Galvanic skin response in auditory threshold evaluation, preliminary report

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Abstract
The galvanic skin response (GSR) is an autonomic reflex that modifies electrical skin resistance after sensory input. Its most famous use regards the lie detector test, which is used in the United States in job interviews, security clearances, and interrogations. It utilises the sympathetic nervous system that modifies electrical skin resistance after sensory input without the patient's collaboration. Our scope was to verify the presence of GSR in the audiometric exam and if this reflex was present at the hearing threshold level. We have evaluated 20 consecutive patients who arrived in our hospital for an audiometric test. We have demonstrated that this reflex is present at the hearing threshold level and absent under the threshold level in all frequencies commonly explored in standard audiometric exams.
These results can lead to objective audiometry, which could finally avoid medico-legal disputes linked to hearing loss simulation.

Introduction

One of the most relevant problems concerning a patient's audiology evaluation is that audiometry, the most important and routinely performed exam globally, is subjective and administrable only to subjects over 4/5 years. This leads to the possibility of obtaining a non-reliable result for different reasons that may induce the patient to lie. This is primarily a forensic medicine-related problem caused by a possible economic compensation after demonstrating, for example, a work-related hearing loss. To claim compensation, patients may pretend the existence of a false hearing loss or increase its seriousness. Therefore, doctors must individuate these simulating patients; in literature, different methods may help them, such as repeated thresholds test, Stenger's test, automatic audiometry, Lombard's test, Azzi's test, or recruitment and stapedial reflex evaluation (Giordano C. et al., 2007). However, the results are substantially operator-dependent, and absolute threshold values may not be obtained. Other techniques, like auditory evoked potentials, require too expensive instruments, a long learning curve, and an insufficient threshold determination accuracy. So, in short, it is possible to assert that now, objective and accurate audiometric evaluation exams do not exist; certain individuation of lying subjects is not possible. The autonomic nervous system (ANS) is a component of the peripheral nervous system that regulates involuntary physiologic processes, including blood pressure and heart rate, respiration, digestion, and sexual arousal and innervates every living tissue in the body. The ANS include the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS), which contain both afferent and efferent fibres that provide sensory input and motor output, respectively, to the central nervous system (CNS). The SNS particularly innervates the musculoskeletal system and skin (Scott G.D., Fryer A.D., 2012) and is the primary way of the galvanic skin response (GSR) characterised by modification of electrical skin resistance after sensory input. It is a very sensitive response that occurs when many other responses fail. In the literature, GSR has been tested in correlation with acoustic and visual stimuli (Khalfa S et al. 2002), individual stress (Nora DB et al. 2007), and sleeping (Kobayashi R. et al., 2003). In the audiometric area, evaluations were conducted especially on mice (Berlin C.I.,1963; Berlin C.I., Gill A. et al. 1968a 1968b) or sick subjects (Chaiklin J.B., et al.,1961; Lamb et al.,1968). These considerations lead to a possible systematic autonomic nervous system evaluation during an audiometric exam, with existing audiometric evaluation protocols, by galvanic skin response (GSR) measurement.

Materials and methods

In this investigation, 20 consecutive patients (12 males and eight females), aged between 30 and 60 (mean 48), were enrolled in SS Annunziata Hospital (Chieti).

Each subject underwent:

- Pure tonal threshold audiometry with "Amplaid 760" utilising an isolated, air-conditioned cabin.
- GSR evaluation with AD Instruments "PowerLab 16/30", connected with two electrodes, applied to the patient's index and ring fingers to measure skin conductance; a trigger as a reference point for sending audiometry tones; and right and left audio input. All measures were registered using a computerised system and analysed with the program "Chart5".

After preparing the subject and before starting audiometry, the stabilisation of the GSR signal was visualised on the PC monitor, and the value reached was considered the basal tone for that patient to improve data acquisition. After this calibration, phasic responses were measured during threshold audiometry on both ears on 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz and 8 kHz frequencies, and intensities between 0 and 100 dB SPL. Tones were sent to the subject after a trigger. Keeping the frequency fixed, the intermittent signal tone intensity was changed after each successive trigger; after identifying the threshold, the frequency was changed, and the process was repeated. GSR signal was registered continuously for the entire exam duration. Once registered, resulting data were filtered with a band-pass digital filter (0,1-0,5 Hz) to eliminate excessively rapid or slow signal variations and obtain a more stable signal; mat derivative was also calculated. Right and left audio, trigger, GSR and its derivative were analysed in parallel using an oscilloscope. This study was conducted following the principles of the Declaration of Helsinki, and all patients provided written informed consent before enrollment.

Results

GSR showed evident changes after acoustic stimulation during pure tone audiometry (Fig 1). After tone sending, a peak appeared in the oscilloscope registration in eighteen patients, testifying to an obvious phasic autonomic nervous system reaction in the subject. However, one female patient with evident emotiveness showed continuous chaotic signal variations, making precise measurement difficult. Another male patient showed significant sweating, influencing skin conduction detection.

Discussion

Collected data have shown an exciting correlation between acoustic stimulation and GSR. Each time a subject hears a tone during audiometry, a phasic variation of skin conductance occurs. This variation is testified by the appearance of a peak on the oscilloscope registration after a two- or three-second latency from tone sending. No phasic signal variation can be appreciated if the patient does not hear the tone.

Therefore, GSR measurement during threshold audiometry may represent a parameter with a real utility in evaluating acoustic stimulus hearing discrimination, which may lead to absolute exam objectivity. However, GSR is strongly influenced by various inner and outer stimuli, such as the patient's emotiveness, visual signals, or environmental variables. For this reason, all registrations have to be conducted in environments without influencing stimuli, and the subject needs to adapt and relax to assure data accuracy. Noteworthy is the existence of extraordinarily emotive or anxious people who present continuous and chaotic GSR variations. Moreover, skin conductance is strictly correlated with anxiety, emotivity and sweating, so the environment must not be warm, and the temperature must be constant.

Finally, audiometry remains a patient- and operator-related exam with a universal acoustic stimulation protocol. Conversely, this study's purpose is not to alter standard audiometry but to improve its execution through a helpful instrument. So, the GSR auditory threshold evaluation is an exciting and new perspective. GSR measurement may lead to an objective patient examination without adverse patient effects.

Further studies may lead to defining a more detailed analysis protocol and introducing GSR in daily clinical practice.

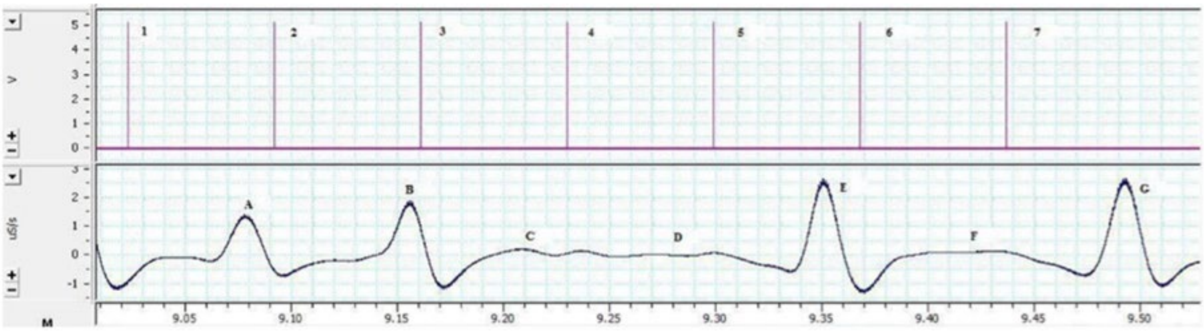

Fig. 1 Correlation between acoustic stimuli and GSR. On the top are represented triggers. On the bottom, GSR mat derivative. The tones frequency is 8 KHz. After trigger 1, a 40 dB tone was sent, and there was an evident response, visible like a peak (A); the second one (35 dB), sent after trigger 2, was heard too (B); the third tone, of 30 dB, wasn't heard, and there is not a visible response (C); the same can be observed on (D), at 35 dB; backing to 40 dB, a peak appears (E); in (F), again on 35 dB, no response; finally, once again at 40 dB, evident response (G). So, this subject's auditory threshold at 8 KHz is 40 dB.

Conclusions and Future Perspective

In our experience, we demonstrate that an influence of acoustic stimulation on GSR phasic response does exist. Therefore, after reducing the interference of its tonic component, GSR may be used as a precise and objective parameter in the threshold evaluation during audiometry. Combining audiometry and GSR can improve the audiometrist's certainty of auditory damage. This may lead to the realisation of instruments able to execute a completely automated and accurate exam, which may constitute an irrefutable document attesting to a patient's hearing capabilities. That may simplify the execution of this exam in non-collaborating or simulating patients. From this point, in the future, we will investigate the presence of GSR in newborns that, at this time, are screened with otoemission only without the possibility of having an exact hearing threshold. If the results are homologous to adults with GSR, it could be possible to have a better precision of newborn hearing threshold for better results in hearing aids or cochlear implants.

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