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## Differences in the Quality of the Photoplethysmograph Signal in Subjects with and without Nail Polish

Изменение качества фотоплетизмографического сигнала  
у субъектов с окрашенными и неокрашенными ногтями

**Key words:** polygraph, forensic psychophysiology, photoplethysmograph, plethysmograph, PLE, nail polish, signal quality

### Abstract

Qualitative indicators are an important element in establishing truth in polygraph examinations. Considering this, a study of the change in the quality of the signal from the photoplethysmograph in subjects who have used nail polish is extremely relevant and requires a comprehensive qualitative study.

The paper uses general scientific and empirical methods of observation and experimentation, and is a comprehensive study of the effects of nail polish on the quality of the photoplethysmograph signal. It is the first time that this type of research has been conducted using a comparative analysis of subjects who did and did not use nail polish.

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## Formulation of the problem

Qualitative indicators in conducting polygraph studies are an important element in the process of establishing truth or deception, and the person subjected to polygraph examination should be confident about the accuracy of the conclusions made by the examiner.

All negative factors that may distort the correct decision should be eliminated. The goal of good scientific research guarantees the correct resolution to these problems, one of which may be whether nail polish has a negative effect on data collection with the plethysmograph.

## Relevance of research

The data from the photoplethysmograph is increasingly being used to assist in the determination of truth or deception in forensic psychophysiology. In some countries, the component is used to replace the traditional blood pressure cuff to monitor cardiovascular activity.

With this in mind, the aim of this research is to study the data from the photoplethysmograph in subjects who have used nail polish before undergoing a polygraph examination and compare it with the data from the subjects who did not use any polish on their nails, and thus provide relevant recommendations to polygraph examiners.

A great deal of research has been conducted in recent years to evaluate and enhance the field of forensic psychophysiology. At the same time, a significant range of issues devoted to the operation of the polygraph remains unnoticed.

Research of the polygraph is a rather complicated process, and even minor trivialities can have a significant effect on its results. External factors are an important group of circumstances that influence the work of the polygraph, a fact that needs very careful consideration by professional polygraph examiners. At the same time, individual cases of such factors influencing the process of polygraph research are disregarded by modern science. For instance, the impact of polish on the nails has not been mentioned in any research to date.

The accuracy of the polygraph procedure to assess the reliability of information communicated by a person is extremely important. The Polygraph Institute of the US Department of Defense conducted a large-scale comparative analysis on the accuracy and reliability of the use of polygraph in medicine and psychology. The sample consisted

of 5189 scientific and practical publications. The study demonstrated that the accuracy of the diagnosis with the use of the polygraph is by no means inferior to other methods of human diagnosis in the fields of medicine and psychology. [1]

Any method used to study a person, be it a diagnosis of certain medical conditions or the definition of psychophysiological qualities, cannot technically reach 100% accuracy as there is always a certain probability of errors in conclusions drawn from the data. With such methods being used for evidence before the court, and in screening for intelligence and business purposes, it is not hard to guess what the price of a mistake may be.

Let us note that there are two types of errors made in a polygraph examination in this regard:

- a false positive or a “false alarm” when, as a result of test, a truthful person is erroneously considered deceptive
- a false negative or pseudo-negative error when a person who is actually lying and was involved in the event being investigated is erroneously considered to be truthful. [2]

The use of countermeasures to distort the test results is a major concern in the polygraph field worldwide. Even a small set of countermeasures carries plenty of potential to change the outcome of the examination. There is therefore a need to develop ways to neutralise known methods of countermeasures.

In order to prevent deliberate or unconscious countermeasures that effect the accuracy of polygraph examinations we need to understand in detail what has a direct impact on the data collected by the polygraph, including the factors that influence changes registered by the photoplethysmograph.

We have recently seen a major increase [3] in the practical use of diagnostic methods based on the photoplethysmograph: a machine that illuminates biological tissue with an infrared beam, and records the radiation that passes through the tissue and is reflected from it. The recording is done by an optoelectronic sensor. Thanks to its non-invasiveness, simplicity of hardware implementation, miniature sensors, and efficiency the process has been used actively in medicine, especially to monitor the state of the cardiovascular system. The main elements of processing the biosignal time zone, whose shape is determined by certain steel structures, indicate: filtration, lump approximation; segmentation of time properties of signals; indication of the most characteristic points of the signals (extremum, points of inflection, points of intersection with the baseline, etc.); calculations of special points of heterogeneous derivative parameters; statistical analysis of sequences of classified fragments; and structural analysis [9, P. 165].

Digital finger photoplethysmography systems automatically represent accurate and objective information concerning changes in blood circulation and heart rate. In medical practice, the photoplethysmograph reflects the state of the cardiovascular system as a whole and is therefore used to predict occurrences of cardiovascular diseases and to evaluate the results of treatment.

For the research in question a computerised Lafayette LX4000 unit was used. The system can register thoracic and abdominal respiration, electro-dermal activity, and cardiovascular activity via a standard blood pressure cuff and/or plethysmograph (PLE) and physical movements.

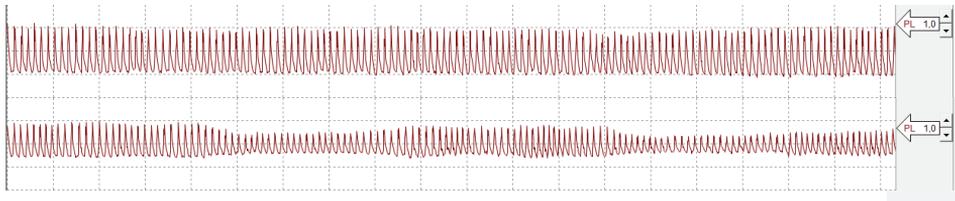
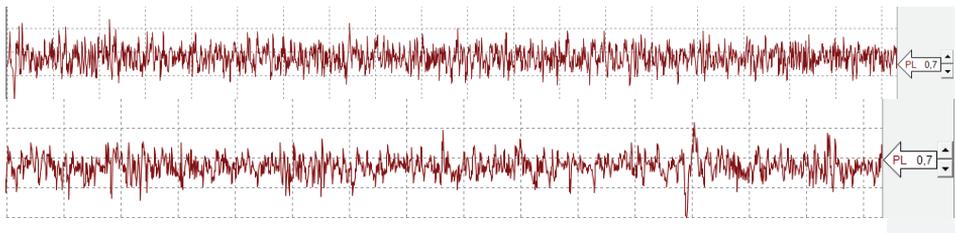
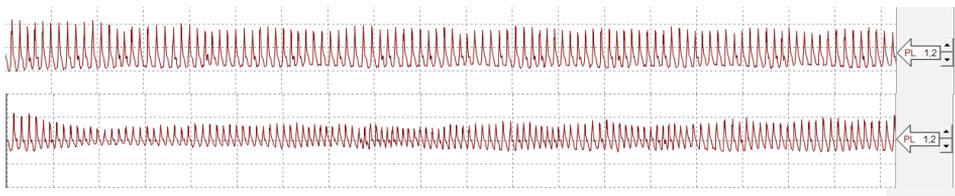
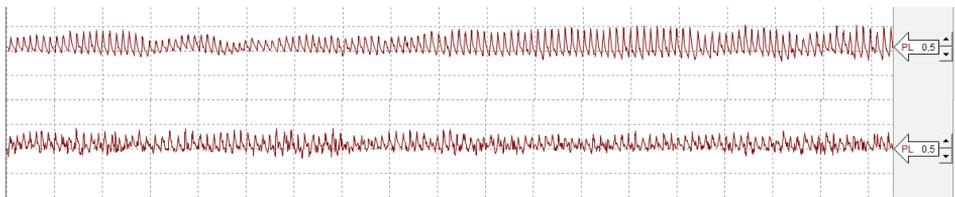
It is obvious that low signal quality has a negative effect on the accuracy of the test. For that reason, it is extremely important to understand factors that may cause such results. Coating of the subject's nails may be a very important factor. Modern women often use nail polish and do not even think that it may significantly distort the results of polygraph examinations. That is why pre-test procedures informing the subjects about proper preparation for the examination is an important responsibility of the forensic psychophysicologist.

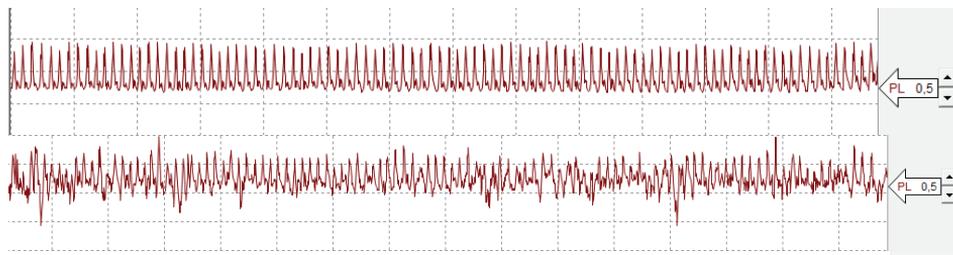
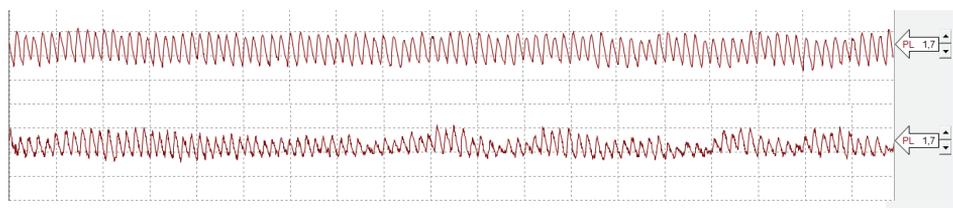
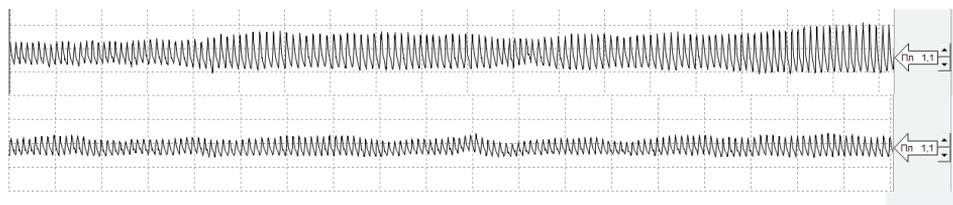
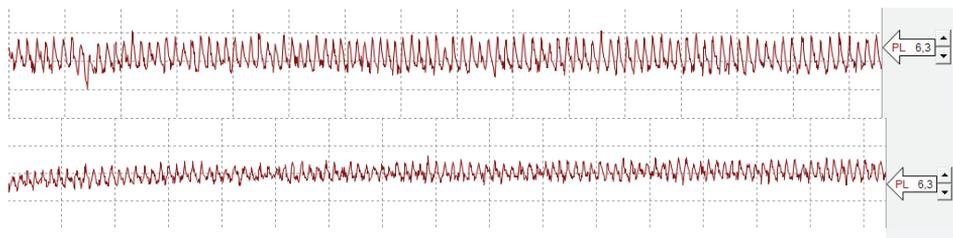
## Results of the study

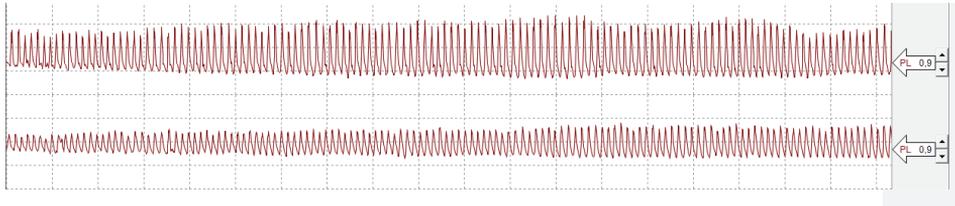
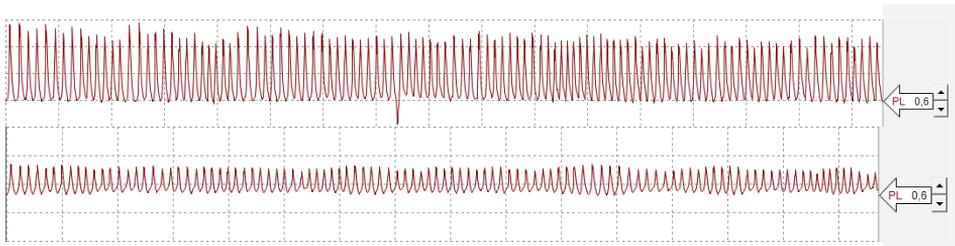
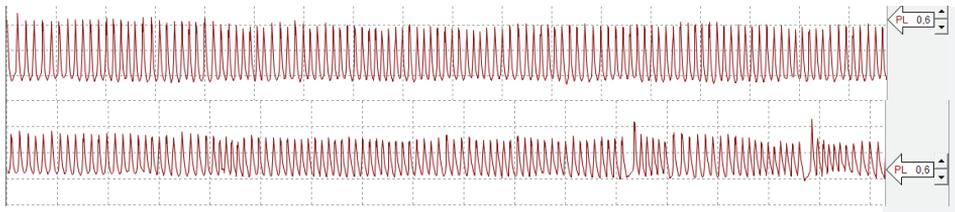
In order to investigate the effect of nail polish on the quality of the photoplethysmograph signal, we conducted a study involving 25 female subjects who participated in it in two stages. For the first stage, we removed the nail polish from the participant's middle finger of the left hand. Data from the photoplethysmograph was recorded and analysed. In the second stage, polish was applied to the nail of the same finger, and we collected plethysmograph data again.

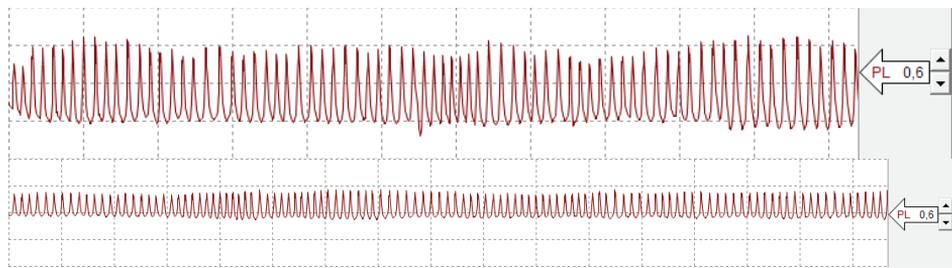
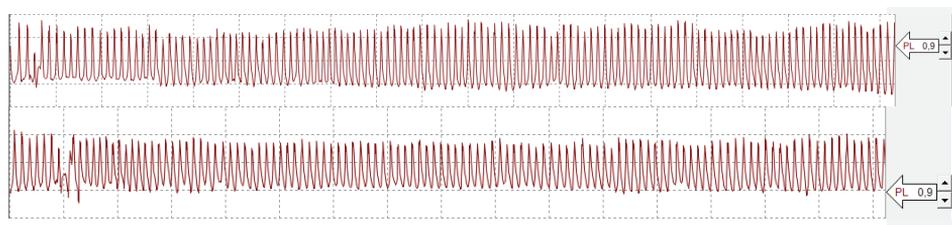
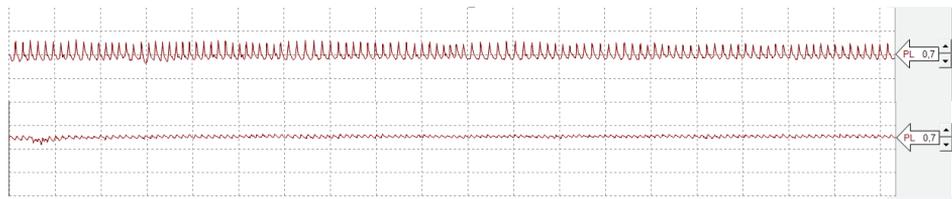
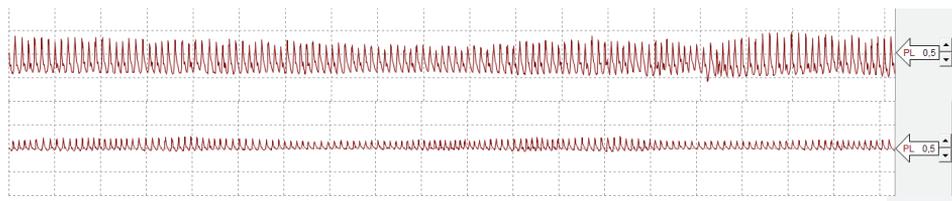
The same polish was used on all the subjects and the conditions in which the subjects were tested did not change significantly. The time between the two successive studies of each individual was in the range of 5÷7 minutes, and all the subjects were tested in a room which eliminated the influence of external factors.

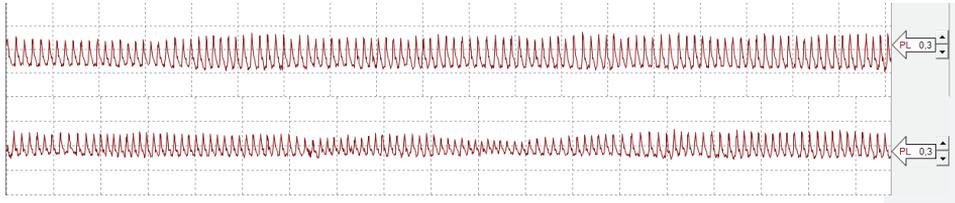
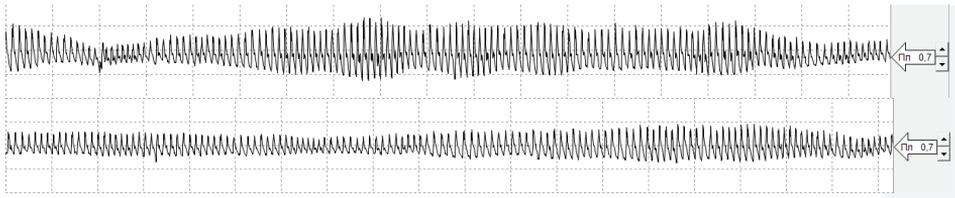
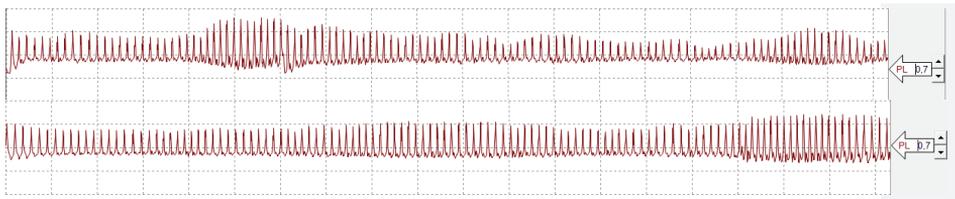
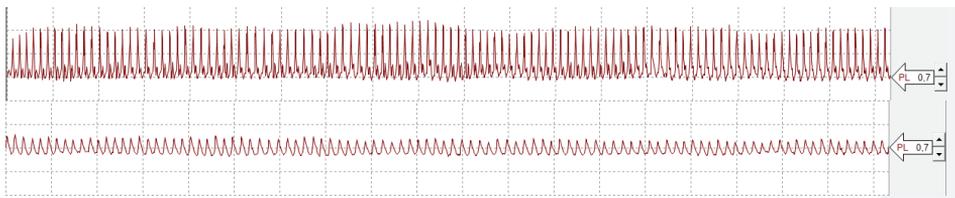
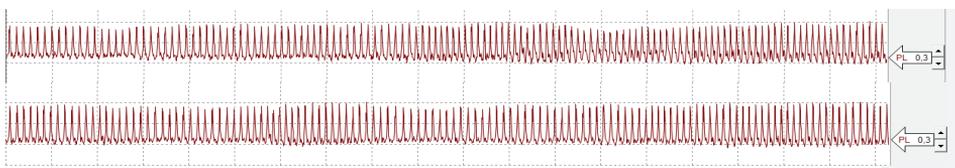
The charts of individual participants presented below show first the plethysmograph signal collected from the unpolished nail with the signal collected from the nail covered with polish below.

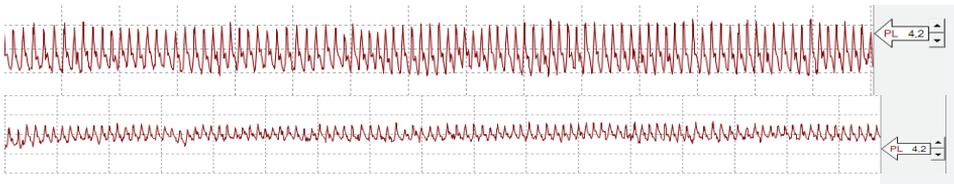
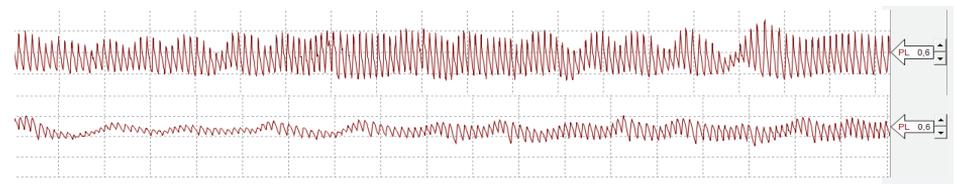
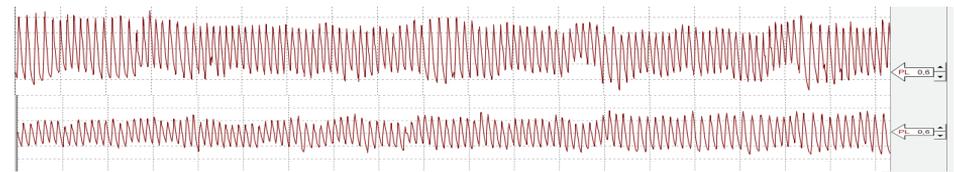
**Participant 1****Participant 2****Participant 3****Participant 4**

**Participant 5****Participant 6****Participant 7****Data by face number 8**

**Participant 9****Participant 10****Participant 11****Participant 12**

**Participant 13****Participant 14****Participant 15****Participant 16**

**Participant 17****Participant 18****Participant 19 (no significant difference was found)****Participant 20****Participant 21 (no significant difference was found)**

**Participant 22****Participant 23****Participant 24****Participant 25**

In 23 out of 25 participants (92%), the quality of the signal transmitted by the photoplethysmograph sensor deteriorated after polish was placed on the nail. In two participants (Nos 19 and 21), the quality of the signal before and after covering the nail with polished showed no or little difference.

## Conclusion

Our research clearly shows that applying nail polish has a negative effect on the quality of data that can be obtained from the photoplethysmograph (PLE).

A polygraph examiner sometimes encounters cases when a subject, whether knowingly or not, has done something that negatively affects the quality of the data that can be obtained. The polygraph examiner should exert maximum care to remove any reasons of possible distortions and factors that may negatively affect the collection of data and cause inaccuracies.

As the results of the study demonstrate, there is a significant change in the quality of the photoplethysmograph signal in most people who apply nail polish. In this case, the negative effect is often achieved without the subject's intent to influence the results of polygraph examination. Unfortunately, such changes can cause significant hurdles to the correct determination of the person's veracity.

With this in mind, it can be pointed out that the polygraph examiner is obliged to warn individuals who undergo a polygraph examination to avoid the use of nail polish prior to the test, in order to establish the most accurate photoplethysmogram index. We hope that this research will contribute to a better quality of data and minimise the number of possible errors in determining whether the subjects are true or deceitful.

## References

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