Influence of the Fragrant Essential Oils' on Psychophysiological State of an Individual

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ABSTRACT

Objective: Evaluation of the influence of aromas of different essential oils on the psycho-physiological condition of people. To show by certain methods that smelling these oils will either have a stimulating, calming/ relaxing, or some other effect (physiological and/ or psychological) on a given individual. The eventual goal is to make a correlation between different tests and the clinical tests.

Design: All the participants were volunteers, average age 20. All experiments were conducted in one and always the same room of the Saint-Petersburg University ITMO (Russia). We have used essential oils made by Aveda Corporation (USA) and specially designed box for aroma testing. For the evaluation process we have used questioners and several types of equipment such as: EPC (Electrophoton capture or Gas Discharge Visualization – GDV) Camera Compact, Surface Frequency Meter (SFM), Heart Rate Variation (HRV) tester.

Results: Significant correlation can be observed both among the instrumental methods (EPC, SFM) and between the instrumental and the subjective evaluations. High correlation of the data produced by the SFM and EPC methods suggests that these methods allow independent registration of the influence of the factors under study, even though the working principles of these methods are absolutely different. The HRV (cardiorhythmogram) of the individuals under study did not reveal any dynamics that would unambiguously correlate with the conducting of the investigations.

Conclusion: Our experiments showed that perception of different odours depends strongly on human and his current condition, and no one can say that concrete odour will always have some definite impact on every individual. EPC method itself is good enough for registering persons' reaction on different fragrances, though it is not new generally, in this field of study it is a novel method.

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INTRODUCTION

Natural essential oils are commonly used in perfumery, food, pharmaceutical production and in aromatherapy. Synthetic essential oils are produced and used like natural essential oils, but have lower price. Modern chemical technologies allow the production of synthetic fragrance compounds that can be hardly distinguished by their odor from natural ones. It is well known that synthetic essential oils doesn't have any biological activity as natural ones and also can result in decrease of total immunologic activity and even toxic effect[1].

There are two main theories of fragrance influence on human olfactory receptors: chemical and wave theories[1]. It can be shown from the results of research[2] that olfaction and sensitivity of human to different odors depends more from energetic (electron) state of fragrance compound atoms and less from its chemical nature. That is why EPC method[3,4], as a very fast method of functional state evaluation of biological objects and some structural properties of materials and liquids[3-5], was chosen for research of natural essential oils influence on human.

By the way we'd like to note that the Nobel prize in physiology or medicine in 2004 was awarded jointly to Richard Axel and Linda B. Buck for their discoveries of "Odorant receptors and the organization of the olfactory system". So we can make the conclusion that this field of research is very important and essential nowadays.

The technique of Electrophotonic (EPC) bioelectrography allows the recording, from a living subject, of electron and photon emission stimulated by an electromagnetic field, as well as the acquisition of these data by computer image processing. The electric impulse on the camera plate stimulates biological subjects (or chemicals evaporated by this subject) and generates a response in the form of an excited gas plasma (that is why in physical terms this approach is known as Gas Discharge Visualization – GDV[3,4]). This plasma emits both light and other electromagnetic fields over a wide frequency band because of the short electrical impulse used (10 microsec). The emissions are directly measured by a charge-coupled device (CCD), the state of the art in measuring low-level light that is used in astrophysics and other scientific endeavors. The CCD registers the pattern of photons detected over time. These digital data are transmitted directly into a computer for data processing, and each image (named a EPC-gram) from the light emitted is stored as a graphics file. These two-dimensional images of the light are then used to calculate the area, emission intensity, density, fracticality, and other parameters. On the basis of the calculated parameters, experimental conclusions are drawn.

Reportedly the EPC has overcome the experimental obstacles of older forms of electrophotography. What were previously considered as confounding parameters (such as pressure, finger size, sweating, or changes in physical conductivity) in the older forms of electrophotography have been demonstrated by different researchers to be overcome by the new EPC method[3,4]. Researchers report replicability of findings across different experimenters, different cameras, and different countries[6-14].

The EPC technique has been found to be effective in evaluating the state of individual human health, in monitoring of individual reactions to different kinds of training, and in studying the energy properties of liquids[15-23].

The EPC system is certified by the Ministry of Health of the Russian Federation as a medical technical device. These devices are being produced in Russia and in Spain.

Scientific researches in the field of fragrance influence on human have started several years ago. Since that time the obtained results were presented at the international conferences and published in different journals[24-32]. In this paper we are going to present

our latest experimental results of investigation the influence of fragrant essential oils on psychophysiological state on individual.

PARTICIPANTS AND METHODS

Research organization

All participants were volunteers, they were explained the aims and protocol of the experiments, and everyone signed a special contract, filled a form for evaluating psycho-somatic heath state and short Aizenk questioner. Only practically health mentally stable people having no allergy reactions were selected for the participation in the experiments.

Conditions of the experiments

Room was well ventilated, temperature was kept at 72±2 ^{o}F, relative humidity not more than 70%. In a single day only one aroma was tested with different participants. Every participant tested only one aroma per day. Before the testing a participant was sitting in a room reading book for accommodation and relaxation. All mobile phones were switched off. Neither participants nor researches were talking during measurements. During testing participant was looking to the picture of a mountain landscape. Before and after the testing participants filled in a special Aveda Essential Oil Evaluation questionnaire. This is a standard subjective test that gauge an individual's perception as to what effect smelling the oil had on him or her. That is, for the individual was the effect of smelling the oil stimulating, calming/ relaxing, something else, or was there no effect at all? This questionnaire was administered to the panelists before (baseline) and immediately after smelling the oils.

Aromas preparation

Essential oils were kept in hermetically sealed bottles. 10% solutions of each oil in alcohol (absolute ethanol or specially denatured [SD] alcohol) was prepared in individual syringes. The mixture was shaken till the homogeneous solution and dropped to the tester paper immediately before the presentation to the nose of a panelist. After smelling the tester was placed in a closed jar. All operations with aromas were conducted inside the smell box.

At any rate, the goal is not to evaluate the aroma strength of the oils, but to evaluate their stimulating or calming/ relaxing effects.

Aromas are coded as follows: A = cinnamon; B = rose alba; C = Roman chamomile; D = lavender, E = empty.

Methods of study

Electrocardiography (ECG) – is a standard objective test to monitor the rhythms of an individual's heartbeat and/ or Heart Rate Variation (HRV) both before (a baseline reading) and immediately after smelling the oil. HRV can be calculated by analyzing the time series of beat-to-beat intervals generated from ECG or the arterial pressure tracings.

EPC (Static) – is an objective test measuring the fingertips. The ring (fourth) finger of the left hand was measured at 15-second intervals during a 5-minute baseline/ before smell phase, a 2.5-minute during smell phase at which adaptation to smelling the oil

takes place halfway through this phase, and during a 5-minute after smell phase. All 10 fingers were measured with commercial EPC camera before and after smelling.

Surface Frequency Meter (SFM) – is an objective test measuring the dynamical high frequency signal from the wrists and ankles of a panelist simultaneously with the dynamical EPC signal. We have designed such an experimental device specially for our research. The obtained signal is called "dynamical" because it is recorded in time, during 10 minutes. More information on this method is given later in describing the realization of it.

The method of subjective estimation of aroma is based on the sensations of the participants, which are reflected in tests completed right before and right after the inhalation of the aroma. The test reflecting the self-evaluation of the individual's mood (merry, calm, active, etc.) was completed before and after the perception of the aroma, while the tests that reflect the properties of the aroma were completed right after the inhalation of the aroma. The tests reflecting the aroma's properties comprise a numeric characteristic along with the verbal one, allowing mathematical treatment of the data. We used the questionnaire developed by the AVEDA Company (USA), which allows presenting the subjective criteria of the odor estimation (intensity and preference) on a 5-grade scale and the questionnaire developed by the Monell Chemical Senses Center (MCSC)[33], which allows evaluating the odor preference in scores from -10 to 10 and the intensity in scores from 0 to 100. All tests are brought together in table 1 for better clarity.

TABLE 1. ESTIMATION OF AROMA ITSELF, ESTIMATION OF AROMA FORCE AND THE CRITERION OF IRRITATION AND ASSOCIATIONS

Aroma preference		Aroma force		Associations Recall		Irritation of nose or eyes	
Very unpleasant	0	Very weak	0	No	0	No	0
Unpleasant	1	Weak	1	Yes	1	Yes	1
Neutral	2	Optimum	2				
Pleasant	3	Strong	3				
Very pleasant	4	Very strong	4				

The method of evaluating the health quality. We used the "HELPSY" valeological program, based on the algorithm of health quality diagnostics[34], which was developed in St. Petersburg Research Institute of Physical Culture. "HELPSY" is a dialogue-based system that includes necessary and sufficient minimum of hardware-measured parameters (arterial blood pressure and pulse), which in conjunction with the anamnestic data allow defining the psychosomatic health quality of the subject, basing on the knowledge that exists in the expert information system's database.

The methods of evaluating the psychoemotional status. We used the "POMS" test[35] intended for evaluating the psychoemotional status by estimating six indices (factors): stress-anxiety, depression-despondency, anger-aggressiveness, power-activity, fatigue-passivity, embarrassment-confusion, and the Eysenk's personality questionnaire[36], which allows determining the temperament's constituents, i.e., the extraversion level and the neurotism level.

Statistical methods of analyzing and processing data: methods of parametric (the t-test) and nonparametric statistics (Kolmogorov-Smirnov-test, the Spearman correlation coefficient), implemented in Statistica 6.0 (version 2004, StatSoft, Tulsa, OK)[37], the "GDV Scientific Laboratory"™ (Biotechprogress Co. Ltd.) or SciLab and MS Excel (Microsoft® Office 2003) programs.

Realization of methods

During the research the data was collected from the 4th finger of right hand of the participants during 10 minutes, consisting of 2.5 minutes of equipment stabilization, followed by 2.5 minutes of background state ("Before" stage), 2.5 minutes of aroma's inhalation ("Smell" stage) and 2.5 minutes of after-effect ("After" stage). The "GDV Compact"™ (Biotechprogress Co. Ltd.) device was used in automatic operation mode: every 15 seconds a voltage impulse was supplied and the glow signal was recorded from the finger of the participant into the computer. Upon completion of each experiment all data were processed: the glow parameters were calculated and the data were statistically processed.

The overall changes in the individual's psychophysiological state under an aroma's influence were also registered by taking the EPC-grams from ten fingers of the individual's hands, right before the "Before" stage and right after the "After" stage.

In the course of the research the SFM (Surface Frequency Meter) device was used, which allows numerically measuring the high frequency current that flows through the individual's tissues upon applying 5 microsecond impulse potentials to skin. The scheme of the electrodes' connection: two potential electrodes are put on the wrists of the right and the left hand, respectively, while the two nulling electrodes are put on the shins. The contacting parts are wiped with alcohol and dried beforehand. The device outputs the values of the integral sum of current in the right and left channels, and in the reference channel, which allows taking into account the background disturbances, as well as performing the detrending when necessary. The registration of the integral sum of current by means of the SFM method was performed during 10 minutes, in synchronization with the registration of the EPC-grams.

The HRV (cardiorythmography) method allows registering the electrical activity of heart and the muscles that participate in the respiratory process. The analysis of the obtained data provides an opportunity to study certain cardiological and respiratory peculiarities of the individual under study. The HRV was recorded twice for studying the influence of each aroma according to the chosen chronology.

Data processing

Pre-processing of data was handled by software suites that had been especially developed to interact with the EPC, SFM and HRV equipment. Then the obtained results were further processed by means of the Statistica 6.0, GDV SciLab and MS Excel software programs. The homogeneity of data was analysed by means of two main statistical methods. At the beginning we have taken 4 different methods of data analysing and compared them, and these two methods have showed the best results: their sensitivity to the changes was better.

T-test for dependent sample. This criterion is used for checking the hypothesis of equality of means of two samples having normal distribution. The t-test for dependent samples is used in those situations (quite common in practice) when an important source of the intragroup variance (or error) can be easily determined and excluded from the analysis. Basically, the t-test consists in calculating the difference between groups and comparing it with the difference. The t-test for dependent samples uses only paired differences, ignoring the initial numeric values and their variation. Thus, the value of said difference is not compared with the dispersion of the initial values, but with the dispersion of the individual differences, which is relatively small.

Kolmogorov-Smirnov-test. This criterion is used for checking the hypothesis stating that two independent samples were obtained from the same general population, i.e. the

distribution functions of both general populations are identical (in this case the general populations are said to be homogeneous).

The SciLab program is intended for multi-parameter processing of static and dynamic GDV-grams and the subsequent statistic comparison of two or more samples of calculated parameters. Statistical tests implemented in the program were based on Student criteria, Wilcockson criteria, Mann - Whitney and Valde - Volfovitz criteria as well as on signs criteria, and ensure the analysis of dependent and independent data samples possessing various distribution types. SciLab can calculate set of parameters of acquired from "GDV Compact" images (EPC-gram), we have used in our analysis two of them: area of EPC-gram and symmetry.

RESULTS

The EPC-grams obtained from the measurements were processed by means of the SciLab program, including generation of a file with numeric parameters. Then the data were saved and transferred to the MS Excel program.

Then the homogeneity of the EPC data was analysed for the "Before", "Smell" and "After" stages, according to the criteria of the abovementioned statistical methods. The statistical processing of the data was performed in the Statistica 6.0 program.

The obtained data were transferred to the MS Excel program, where the reaction of the participant towards the aroma was analysed. The data of the EPC-grams obtained from 10 fingers allow estimating the changes in the psychophysical state of a participant under the influence of the aroma.

To make these data more acceptable, we presented them as a difference (after – before) measurements for R and L hands (fig.1) and average between L and R (fig.2).

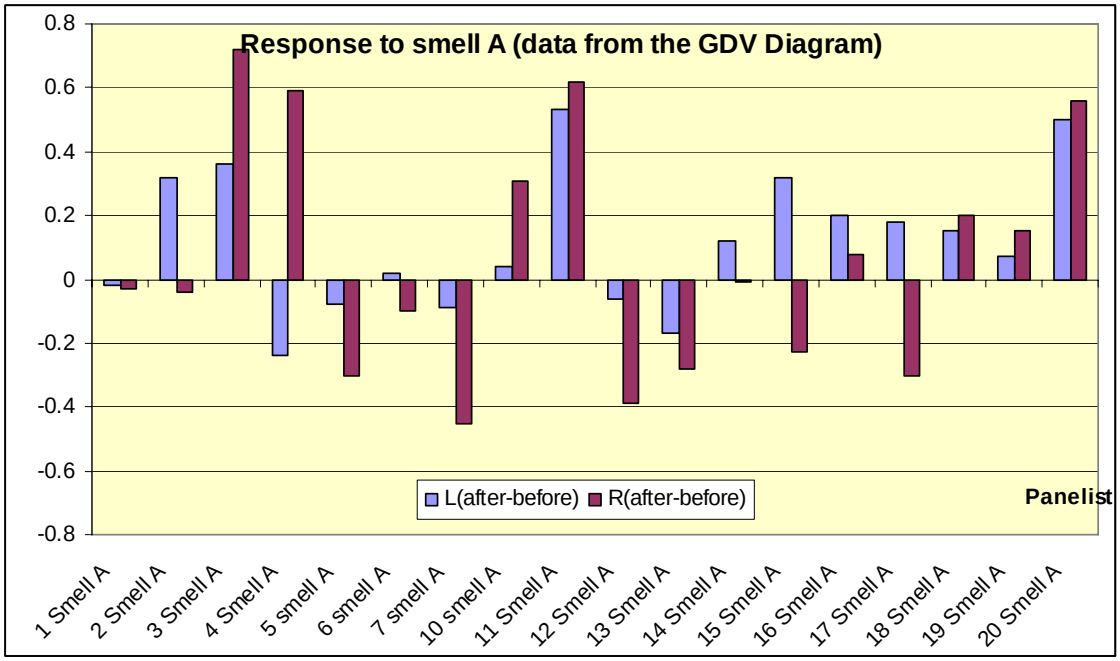

Fig. 1. Data for 18 panellists as a difference between before and "after" measurements from Right and Left hands for smell A.

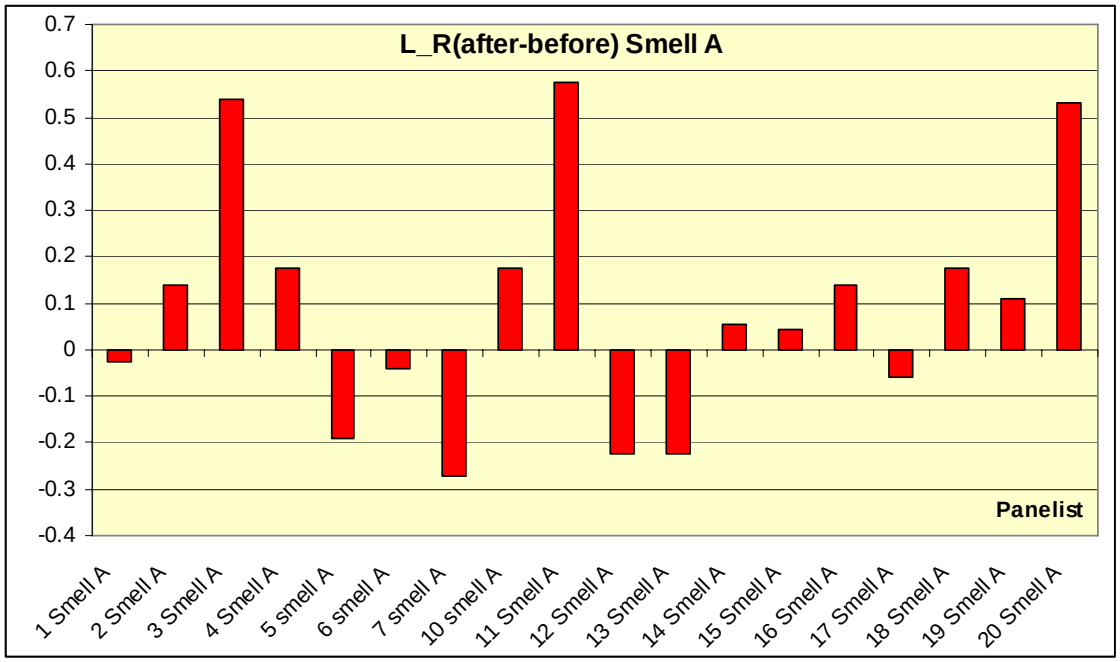

Fig. 2. Data for 17 panellists as a difference between before and after measurements averaged on Right and Left hands for smell A.

Same data for smell B, C and D are presented at fig. 3, 4, 5.

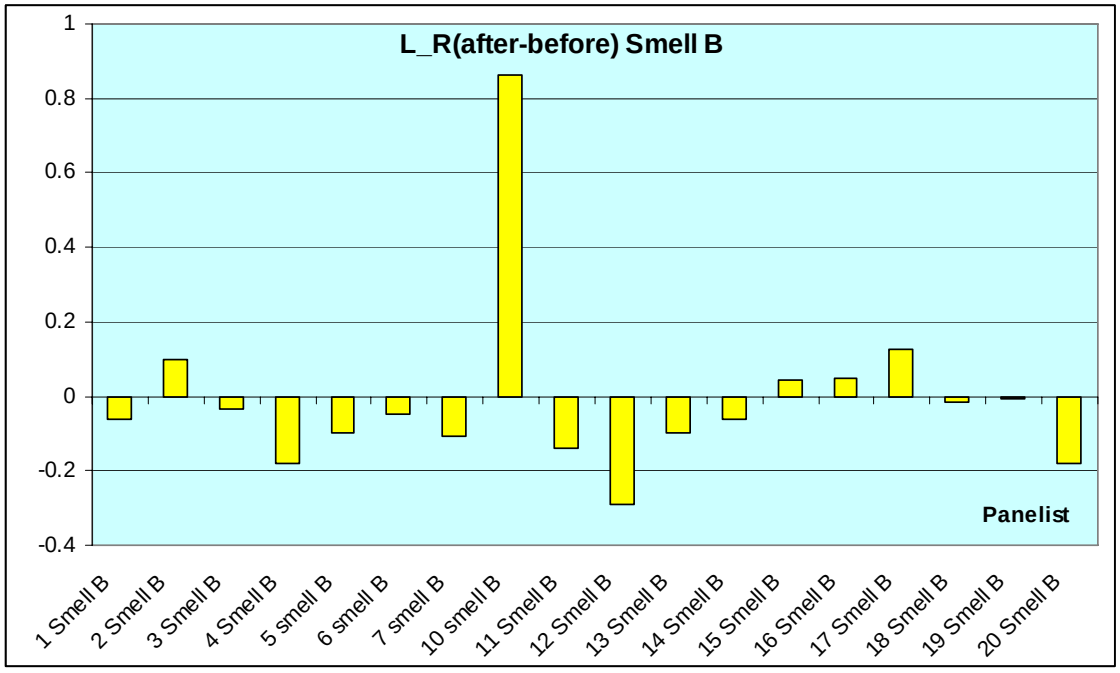

Fig. 3. Data for 17 panellists as a difference between before and after measurements averaged on Right and Left hands for smell B.

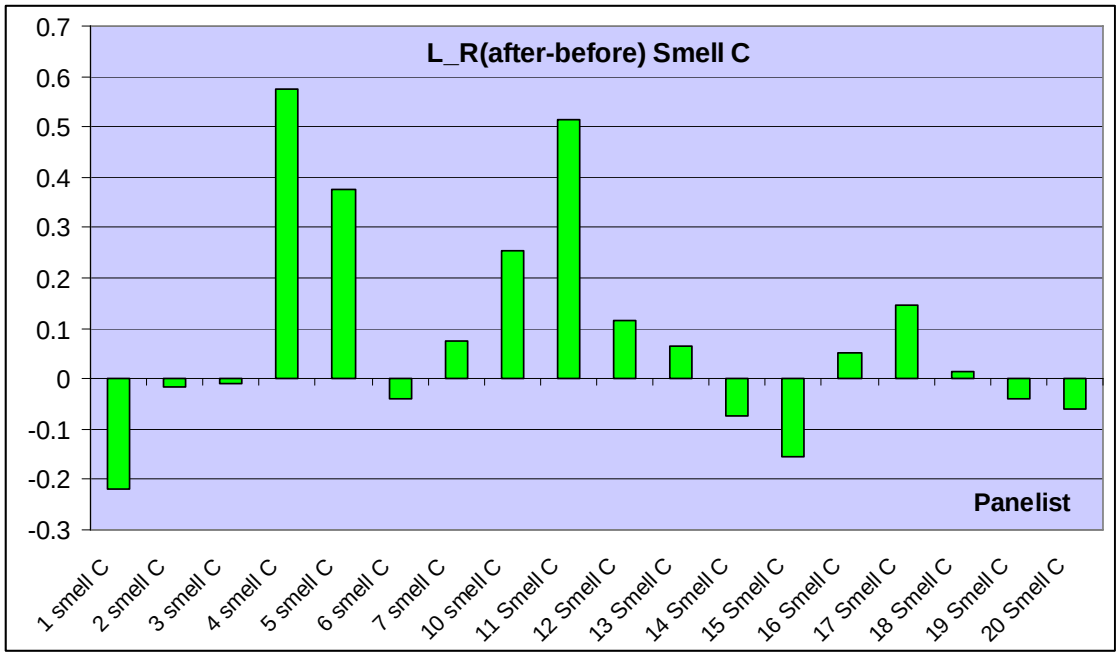

Fig. 4. Data for 17 panellists as a difference between before and after measurements averaged on Right and Left hands for smell C.

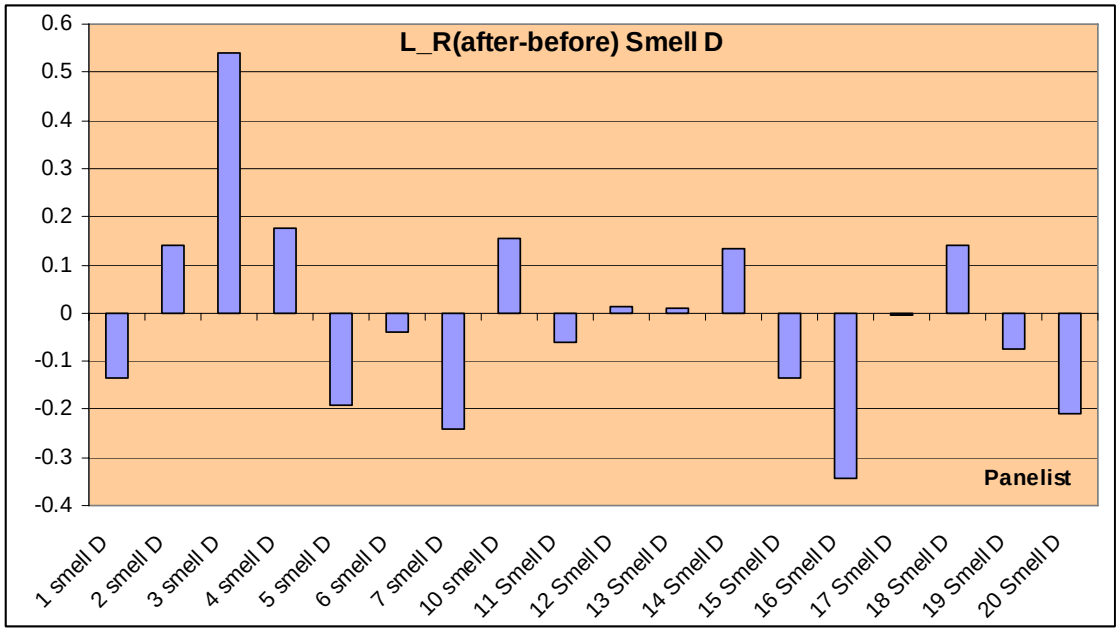

Fig. 5. Data for 17 panellists as a difference between before and after measurements averaged on Right and Left hands for smell D.

Results of the SFM measurements

The most effective vector for use when working with the SFM with the purpose of obtaining the integral information is the vector of values of the differences between the right and the left channels, which is calculated according to the following formula:

$$D_i=abs[R_i-L_i]/max\{R_i,L_i\} \qquad (1)$$

The ***D*** vector allows for the background influence upon the SFM values and, therefore, does not require detrending.

Before the calculation of the ***D*** vector the SFM values are calibrated in advance on the basis of the calibration coefficients that are obtained through a separate series of measurements for every day of the investigation.

Some examples of the generalized obtained data is shown in the bar charts (figs.6, 7).

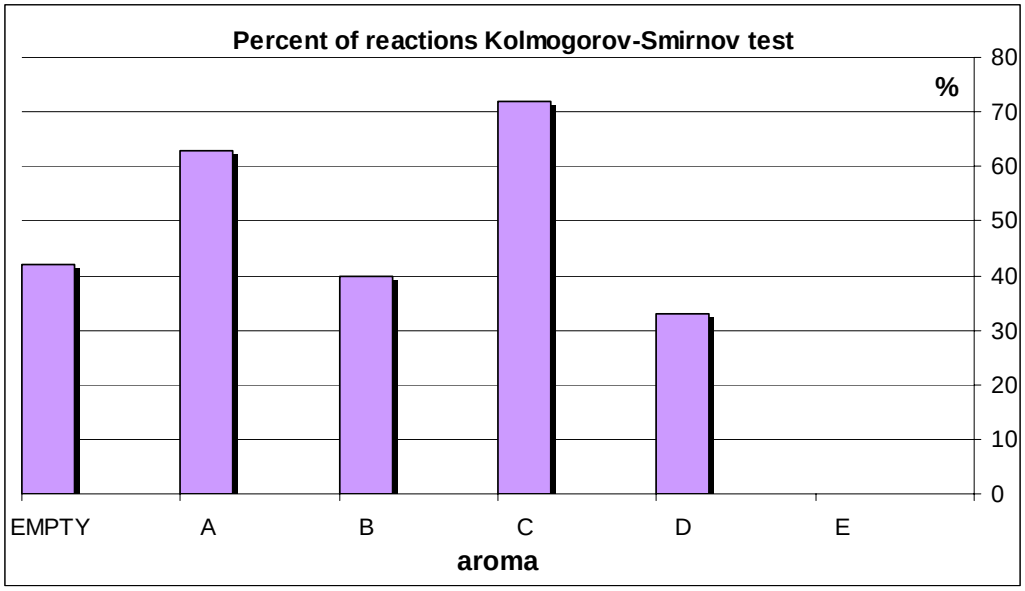

Fig. 6. Integral estimation by means of the Kolmogorov-Smirnov-test of the SFM data for aromas.

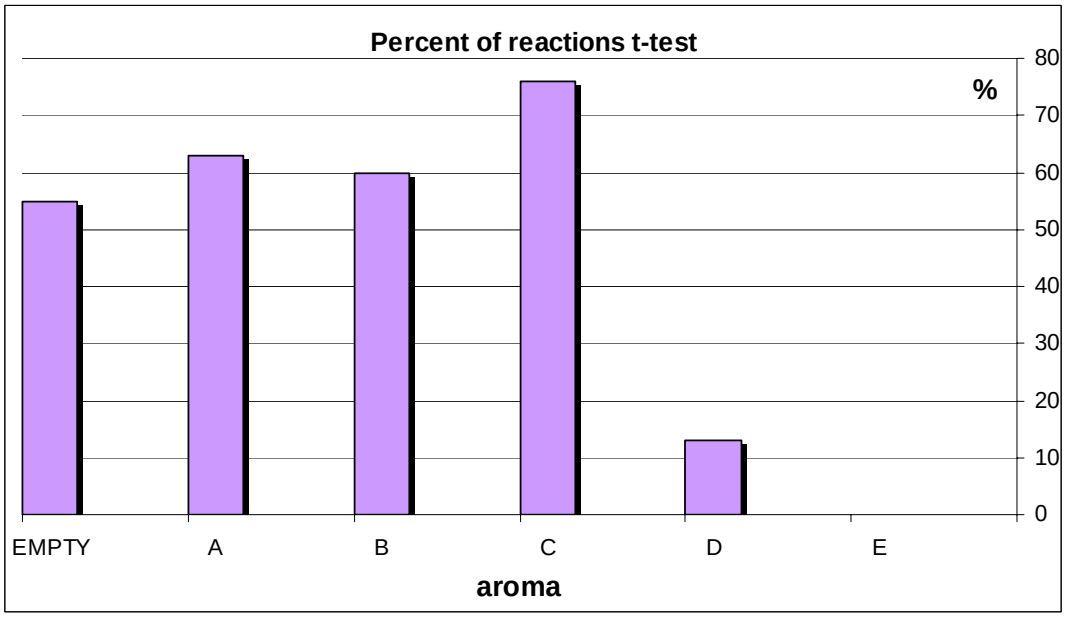

Fig. 7. Integral estimation by means of the t-test of the SFM data for aromas.

Subjective estimation of aromas

The results of the participants' questionnaire poll were inserted into Excel tables and then presented in graphic form for better clarity as bar graphs shown in figs. 8-10.

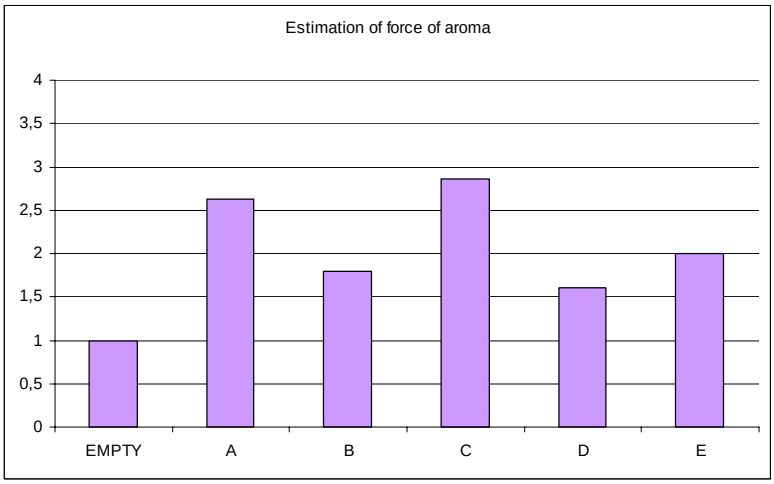

Fig. 8. Average subjective estimation of force of aroma by the participants of the investigation.

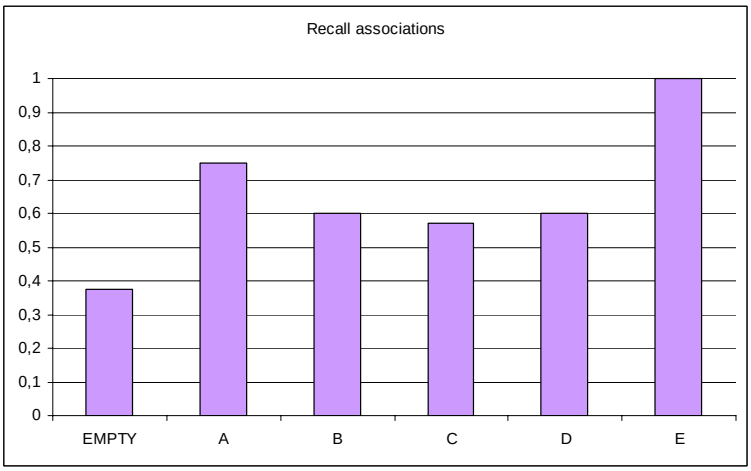

Fig. 9. Average subjective estimation of recall of associations with aroma by the participants of the investigation.

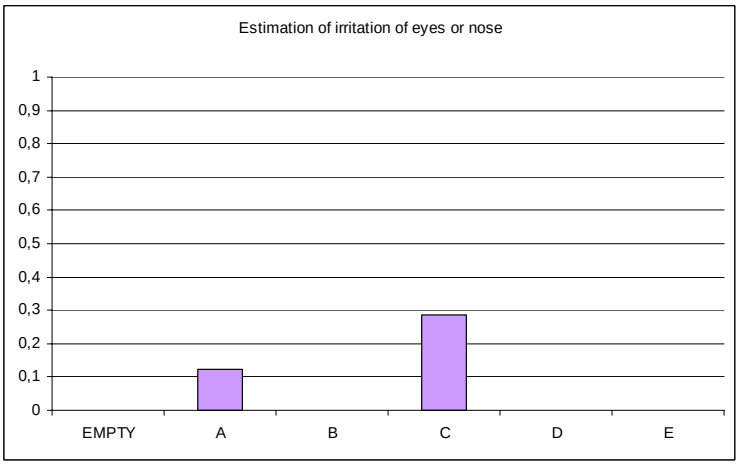

Fig. 10. Reported irritating influence of aroma upon the mucous membranes.

Results of the HRV measurements

The HRV (cardiorhythmogram) of the individuals under study did not reveal any dynamics that would unambiguously correlate with the conducting of the investigations.

The differences between the samples in the indices of the variational pulsometry allow assuming that the procedure did not influence the condition of the individual under study. Small positive dynamics is most probably accounted for by relaxed atmosphere during the investigations.

In order to provide more specific conclusions on the basis of the HRV parameters, the data from the complex analysis should be correlated and a more extensive database with results of the HRV testing should be provided.

Correlation analysis

We analyzed the correlation between the subjective and objective reactions of the tested individuals to the introduction of odorous substances and the indices of the state of health and psycho-emotional state of the subjects.

The following correlation between the probability of the subjects' virtual reaction VR, % and the indices of the subjects' physiological state was discovered: positive correlation (r=0.71) between the VR% (Averaged Intensity) and the systolic blood pressure (see fig. 11).

The following correlations between the probability of the virtual reaction *VR, %* and various indices of the subjects' psychoemotional state were discovered: positive correlation (r=0.65) between the VR% (Area) and the V (Vigor, POMS) factor; positive correlation (r=0.55) between the VR% (Entropy) and the C (Confusion, POMS) factor; negative correlation (r=-0.74) between the VR% (Averaged Intensity) and the D (Depression, POMS) factor (depression); negative correlation (r=-0.57) between the VR% (Averaged Intensity) and the A (Aggression, POMS) factor.

The following correlations between the subjective estimation of the influence of odorous substances and the indices of the subjects' state of health were discovered: negative correlation (r=-0.54) between the preference rating (AVEDA scale) and the health group [4-healthy, 3-apparently healthy, 2-altered psychosomatic state]; negative correlation (r=-0.79 [see fig. 12] and –0.69 for the odor evaluation by the MCSC and the AVEDA scales respectively) between the subjective estimation of the odor intensity and the number of chronic illnesses; negative correlation (r=-0.58) between the subjective estimation of the odor intensity (AVEDA scale) and the subjects' psychosomatic state.

Positive correlation (r=0.58) between the subjective estimation of the influence of odorous substances and the temperament's characteristics (extraversion level, Eysenk's questionnaire) was discovered.

The following results of the analysis are of special interest: the correlation between the indices of the systolic blood pressure and the probability of the virtual reaction (%) (see fig. 11) and the correlation between the number of chronic illnesses and the subjective estimation of the odor intensity (see fig. 12).

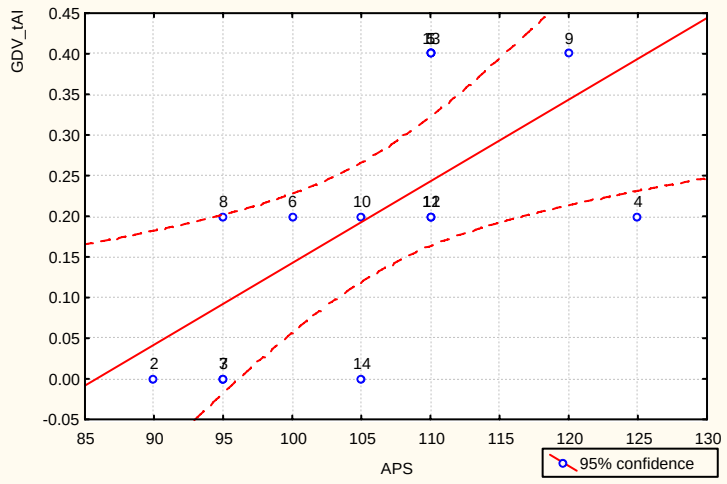

Fig. 11. Correlation between the systolic blood pressure and the probability of the virtual reaction to the introduction of odorous substances in % (N (number of panelists) =14; r=0.71). Where GDV_tAI – probability of virtual reaction evaluated from the detrended time dependence of the Intensity, %, and APS – arterial pressure systolic.

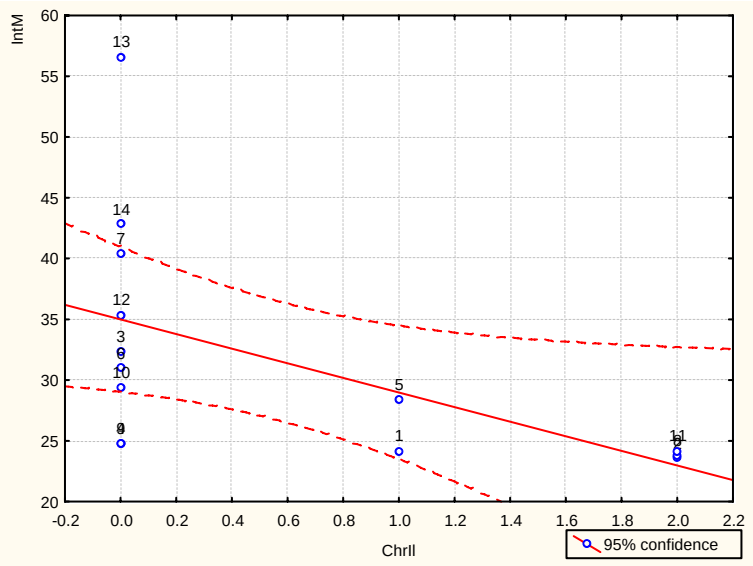

Fig. 12. Correlation between the number of chronic illnesses and the subjective estimation of the odor intensity (N=14; r=-0.79). Where IntM – odor intensity after Monell Chemical Senses Center and ChrI1 – number of chronic problems.

DISCUSSION

In the course of the accomplished work the results of the instrumental and subjective (test) information on the influence of certain aromas on individuals were obtained. The obtained data allow drawing a number of conclusions.

The correlation between the indices of the systolic blood pressure (background) and the probability of the virtual reaction (fig. 11) most likely can be explained by the peculiarity (nonlinearity) of the EPC-signal dynamics for the subjects with high systolic blood pressure.

The subjective estimation of the odor intensity of the subjects with chronic illnesses (fig. 12) can be explained by the fact that the majority of the chronic illnesses fall into the category of the ENT (ear, nose, throat) organs illnesses.

The correlation analysis showed no correlation between the intensity of the presented stimulus and the number of significant virtual reactions.

Significant correlation can be observed both among the instrumental methods (GDV, SFM) and between the instrumental and the subjective methods.

Despite the fact that each aroma is perceived by a particular person in his/hers special way, and that the total number of tests is currently fairly limited, the tendencies of the strongest reactions can be noted by all methods of estimation for the **A** and **C** aromas.

The GDV and SFM methods registered significant reactions towards the background; this may be caused by the fact that the participants didn't know about the background measurements, and the absence of any perceptible odours might have confused them, thus causing corresponding reactions. Another reason might be in that the background was estimated in the very first test for each participant, which naturally was accompanied by certain excitement caused by new unfamiliar and unusual conditions. Consequently, said factors could have influenced the parameters of the instrumental registration of the background.

High correlation of the data produced by the SFM and GDV methods suggests that these methods allow independent registration of the influence of the factors under study, even though the working principles of these methods are absolutely different. In other words, these methods allow registering the changes of the psychophysical state, in particular the influence of aromas on the individual.

The issue of the preliminary selection of individuals according to the level of their reactions towards aromas should be elaborated: some individuals are unresponsive towards aromas, which can be caused by some physiological peculiarities.

The method of the cardiorhythmography showed that the individuals under study should satisfy more rigid conditions, i.e. 24 hours before the investigation the impact of various drugs having strong influence on the cardio rhythms should be excluded, and 4 hours before the investigation the physical activities substantial for this particular individual should be excluded as well. In this way more homogeneous values of the HRV background can be achieved and the HRV dynamics before and after the influence of the aroma can be tracked with higher accuracy.

Therefore, we can conclude that EPC method itself is good enough for registering persons' reaction on different fragrances, though it is not new generally, in this field of study it is a novel method. Considering obtained results we can say that EPC method appeared to be quite good for registering influence of fragrant essential oils on given individual. Using EPC method one can say, with high probability, what kind of effect one aroma make on one individual.

Our experiments showed that perception of different odours depends strongly on human and his current condition, and no one can say that concrete odour will always have some definite impact on every individual.

ACKNOWLEDGEMENTS

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