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Top–Down Cognitive Control in Students with a Rigid Set-on Facial Expression

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Abstract

Top–down cognitive control was studied in students by the model of fixed set for facial expression. In subjects with errors in the set fixing, it is weakened to the greatest extent. The hypothesis about the influence on the top–down cognitive control of the functional state of subjects caused by signs of autonomic dysfunction, personal anxiety, depression and sleep quality is considered.

Keywords: top–down cognitive control, emotional facial expression, errors recognition, EEG, alpha oscillations

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1. Introduction

A mass survey of second-year medical students with different degrees of autonomic dysfunction was conducted [1]. After the testing an EEG investigation was performed the state of top–down cognitive control [2, 13] with the help of the facial expression fixed set model [7, 14]. We have shown, when a negative emotional facial expression is perceived repeatedly, an unconscious internal state is generated in the subject in the form of a set [10]. In a given number of trials, the majority of subjects tested a neutral facial expression as negative. More trials with erroneous visual perception are specific for more rigid sets. We suggest, that this resulted that descending influences on the higher visual centers from the prefrontal cortex arising from the previously formed set are greater than ascending visual spikes from the new stimulus, which leads to distorted perception of the new stimulus. On repeated exposure to the new stimulus, learning from comparison of ascending and descending spike activity leads to the formation of a new, 'corrected' set.

The top–down cognitive control plays an important role from a replacement of an old set by a new set more appropriate to the changing conditions [14]. A rigid set is associated with weakening a top–down cognitive control. It is important that at set formation stage all enrolled subjects correctly recognized facial stimuli differing in emotional expression. This observation suggests that a weakened top–down inhibitory control in subjects with rigid set appears to be insignificant to cause the abnormal functioning of recognition of facial emotional expression at the stage of experiment with undeveloped set [8].

In present study significant part of students appeared to fail the recognition of facial emotional expressions at the stage of set formation. We assume, that errors recognition can be determined not only by the set formation, but also by other factors that affect visual recognition. These factors are reflected in such a phenomenon as errors in distinguishing between a neutral and an angry faces at the stage of set formation.

The present study aimed to: (1) detect characteristic psychological and bioelectric parameters in subjects with errors and without errors in the recognition of facial expression during set formation; (2) compare them with the data of students without mistakes in the recognition of facial expression at all stages of the experiment. In this work they formed a control group.

2. Methodology

2.1. Subjects

The study involved 82 2nd year Russian National Research Medical University medical and pediatric faculties students aged from 19 to 21 (mean 19.1 ± 0.7) years, not on psychiatric or neurologic supervision and having a normal or corrected to normal vision. Were investigated three groups of students. Subjects from the 1 group ('erroneous' subjects, n = 12) made mistakes in recognition of facial expression at the set forming stage and more than 5 mistakes at the set testing stage. Subjects from the 2 group (with the rigid set, n = 14) did not make mistakes at the set forming and more than 5 errors at the testing. Students from the 3 group (the 'no mistakes' group, n = 16) were not mistaken in both stages of the experiment with the set.

2.2. Stimuli and stimulation procedure

A model of fixed psychophysiological set with the recognition of facial expression was used. In the phase of set formation paired pictures of a man from The Ekmans' Atlas of Emotions [5] were presented by 20 times; in the left side of the picture — with an angry unpleasant expression, in the right — with a neutral one. In the phase of set testing the impact of the setting on facial expression recognition paired pictures of the same man with a neutral expression on both sides were presented by 40 times. Exposition time was set at 0.35 s. At both phases of the experiment a subject had to decide if the expressions of the two faces (on the left and the right side) were identical or of one of them was more unpleasant and memorize the decision.

2.3. Data acquisition

The autonomic Wein questionnaire, Beck Depression Inventory, Spielberger State-Trait Anxiety Inventory, Toronto Alexithymia Scale (TAS-20), Taylor Manifest Anxiety Scale (TMAS) and questionnaire value subjective characteristics of sleep were used as personality measures.

The EEG was recorded continuously during the experiment. For EEG recording, amplification and filtration a Neocortex–Pro ('Neurobotics', Russia) system was used. Sampling frequency was set at 250 Hz, and the frequency bandwidth — at 0.5–70 Hz. Twenty Ag/AgCl electrodes ('Micromed', Hungary) with a resistance < 5 kOhm were applied accordingly to the standard 10–20 scheme with additional leads (F3, F4, F7, F8, Fz, FT7, FT8, C3, C4, Cz, FC3, FC4, T3, T4, P3, P4, T5, T6, O1, O2). The leads were unipolar, the reference electrode was a combined auricular. Stimuli presentation, response recording and their synchronization with the EEG were performed by means of a Neostimul ('Neurobotics', Russia) system.

2.4. Data analysis

We analyzed 5 EEG 0.5-s fragments: 1 before and 4 after the presentation of the target stimulus at the stages of fixing (paired pictures of a face with a neutral and an angry emotional expressions) and testing (paired pictures of a face with a neutral emotional expressions) the set. A continuous wavelet transform based on Morlet wavelet was performed. Distribution maps of wavelet transform ratio (WTR) module, representing the amplitude of a potential, were drawn in a bandwidth of 1–70 Hz with 0.5 Hz steps and a temporal resolution of 1 ms. Then a frequency averaging for domain of 8–13.5 Hz was performed. The transformation results were summed over all EEG leads. Further, from the WTR obtained after the presentation of the targeted stimuli, the WTR of the pre-stimulus period was subtracted and the difference was divided by the same amount and multiplied by 100. Thus, we determined the change in the examined WTR index relative to the pre-stimulus state. We used this index as a characteristic of the synchronization/desynchronization reaction of the EEG alpha-rhythm oscillations on the target stimulus.

The assessment of statistical significance between 3 groups for the calculated index was made by repeated measures analysis of variance (RM ANOVA), where the between-group factor was the 'Group' (3 levels), and the within-group factors — the 'Condition' (2 levels — set formation and testing of set effect), 'Time' (4 level – 4 EEG fragments from 0.5-s) and the 'Lead' (20 levels). For analysis of between-group differences for each condition a one-way ANOVA was used. Individual differences were determined using the Student's test. Statistical analysis was conducted using the Statistica v.10 and SPSS v.12 software.

3. Results

The personality measures from the subjects with different numbers of errors recognition was show in Figure 1. In all enrolled students a high prevalence of autonomic dysfunction, personal anxiety and de decreases sleep quality was revealed. This personality measures do not significant bay group. Individual characteristics in the groups did not differ except for depression. Its rate was higher for 'erroneous' subjects.

The repeated measures ANOVA showed significant differences in interactions of factors 'Condition*Group' and 'Condition*Time*Group' for alpha rhythms values (see Table 1).

Table 1: RM ANOVA results of the synchronization/desynchronization index of subjects with a different number of errors in the recognition of facial expression.

Effect	F	Hypothesis df	Error df	Significance
Condition	11.20	1	79	0.002
Condition * Group	6.06	2	79	0.004
time	24.59	3	77	0.0001
Condition * time	9.32	3	77	0.0001
Condition * time * Group	2.68	3	78	0.05
time * Group	1.00	3	78	0.39

Dynamics of induced alpha rhythm synchronization/desynchronization in recognition facial expression was show in Figure 2.

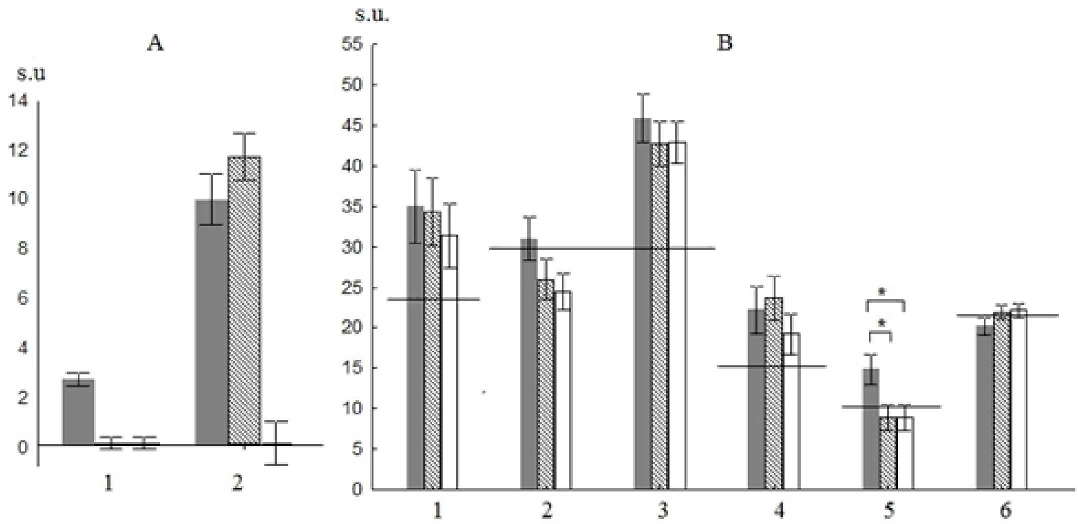

Figure 1: Behavioral and individual characteristics of subjects with a different number of errors in the recognition of facial expression. A – the average number of recognition errors: 1 – when a pair of faces with an 'angry' and 'neutral' expression are presented (the set fixing stage), 2 – with a 'neutral' expression (the set testing stage). B – the results of the questionnaires. Horizontal – 1 (autonomic Wein questionnaire), 2 and 3 (Spielberger State-Trait Anxiety Inventory), 4 (Taylor Manifest Anxiety Scale), 5 (Beck Depression Inventory), 6 (questionnaire value subjective characteristics of sleep); gray, shaded and white bars – groups 1–3, respectively, the error of the mean is given; horizontal lines show the level of the norm in the tests. Vertical axis – the average value of points (stanlart units). * – differences between groups ($P < 0.05$).

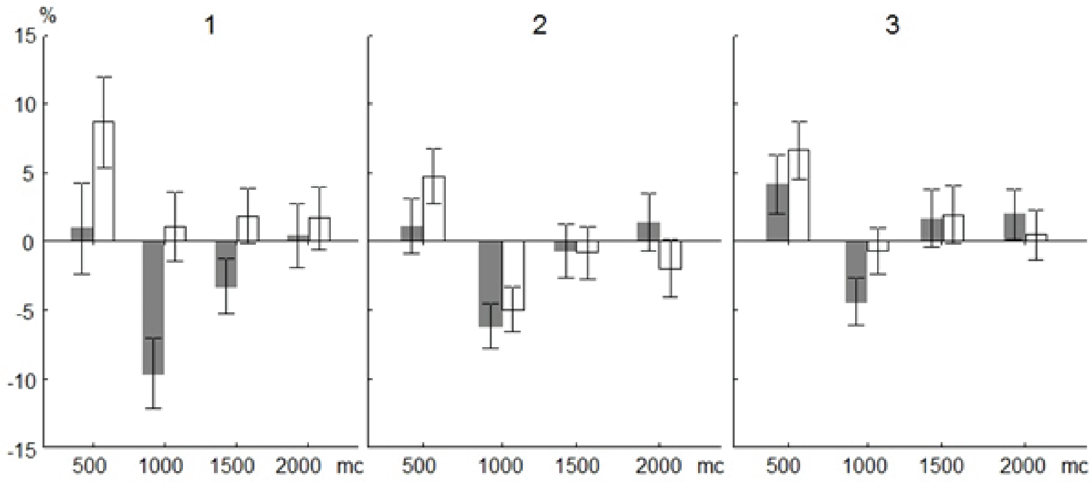

Figure 2: Synchronization/desynchronization of the EEG alpha-rhythm oscillations in total for all leads after presentation of the facial stimulus in the groups of subjects with different number of errors in the recognition of facial expression. 1–3 – groups 1–3; gray and white bars – stages of fixing and testing of the set respectively; the horizontal axis shows the time after the stimulus begins to appear, vertical – changes in the amplitude characteristics of the EEG alpha-rhythm in response to facial stimuli in percentage with respect to its pre-stimulus values, the error of the mean is given.

4. Discussion

Students of all groups had an increased level of autonomic dysfunction and personal anxiety, as well as a decreased level of sleep quality. These facts indicate that there are no clear boundaries in the functional state of the students of these groups. In the 1 group, in addition to this, there is an increased level of situational anxiety and depression. Significant differences between this group and the other two were obtained only for the depression index.

When analyzing the induced synchronization/desynchronization reactions, differences were found between the stages of formation and testing of the set in only 1 group of students. At the stage of formation after stimuli exposure, desynchronization of alpha activity is observed, and synchronization at the testing stage.

The synchronization reaction is observed when the cognitive task is regulated mainly by the internal states (top down cognitive control). When the decision basically occurs automatically, directly in response to the action of an external signal, then the EEG is dominated by desynchronization [9, 11]. Desynchronization also indicates the prevalence of activation processes associated with the analysis of incoming information [3, 4]. It can be assumed that the students of group 1, unlike the others, are in a more stressed state, which makes their cognitive activity at the set forming stage. of setting up difficult.

In response to the presentation of neutral facial stimuli (at the set testing stage), they showed marked synchronization. Such a reaction is characteristic for subjects with signs of depression [12]. The expectation of an 'angry' person at the set testing stage causes them to have a synchronization, since they are more likely to expect negative information [4, 6, 12].

Students of groups 2 and 3 have no statistical differences in the synchronization/desynchronization reactions in the formation and testing of set. In this case, they have marked differences in the number of errors in testing. These facts indicate a weakening of the influence of cognitive control in the recognition of facial expression.

The psychological tests results suggest that cognitive activity passes under the conditions of a non-optimal functional state. Even more it concerns the students of the 1st group who were mistaken in both stages of the experiment.

5. Conclusions

Students with signs of autonomic dystonia syndrome, trait anxiety and depression experience weakening of top–down cognitive control when forming a set for facial expression and testing its effect. This weakening is most evident in students who were mistaken in identifying facial expressions in both stages of the study of the set.

References

[1] Alipov, N. N., Gordeev, S. A., Prisukha, N. S., et al. (2017) Autonomic and psychometric state in second-year medical students: The results of a three-years study. *Vesn. neurology, psychiatry and neurosurgery*, vol. 12 (in Russian). Retrieved from http://panor.ru/magazines/vestnik-nevrologii-psikhiatrii-i ney-rokhirurgii/numbers/228501.html

[2] Bar, M. A., Kassam, K. S., Ghuman, A. S., et al. (2006) Top-down facilitation of visual recognition. *Proceedings of the National Academy of Sciences of the United States of America*, vol. 103, no. 2. Retrieved from http://www.pnas.org/content/103/2/449.long

[3] Bazar, E. (2012). A review of alpha activity in integrative brain function: Fundamental physiology? sensory coding? cognition and pathology. *International Journal of Psychophysiology*, vol. 86. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0167876012003492

[4] Cheremushkin, E. A., Petrenko, N. E., Yakovenko, I. A., et al. (2017). Neurophysiological markers of high anxiety level in man during the process of preparing for a visual recognition. *Journal of Integrative Neuroscience*, Preprint. Retrieved from https://content.iospress.com/articles/journal-of-integrative-neuroscience/jin074

[5] Ekman, P. and Friesen, W. V. (1976) *Pictures of Facial Affect*. Palo Alto (CA), Consulting Psychologist Press.

[6] Kohler, C. G., Hoffman, L. J., Eastman, L. B., et al. (2011). Facial emotion perception in depression and bipolar disorder: A quantitative review. *Psychiatry Research*, vol. 188. Retrieved from http://www.psy-journal.com/article/S0165-1781(11)00350-7/fulltext

[7] Kostandov, E. A. (2015). The role of implicit estimation of time intervals and set plasticity in facial expression processing. *Cognitive Systems Monographs*, vol. 25. Retrieved from https://link.springer.com/chapter/10.1007/978-3-319-19446-2_21

[8] Kostandov, E. A. and Cheremushkin, E. A. (2017) Disorders of top–down cognitive control in students with learning difficulties. *Human Physiology*, vol. 43, no. 4. Retrieved from https://link.springer.com/article/10.1134/S0362119717040065

[9] Kostandov, É. A., Cheremushkin, E. A., and Kozlov, M. K. (2010). Evoked synchronization/desynchronization of cortical electrical activity in response to facial stimuli during formation of a set to an emotionally negative expression. *Neuroscience and Behavioral Physiology*, vol. 40, no. 4. Retrieved from https://link.springer.com/article/10.1007/s11055-010-9273-9

[10] Kostandov, E. A., Cheremushkin, E. A., Yakovenko, I. A., et al. (March 2012) The role of the context of cognitive activity in the recognition of facial emotional expressions. *Neuroscience and Behavioral Physiology*, vol. 42, no. 3. Retrieved from https://link.springer.com/article/10.1007/s11055-012-9565-3

[11] Klimesch, W., Sauseng, P., and Hanslmayr, S. (2007). EEG alpha oscillations: The inhibition-timing hypothesis. *Brain Research Reviews*, vol. 53, no. 1. Retrieved from https://www.sciencedirect.com/science/article/pii/S016501730600083X

[12] Knyazev, G. G., Bocharov, A. V., and Savostyanov, A. N. (2016). Severity of depressive symptoms and oscillatory responses to emotional facial expressions. *Human Physiology*, vol. 42, no. 3. Retrieved from https://link.springer.com/article/10.1134/S0362119716010114

[13] Kveraga, K., Ghuman, A. S., and Bar, M. (2007). Top-down predictions in the cognitive brain. *Brain and Cognition*, vol. 65, no. 2. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0278262607000954

[14] Uznadze, D. N. (1958). Experimental basis of set psychology, in *Experimental Studies of Set Psychology*. Academy of Sciences of the Georgian SSR Press.