Reflection of the Emotional Significance of Visual Stimuli in the Characteristics of Evoked EEG Potentials

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Healthy subjects (n = 88) were asked to passively visualize positive and passive emotiogenic visual stimuli and also stimuli with a neutral emotional content. Images of the International Affective Picture System (IAPS) were used. Amplitude/time characteristics of the components of evoked EEG potentials (EPs), P1, N1, P2, N2, and P3 and topographic distribution of the latter components were analyzed. The latencies, amplitudes, and topography of the EP waves induced by presentation of positive and negative stimuli were found to be different from the respective values for the EPs induced by neutral stimuli. The level and pattern of these differences typical of different EP components were dissimilar and depended on the sign of the emotions. Specificities related to the valency of an identified stimulus were observed within nearly all stages of processing of visual signals, for the negative stimuli, beginning from an early stage of sensory analysis corresponding to the development of wave P1. The latencies of components P1 in the case of presentation of emotiogenic negative stimuli and those of components N1, N2, and P3 in the case of presentation of the stimuli of both valencies were shorter than the latencies observed at neutral stimuli. The amplitude of component N2 at perception of positive stimuli was, on average, lower, while the P3 amplitude at perception of all emotiogenic stimuli was higher than in the case of presentation of neutral stimuli. The time dynamics of topographic peculiarities of processing of emotiogenic information were complicated. Activation of the left hemisphere was observed during the earliest stages of perception, while the right hemisphere was activated within the intermediate stages. Generalized activation of the cortex after the action of negative signals and dominance of the left hemisphere under conditions of presentation of positive stimuli were observed only within the final stages. As is supposed, emotiogenic stimuli possess a greater biological significance than neutral ones, and this is why the former attract visual attention first; they more intensely activate the respective cortical zones, and the corresponding visual information is processed more rapidly. The observed effects were more clearly expressed in the case of action of negative stimuli; these effects involved more extensive cortical zones. These facts are indicative of the higher intensity of activating influences of negative emotiogenic stimuli on neutral systems of the higher CNS structures.

Keywords: evoked potentials, amplitude, latency, emotiogenic stimuli, emotional valency, images of IAPS.

INTRODUCTION

At present, a significant increase in the number of studies dealing with the neurophysiological basis of emotional reactions in humans is observed (the respective information is presented in a few reviews [1, 2]). According to modern psychological and physiological theories emphasizing the differentiated structure of emotional reactions [3], the first stage of development of such responses is based on perception of emotiogenic information, including decoding of external (auditory, visual, tactile, etc.) and internal (cognitive and interceptive) emotional signals, estimation of the sign of incoming emotional information, and evaluation of its significance for the individual. Within the second stage, experiencing of the induced emotion *per se* occurs, i.e., its real induction in the individual accompanied by additional activation of the somatic and autonomic systems is realized [4]. The data of neurophysiological, positron-emission, and magnetoresonance studies demonstrated that the stages of perception and experiencing of emotions are associated with the activity of various subdivisions of emotiogenic and regulatory cerebral systems [5].

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The electrophysiological correlates of the experiencing of emotions and the probable neurophysiological mechanisms of emotional reactions have been subjected to rather extensive studies. Usually, the analysis of spectral and coherence characteristics of ongoing field electrical activity of the cerebral cortex (EEG) related to the induction of emotional experience was used [6, 7]. This approach, however, was poorly effective for the analysis of the earliest stages of development of emotional reactions, because it suffers from a relatively low time resolution. We believe that techniques for recording and analysis of evoked EEG potentials (EPs) are much more successful from the above aspect. Recording of EPs provides rather high time and to a lesser extent spatial resolution and allows researchers to obtain a rather detailed spatiotemporal pattern of the consequence of electrical events developing in the brain before, in the course of, and after the performance of one psychophysiological task or another. In such a way, the experimenter has the possibility to identify the electrophysiological correlates of consecutive stages of processing of sensorimotor information and a few cognitive processes [8].

It was experimentally proved that processing of affective information can be quantitatively estimated, from certain aspects, by analyzing the amplitudes and latencies of consecutive EP components [9]. Despite this fact, the use of the technique for recording and analysis of EPs has been, until recently, mostly concentrated on examination of the characteristics of one of the latest components of these potentials (P3) and of its interhemisphere asymmetry [10, 11]. The effects of the sign (valency) of an emotion on the amplitude/time parameters of earlier EP components and on topographic peculiarities of the development of EP waves after presentation of affective signals remain little studied until now. Results of single studies in this field are ambivalent and, frequently, simply contradictory. It seems possible that this circumstance is, first of all, due to the wide variety of stimulus sets used for the formation of an emotional reaction under experimental conditions. For example, evoked EEG activity in many studies was recorded in the tested subjects in the course of identification of the facial expression of different emotions. It is obvious that the use of images of the face, i.e., complicated and exclusively specialized stimulating objects, as the experimental stimuli could significantly influence the pattern of spatial and amplitude/time characteristics of EPs [12]. This statement is practically applicable to the same extent with respect to visually presented verbal stimuli having an emotional tint. Extensive variability of the experimental paradigms for recording of EPs is another source of contradictions and complications. In a great majority of studies, the subjects were faced with tasks requiring detection of the emotiogenic stimuli from a mixed set of the latter and neutral stimuli or categorization of the stimulus immediately after its presentation; these situations are to a considerable extent necessarily involved in the action of a cognitive component of the reaction.

Taking into account all the above data and interpretations, we based our study on the use of signals having a static emotional content and presented in a mode of passive viewing. This situation amplified the emotional component of analysis *per se* and did not require the necessity to perform accompanying special tasks (an immediate response to presentation of the stimulus, estimation of the stimulus within the moment of presentation, tracking for the test signal, etc.). As the stimulus set, we used visual signals of the International Affective Picture System, IAPS (Center for the Study of Emotion and Attention, CSEA-NIMH, 1999). This allowed us to control factors of the signs of emotion intensity of emotional activation. As is known, the action of the stimuli of this system evokes a complex of subjective, autonomic, and neurophysiological reactions varying depending on the sign and activating content of the stimulus [13].

Therefore, our study included the analysis of the amplitude/time and topographic characteristics of EPs in humans; the EPs were induced by perception of the above-mentioned emotionally significant visual stimuli.

METHODS

Eighty-eight subjects, 35 men and 53 women, dextrals, 18 to 25 years old, took part in the tests. All subjects gave informed consent for the participation in the experiments. Visual stimuli from the set of the International Affective Picture System, IAPS, were used as the stimulation material. These stimuli look like photoimages; in an overwhelming majority of people, their visual perception induces positive emotions (pretty faces, with expression of positive emotions, pleasant events, esthetically attractive landscapes) or negative emotions (images of accidents and catastrophes, disfigured injured parts of the body, etc.); also images neutral from the emotional aspect (common things in routine surroundings) can be presented. All stimuli were divided into three categories depending on the level of emotional activation. For each category, 30 stimuli were selected: neutral, positive with a high emotional content, and negative with a similarly high emotional content. The following IAPS stimuli were used: 2102, 2190, 2200, 2514, 2880, 5390, 7000, 7002, 7004, 7006,7009, 7010, 7020, 7030, 7031, 7035, 7040, 7090, 7100, 7130, 7150, 7175, 7211, 7217, 7233, 7705 (neutral); 1300, 2053, 2730, 2800, 2811, 3000, 3010, 3016, 3022, 3100, 3101, 3120, 3130, 3170, 3225, 3250, 3400, 3550, 6350, 9042, 9253, 9265, 9320, 9405, 9410, 9433, 9561, 9570, 9582, 9600 (negative), and 1440, 1441, 1460, 1463, 1722, 1920, 1999, 2040, 2070, 2311, 4599, 4611, 4626, 4641, 4658, 5621, 5623, 5629, 5660, 5831, 5833, 5890, 5910, 7230, 7325, 7508, 8030, 8180, 8190, 8490 (positive).

Stimulation images were presented on the screen of a monitor in randomized order; the duration of each presentation was 1 sec, while the interstimulus intervals when the subject observed only a dark screen were 3 to 4 sec long.

During presentation of the stimuli, the subjects sat in an armchair in a darkened soundproof chamber; the monitor was at a distance of 80 cm. To minimize muscle contraction-related artifacts, the tested subject was asked to maintain a relaxed state and perform no movements. To limit eye movements and to decrease the power of the alpha rhythm (which can be partially synchronized with the EP components and makes more difficult their detection), the subject was asked to fix his/her gaze on a continuously switched-on red light-emitting diode in the center of the monitor screen.

A multichannel electroencephalograph Neiron-spektr-4 (Russia) was used. Visual EPs were recorded monopolarly from 17 leads, according to the standard international 10-20 system (F3/4, F7/8, C3/4, P3/4, O1/2, T3/4, T5/6, Fz, Cz, and Pz). The rejection frequency of a high-frequency filter was 35 Hz, the time constant of recording channels was 0.32 sec, and the digitization frequency of EEG signals was 10^3 sec^{-1}. Connected ear electrodes A1 and A2 served as reference electrodes. Recordings from the anterior forehead leads Fp1/2 were excluded from the analysis because the respective samples contained a considerable amount of artifacts. The ERP-3 software (programmer V. Arbatov) was used for recording and data processing.

Artifact-free EP samples were recorded from the records under visual control; these samples were then classified and averaged depending on the type of stimulation. Thus, all realizations containing no artifacts (usually 25-27 of 30 initiated by presentation of stimuli of the above-mentioned categories) were averaged. The individual variability of EPs was rather high. This is why time intervals within which one component or another was identified were set for each subject considering individual peculiarities of his/her visual EPs; this allowed obtaining more accurate results. Nonetheless, the maximum time intervals (msec) of the analyzed EP components were from the moment of presentation of the signals, on average, as follows: 80 to 120 (P1), 120 to 160 (N1), 160 to 220 (P2), 220 to 300 (N2), and 300 to 450 (P3) [14]. When each group containing 25 to 30 realizations was averaged, the mean level of the signal within a 200-msec-long interval preceding presentation of the stimulus was taken as a baseline. In averaged EPs induced by stimuli of each of the above-mentioned category (negative, positive, and neutral), we measured the peak latencies of the successive EP components (P1, N1, P2, N2, and P3) and the amplitudes corresponding to these maxima. The general shape of the complex of averaged EPs developing after presentation of a visual emotiogenic stimulus is shown in Fig. 1.

Numerical data were treated using standard techniques of variation statistics. The distributions of most indices did not correspond to the normal (Gaussian) low; this is why the nonparametric Wilcoxon test was used for estimation of the significance of intergroup differences.

RESULTS

Measurements of the latencies of the maxima and amplitudes of EPs recorded at perception of emotionally positive and negative visual stimuli showed that the values of these indices differ from the corresponding parameters of EPs induced by the action of neutral stimuli. The level and pattern of these differences typical of different EP components were dissimilar and depended on the sign of emotions.

Component P1 (Latency 80 to 120 msec). The mean values of the latency of this component measured upon presentation of the neutral stimuli varied in different leads within a 109 to 113 msec range. At the same time, when emotionally negative stimuli were presented, the P1 latencies in the lateral and medial frontal and anterior parietal regions of the right hemisphere and also in the medial frontal lead (F8, F4, Fz, and T4) were found to be significantly shorter ($P < 0.05$; Fig. 2). When emotionally positive stimuli were perceived, we observed no effect of this characteristic of emotiogenic signal on the latency of component P1. Under conditions of presentation of affective stimuli (both positive and negative), the P1 amplitudes in most cortical regions were, in general, somewhat higher than in the case of action of neutral stimuli, but these differences did not reach the significance level.

Component N1 (Latency 120 to 160 msec). The latencies of the early negative (N1) component of EPs induced by presentation of affective stimuli also differed from the corresponding values in EPs related to neutral visual stimuli (Fig. 2). When the latter stimuli were presented, the N1 maximum was reached, on average, on the 157th to 162nd msec after visualizing the stimulus. In the case of emotionally negative stimuli, this component developed somewhat earlier in the anterior temporal, parietal, and occipital regions of the left hemisphere and also in the medial lead of the central cortical zone (in T3, P3, O1, and Cz, the differences were significant; $P < 0.05$). Upon perception of positive stimuli, the latency of component N1 was also significantly shorter in the central, anterior and posterior temporal, and parietal leads of the left hemisphere; this was also observed in the medial lead of the parietal region (leads C3, T3, T5, P3, and Pz; $P < 0.05$).

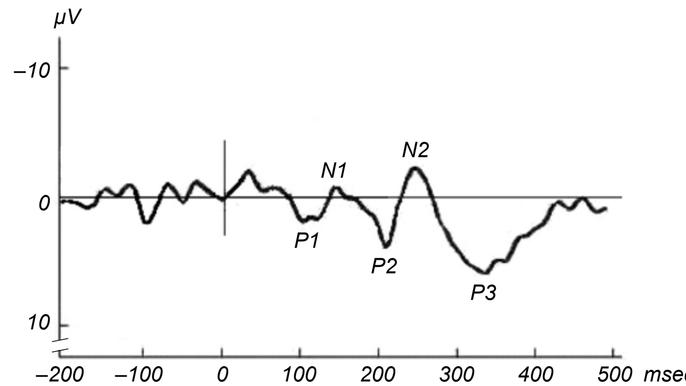

Fig. 1. Example of an averaged evoked potential (EP) recorded after presentation of a visual emotionally significant stimulus in one of the tested subjects. Vertical line shows the moment of presentation of the stimulus. Abscissa) Time, msec; ordinate) amplitude, μV. N1, N2, P1, P2, and P3 are the EP components.

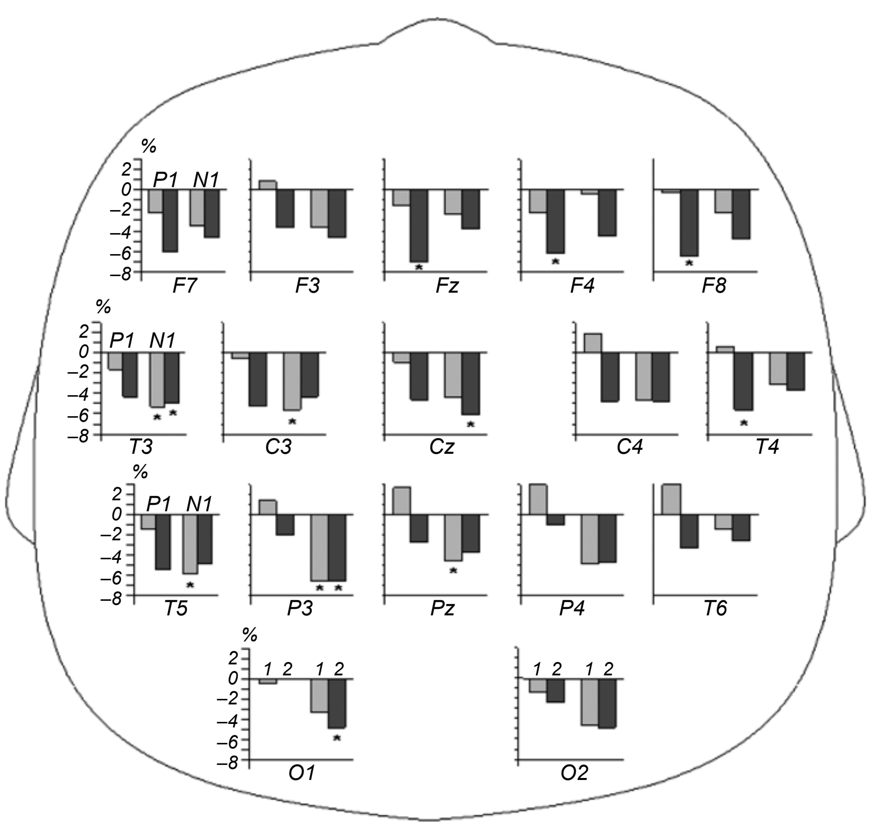

Fig. 2. Diagrams of the differences between the latencies of the maxima of components P1 and N1 in evoked potentials recorded from the respective leads (shown below the diagrams) and induced by emotionally tinted stimuli and the corresponding latencies of the EP components in the case of emotionally neutral stimuli. Vertical scale) Normalized difference (%) between the latencies of EP components induced by emotionally positive (1) and negative (2) stimuli and the latencies of the respective components in the case of action of neutral stimuli (taken as 100%). Asterisks show cases of significant intergroup differences ($P < 0.05$).

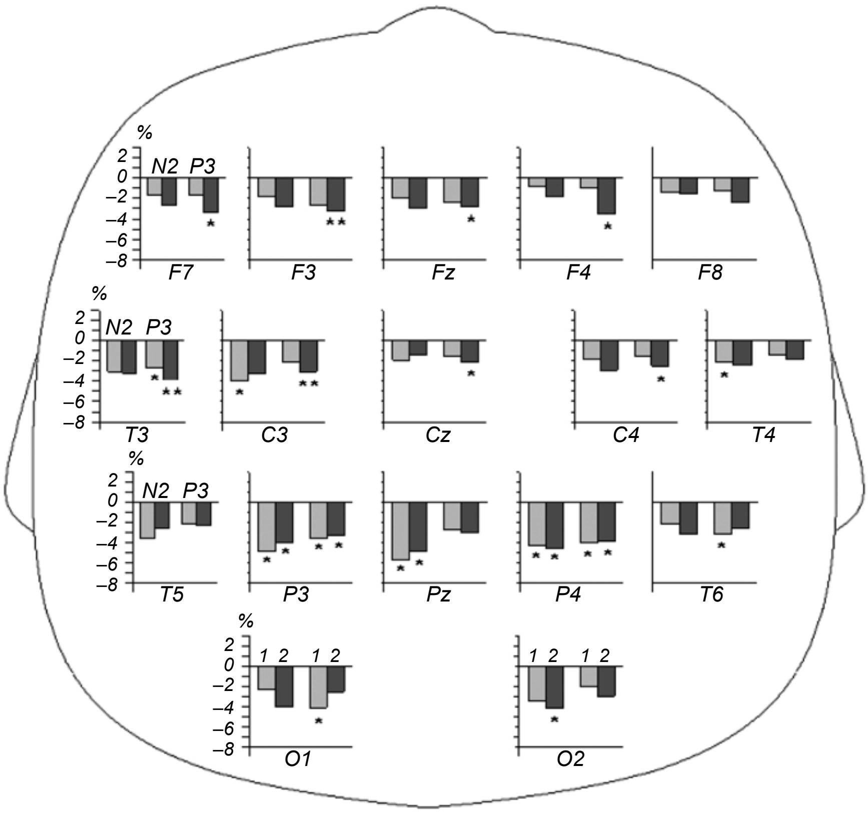

Fig. 3. Diagrams similar to those in Fig. 2 but for the latencies of components N2 and P3. Two asterisks show cases of highly significant intergroup differences ($P < 0.01$). Other designations are similar to those in Fig. 2.

Component N2 (Latency 220 to 300 msec). There were no significant differences between the amplitudes of wave N1 related to the sign of emotions. At the same time, the amplitude of a later mid-latency negative component, N2, was significantly influenced by presentation of emotionally positive (but not negative) stimuli. The mean N2 amplitude in the case of presentation of neutral stimuli varied within a –0.5 to –2.4 μV range. When positive stimuli were presented, smaller N2 components developed in the central and occipital regions of the left hemisphere (C3 and O1), i.e., a shift of the peak of this oscillation toward positivity was observed ($P < 0.05$). The latency of the N2 component also demonstrated the dependence on the emotional valency of the stimulus; it was shorter when affective stimuli were perceived, as compared with the analogous indices recorded in the case of action of neutral stimuli (means of the "neutral" latencies varied from 248 to 261 msec in different leads). Significant differences of the latency values for the N2 initiated by stimuli of both emotional valencies were observed in the parietal regions (P3, P4, and Pz_{neg}; $P < 0.05$; and Pz_{pos}; $P < 0.01$); the latter effect under conditions of presentation of negative stimuli was also observed in the occipital zone of the right hemisphere (O2; $P < 0.05$); in addition to the above-mentioned observations, shortening of the N2 latency was found upon the action of positive stimuli in the central and posterior parietal zones of the left hemisphere (C3 and T5; $P < 0.05$; Fig. 3).

Component P3 (Latency 300 to 450 msec). Emotionally tinted stimuli of both valencies influenced both the amplitude and latency of the P3 component (wave P300). The delay of the maximum of potential P3 developing after presentation of neutral stimuli was, on average, from 314 to 321 msec in different leads. The respective values observed at viewing of emotionally negative images were significantly shorter in the frontal, central, and parietal regions and also in the anterior temporal zone of the left hemisphere (C4, Cz, F4, F7, Fz, P3, and P4, $P < 0.05$; C3, F3, and T3, $P < 0.01$). Under conditions of the action of emotionally positive stimuli, comparable effects were observed in the anterior temporal and parietal regions and also in the posterior temporal zone of the right hemisphere and occipital zone of the left hemisphere (P3, P4, T3, T4, T6, and O1, $P < 0.05$; Fig. 3).

The amplitude of wave P3 in response to the action of negative stimuli was significantly higher than that observed at presentation of neutral visualized pictures (i.e., this wave was more positive) in the mediofrontal, central, parietal, and occipital regions (F3, F4, Fz, and

O1, $P < 0.05$; P3, P4, and O2, $P < 0.01$; C3, C4, Cz, and Pz, $P < 0.001$). In the case of action of positive affective stimuli, the relative increase in the P3 amplitude was significant in the central regions (symmetrically), frontal zone and parietal regions of the left hemisphere, and also in the medial leads from the frontal, central, and parietal cortex (F3 and Fz, $P < 0.05$; C4 and P3, $P < 0.01$; C3, Cz, and Pz, $P < 0.001$; Fig. 4).

DISCUSSION

According to the concept practically generally accepted at present, the emotional significance of visual stimuli is mostly reflected in the characteristics of the EP components with latencies longer than 200 msec. This is why information on the influence of the emotional tint of the stimuli on earlier stages of processing of visual information remains rather scanty. Nonetheless, the results of some studies show that the amplitude of a relatively early EP component, P1, depends noticeably on the valency of the presented image. This component was clearly greater under conditions of presentation of negative stimuli than in the cases of viewing of positive and neutral images [15, 16]. Comparable data were obtained with respect to the N1 component whose amplitude in the occipital/temporal regions of the cortex was higher under conditions of perception of all emotiogenic stimuli, independently of their sign [17]. At the same time, according to the opinion of a few authors [2], the emotional component of the stimulus mostly influences the amplitude characteristics of EP components, while the respective dependence of the time parameters is insignificant. Our study demonstrated that the latencies of EP components also correlate significantly with the sign of the induced emotion, and the respective specificities are manifested within rather early time intervals. In the case of presentation of negative emotiogenic stimuli, such differences become obvious within an interval where wave P1 (latency 80 to 120 msec) develops. Only single reports on such peculiarities have been presented. In particular, Mikhailov and Rosenberg [18] noticed that the latencies of the early EP components P1 and N1 were relatively shorter under conditions of identification of the facial expression of negative emotions of fear and anger.

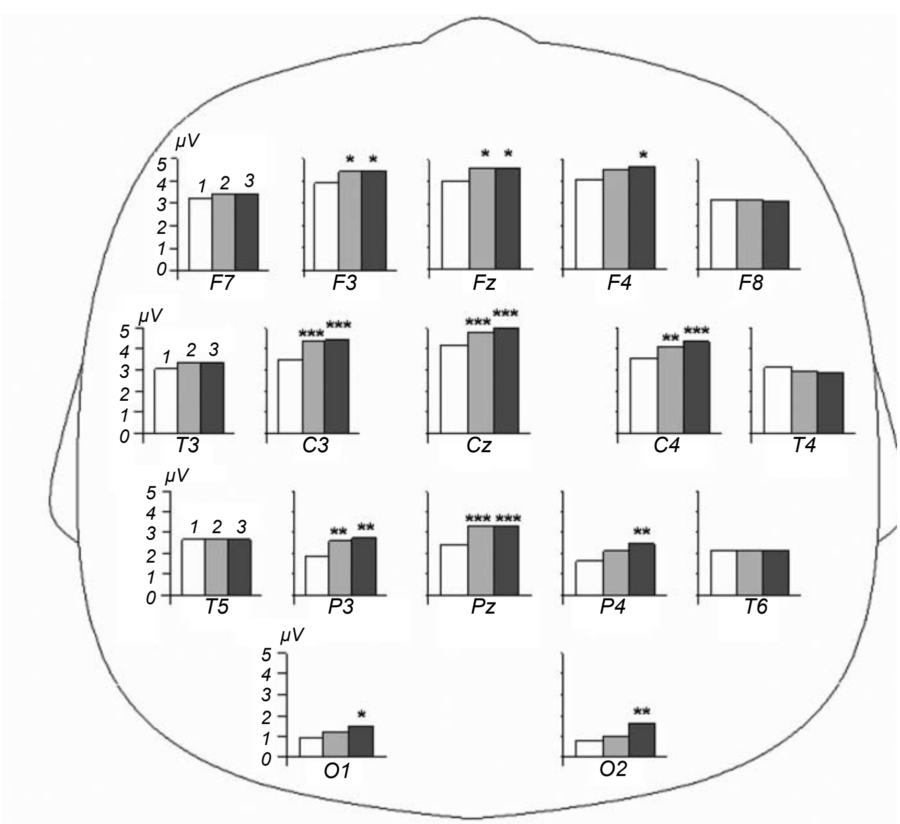

Fig. 4 Diagrams of the amplitudes of waves P3 generated after presentation of neutral (1), emotionally positive (2), and emotionally negative (3) visual stimuli. Vertical scale) Amplitude, μV. Three asterisks show highly significant intergroup differences with $P < 0.001$. Other designations are the same as in Figs. 2 and 3.

According to modern concepts, the P1 oscillation in EPs is interpreted as a neurophysiological correlate of dominating attention to incoming information via certain sensory input and suppression of information attracting no attention; it is also believed that the characteristics of P1 reflect, in some way, the general level of cerebral activation [19]. The sensitivity of characteristics of component P1 to stimuli having a special subjective significance for a person was also demonstrated [20]. Probably, relatively the shorter latencies of component P1 observed in the frontoparietal regions of the right hemisphere in the case of perception of negative emotiogenic stimuli, as compared with the corresponding values upon visualization of neutral images, and the absence of significant differences in the effects of positive stimuli are related to the greater significance of negative emotional information for an individual; this leads to more rapid processing of such information.

At the same time, beginning from the time interval corresponding to initiation of the N1 wave, the influence of positive affects on the parameters of evoked field cortical activity became quite obvious. The latencies of the mentioned component in the left-hemisphere cortical regions were found to be comparatively shorter in the case of the use of both emotionally negative and emotionally positive visual signals. The effects of "negative" stimulation were, however, more clearly expressed, as compared with the effects of "neutral" stimulation, i.e., when negatively emotionally tinted information was perceived, the N1 component developed somewhat earlier. This fact can be considered a reflection of different rates of processing of emotional information characterized by different signs.

Earlier, the parameters of the N1 component were shown to correlate with the attention processes. In particular, a dependence of the parameters of component N1 and P1 on the level of activation of selective attention was found; the respective correlations were direct for the amplitude and reverse for the latency [21]. It seems probable that comparative shortening of the N1 latency reflects the higher level of selective attention attracted by clearly affective stimuli; this provides the formation of a "faster" and more expressed EP response, as compared with the effects of action of neutral and positive stimuli.

The N2 oscillation, similarly to the preceding N1 component, was elicited earlier after presentation of emotionally tinted stimuli, as compared with the effects of neutral stimuli, and a trend toward earlier generation of the N2 component upon action of emotionally negative stimulation was presented. It should be emphasized that, according to the published data, a coordinated concept on the psychophysiological interpretation of component N2 has not been formed. It is, however, assumed that the stage of psychological identification of the stimulus begins from the moment of initiation of this component [22]. Thus, shorter latencies of the N2 oscillations in the case of action of emotiogenic signals can correspond to the earlier beginning of the stage of identification of the latter, as compared with the situation where neutral stimuli were used. The specific decrease in the amplitude of component N2 (i.e., a shift of its maximum toward positivity) upon the influence of emotionally positive stimuli, as compared with the effects of neutral stimuli, was somewhat unexpected. Data of other researchers show that the amplitude of component N2 observed after presentation of positive stimuli was higher than that in the case of action of negative and neutral images [23]. Other authors mentioned that the amplitude of these components was higher under conditions of the use of emotionally tinted stimuli of both valencies [24].

On the other hand, it is believed that the development of wave N2 is related to the activity of the mechanisms of selection of information; the higher the level of selective attention, the lower the amplitude of this wave [25]. There are also indications that subjects characterized by an increased level of anxiety demonstrate significant reduction of the N2 component in EPs generated after presentation of emotionally negative threatening stimuli. This phenomenon was interpreted by the authors as related to more effective activity of the attention sphere in such individuals [26]. Considering this, one should expect a drop in the amplitudes of oscillation N2 under the influence of negative emotional stimulation. Additional comparison of the values of the N2 amplitude in the cases of presentations of negative and positive stimuli, however, demonstrated significantly higher amplitudes of this component in response to negative stimulation. Olofsson and Polich [14] mentioned that the N2 amplitude in response to the action of neutral stimuli was higher than that upon presentation of emotionally positive and negative stimuli. This fact agrees with our results, but it was not in any manner explained by the other authors. It can be supposed that, considering that oscillation N2 is characterized by high individual variability [27], the existence of clearly expressed personality-related peculiarities of emotional reactions resulted in the absence of statistically significant differences between the N2 amplitudes in EPs elicited by negative and neutral stimuli in the case where the entire studied group was analyzed. It is possible that this is also the reason for the absence of significant differences between the correlates of processing of emotionally tinted *vs* neutral information within the time range of component P2 (latency 160 to 220 msec). In general, the question on the relation between the personality-determined profile of emotional reactions and the pattern of evoked cortical activity remains open at present and needs further examination.

According to the results of the analysis, the amplitude/time parameters of component P3 were to the greatest extent subjected to modulation determined by the emotional content of the perceived information. As was expected, shortening of the P3 latency and increase in the amplitude of this wave were found under conditions of perception of emotiogenic stimuli of both valencies, as compared with the corresponding parameters under conditions of presentation of neutral stimuli. Our data agree with the results of studies where higher amplitudes of the P3 wave [28, 29] and shorter latencies of this potential [30] were found under conditions of perception of emotiogenic signals, as compared with the effect of emotionally neutral stimulation.

It is believed that the P3 component is related to evaluation of the significance of the stimulus and correction of the information present in memory in accordance with the obtained new data [31], and also to the processes of reaching a decision based on a comparison of the received signal with a model of some similar stimulus present in memory [32]. There are reasons to think that generation of the P3 component is related to the realization of a perceptive decision on identification of the relevant signal, and this generation corresponds to the final stage of processing of information in higher CNS structures [33].

To generalize the published data and results of our study, we can suppose that the cerebral system of information processing is, as a whole, more sensitive to signals possessing an emotional tint. These signals first attract selective attention; they more intensely activate the respective cortical zones and are more rapidly processed. The observed effects of cerebral activation were in general more intensely expressed in the case of presentation of negative emotional stimuli and involved more extensive cortical regions; these facts allow us to conclude that these signals possess greater integrative effects.

Analysis of the topographical aspects of perception of emotional information is also an interesting field of studies. When analyzing the time dynamics of topographic peculiarities of processing of such information, the following sequence of events can be observed. Within the first stage of such processing (80 to120 msec), a more intense activation of the frontotemporal regions of the right hemisphere was observed; shorter latencies of the P1 component in these zones in the case of presentation of negative stimuli confirm this conclusion (Fig. 2). This fact can be interpreted based on the existing concepts on the role of the right hemisphere in the mechanisms underlying attention within the context of identification of emotionally significant stimuli from the environment. This supposition is confirmed by the results of recent EEG studies, which showed that emotionally tinted stimuli are processed in the right hemisphere more rapidly (by about 20 to 30 msec) than in the left hemisphere, and this processing is carried out more automatically (at a pre-attention level) [34]. The network of the so-called alerting attention is associated just with the frontal (and also parietal) regions of the right hemisphere; this network maintains the level of general awakeness (general preparatory attention) and is responsible for the function of preparation for perception of the stimulus.

One hundred twenty to 160 msec after presentation of the stimulus, the focus of activation is, however, shifted to the left hemisphere; the more rapid development of oscillation N1 in the central/temporal/parietal regions of this hemisphere in the case of action of affective stimuli of both valencies confirms this statement. Actualization of consecutive left-hemisphere analytical strategies of information processing [36] can provide a more detailed estimate of such signals.

Only within the time range of development of wave N2 (220 to 300 msec) were manifestations of the interhemisphere asymmetry in the processing of emotional information, which were dependent on its valency, first observed. Together with a general activation of the entire parietal region, stimuli of negative valency began to earlier activate the right-hemisphere occipital zone, while stimuli of the positive valency earlier activated the central zone of the left hemisphere (Fig. 3). On the one hand, this situation agrees with the generally accepted concepts on the relations of the right and left hemispheres with the formation and intellectual realization of negative and positive emotions, respectively; on the other hand, these differences can reflect the process of differentiation of the affects. Our data confirm the results of recent studies according to which this process is performed within a 150 to 260 msec interval after presentation of the signal [37].

Within the final stage of information processing (300 to 450 msec), activation of nearly the entire cortical surface was observed under conditions of action of negative stimuli; at the same time, the predominance of the left hemisphere was preserved in the case of positive stimuli. Within this time range, the greatest increase in the amplitude and a decrease in the latency of potential P3 of the EPs induced by affective stimuli were observed (Figs. 3 and 4). Probably, this is another proof of the hypothesis on the greater biological importance of negative emotional signals for an absolute majority of individuals.

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