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GALVANIC SKIN RESPONSE IN CONSUMER NEUROSCIENCE

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What Is GSR?

Electrodermal Activity or Galvanic Skin Response occurs when the skin transiently becomes a better electrical conductor due to increased activity of the eccrine (sweat) glands, which are in turn related to changes in the sympathetic branch of the autonomous nervous system [1, 2]. Galvanic Skin Response does not reflect a single psychological process, but an array of processes like attention, habituation, arousal, anticipation, and cognitive effort, making it a valuable tool for behavioral and neuroscientific research in many subdomains of psychology and related disciplines. In marketing, it has been primarily used as a measure of arousal.

Background and Signal Characteristics

The term electrodermal activity (EDA) or Galvanic Skin Response (GSR) refers most generally to any changes in the electrical phenomenon of the skin, whether active or passive. Skin conductance, on the other hand, is one form of GSR that measures how well the skin conducts electricity when an external direct current of constant voltage is applied [2]. Most measures used in decision-making literature and marketing are based on a measure of skin conductance, which are related to changes in the activity (specifically sweating) of eccrine sweat glands. As sweat is an electrolyte solution, the more individuals sweat, the more conductive (or less resistive) the skin becomes. Since the sympathetic branch of the Autonomous Nervous System (ANS) controls eccrine sweating, skin conductance reflects a measure of sympathetic or autonomous arousal that accompanies various psychological processes and is a key component of core affect, along with emotional valence. Please refer to Appendix A for more technical details on signal characteristics and measuring skin conductance.

Relationship to Brain Activity

The mechanisms and pathways involved in the central nervous control of eccrine sweating are relatively complex [3,4]. A recent fMRI study suggested that skin conductance level (SCL) and skin conductance response (SCR) are related to activity in different brain areas [5]. While the central origins of the ANS are within the hypothalamus and the brainstem, other parts of the brain have been found to be involved in the control of eccrine sweating. Specifically, while activity in ventromedial prefrontal cortex covaried with SCL irrespective of task, activity within anterior cingulate, insular cortices, amygdala, the basal ganglia, and the prefrontal cortex correlated with transient SCRs [5]. Several of these “higher” areas are part of the limbic and paralimbic networks, which are involved in affective processes consistent with skin conductance being an indicator of emotional arousal and other affective processes. Critically though, it has been shown that these higher brain areas are not necessary for spontaneous SCRs to non-emotional stimuli such as deep breaths and orienting stimuli like loud noises, but they are necessary for SCRs in response to stimuli that have acquired emotional value through experience, e.g., in classical conditioning [6, 7]. **This suggests that GSR still has distinct advantages over measures like EEG when it comes to measuring arousal.**

Constructs and Psychological Measures

In the psychological literature, while GSR has primarily been used as a measure of emotional arousal, it has also been used in both normal and clinical populations as indicators of a wide range of psychological processes including orienting responses [8-10], classical and operant conditioning [11], and depth of information processing and cognitive effort [12, 13]. **GSR also provides a signal of anticipatory responses often prior to the decision, consistent with the idea of somatic markers that guide decisions** [14]. Therefore, it can be used as a process indicator of arousal before, during and after decisions and not just a proxy of arousal related to outcomes as it is often used in the literature. Critically, skin conductance does not provide a measure of emotional valence or the category of emotion (e.g., fear versus anger versus disgust) and it is important to use other measures like self-report, facial coding and/or facial electromyography to measure these aspects of emotion.

GSR in Consumer Neuroscience

Some studies have sought to characterize the role of GSR with marketing stimuli. In one study, Simons and colleagues showed that skin conductance responses (SCR magnitude) were greater for pictures with motion than those without motion consistent with increased arousal associated with motion [15]. Similarly, Hubert and de Jong-Meyer [16] found increased electrodermal activity (SCL and SF) to suspense films which were associated with increased arousal, compared to cartoon films which were characterized by pleasant amused state with low levels of arousal. In another more recent study, though SCR amplitude did not contribute significantly beyond self-report measures in predicting advertising effectiveness, it did have some predictive validity by itself, and was also strongly correlated with the EEG measure of frontal alpha asymmetry [17]. Critically, GSR was not used to evaluate differences in time course of an ad in this study, but more as an aggregate measure of the overall ad effectiveness. However, Ohme and colleagues showed reliable differences in skin conductance across two variants of a TV commercial despite the lack of self-report differences [18], suggesting that it may be **more sensitive to temporal differences than aggregate measures**. Finally, some recent yet-to-be published studies from University College of London (UCL) suggest that the synchrony in EDA responses across participants in response to movie trailer is predictive of subsequent box office sales. Together, these findings suggest an important role for GSR that remains unexplored in consumer research.

Validation of Shimmer Neurolynq for Creative Excellence at IPSOS

While GSR is an important tool in consumer research, there are several nuances in both the data collection and analyses that make it challenging to administer and scale. To this end, IPSOS has employed Shimmer Neurolynq to collect GSR data. Founded in 1999, Shimmer uses GSR to quantify emotional arousal. Specifically, skin conductance is coded based on trends in the SCR signal, and these codes are translated into a “response” at each time point. In additional to the individual responses which are likely to be noisy, Neurolynq also estimates the proportion of participants who demonstrate this response – the higher this value, the more confident we can be that this moment is producing arousal. This provides a reliable measure of the effectiveness of a creative or stimulus at the aggregate level, consistent with some of the more recent findings from UCL discussed above.

The IPSOS GSO Lab has carried out its own validation of the Neurolynq KPI and applied it to creative executions, concepts, and still images. Based on my evaluation of these analyses, I concur with the lab’s recommendation that Neurolynq based measurements be used primarily for video stimuli and concepts, with a sample size of at least 60 participants, but not for still images. Additionally, only differences that exceed 18% must be treated as

meaningful and significant based on extensive bootstrap testing, or explicit statistical comparisons need to be run at each time point if a more dynamic temporal measure is required. As discussed in the Appendix, GSR has onset latency and hence it is important to adjust the response by this latency (approximately 2.5sec based on validation testing at the GSO lab) before interpreting the responses.

I also recommend revisiting the significance thresholds with the ground-truth stimuli where converging data from other methodologies like EEG and facial coding can be used to further validate the sensitivity of these thresholds and boundaries. Since the ground-truth dataset was not collected with Neurolynq, it also provides an opportunity to evaluate the contributions of GSR for both still images and videos independent of Neurolynq constraints for additional insights. I understand that this may require collecting additional responses to the same stimuli using Neurolynq, but this will increase the confidence in our offerings based on GSR.

GSR and Creative | Labs: Qual/Quant Integration

Creative | Labs at IPSOS integrates GSR with quantitative and qualitative data on early stage creative executions (concepts, storyboards, animatics, etc.) during a one-day clinic. The use of GSR provides real-time insights into the respondents' individual and group physiological response to the stimuli and the identification of key moments or phrases that facilitate subsequent qualitative discussion. This in turn provides valuable insights into the development process of an effective creative campaign. While caution must be exercised in interpreting each individual's GSR data, I am confident that the integration of GSR with other qualitative and quantitative data can increase the sensitivity of discrimination among several candidate creative executions. Additionally, the ability to guide deeper insights and discussions based on identifying key temporal moments implicitly has the potential for application in several disciplines like creative excellence, customer experience, and product testing.

Summary

GSR is an important tool in the Consumer Neuroscience toolbox that is necessary for total understanding of the decision-making process. Within the new Dynamic Decision Making Model developed at IPSOS in collaboration with LaPsyDE, there are several aspects of the model that rely on the ability to measure autonomic responses and arousal using GSR. However, it is important to appreciate its limitations and capabilities, and use it in conjunction with other methodologies including self-reports, EEG and facial coding to leverage their complementarity. Analysis and models built from the ground-truth dataset should provide valuable additional insights into the relative contributions of each of these methods. Finally, applications of GSR beyond Creative | Lab should be validated for the use case and employ additional neurophysiological measures, if practicable.

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Appendix A: Measuring Skin Conductance

Skin conductance has two components: tonic and phasic, which are characterized by differences in time scales and the relationship to an external stimulus [2]. Tonic skin conductance is the slow varying and measured using skin conductance levels (SCL). SCL refers to the overall conductivity of the skin over longer time intervals, typically ranging from tens of seconds to tens of minutes and is often in the absence of any external stimuli but related to factors like dryness of skin, temperature, ambient moods and other physiological factors that differ from one individual to another. On the other hand, phasic activity refers to the higher frequency, faster changing response that is often embedded within the different SCLs. Each peak within the phasic activity represents a skin conductance response (SCR), which is defined as a discrete short fluctuation in skin conductance that lasts a few seconds and follows a characteristic pattern.

There is an initial rapid increase in conductivity represented by a steep rise in the response signal followed by a short peak and a slow return to baseline. Therefore, SCRs can be quantified using various characteristics and measures: (a) the onset latency, which is the time between the onset of the stimulus and the start of an SCR (typically 1-3 seconds); (b) the rise time, which is the time between the onset of the SCR and its peak amplitude (typically also 1-3 seconds); (c) amplitude, which is the difference between the conductivity at the onset (i.e. baseline) and the peak and (d) frequency, which represents the number of SCRs per unit time. The SCRs in response to multiple stimuli presented in close succession may be superimposed into an aggregate signal, where the individual responses may not be easily separable. Critically, not all SCRs are directly related to an external stimulus but may represent spontaneous fluctuations (SFs) related to tonic autonomous nervous system activity. These SF measures therefore provide a more reliable measure of autonomic arousal.