subject is tabulated. From the tabular column, we can come to know that 5 among 7 subjects have shown incremental change in conductivity in Pain stage. During In other two stages of experiment, the conductivity is comparatively lower than the conductivity of During Pain stage. This is graphically shown in fig.6. Even though the experiment was conducted in same ambient conditions; the other two subjects have not shown the incremental change in conductivity. This may because of the individual's pathological conditions at the time of experiment. These results show that any type of arousal is increasing the conductivity of skin-GSR [8]. From these results, we can conclude that the relationship between GSR and Pain is vital to be considered and GSR could be the indicator of pain.

In the HPG experiment, we consider the output of the stages (i), (ii) and (iv). By considering only these three stages, we can easily check the effect of hypnotic analgesia. The consolidated results and statistical analysis report are given in table. From the results, it is observed that there is a decremental change in GSR in 'During Hypnosis' stage. It shows that during hypnosis, the persons are getting relaxed

and are not aroused by any means. From the results, it has been known that 2 among 3 subjects have shown the incremental change in 'Pain without Hypnosis' stage and the values of GSR in 'Pre Pain without Hypnosis' and 'During Pain with Hypnosis' stages are almost same, but not equal (Fig.7). This is because of; the subjects who underwent the HPG experiments were low hypnotizable persons. If this experiment is repeated with highly hypnotizable persons, then we can expect the same GSR values in above said both the stages of experiment.

Table 1 Results from PG experiments; MS – Male Subject, FS – Female Subject

Sl. No.	Subject	Age	Conductivity (Siemens)		
			Pre Pain $\times 10^{-6}$	During Pain $\times 10^{-6}$	Post Pain $\times 10^{-6}$
1	MS1	28	3.63304	3.7774	3.62627
2	MS2	23	4.18984	4.00881	4.18524
3	MS3	22	3.30398	3.69081	3.11705
4	MS4	25	3.48038	4.55016	3.56183
5	MS5	29	4.167	4.16862	4.0091
6	FS1	28	3.39444	2.83738	3.81707
7	FS2	22	4.32863	4.74931	3.48883

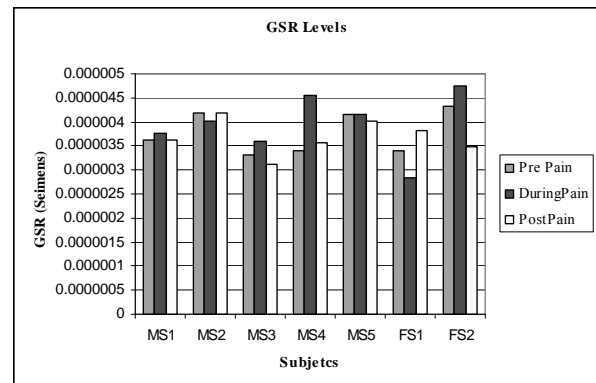


Figure 6: Comparison of GSR during PG experiments; Encircled portions show the incremental change of GSR in 'During Pain' stage'.

Table 2: Results of HPG experiment; (Note: MS–Male Subject, FS–Female Subject)

Sl. No.	Subject	Age	Average values of Conductivity (Siemens) x10 ⁻⁶				
			Pre Pain without Hypnosis	Pain without Hypnosis	During Hypnosis	During Pain with Hypnosis	After Hypnosis without Pain
1	MS1	30	4.132	4.051	3.856	4.088	4.074
2	MS2	28	4.710	4.869	4.455	4.707	4.840
3	FS1	21	3.579	3.596	3.578	3.582	3.582

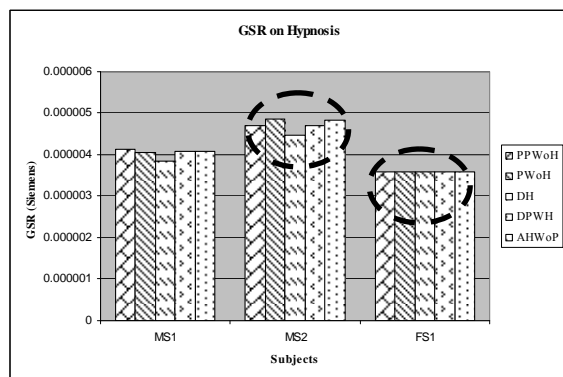


Figure 7: Results of PPG experiment; Encircled portions show the decremental change of GSR in 'During Pain with Hypnosis' stage

4. Conclusion

The specific but future goal of this work is to design and prototype a device which will quantitatively measure the pain and control the administration of analgesic to the sufferers of pain in order to reduce the side effects of the pain killers. And also this work aims to analyze the changes in GSR during hypnotic analgesic condition. In the PG experiments, the conductivity of 5 subjects among 7 increased in the 'During Pain' stage. And the conductivity is less in the other two stages of the same experiment. It shows a clear relation between Pain and GSR and there is a scope for measuring pain objectively using GSR. However the relation between pain and other physiological parameters have to be studied before accepting GSR as an indicator of pain. In the HPG experiment, all the three subjects show less conductivity in the 'Pre Pain without Hypnosis' and 'During Pain with Hypnosis' stages. But in the 'Pre Hypnosis with Pain' stage of the same experiment, the conductivity is higher than the other two stages. It shows that the subjects do not feel pain during hypnotic analgesia, and GSR is a true indicator of pain. In this work both PG and HPG experiments were done with induced pain, in spite of real pain. The induced pain may not be the representative of all types of pains, but some type of pains. The future work include experiments with more subjects in a clinical setup with actual pain rather than in a laboratory set up with induced pain, and this could help us to design a device which will measure the pain objectively, in order to alleviate the pain effectively with just required amount of pain killers.

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6. About the authors



K. Shankar is a graduate student of Biomedical Engineering at IIT Madras. Her main research interests include Biomedical Instrumentation and Biomedical Imaging.



M. Manivannan is a faculty in Biomedical Engineering at IIT Madras. He is also a research affiliate/visiting scientist at the Massachusetts Institute of Technology in Cambridge USA. He received his Masters and PhD degrees in mechanical engineering from the Indian Institute of Science in 2000. His main research interests are in brain and cognition, motor and somatosensory systems, haptics, and human disease diagnosis.



Peter Fernandez is an International Psychiatrist specializing in the dynamics of the Human Mind and Behavior. He retired as a Professor of Psychiatry and the Chief of the Institute of Mental Health in Chennai. He was a Professor and HOD of the Department of Psychiatry at Sri Ramachandra Medical College, Chennai. He is a council member of International Society of Hypnosis. He is now the Director of Psycholab for Disabled at Chennai, a model rehabilitation centre for Chronic Mental Patients.