Original article:

Emotional Substrates in Neuroticism: The Reactions to Arousal-evoking Stimuli of Various Strengths

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Abstract:

Objective: Neuroticism is a medical condition associated with negative affect and is considered to predispose one to mental disorders. This study examined the effectsof arousal-evoking stimuli of various strengths on the severity of neuroticism. ***Materials and Methods:*** In the Event Related Potential (ERP)/electroencephalograph (EEG) recording session that was held at the Clinical Neuroscience Laboratory at a local hospital, Electroencephalogram was recorded in 58 participants (N=29 for moderate neuroticism and 29 for mild neuroticism) after they were screened for the severity of the neurotic trait. Universal emotional pictures were chosen randomly from the International Affective Picture System (IAPS) and were used as visual stimuli in the experiment. Visual stimuli weredivided into three categories (high, moderate, low) based on the IAPS normative mean values of arousal. ***Results:*** The significant interaction effect of P300 latency between neuroticism and arousal strength was found in the mid-frontal region. Meanwhile, independent of neuroticism, the main effects of arousal strength of the P300 (amplitude and latency) and N200 (latency) were observed in the mid-central region. ***Conclusion:*** There is a significant interaction between the severity of neuroticism and the emotional arousal strength, thus, points to the implication of the emotion process in the brain rewards system especially among individuals with neuroticism.

Keywords: arousal; evoked potentials; emotion; neuroticism; P300 component

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Introduction

Neuroticism is a personality trait that is associated with the experience of negative affectand social dysfunction and has been recognized as a medical condition that could potentially develope into mental disorders.[1,2,3,4,5] Biological and anatomical data had shown the impact of neurotic trait on emotional responses. For example, it was found that the skin conductance reactivity was greater among those with high neurotic symptomatology, than stable participants.[6] This fact was reinforced by the finding that individual with high level of neuroticism experienced decreased reward processing which was associated with reduced sustained activation in the orbitofrontal cortex (OFC), as well as decreased valence processing in the right temporal lobe when responding to emotional images.[7] In a study among sample high in neuroticism, the N200 amplitude was found increased when participants responded to high and mild levels of pleasant stimuli (as based on valence domain) than neutral stimuli.[8] Studies surrounding experimental neuropsychology further recognized the appearance of P300 in the mechanism of emotion. The P3b for example, was seen at several posterior sites with high amplitude when one responded to unpleasant emotional stimuli.[9]

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Beyond the above-mentioned facts, neuroticism is a psychobiological condition that associated with addiction behaviour[10]that might have implication in treatment strategy and biological mechanisme[11,12]

This study was undertaken to delve further the electropsychological process of emotion (with specific attention to the arousal domain) as modulated by individuals with neurotic trait. Different from other studies that stressed on the emotion reaction from the pleasantness continuum of valence domain,[8,9] this study explored the arousal domain in emotion processing - an important emotional element in modulating consciousness, attention, and information processing especially in achieving motivational behaviours that involve the activation of the reticular activating system in the brain stem, the autonomic nervous system and the endocrine system.

Materials and Methods

Subjects

A total of 58 participants (60% were females and 56% were of Chinese ethnicity) were recruited. The mean age of the participants was in the range of young adult (22.51±1.96 years old), with 88% of them currently completing a bachelor's degree at a public university. Fourty percents of the participants were detected to be left eye dominant with right handedness. Majority of participants (73%) experienced vision problem but was corrected by glasses or contact lenses.

Neuroticism Screening

Prior to obtaining the EEG recording in the ERP session, the neurotic symptomatology of the participants was determined using the validated version of Neuroticism Five Factor Non-verbal Personality Questionnare (N-FF-NPQ).[13] Those who had a lifetime history of any major medical disorder, uncorrected visual acuity, a history of affective disorder, and who were using psychiatric medication were not selected as participants.

The N-FF-NPQ consists of non-verbal items that are able to quantify the trait of neuroticism especially in a cross-cultural context, in which those who were not fluent in languages other than their mother language were taken into consideration. These four items of neuroticism portrayed a series of figures related to the constructs of neuroticism that were estimated along a seven-point Likert scale - ranging from 'extremely unlikely' (score of 1) to 'extremely likely' (score of 7).

Cut-off score of N-FF-NPQ was used to classify participants into three groups, as follows: 22-28 for severe neuroticism, 15-21 for moderate neuroticism and 1-14 for mild neuroticism. Since high neurotic symptomology is associated with emotional instability,[3,14] participants high in neuroticism were not proceeded with the EEG recording in order to avoid any misleading assesment. Thus, the final number of participants were 29 for moderate neuroticism and 29 for low neuroticism.

ERP Session/EEG Recording

After screening was done to determine the level of neuroticism, participants were invited to the EEG recording room. Net outfitting and other preparations for recording were based on the standard protocol provided by Electrical Geodesics, Inc. (EGI).

Pictures were displayed randomly during the ERP session, thus, participants were unaware of the categories of the pictures (high, moderate or low arousal). The recording was controlled by the 128 HydroCel GSN connected to a high-input impedance NetAmps 300 amplifier.

Visual Stimuli

Standard universal pictures were used as the visual stimuli, whereby these pictures were randomly selected from the International Affective Picture System (IAPS).[15]Aiming to capture the emotion flow, selection of the pictures were based on the IAPS normative values for the three levels of arousals as follows - (high: scores of 7-9, N=10; moderate: scores of 4-6, N=10; low: scores of 1-3, N=10).[15]Equal distribution of the various natures of the pictures in each category was also ensured by mixing all genres of images - natural surroundings, people activity, tragedy and object.

Visual stimuli with a resolution of 640 pixels x 480 pixels were installed in the E-Prime® 2.0 software with 30 trials being allocated in each experimental block, making up a total of 90 trials. A schematic illustration of the experimental procedure is depicted in Figure 1.

Statistical Analysis

The ERP components were extracted by using the procedures as follows–filtering, segmentation, artifact detection, bad channel replacement, montage operation and baseline correction. The analysis of variance of a two-way mixed design was applied to determine the effects of neuroticism (two levels of the between-subjects effect: moderate level of

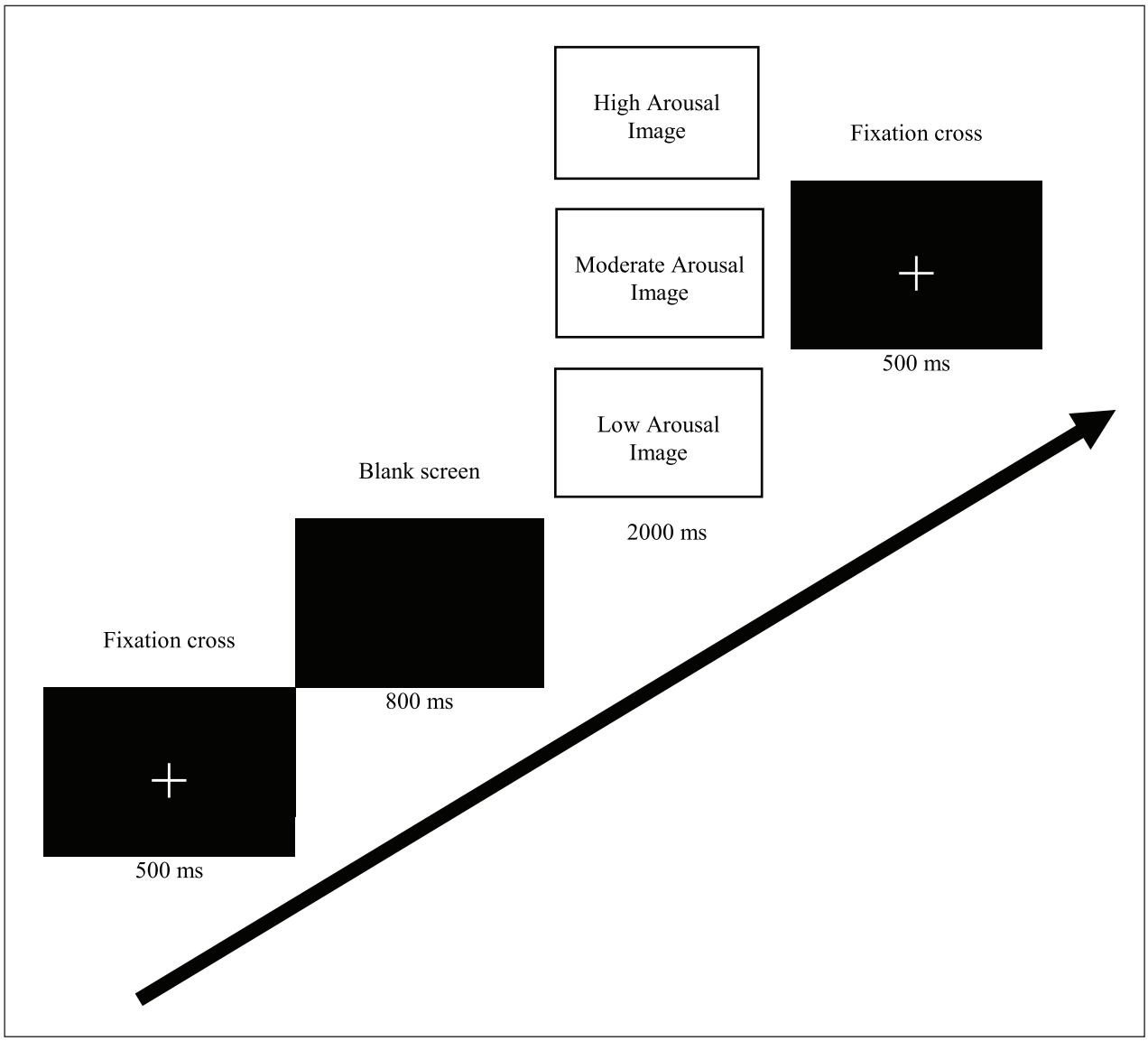

Figure 1: Schematic illustration of the experimental procedure

neuroticism, low level of neuroticism) and arousal strength (three levels of the within-subject effect: high, moderate, low) on the emotional arousal processing as indexed by the ERP components of P300 and N200.

Ethical clearance: Study protocol was endorsed by the Human Ethical Committee of Universiti Sains Malaysia (reference number: USM/JEPeM/15040127). Participants signatures for the consent forms were obtained and anonymity was preserved.

Results

P300 Substrate

As displayed in Table 1, the interaction effects between neuroticism and arousal strength were not significant in all brain regions for P300 amplitude [mid-frontal: F (2, 55) = 2.82, ns; mid-central: F (2, 55) = 0.29; ns and mid-parietal: F (2, 55) = 0.46, ns]. However, for P300 latency, with the exception of mid-central [F (1.90, 106.30) = 2.46, ns] and mid-parietal [F (2, 55) = 0.23, ns], the interaction effect between neuroticism and arousal strength was found significant in the mid-frontal region [F (2, 112) = 3.44, $p<0.05$].

For the main effect of arousal, with the exception of the mid-frontal [amplitude:F (2, 55) = 2.82, ns; latency: F (2.00, 55.00) = 2.01, ns] and mid-parietal regions[amplitude:F (2.0, 55) = 1.70, ns; latency: F (2.0, 55.0) = 2.97, ns], both P300 amplitude and latency indicated significant main effectsin the mid-central region [amplitude: F (2, 55) = 12.12, $p<0.001$; latency: F (1.90, 106.30) = 4.44, $p=<0.05$].

Table 1. Amplitude and latency of P300 component in Neuroticism

		Mean (Standard Error)Degree of Freedom							
		Moderate Neuroticism			Low Neuroticism			ME	IE
		High arousal	Moderate arousal	Low arousal	High arousal	Moderate arousal	Low arousal		
A	Fz	2.80 (0.56)	3.00 (0.52)	2.37 (0.38)	3.27 (0.56)	2.93 (0.52)	2.37 (0.38)	2.82	2.82
	Cz	2.84 (0.31)	2.22 (0.30)	1.57 (0.27)	3.00 (0.31)	2.21 (0.30)	1.91 (0.27)	12.12[b]	0.29
	Pz	6.60 (0.60)	5.63 (0.60)	6.36 (0.60)	4.93 (0.60)	5.58 (0.60)	5.26 (0.60)	1.70	0.46
L	Fz	591.86 (22.38)	563.72 (25.26)	513.24 (26.71)	567.59 (22.38)	518.35 (25.26)	576.41 (26.71)	2.01	3.07[a]
	Cz	587.17 (15.52)	575.17 (17.71)	521.10 (20.22)	590.76 (15.52)	563.17 (17.71)	570.76 (20.22)	4.44[a]	2.46
	Pz	419.03 (22.40)	375.17 (18.49)	362.35 (14.46)	431.86 (22.40)	388.00 (18.49)	384.83 (14.46)	2.97	0.23

[a]p<0.01 [b]p<0.001; Fz=Mid-frontal; Cz=Mid-central; Pz=Mid-parietal; A=Amplitude; L=Latency; ME=Main effect; IE=Interaction effect

N200 Substrate

As pointed out in Table 2, the N200 amplitudesin mid-frontal [F (2, 55) = 0.11, ns], mid-central [F (2, 55) = 0.66, ns] and mid-parietal [F (1.88, 105.12) = 0.64, ns] did not show any significant interaction effect of neuroticism and arousal strength. Likewise, this pattern was also observed for N200 latency in all brain regions: mid-frontal [F (2, 55) = 0.78, ns], mid-central [F (2, 55) = 1.85, ns] and mid-parietal [F (2, 55) = 0.51, ns].

N200 amplitudes in all brain regions did not exhibit the significant main effect of arousal strength (independent of neuroticism): mid-frontal [F (2, 55) = 1.51, ns], mid-central [F (2, 55) = 1.26, ns] and mid-parietal [F (1.88, 105.12) = 1.92, ns]. However, with the exception of N200 latenciesin mid-frontal [F (2, 55) = 0.18, ns] and mid-parietal [F (2, 55) = 1.12, ns], the significant main effect of arousal strength (independent of neuroticism) for N200 latency was found in the mid-central region [F (2, 55) = 7.19, p<0.01].

Table 2. Amplitude and latency of N200 component in Neuroticism

		Mean (Standard Error)						Degree of Freedom	
		Moderate Neuroticism			Low Neuroticism			ME	IE
		High Arousal	Moderate Arousal	Low Arousal	High Arousal	Moderate Arousal	Low Arousal		
A	Fz	2.41 (0.51)	2.53 (0.49)	2.14 (0.28)	2.73 (0.51)	2.93 (0.49)	2.26 (0.28)	1.51	0.11
	Cz	2.01 (0.27)	1.55 (0.24)	1.54 (0.25)	1.90 (0.27)	1.80 (0.24)	1.85 (0.25)	1.26	0.66
	Pz	4.67 (0.54)	4.34 (0.58)	3.88 (0.45)	4.53 (0.54)	3.72 (0.58)	4.06 (0.45)	1.92	0.64
L	Fz	290.21 (11.25)	282.76 (13.11)	294.35 (11.58)	261.79 (11.25)	259.59 (13.11)	245.10 (11.58)	0.18	0.78
	Cz	319.03 (9.46)	282.76 (9.16)	283.59 (9.90)	300.69 (9.46)	291.45 (9.16)	273.38 (9.90)	7.19[a]	1.85
	Pz	284.83 (11.65)	288.41 (10.96)	272.41 (10.66)	304.69 (11.65)	291.72 (10.96)	288.97 (10.66)	1.12	0.51

[a]p<0.01; Fz=Mid-frontal; Cz=Mid-central; Pz=Mid-parietal; A=Amplitude; L=Latency; ME=Main effect; IE=Interaction effect

Discussion

Two main findings are highlighted – (i) The significant interaction effect between neuroticism and arousal strength, indexed byP300 latency, detected in the mid-frontal region; and (ii) the main effect of arousal strength (independent of neuroticism), indexed by P300 amplitude and latency as well as N200 latency, in which bothwere detected in mid-central.

P300 latency inthe mid-frontal region was found as an important parameter that shed light on the effect of neurotic trait on emotional arousal. This occurrencecould be linked to the duration taken to react to positive and negative stimuli between the high and low arousal images.[16]On the other hand, the fundamental base of emotional arousal as indicated by the duration of emotion processes (or lengthening effect) was suggested as an important argument that needed to be considered.[17] It was also argued that P300 was a neural substrate that is important in controlled evaluative processes.[18]

Another important finding that needs to be highlighted is that the effect of arousal strength, which was independent of the neurotic trait, was obvious in the mid-central region of the brain as indexed by the components of P300 and N200. However, the effect of arousal strength was stronger for P300 component as it involved both parameters - amplitude and latency. In contrast,for N200 component, the effect of arousal strength was seen for the parameter of latency only.

In the current study, the latency of P300 and N200 indicated some dissimilarities. The neural component of N200, as reflected in the mid-central region, exhibited the arousal effect at two occasions of comparison – (i) high versus moderate arousal strengths; and (ii) high versus low arousal strengths. However, no arousal effect was seen between moderate and low strengths of arousal. This occurrence was not comparable to P300 latency especially in the mid-central region of the brain as the effect of arousal strength was only observed between high and low arousal. This means that the stimulation of images with moderate arousal strength (IAPS mean strength of 4-6) did not give impact to the latency of P300 component. The arousal effect of N200was nonetheless, slightly similar to P300 amplitude especially between high and low arousals. In fact, high and moderate arousals had also shown effect on participants' emotional experience as reflected by P300 amplitude, which was not displayed by P300 latency. Such pattern of findings indicated some implications when compared to previous studies.[19,20]For instance, it was reported that the small effect of emotional strength, from negative relative to neutral stimuli, was observed in the frontal areas as indexed by the amplitude of P300.[20] On the other hand, some studies indicated less robust effect of emotional strength from the emotional stimuli and neutral stimuli, as indexed by smaller P300 amplitudes.[21]This observation, indeed, has been supported by the electrophysiological data[22,23]especially when the effect of the stimuli with high arousal content was examined.[24]In addition, it was observed that functional activity of the emotional stimuli was greater compared to neutral stimuli, as shown by the Functional Magnetic Resonance Imaging (fMRI) findings.[25]

Conclusion

This current finding put forward the evident of the significant interaction between the severity of neuroticism and the arousal strength that can be seen in the mid-frontal region, as indexed by the latency of the P300 substrate. In contrast, the emotion modulation that is independent of neuroticism trait can be observed in another region of the brain such as mid-central region, as indexed by the amplitude and latency of P300 substrate, as well as the latency of N200 substrate. Implication of neuroticism on emotion processing should be highlighted in future research especially in relation to the rewards system of the brain.

Declaration of Conflict of Interest

The authors of this manuscript declare that they have no conflict of interest concerning its drafting, publication, or application.

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Authors' contribution:

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Data gathering: Yusoff N, Reza F, Anuar NNA , Ahmad R

Writing and submitting manuscript: Yusoff N, Reza F, Anuar NNA , Ahmad R

Editing and approval of final draft: Yusoff N, Reza F, Anuar NNA , Ahmad R

References:

1. Thompson ER. Development and validation of an international English Big-Five mini-markers. *Pers Individ Dif* 2008; **45**: 542-548. https://doi.org/10.1016/j.paid.2008.06.013
2. Larsen RJ and Ketelaar T. Personality and susceptibility to positive and negative emotional states. *J Pers Soc Psychol* 1991; **61**: 132-140. https://doi.org/10.1037/0022-3514.61.1.132
3. Miller JD and Pilkonis PA. Neuroticism and affective instability: the same or different? *Am J Psychiatry* 2006; **163:** 839-845. https://doi.org/10.1176/appi.ajp.163.5.839
4. Jeronimus BF, Kotov R, Riese H andOrmel J. Neuroticism's prospective association with mental disorders halves after adjustment for baseline symptoms and psychiatric history, but the adjusted history hardly decays with time: a meta-analysis on 59 longitudinal / prospective studies with 443313 participants. *Psychol Med* 2016; **46**: 2883-2906. https://doi.org/10.1017/S0033291716001653
5. Ormel J, Jeronimus BF, Kotov R, Riese H, Bos EH, Hankin B, et al. Neuroticism and common mental disorders: Meaning and utility of a complex relationship. *Clin Psychol Rev* 2013; **33**: 686-697. https://doi.org/10.1016/j.cpr.2013.04.003
6. Norris CJ, Larsen JT and Cacioppo JT. Neuroticism is associated with larger and more prolonged electrodermal responses to emotionally evocative pictures. *Psychophysiology* 2007; **44:** 823-826. https://doi.org/10.1111/j.1469-8986.2007.00551.x
7. Kehoe EG, Toomey JM, Balsters JH andBokde AL. Personality modulates the effects of emotional arousal and valence on brain activation. *Soc Cogn Affect Neurosci* 2012; **7**: 858-870. https://doi.org/10.1093/scan/nsr059
8. Lou Y, Meng X, Yang J, Zhang S, Long Q and Yuan J. The impact of extraversion on attentional bias to pleasant stimuli: neuroticism matters. *Exp Brain Res* 2016; **234**: 721-731. https://doi.org/10.1007/s00221-015-4492-5
9. DelplanqueS, Silvert L, Hot P, Rigoulot S and Sequeira H. Arousal and valence effects on event-related P3a and P3b during emotional categorization. *Int J Psychophysiol* 2006; **60**: 315-322. https://doi.org/10.1016/j.ijpsycho.2005.06.006
10. Zhao Y, Zheng ZL and Castellanos FX. Analysis of alcohol use disorders from the Nathan Kline Institute-Rockland Sample: Correlation of brain cortical thickness with neuroticism. *Drug Alcohol Depend* 2017;**170**: 66-73. https://doi.org/10.1016/j.drugalcdep.2016.10.040
11. Bhandal A, Sultana T and Janjua K. Transcranial direct current stimulation: a potential novel treatment for alcohol addiction and abuse. *Bangladesh Journal of Medical Science* 2018;**17**(1): 7-15. https://doi.org/10.3329/bjms.v17i1.35272
12. Yargic I. Biological mechanisms underlying addiction. *International Journal of Human and Health Sciences* 2018;**2** (3):107-111. https://doi.org/10.31344/ijhhs.v2i3.37
13. Ab Rashid NF, Arifin WN, Kueh YC and Yusoff N. Translation and Validity of the Malay Version of the Five-Factor Nonverbal Personality Questionnaire (FFNPQ). *IMJM* 2018; 17: 91-98
14. Verduyn P and Brans K. The relationship between extraversion, neuroticism and aspects of trait affect. *Pers Individ Dif* 2012;**52**: 664-669 https://doi.org/10.1016/j.paid.2011.12.017
15. Lang PJ, Bradley MM and Cuthbert BN. International Affective Picture System (IAPS): Technical manual and affective ratings. Gainesville, FL: NIMH Center for the Study of Emotion and Attention; 1997.
16. Angrilli A, Cherubini P, Pavese A andMantredini S. The influence of affective factors on time perception. *Percept Psychophys* 1997; **59**: 972-982. https://doi.org/10.3758/BF03205512
17. Gil S and Droit-Volet S. Emotional time distortions: the fundamental role of arousal. *Cogn Emot* 2012**;26**: 847-862. https://doi.org/10.1080/02699931.2011.625401
18. Ito TA, Larsen JT, Smith NK and Cacioppo JT. Negative information weighs more heavily on the brain: the negativity bias in evaluative categorizations. *J Pers Soc Psychol* 1998; **75**: 887-900. https://doi.org/10.1037/0022-3514.75.4.887
19. Dillon DG, Cooper JJ, Grent-'t-Jong T, Woldorff MG andLaBar KS. Dissociation of event-related potentials indexing arousal and semantic cohesion during emotional word encoding. *Brain Cogn* 2006**; 62**: 43-57. https://doi.org/10.1016/j.bandc.2006.03.008
20. Conroy MA andPolich J. Affective valence and P300 when stimulus arousal level is controlled. *Cognition and Emotion* 2007; **21:** 891-901. https://doi.org/10.1080/02699930600926752
21. Yuan J, Zhang J, Zhou X, Yang J, Meng X, Zhang Q, et al. Neural mechanisms underlying the higher levels of subjective well-being in extraverts: pleasant bias and unpleasant resistance. *Cogn Affect Behav Neurosci* 2012; **12**: 175-192. https://doi.org/10.3758/s13415-011-0064-8
22. Keil A, Müller MM, Gruber T, Wienbruch C, Stolarova M, Elbert T. Effects of emotional arousal in the cerebral hemispheres: a study of oscillatory brain activity and event-related potentials. *Clin Neurophysiol* 2001; **112**: 2057-2068. https://doi.org/10.1016/S1388-2457(01)00654-X
23. Keil A, Bradley MM, Hauk O, Rockstroh B, Elbert T, Lang PJ. Large-scale neural correlates of affective picture processing. *Psychophysiology* 2002; **39**: 641-649. https://doi.org/10.1111/1469-8986.3950641
24. Schupp HT, Cuthbert BN, Bradley MM, Cacioppo JT, Ito T, Lang PJ. Affective picture processing: the late positive potential is modulated by motivational relevance. *Psychophysiology* 2000; **37**: 257-261. https://doi.org/10.1111/1469-8986.3720257
25. Lang PJ, Bradley MM, Fitzsimmons JR, Cuthbert BN, Scott JD, Moulder B, et al. Emotional arousal and activation of the visual cortex: an fMRI analysis. *Psychophysiology* 1998; **35:** 199-210. https://doi.org/10.1111/1469-8986.3520199