

# Quantum point-contact sensors for the emotion state detection in real time

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## Introduction

Quantum point-contact sensors have proven to be a highly effective tool for analyzing a variety of human body states. The features of electric current flow through Yanson point contacts provide a unique opportunity to examine a wide range of gas mixture components in real time [1].

Recent studies have shown that, among other things, quantum point-contact sensors can be used to study human hormonal states [1, 2]. It is well known that certain emotional states are closely related to the content of the corresponding hormones. Moreover, emotional self-regulation cannot be achieved without hormones and neuromediators production variation [3]. At the same time, the content of hormones such as serotonin and cortisol in the body is associated with various types of socially aggressive behavior [4]. The introduction of a tool suitable for analyzing human emotional states in real time regime would open up many opportunities, in particular in the field of public safety. This work is devoted to pioneering research aimed at developing such a tool.

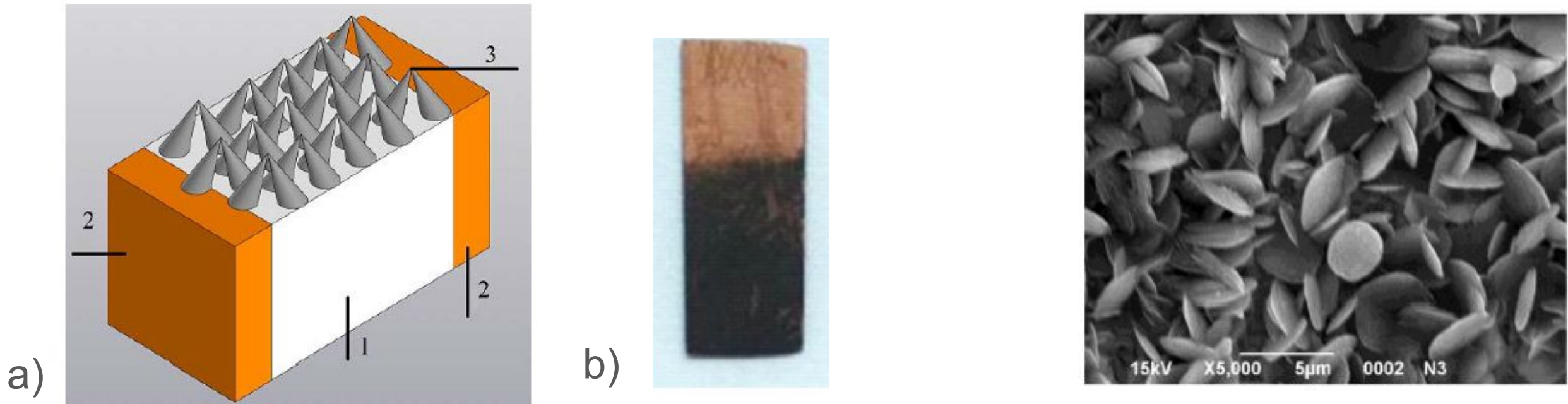


Fig. 1. a) Model image of a point-contact multistructure. 1 – textolite, 2 – copper foil, 3 – point contact.

Fig. 2. Photomicrographs of the sensitive surface of high-quality functional sensors

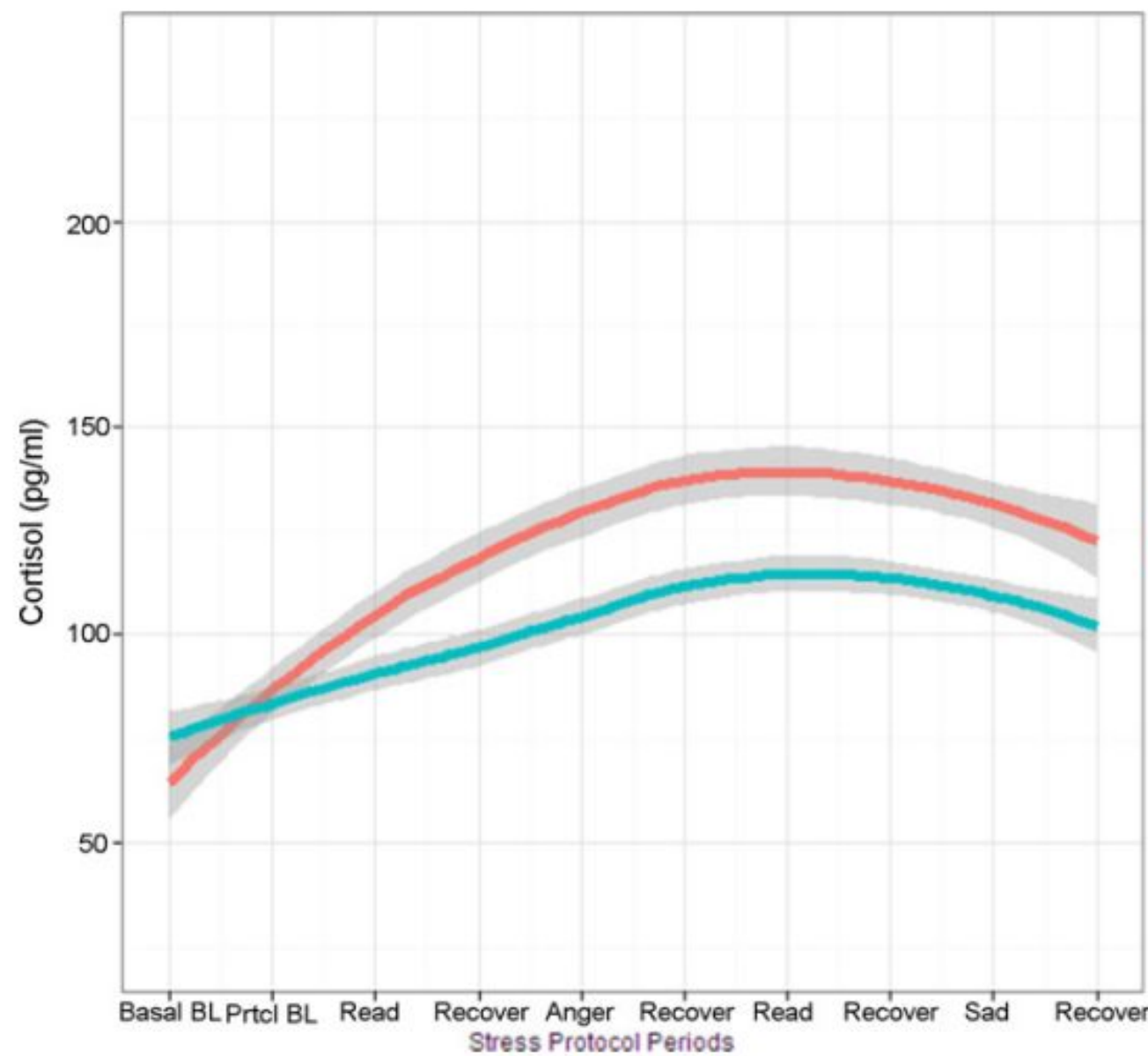


Fig. 3. Plasma cortisol levels (means and 95% CIs) during each period of the stress [5]

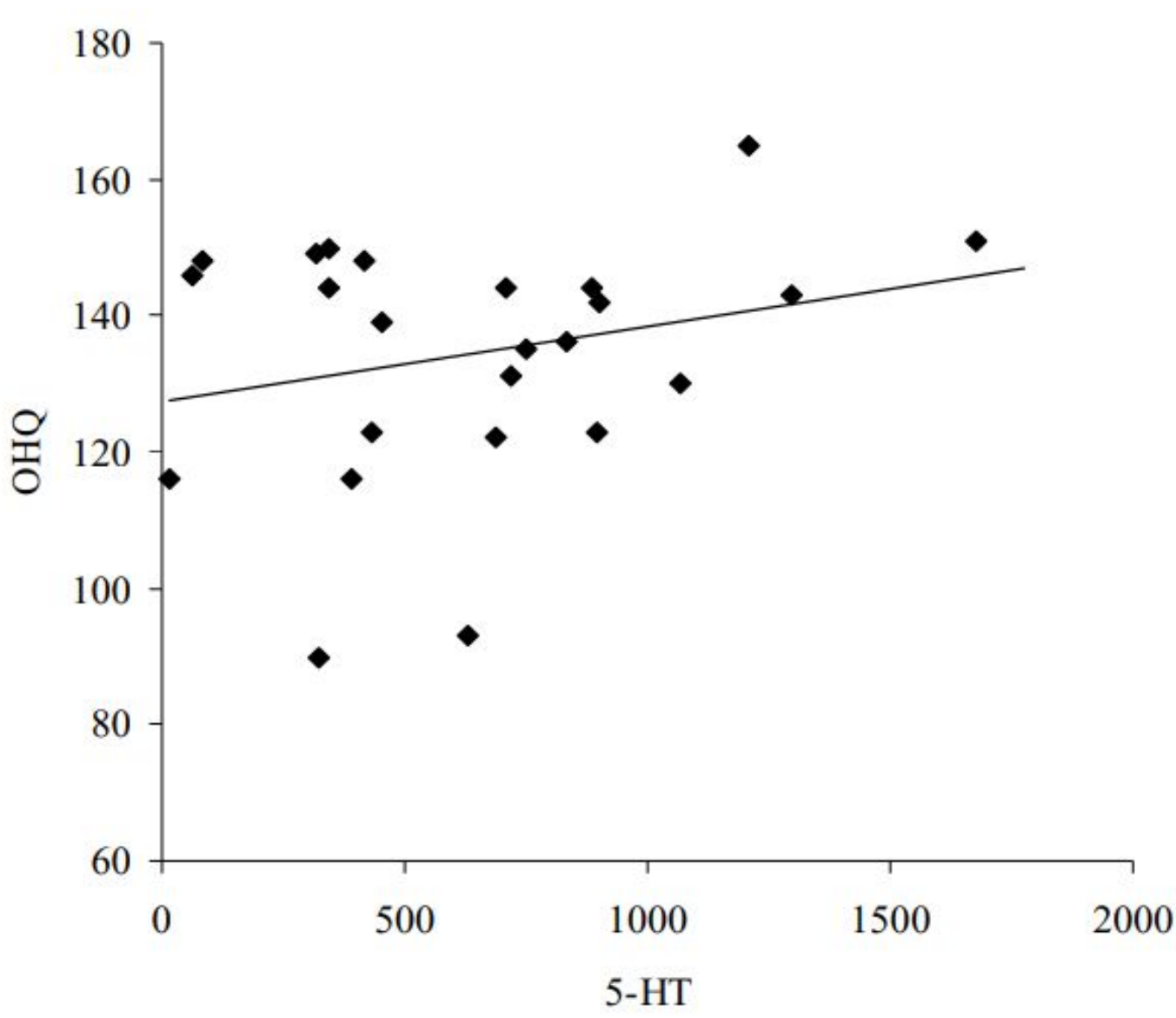


Fig. 4 Oxford Happiness Questionnaire score plotted against concentration of urinary serotonin (ng/ml) [6]

## Methodology

Quantum point-contact sensors based on the Cu-TCNQ compound, obtained by combined electrochemical deposition from a saturated solution in acetonitrile, were used for the research. A specially developed device for vacuum zone sublimation was used for the preliminary purification of the gas-sensitive substance. In the study, 30 volunteers took part. The response curves of the point-contact sensor to the action of breath were recorded before and after the emotional impact. The impact was realized by watching a video by a volunteer, which a person found funny, for 10 minutes.

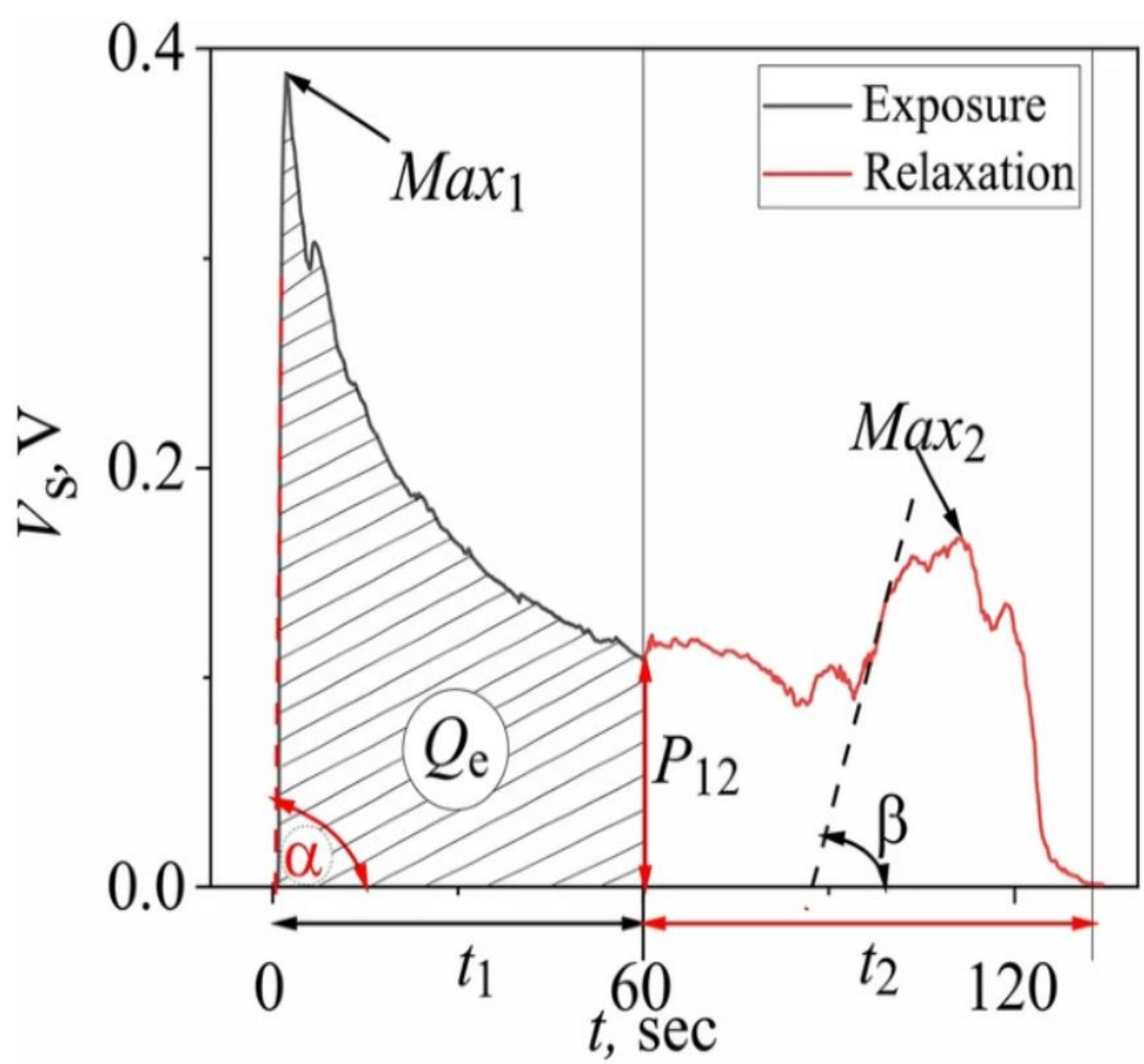


Fig. 5. Spectroscopic breath profile obtained by the point-contact sensor based on the TCNQ compound. Vs—voltage drop that occurs in the sensor; t—response time; characteristic parameters of the response curve: t1—exposure time; t2—relaxation time; Max1—exposure maximum; Max2—relaxation maximum; p12—ordinate of the final segment of the exposure phase; d1 = tgα—slope of the initial section of the exposure maximum; d21 = tgβ—slope of the initial section of the most intensive maximum in the relaxation period; Qe—area under the exposure curve.

$$C_{\text{cor}}[\text{nmol} \cdot \text{L}^{-1}] = 765.54 - 1612.32 \times \bar{V}_s$$

$$C_{\text{ser}}[\mu\text{mol/l}] = 1.17 - 2.41 \times \bar{V}_s$$

## Results

Volunteer	Cortisol, before, nmol/l	Cortisol after nmol/l	serotonin before, μmol/l	serotonin after, μmol/l
1	478.16	374.13	0.76	0.66
2	476.15	424.98	0.75	0.7
3	397.21	306.63	0.7	0.65

Table 1. Data obtained using the algorithm from our previous articles [1,2]. The content of cortisol in the body of a healthy adult is within the range of 100-540 nmol/l, and serotonin – 0.22-2.05 μmol/l.

## Results

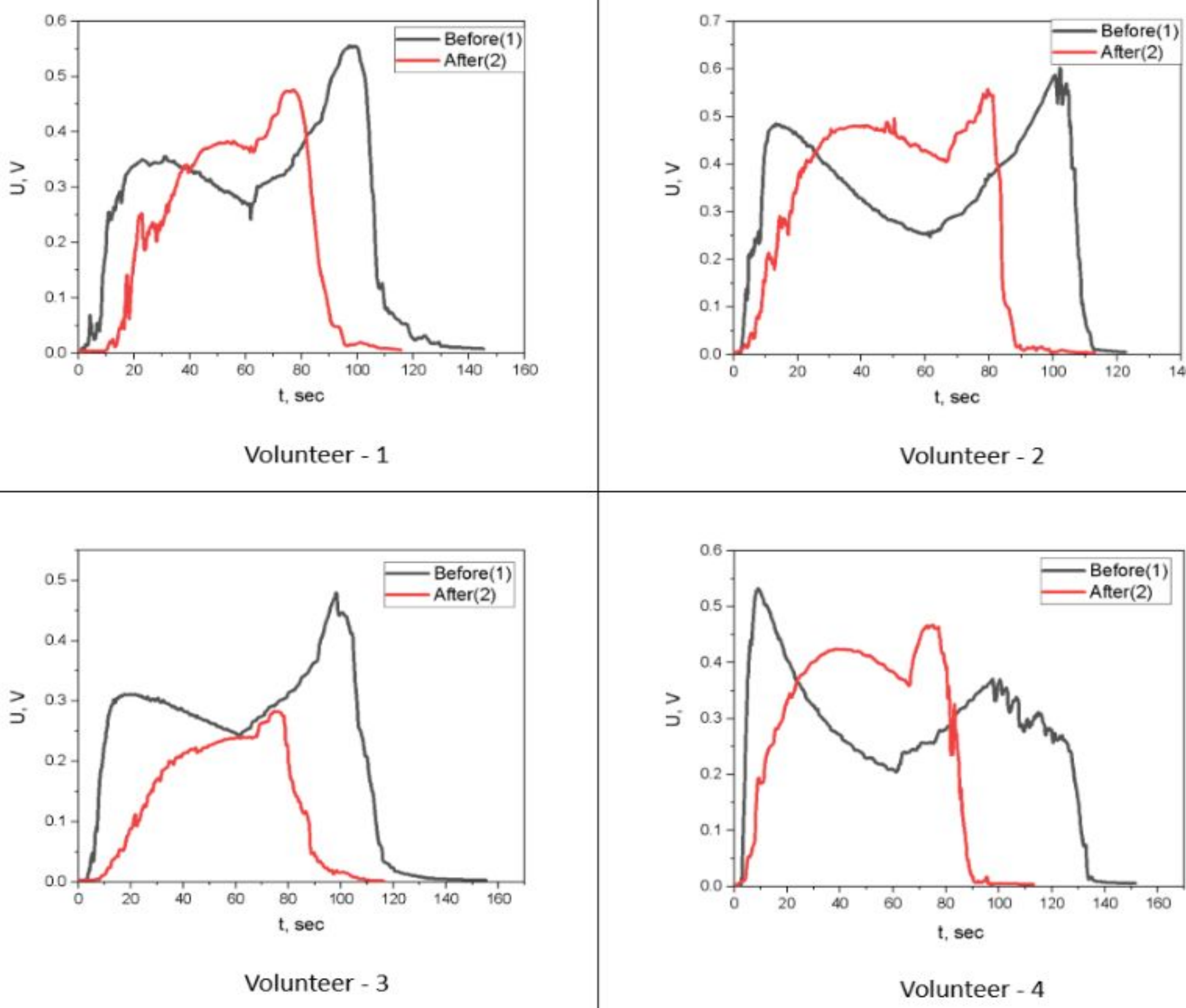


Fig. 7. Curves obtained by gas sensor response.

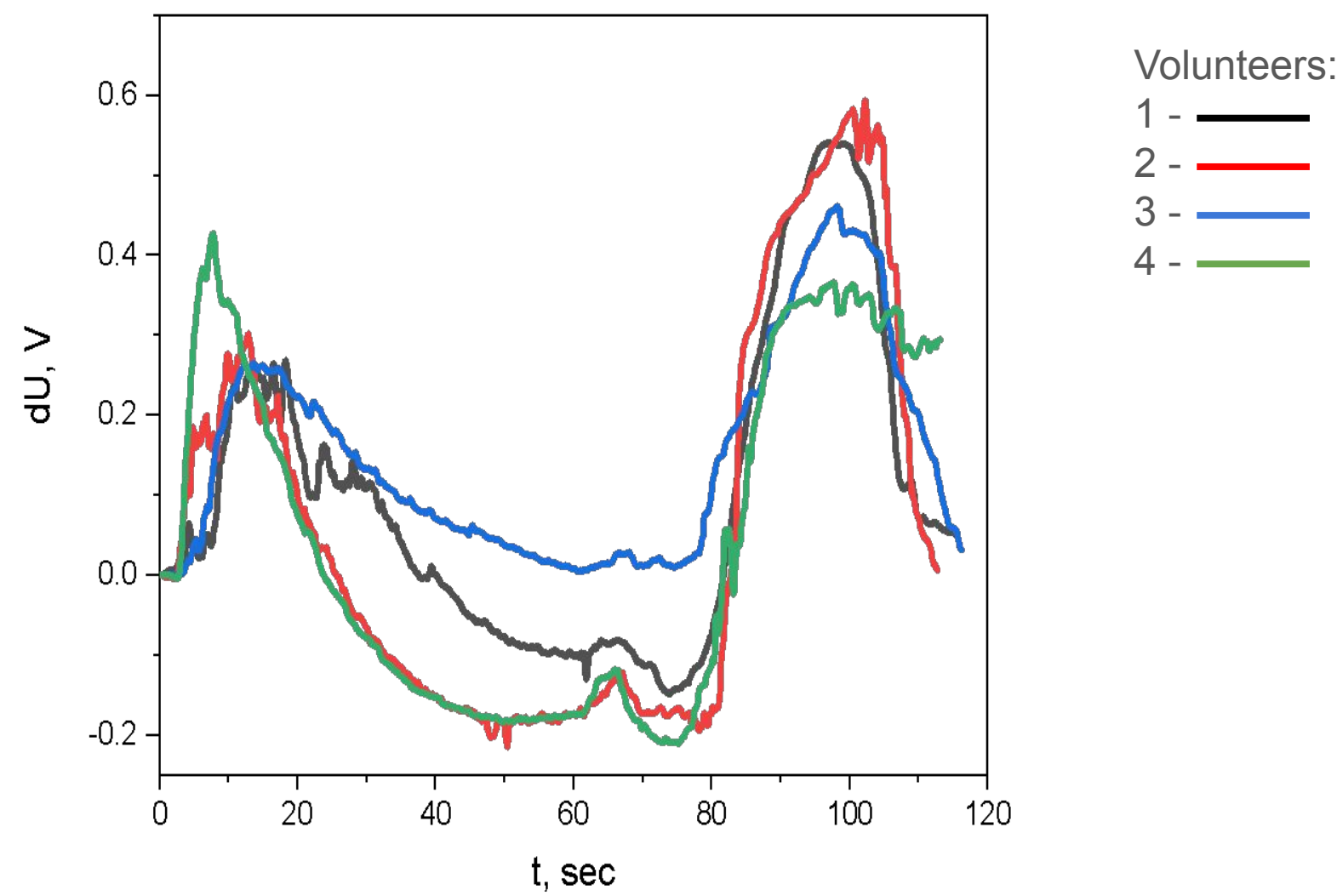


Fig. 7. Curves obtained by subtracting from the signal before the impact, the same value after the impact

## Conclusions

Analysis of the spectral curves of the response of the quantum point-contact sensor to the action of breath made it possible to find an experimental relation between the features of the response curve and the emotional state of a person. Based on the method proposed in our previous works [1, 2], the levels of serotonin and cortisol hormones in the human body were estimated using breath analysis. The results obtained demonstrate a high agreement with previously obtained data, which indicates the high reliability of the method proposed.

Therefore, during this work, an approach to detect human emotional states using point-contact sensors of human breath was proposed. The proposed approach has broad prospects for use in applied purposes – for public safety or lie detectors, which are based on a new physical principle of operation.

## References

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