Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 7 (23): 3743-3749, 2007
ISSN 1812-5654

Brain Activity, Personality Traits and Affect: Electrocortical Activity in Reaction to Affective Film Stimuli

[1]Sh. Makvand Hosseini, [1]P. Azad Fallah, [1]S.K. Rasoolzadeh Tabatabaei,
[2]S.H. Ghannadyan Ladani and [3]C. Heise
[1]Department of Psychology, Faculty of Humanities, Tarbiat Modares University, Tehran, Iran
[2]Department of Neurology, Faculty of Medicine, Army Medical Science University, Tehran, Iran
[3]Prince of Wales Medical Research Institute, (UNSW), Sydney, Australia

Abstract: We studied the patterns of activation over the cerebral cortex in reaction to affective film stimuli in four groups of extroverts, introverts, neurotics and emotionally stables. Measures of extraversion and neuroticism were collected and resting EEG was recorded from 40 right handed undergraduate female students (19-23) on one occasion for five 30s periods in baseline condition and in affective states. Mean log-transformed absolute alpha power was extracted from 12 electrode sites and analyzed. Patterns of activation were different in personality groups. Different patterns of asymmetries were observed in personality groups in reaction to affective stimuli. Results were partly consistent with approach and withdrawal model and provided supportive evidence for the role of right frontal asymmetry in negative affects in two groups (introverts and emotionally stables) as well as the role of right central asymmetry (increase on right and decrease on left) in active affective states (anxiety and happiness) in all personality groups. Results were also emphasized on the role of decrease activity relative to baseline in cortical regions (bilaterally in frontal and unilaterally in left parietal and temporal regions) in moderating of positive and negative emotion.

Key words: Extroversion, introversion, neuroticism, emotional stability, asymmetry, emotion

INTRODUCTION

Research examining the relations between personality traits and affect has strongly supported these are systematically related and current evidence suggests that they may be manifestations of the same underlying substrates. There is also a growing body of evidence that frontal asymmetries might predict affective dispositions. Since affect dispositions are linked to extraversion and neuroticism there might be a relation between frontal asymmetry and personality as well. Further, previous studies in the field of emotion revealed that neglect of individual differences is likely to inflate the error term (Gale *et al*., 2001). However, recent studies that have tried to extend models of brain activity and affect to personality traits had limited success (Hagemann *et al*., 1999; Gale *et al*., 2001; Schmidtke and Heller, 2004). The present study examine individual differences in brain functioning in reaction to affective stimuli relating to extroversion/introversion and neuroticism/stability in an attempt to integrate theories of brain activity, personality and affect.

Research in the field of neurophysiological basis of personality revealed some obvious dimensions for personality. Eysenck regarded extraversion and neuroticism as fundamental traits, each deriving from a specific biological substrate (Eysenck and Eysenck, 1985). Similar two-factor models have been proposed by Gray (1987) and Wiggins (1968). There are also great body of empirical evidence that personality can be accurately described using a five-factor model (Digman and Inouye, 1986; McCrae and Costa, 1987; Peabody and Goldberg, 1989) in which two of these factors closely resemble the constructs proposed by Eysenck and Eysenck (1985).

Further, there is general consensus among most researchers that affective experience can be broadly represented within an orthogonal two-factor space valence and arousal. These two sets of dimensions

Corresponding Author: Sh. Makvand Hosseini, Department of Psychology, Faculty of Humanities, Tarbiat Modares University, No. 70 Jomhoori Islami Alley, Uromieh Street, Post Code 1311795618, Tehran, Iran
Tel: 0098-912-3072411/0098-21-66926921

have been demonstrated to be 45° rotations of each other and are both represented in a circumplex structure (Russell, 1980; Watson and Tellegen, 1985; Diener *et al*., 1985). Aside from the consistencies in the number of factors and the similarity in structure, a strong theoretical basis (Eysenck and Eysenck, 1985; Gray, 1990) and a great body of empirical evidence (Canli *et al*., 2001; Meyer and Shack, 1989) indicated that the two separate emotion and personality models are systematically related.

Otherwise, in a parallel attempt to explore relationship between brain activity and affect, Davidson (1992, 1993, 2003, 2004), Sutton and Davidson (2000), Davidson and Tomarken (1989) and Coan and Allen (2003, 2004) proposed an approach and withdrawal model in which frontal regions of the brain house a convergence zone for two separate fundamental systems involved in emotion. The approach system is associated with pleasant affect whereas withdrawal system has generally been associated with unpleasant affect. In this model increased left frontal activity relative to the right indicates the experience of pleasant affect, whereas increased right frontal activity relative to the left indicates negative affect. Affective manipulations have also been investigated and were found to be related to asymmetry in frontal regions (Aftanas *et al*., 2003; Altenmüller *et al*., 2002; Schmidt and Trainor, 2001).

In a similar model, focusing on both valence and activation dimensions of emotion, Heller (1990, 1993) hypothesized that the right parietotemporal region is influential in the activation component of affect. Measures of brain activity (Davidson and Tomarken, 1989; Sarlo *et al*., 2005; Schutter *et al*., 2001; Aftanas and Pavlov, 2005) have generally supported the idea that the right hemisphere houses a system that is involved in the arousal component of emotion.

In this study we used a cortical activation paradigm induced by affective film stimuli and post affective EEG recordings to examine four central hypothesis: (1) A relatively higher activation in the left frontal and right posterior regions (parietal and temporal) in positive active affective state (happiness) for extroverted individual. (2) A relatively higher activation in the right frontal in negative passive affective state (sadness) for introverted individual (3) A relatively higher activation in the right frontal and right posterior regions (parietal and temporal) in negative active affective state (anxiety) for neurotics and (4) A relatively higher activation in the right frontal in positive passive affective state (relax) for emotionally stable individual. We have also considered the greater alpha power as an indicative of lower cortical activity in underlying regions. In short, sensory stimulation that should require active cortical processing leads to modality specific alpha blocking, a principle that might lead to the inference that diminished alpha recorded over any cortical region signifies greater cortical activity (Allen *et al*., 2004).

MATERIALS AND METHODS

Procedure: The study was conducted in a EEG laboratory in Tarbiat Modares university in Iran during year 2006. Four groups of (n = 10) Iranian female university students with high and low E and N scores (E>16.5, E<12.5, N>17, N<11) were selected among n = 300 students who were asked to fill an Iranian version of EPI and variables such as sex, laterality, history of mental and neurological disease and use of drugs were controlled for. After written and verbal informed consent was obtained, electrodes were placed and EEG was recorded in 15 sites. A total of 150 s of resting brain activity was recorded in 30 s intervals; between these recordings they were shown four video clips. The stimuli (short movie clips) were selected among cinema and documentary repertoires to induce affective states of relaxation, happiness, anxiety and sadness. Each clip lasted 3 min and presented to subjects in a random order. Validity of affective stimuli were examined among (n = 31) female students by rating on a likert (1-7) scale. The averages of self report ratings about effectiveness of stimuli were 4.61 for relax, 4.43 for happiness, 4.03 for anxiety and 5.61 for sadness.

Participants: Because differences for males and females have been found in previous studies of brain function and affect (Levy and Heller, 1992) the effect of sex variable was controlled. Participants for the study were n = 40 right handed female university undergraduates ranging from (19 to 23) years old, all reported being free from current or past history of head injuries, mental or neurological disorders and psychoactive drugs. Participants were assigned to four (n = 10) experimental groups (extroverted, introverted, neurotic and emotionally stable) based on their scores in (EPI).

EEG recording and quantification: A coupling EEG was recorded in an eye closed baseline (Pre-stimulus) state and four eye closed affective (Post-stimulus) states from 12 locations: left and right medial frontal (F3 and F4), left and right lateral frontal (F7 and F8), left and right central (C3 and C4), left and right parietal (P3 and P4), left and right medial temporal (T3 and T4), left and right lateral temporal (T5 and T6). All electrodes were referenced to linked earlobes and earlobe impedances were reduced to within 0.1 K ohms of each other. Five 2-s chunks of artifact-free data was spectral analyzed using a Fast Fourier Transform (FFT) with a Hamming window and estimates of Absolute Spectral Power were generated for the alpha band (8-13 Hz). Power density values (in $\mu v^2\ Hz^{-1}$) were computed by dividing the number of Hz estimates within each band, providing an index of the mean power density within the alpha frequency range. The alpha power densities were log-transformed to normalize the distributions for parametric statistics and finally, grand mean computed for all five 2-s chunks. For a further analysis the alpha power means averaged for every 2 single sites in the frontal, temporal and parietal to gain an Averaged Alpha Power for brain regions at each hemisphere. Statistical analysis, then, focused on log-transformed absolute alpha power value means for single sites and averaged alpha power over brain regions.

RESULTS

Asymmetry analysis: Measures of asymmetry computed by subtracting right/left alpha power means and analyzed using a one sample t-test in personality groups. Significantly positive and negative mean differences in this analysis (considering reverse relation between alpha power and cortical activity) is an indication of left and right asymmetry, respectively. Results have shown a significantly asymmetry for emotionally stables on parietal in baseline; on lateral frontal in relax; on lateral frontal, medial and lateral temporal and central in happiness and on medial and lateral frontal, medial and lateral temporal and central in anxiety states, while neurotics showed significantly asymmetry on lateral frontal in relax; medial temporal and central in happiness and anxiety and on central in sadness states (Table 1, 2).

In contrast, significantly asymmetry among introverts were revealed on lateral temporal in baseline; on medial and lateral temporal in relax; on medial temporal and central in happiness; on lateral frontal, central and medial and lateral temporal in anxiety and on medial and lateral temporal in sadness states, whereas extroverts showed significantly asymmetry on lateral temporal in baseline; on lateral frontal and temporal in relax; on lateral frontal, medial and lateral temporal and central in happiness; on medial and lateral temporal and central in anxiety and on medial and lateral temporal in sadness states (Table 3, 4).

In the frontal region, significantly higher activation were evident for right lateral frontal (F8) in happy state among extroverts, in anxiety state among introverts, in relaxed state among neurotics and in relaxed, happy and anxiety states among emotionally stables. A significant higher activation was also evident for right medial frontal (F4) in anxiety state among emotionally stables.

Significantly higher activation in parietal sites were evident for right central (C4) in happy and anxiety states among all personality groups. A significantly higher activation was also evident for left central (C3) in sad state among neurotics. Emotionally stables, in addition, showed higher activation for left parietal (P3) in baseline condition.

Table 1: Significant asymmetries in emotionally stables under different states

States	Regions	Mean difference	t	Significant
Baseline	P4-P3	0.19	3.131	0.012
Relax	F8-F7	-0.83	-4.280	0.002
Happiness	F8-F7	-0.11	-2.238	0.052
	T4-T3	-0.72	-13.981	0.000
	C4-C3	-0.63	-31.190	0.000
	T6-T5	-0.29	-4.743	0.001
Anxiety	F8-F7	-0.85	-4.396	0.002
	F4-F3	-0.11	-2.286	0.048
	T4-T3	-0.67	-7.271	0.000
	C4-C3	-0.54	-12.937	0.000
	T6-T5	-0.29	-3.227	0.010

Table 2: Significant asymmetries in neurotics under different states

States	Regions	Mean difference	t	Significant
Relax	F8-F7	-0.15	-2.270	0.049
Happiness	T4-T3	-0.93	-8.581	0.000
	C4-C3	-0.76	-24.367	0.000
Anxiety	T4-T3	-1.01	-15.796	0.000
	C4-C3	-0.67	-23.989	0.000
Sadness	C4-C3	0.11	2.342	0.044

Table 3: Significant asymmetries in introverts under different states

States	Regions	Mean difference	t	Significant
Baseline	T4-T3	-0.25	-2.995	0.015
Relax	T4-T3	-0.29	-3.193	0.011
	T6-T5	-0.28	-2.678	0.025
Happiness	T4-T3	-1.04	-13.233	0.000
	C4-C3	-0.77	-8.933	0.000
Anxiety	F8-F7	-0.19	-2.461	0.036
	T4-T3	-1.01	-12.114	0.000
	C4-C3	-0.72	-16.403	0.000
	T6-T5	-0.31	-3.880	0.004
Sadness	T4-T3	-0.31	-3.638	0.005
	T6-T5	-0.27	-4.877	0.001

Table 4: Significant asymmetries in extroverts under different states

States	Regions	Mean difference	t	Significant
Baseline	T6-T5	-0.27	-2.639	0.027
Relax	F8-F7	-0.19	-3.049	0.014
	T6-T5	-0.26	-3.093	0.013
Happiness	F8-F7	-0.14	-1.796	0.106
	T4-T3	-0.73	-8.492	0.000
	C4-C3	-0.73	-16.832	0.000
	T6-T5	-0.28	-3.169	0.011
Anxiety	T4-T3	-0.88	-11.972	0.000
	C4-C3	-0.68	-13.927	0.000
	T6-T5	-0.24	-2.980	0.017
Sadness	T4-T3	-0.19	-3.267	0.010
	T6-T5	-0.15	-2.241	0.052

Significantly higher activation in temporal sites was evident among extroverts for right lateral temporal (T6) in all states and also for right medial temporal (T4) in happy, anxiety and sad states, while among introverts a significantly higher activation was evident for right medial temporal (T4) in all conditions and for right lateral temporal (T6) in relaxed, anxiety and sad states. In contrast, neurotics showed a significantly higher activation for right medial temporal (T4) in happy and anxiety states, whereas emotionally stables showed a significantly activation for right medial and lateral temporal (T4 and T6) in reaction to happy and anxiety stimuli.

Table 5: Asymmetry on frontal sites in personality groups under different states

	Groups			
States	Extrovert	Introvert	Neurotic	Stable
Baseline	-	-	-	-
Relax	-	-	F8	F8
Happiness	F8	-	-	F8
Anxiety	-	F8	-	F4,F8
Sadness	-	-	-	-

Table 6: Asymmetry on parietal sites in personality groups under different states

	Groups			
States	Extrovert	Introvert	Neurotic	Stable
Baseline	-	-	-	P3
Relax	-	-	-	-
Happiness	C4	C4	C4	C4
Anxiety	C4	C4	C4	C4
Sadness	-	-	C3	-

Table 7: Asymmetry on temporal sites in personality groups under different states

	Groups			
States	Extrovert	Introvert	Neurotic	Stable
Baseline	T6	T4	-	-
Relax	T6	T4,T6	-	-
Happiness	T4,T6	T4	T4	T4,T6
Anxiety	T4,T6	T4,T6	T4	T4,T6
Sadness	T4,T6	T4,T6	-	-

Baseline/Affective state comparison: A Paired-sample t-test was also made between the baseline condition and affective states (using averaged alpha power over the brain regions) for every personality groups. Surprisingly, results were revealed a frontal decrease activity bilaterally in all groups, whereas different decrease activity patterns were observed in posterior regions; a bilaterally decrease temporal activity observed in neurotic and emotionally stable individuals while a unilateral decrease left temporal activity was revealed in introverted and extroverted individuals. A decrease left parietal activity was also evident in emotionally stable, introverted and extroverted individuals in happy state while a decrease bilateral parietal activity observed in neurotics (Table 5-7).

Results were also revealed a decrease unilateral left posterior (parietal and temporal) activity in reaction to anxiety state in all personality groups (not Reported). A significantly increase activity was also evident among introverts in the left frontal and right parietal regions in sad and happy states respectively (Table 8, 9).

Table 8: Baseline/affective state comparison for introverts and extroverts under the happy affective state

	Groups							
	Introverts				Extroverts			
	Alpha power means				Alpha power means			
Regions	Baseline	Happy	t	Significant	Baseline	Happy	t	Significant
Left frontal	0.20	0.83	-6.99	0.000*	0.09	0.26	-8.610	0.000*
Right frontal	0.18	0.81	-7.30	0.000*	0.02	0.66	-7.080	0.000*
Left temporal	0.21	0.55	-6.13	0.000*	0.17	0.14	-4.730	0.001*
Right temporal	0.02	-0.10	1.88	0.093	-0.05	0.65	-1.920	0.086
Left parietal	0.34	0.63	-5.79	0.000*	0.17	0.86	-4.360	0.002*
Right parietal	0.35	0.23	2.29	0.048**	0.20	0.92	-0.538	0.603

*: Significantly decrease activity relative to the baseline level, **: Significantly increase activity relative to the baseline level

Table 9: Baseline/affective state comparison for neurotics and emotionally stables under the happy affective state

	Groups							
	Neurotic				Emotionally Stable			
	Alpha power means				Alpha power means			
Regions	Baseline	Happy	t	Significant	Baseline	Happy	t	Significant
Left frontal	-0.09	1.07	-10.30	0.000*	0.08	1.06	-6.90	0.000*
Right frontal	-0.05	1.08	-9.70	0.000*	0.07	0.99	-7.31	0.000*
Left temporal	0.00	0.84	-9.44	0.000*	0.14	0.76	-5.32	0.000*
Right temporal	-0.17	0.32	-2.77	0.022*	0.00	0.25	-2.82	0.020*
Left parietal	0.03	0.84	-7.08	0.000*	0.20	0.76	-4.47	0.002*
Right parietal	0.11	0.48	-3.41	0.008*	0.23	0.45	-1.85	0.096

*: Significantly decrease activity relative to the baseline level

DISCUSSION

Patterns of activation were different under the happy and anxiety states between personality groups in anterior sites (F4, F8), whereas same patterns of activation was revealed in posterior sites (P3, P4) under those states. Examining asymmetries under all states was revealed a right lateral frontal (F8) activation for introverts and also a right medial and lateral frontal (F4, F8) activation for emotionally stables in anxiety state, as well as the right central (C4) activation among all personality groups in active affective states (happy and anxiety). These patterns of activations were partly consistent with (Heller, 1993) and (Davidson, 1992, 1993) approach and withdrawal models. In contrast a right lateral frontal (F8) activation in happy state among extroverts and emotionally stables and in relaxed state among neurotics and emotionally stables were contradictory to the models. No supportive evidence was found for the role of the left frontal region in positive affect. This result was compatible with (Esslen *et al*., 2004) who found a dominant right frontal activation in reaction to both negative and positive affective elicitors. Results were also consistent with research findings relating to the role of right posterior asymmetry in negative emotion. For example (Sarlo *et al*., 2005) was found the highest cortical activation, during the viewing of the surgery scene than other stimuli, prominently over the right posterior regions; and (Schutter *et al*., 2001) suggested that asymmetrical parietal beta activity might be linked to the behavioral dimensions of approach and withdrawal. (Aftanas and Pavlov, 2005) were also showed that viewing aversive movie clip by the high anxiety group led to significant lateralized decrease of the right parieto-temporal beta-1 power, which was initially higher in the emotionally neutral conditions and (Schmidtke and Heller, 2004) were observed higher parieto-temporal activity among neurotic individuals in resting state.

In addition, neurotics showed a left central (C3) activation in sad state which suggested a novel role for this region in negative passive affective state (sadness) among neurotics and resembled (Hagemann *et al*., 1999) who showed that left anterior temporal activity was associated with negative affect.

We have also found a decrease (relative to the baseline) frontal activity (bilaterally) for all groups; a decrease temporal activity (bilaterally) in stables and neurotics; and a decrease left temporal activity in introverted and extroverted individuals under the happy state. In contrast, a left parietal activity was observed among introverted, extroverted and emotionally stable individuals in happy state whereas neurotic individual showed an overly decrease cortical activity in this state. Further, anxiety stimuli induced a unilateral left posterior (parietal and temporal) decrease activity in all personality groups.

The findings provided from baseline/affective state comparison, were obviously suggested that: 1-decrease activity in left hemisphere regions may have important role in moderating of emotions, specifically anxiety and happiness. Indeed, the observed right central asymmetry under the anxiety and happy states was more due to a decrease left posterior activity than increase right posterior activity. This view is consistent with Davidson *et al.* (2000) and Davidson (2002) who has suggested that regions of the left prefrontal cortex may play an important role in inhibiting the amygdala. (Quirk *et al*., 2003) have also shown that stimulation of left medial prefrontal in rodents decreases the responsiveness of output neurons in the central nucleus of the amygdala and Ochsner *et al.* (2002) reported strong inverse relations between activation in the left ventrolateral prefrontal and the amygdala when subjects were requested to voluntarily down regulate their negative affect 2-A bilaterally frontal and temporal variation may have also important implication for emotional experience. Recent studies have provided some evidence that highlighted the importance of bilateral variations specifically in frontal region under affective states (Herrington *et al*., 2005; Nitschke *et al*., 2004; Altenmüller *et al*., 2002).

However, a dominantly right temporal and central activation observed in our analysis, could be attributed to cognitive processes such as mental imagery and reviewing of movie scenes, that may run after watching movie clips in subjects' mind and resembled. Ahern and Schwartz (1985) who found a role for right parietal region in spatial processes and also (Smith *et al*., 1987) who found right hemisphere play a role in differentiation between affective and cognitive conditions.

In summary, different patterns of asymmetries were observed in personality groups in reaction to affective stimuli. Results were partly consistent with approach and withdrawal model and provided supportive evidence for the role of right frontal asymmetry in negative affects in two groups (introverts and emotionally stables) as well as the role of right central asymmetry (increase on right and decrease on left) in active affective states (anxiety and happiness) in all personality groups. Results were also emphasized on the role of decrease activity relative to baseline in cortical regions (bilaterally in frontal and unilaterally in left parietal and temporal regions) in moderating of positive and negative emotion.

REFERENCES

Aftanas, L.I., A.A. Varlamov, N.V. Reva and S.V. Pavlov, 2003. Disruption of early event-related theta synchronization of human EEG in alexithymics viewing affective pictures. Neurosci. Lett., 340: 57-60.

Aftanas, L.I. and S.V. Pavlov, 2005. Trait anxiety impact on posterior activation asymmetries at rest and during evoked negative emotions: EEG investigation. Int. J. Psychophysiol., 1: 85-94.

Ahern, G.L. and G.E. Schwartz, 1985. Differential lateralization for positive and negative emotion in the human brain: EEG spectral analysis. Neuropsychologia, 23: 745-755.

Allen, J.J.B., J.A. Coan and M. Nazarian, 2004. Issues and assumptions on the road from raw signals to metrics of frontal EEG asymmetry in emotion. Biol. Psychol., 67: 183-218.

Altenmüller, E., K. Schürmann, V.K. Lim and D. Parlitz, 2002. Hits to the left, flops to the right: Different emotions during listening to music are reflected in cortical lateralisation patterns. Neuropsychologia, 40: 2242-2256.

Canli, T., Z. Zhao, J.E. Desmond, E. Kang, J. Gross and J.D.E. Gabrieli, 2001. An fMRI study of personality influences on brain reactivity to emotional stimuli. Behav. Neurosci., 115: 33-42.

Coan, J.A. and J.J.B. Allen, 2003. Varieties of emotional experience during voluntary emotional facial expressions. Ann. NY Acad. Sci., 1000: 375-379.

Coan, J.A. and J.J.B. Allen, 2004. Frontal EEG asymmetry as a moderator and mediator of emotion. Biol. Psychol., 67: 7-50.

Davidson, R.J. and A.J. Tomarken, 1989. Laterality and Emotion: An Electrophysiological Approach. In: Handbook of Neuropsychology, Boller, F. and J. Grafman (Eds.). Amsterdam: Elsevier, pp: 419-441.

Davidson, R.J., 1992. Anterior cerebral asymmetry and the nature of emotion. Brain and Cognition, 20: 125-151.

Davidson, R.J., 1993. Parsing affective space: Perspectives from neuropsychology and psychophysiology. Neuropsychology, 7: 464-475.

Davidson, R.J., K.M. Putnam and C.L. Larson, 2000. Dysfunction in the neural circuitry of emotion regulation-a possible prelude to violence. Science, 289: 591-594.

Davidson, R.J., 2002. Anxiety and affective style: Role of prefrontal cortex and amygdala. Biological Psychiatry, 51: 68-80.

Davidson, R.J., 2003. Affective neuroscience and psychophysiology: Toward a synthesis. Psychophysiology, 40: 655-665.

Davidson, R.J., 2004. What does the prefrontal cortex do in affect: Perspectives on frontal EEG asymmetry research. Biol. Psychol., 67: 219-233.

Diener, E., R.J. Larsen, S. Levine and R.A. Emmons, 1985. Frequency and intensity: Dimensions underlying positive and negative affect. J. Personality and Social Psychol., 48: 1253-1265.

Digman, J.M. and J. Inouye, 1986. Further specification of the five robust factors of personality. J. Personality and Social Psychol., 50: 116-123.

Esslen, M., R.D. Pascual-Marqui, D. Hell, K. Kochi and D. Lehmann, 2004. Brain areas and time course of emotional processing. Neuroimaging, 21: 1189-1203.

Eysenck, H.J. and M.W. Eysenck, 1985. Personality and Individual Differences: A Natural Science Approach. Plenum Press, New York.

Gale, A., J. Edwards, P. Morris, R. Moore and D. Forrester, 2001. Extraversion-introversion, neuroticism-stability and EEG indicators or positive and negative empathic mood. Personality and Individual Differences, 30: 449-461.

Gray, J.A., 1987. The Neuropsychology of Emotion and Personality. In: Cognitive Neurochemistry, Stahl, S.M., S.D. Iverson and E.C. Goodman (Eds.). Oxford University Press, Oxford, pp: 171-190.

Gray, J.A., 1990. Brain systems that mediate both emotion and cognition. Cognition and Emotion, 4: 269-288.

Hagemann, D., E. Naumann, A. Lurken, G. Becker, S. Maier and D. Bartussek, 1999. EEG asymmetry, dispositional mood and personality. Personality and Individual Differences, 27: 541-568.

Heller, W., 1990. The Neuropsychology of Emotion: Developmental Patterns and Implications for Psychopathology. In: Psychological and Biological Approaches to Emotion, Stein, N., B.L. Leventhal and T. Trabasso (Eds.). Lawrence Erlbaum, Hillsdale, NJ, pp: 167-211.

Heller, W., 1993. Neuropsychological mechanisms of individual differences in emotion, personality and arousal. Neuropsychology, 7: 476-489.

Herrington, J.D., A. Mohanty, N.S. Koven, J.E. Fisher, J.L. Stewart, M.T. Banich, A.G. Webb, G.A. Miller and W. Heller, 2005. Emotion-modulated performance and activity in left dorsolateral prefrontal cortex. Emotion, 5: 200-207.

Levy, J. and W. Heller, 1992. Gender Differences in Human Neuropsychological Function. In: Sexual Differentiation, Gerall, A.A., H. Moltz and I.L. Ward (Eds.). Handbook of Behavioral Neurobiology. Vol. 11, Plenum, New York, pp: 245-274.

McCrae, R.R. and P.T. Jr. Costa, 1987. Validation of the five factor model of personality across instruments and observers. J. Personality and Social Psychol., 52: 81-90.

Meyer, G.J. and J.R. Shack, 1989. Structural convergence of mood and personality: Evidence for old and new directions. J. Personality and Social Psychol., 57: 691-706.

Nitschke, J.B., W. Heller, M.A. Etienne and G.A. Miller, 2004. Prefrontal cortex activity differentiates processes affecting memory in depression. Biol. Psychol., 67: 125-143.

Ochsner, K.N., S.A. Bunge, J.J. Gross and J.D. Gabrieli, 2002. Rethinking feelings: An fMRI study of the cognitive regulation of emotion. J. Cognitive Neurosci., 14: 1215-1229.

Peabody, D. and L.R. Goldberg, 1989. Some determinants of factor structures from personality-trait descriptors. J. Personality and Social Psychol., 57: 552-567.

Quirk, G.J., E. Likhtik, J.G. Pelletier and D. Pare, 2003. Stimulation of medial prefrontal cortex decreases the responsiveness of central amygdala output neurons. J. Neurosci., 23: 8800-8807.

Russell, J.A., 1980. A circumplex model of affect. J. Personality and Social Psychol., 39: 1161-1178.

Sarlo, M., G. Buodo, S. Poli and D. Palomba, 2005. Changes in EEG alpha power to different disgust elicitors: The specificity of mutilations. Neurosci. Lett., 382: 291-296.

Schmidtke, J.I. and W. Heller, 2004. Personality, affect and EEG: Predicting patterns of regional brain activity related to extraversion and neuroticism. Personality and Individual Differences, 36: 717-732.

Schmidt, L.A. and L.J. Trainor, 2001. Frontal brain electrical activity (EEG) distinguishes valence and intensity of musical emotions. Cognition and Emotion, 15: 487-500.

Schutter, D.J.L.G., P. Putman, E. Hermans and J. van Honk, 2001. Parietal electroencephalogram beta asymmetry and selective attention to angry facial expressions in healthy human subjects. Neurosci. Lett., 314: 13-16.

Smith, B.D., M. Meyers, R. Kline and A. Bozman, 1987. Hemispheric asymmetry and emotion: Lateralized parietal processing of affect and cognition. Biol. Psychol., 25: 247-260.

Sutton, S.K. and R.J. Davidson, 2000. Prefrontal brain electrical activity predicts the evaluation of affective stimuli. Neuropsychologia, 38: 1723-1733.

Watson, D. and A. Tellegen, 1985. Toward a consensual structure of mood. Psychol. Bull., 98: 219-235.

Wiggins, J.S., 1968. Personality structure. Ann. Rev. Psychol., 19: 293-350.