

Relationships Between Alpha Power in Frontal and Temperament-Character with Self Injuring Behavior in Borderline Personality Disorder

¹Abbas Bakhshipor, ¹Mansour Beyrami, ¹Amir Hooshang Mehryar,
³Ali Reza Farnaam and ²Gholam Reza Chalabianloo

¹Department of Psychology, ²Department of Cognitive Neuroscience, Tabriz University, Iran

³Department of Psychiatry, Tabriz University of Medical Sciences, Iran

Abstract: In recent years, researchers conceptualized BPD as a biological specially brain disorder. Crowell's revised biosocial model of BPD has stated that interaction of biological vulnerabilities specially frontolimbic dysfunctions with personality and temperamental factors play an important role in behavioral, cognitive and emotional symptoms of BPD. In order to study of relationships between absolute power of alpha in frontal with temperament and character for predicting of self injury behavior of BPD, 50 males with BPD and history of non suicidal self injuring behavior completed Temperament-Character Inventory-125 (TCI-125). EEG recorded with a 32 channels DC amplifier and acquisition software. Data analyzed by Multivariate Regression Method. Results indicated that there are significant correlations among frontal alpha power ($r = -0.85$, $p = 0.001$), novelty seeking ($r = 0.45$, $p = 0.01$), harm avoidance ($r = -0.66$, $p = 0.001$), cooperativeness ($r = -0.38$, $p = 0.01$) and self transcendence ($r = 0.36$, $p = 0.01$) with self injuring. Regression analysis showed that frontal alpha power, novelty seeking, harm avoidance and persistence predicted self injuring behavior ($R = 0.89$, $R^2 = 0.79$). The present study provides support for the validity of Crowell's Model of BPD as predictors of self injuring through frontal function and personality factors especially, frontal dysfunction and temperamental factors appear to have a significant influence on self injuring in BPD.

Key words: Alpha power, borderline personality disorder, frontal lobe, self injury, temperament character, Iran

INTRODUCTION

Borderline Personality Disorder (BPD) is a persistent and severe mental disorder which affects approximately 1-6% of individuals in the community (Grant *et al.*, 2008; Coid *et al.*, 2006; Samuels *et al.*, 2002) and up to 20% of psychiatric inpatient samples (Skodol *et al.*, 2002). It has a heterogeneous constellation of symptoms characterized by a variety of symptoms like a pervasive pattern of instability of interpersonal relationships, self-image, high rates of recurrent suicidal behavior, affective instability, feelings of emptiness and high rates of comorbid mental disorders (Barlow and Durand, 2012; Millon *et al.*, 2004). Among these, increased impulsiveness and emotional instabilities have received special attention as central features of this disorder (Paris, 2007) which manifests themselves in severe self-harming behaviors (Linehan, 1993). In other words, approximately three quarters of BPD patients are engaging in suicidal behavior (Black *et al.*, 2004; Paris *et al.*, 2004; Zanarini *et al.*, 2004) with up to 10% eventually committing suicide (Lieb *et al.*, 2004). BPD patients reported more impulsivity than healthy volunteer and patients with Axis I disorders (Paris *et al.*, 2004;

Jacob *et al.*, 2008; Kunert *et al.*, 2003). Researchers indicated that self injury is a behavior that terminates states of negative affects (Schmahle *et al.*, 2004; Coid, 1993; Russ *et al.*, 1992). Therefore, self injuring behaviors related to emotion dysregulation. Emotion dysregulation is defined as a person's failure to modify emotions that leading to context inappropriate emotions and behaviors (Gratz and Roemer, 2004).

Currently, the etiology of BPD is poorly understood, in fact it is well recognized that BPD, results from complex biosocial interactions that begin in early childhood (Crowell *et al.*, 2009; Beauchaine *et al.*, 2009) and its biological basis remains largely unknown. There is still an ongoing debate on the neurobiological and neuropsychological mechanisms underlying BPD.

As seen in BPD patient, impulsivity is associated with underlying neurological impairments such as serotonergic pathways dysregulation and dysfunctional of frontal circuits specially in voluntary regulation of negative emotion (Kraus *et al.*, 2010; Koenigsberg *et al.*, 2009; Guitart-Masip *et al.*, 2009; Goldin *et al.*, 2008; Minzenberg *et al.*, 2008). Other research findings indicated that prefrontal cortex exhibit hypometabolism

(Soloff *et al.*, 2003). Because of the main function of frontal cortex in regulation of emotion and impulsivity, the hypothesis straightens that dysfunction of this cortex may underlies some typical severe behavioral problems such as self-injuring behaviors of BPD.

Among different methods of assessing brain activation, one of the best methods is the EEG. Because it is a relatively inexpensive and non-invasive method to examine mental processes that reflects the temporo-spatial pattern of synchronized cortical activity. There is increasing data about neurological dysfunctions in BPD patients however a few researches have been conducted to evaluate cortical dysfunctions by QEEG analysis especially in BPD patients.

Now-a-days, scientists believe that interaction of genetically and environmental factors results in vulnerability to psychopathology. One of the most important theories which describe the interaction factors together is Cloninger (1987)'s Biosocial Theory. He tries to describe personality from biosocial perspective who postulates four temperament and three character dimensions. Harm Avoidance (HA), Novelty Seeking (NS), Reward Dependence (RD) and Persistence (P) are the temperament dimensions which regulate automatic emotional reactions based on neurobiological functions. The three character dimensions Self-Directedness (SD), Cooperativeness (C) and Self Transcendence (ST) include both a cognitive perspective about self and an emotional perspective based on social experiences (Cloninger *et al.*, 1993).

This model was based on the assumption that personality is composed both by traits that are heritable and stable throughout life and traits that are influenced by socio-cultural learning and mature throughout life. Cloninger (1987)'s Model personality categorized BPD with histrionic personal disorder in same category which including high NS, low HA and high RD. Other researchers showed that BPD patients have high NS, HA and moderate RD (Calati *et al.*, 2008; Joyce *et al.*, 2003; Pukrop, 2002). Others proposed that there are relationships between suicidal behaviors with low RD, P, SD, C and high ST (Brezo *et al.*, 2006).

Totally, self injuring behavior is prevalent finding in clinical feature of patients with BPD that impulsivity and emotional dysregulation plays an important role in self injuring. On the other hand, findings showed that frontolimbic dysfunction is the main neurological impairments in BPD patients' especially impulsive behaviors of them. But there is a little literature about alpha power in frontal areas cortical dysfunction of patients with BPD especially by QEEG and its relationship with personality dimensions.

The present study sought to extend the multidimensional nature of self injuring behavior in patient with BPD determine whether there is a relationship between alpha absolute power in frontal lobe and temperament-character with self injuring behavior of BPD.

MATERIALS AND METHODS

Participants: About 50 hand writhed male patients between the ages of 18 and 45 (mean age 28.6 years, SD = 7.34) who met BPD criteria according to DSM-IV-TR (APA, 2000) recruited over a period of 1 year in a specialized Razi Psychiatric Hospital inpatient clinic of the Tabriz University of Medical Science by using Structured Clinical Interview for DSM-IV Axis II Disorders (SCID-II) (First *et al.*, 1997) criteria for BPD. All clinical and SCID-II interviews were conducted by an experienced psychiatrist and a clinical psychologist previously trained in the use and scoring of this interview. Subjects were excluded if any of the followings were detected: schizophrenia or other psychotic disorders, current severe substance abuse or dependence, major depression, history of Electro Convulsive Therapy (ECT), neurological or general medical disorders, head trauma, severe organic illness or mental retardation and ADHD. Medication was stable and matched during the last 2 weeks before examination. After complete description of the study to the subjects, written informed consent was obtained.

Measures

Temperament and Character Inventory-125 (TCI-125): This inventory is the tool designed based on the psychobiological theory of Cloninger *et al.* (1994) to account for individual differences in both normal and pathological behavior patterns. The scores have been calculated according to the manual. It consists of 125 questions with a true-false answer format. The mean values and standard deviations for each scale were respectively for NS: 8.97 (2.59); HA: 9.87 (2.95); RD: 11.92 (2.96); P: 2.53 (1.34); SD: 11.82 (3.59); C: 14.47 (4.83) and ST: 9.79 (2.75). Finally, Cronbach's alpha was calculated for each subscales NS (0.71), HA (0.73), RD (0.69), P (.071), SD (0.78), C (0.81) and ST (0.76).

Personality Assessment Inventory-Borderline Features Scale (PAI-BFS): Participants completed an adapted Persian Version of PAI-BFS (Morey, 1991) which consists of 24 items in with four response categories (0; false, 1; slightly true, 2; mainly true and 3; very true) that reflects four characteristics of BPD: Affective Instability (AI),

Identity Problems (IP), Negative Relationships (NR) and Self Harm (SH). For the purpose of the present study only the SH subscale was used with an internal consistency of 0.73 for the current sample. The mean value and standard deviation for this scale were 15.97 (3.57).

EEG recording and quantification: The EEG was recorded with a 32-channel DC amplifier (SynAmps System) of the international 10-10 system including the earlobes (A1, A2) and acquisition software (Neuroscan 4.2). An ElectroCap with Ag/AgCl electrodes was used to record EEG. Prior to the placement of electrodes, the expected electrode sites on the participant's scalp and face were cleaned with alcohol and gently abraded. An offline common average reference was successively computed in order to limit the problem of signal-to-noise ratio. The data were recorded using sampling rate of 500 Hz with a frequency band of 0.1-40 Hz. Only artifact-free trials were considered. The digital EEG data were band-pass filtered in alpha frequency bands (8-12 Hz) by using a fast Fourier transform of the data. Because the goal was consider alpha power in frontal lobe, after artifact removing, mean of absolute power in 6 electrodes including Fp1, Fp2, F3, F4, F7, F8 were calculated. The mean value and standard deviation for all patients in frontal site were 1.53 (0.66).

Data analysis: EEG data were log transformed to approximate normality. The Shapiro-Wilk test was used to confirm normality of the transformed data. Multiple regression analysis was used to analyze predictability of self injury behaviors by frontal alpha power and temperament-character. Researchers consider $p < 0.05$ to be significant. Other statistical methods such as Pearson's correlation were used where indicated in the text.

RESULTS AND DISCUSSION

Results of Pearson's correlations between TCI and alpha power in frontal with self injury behavior are shown in Table 1. Significant positive correlations appeared between alpha power in frontal and the three TCI subscales (HA, SD and C) and significant negative correlations appeared between alpha power in frontal and NS, RD and ST. But there is no significant correlations between alpha power in frontal and P.

Also, the positive correlation between SH with NS and ST was significant whereas the significant negative correlations appeared between SH with alpha power in frontal, HA and C. Results indicated that correlations between SH with RD, P and SD were not significant.

The results of the hierarchical regressions are shown in Table 2. Results indicated that alpha power and temperament character characteristics predicted self injuring behavior of borderline personality with 0.89 multiple correlational coefficient. Self injuring behavior was best predicted by alpha power in alpha, HA and P negatively and by NS positively. Results revealed that character subscales of TCI could not predicted self injury behavior. Regression analysis suggested that neurophysiologic variables such as alpha power and temperament could predicted self injury and character was not significant anymore.

The purpose of the present study was to examine relationships between alpha power in frontal and Cloninger's temperament-character with self injuring behavior in borderline personality disorder.

As expected, self injury behavior was predicted by alpha power in frontal site (jointly with temperament scores). The results indicated that there is significant

Table 1: Correlation between temperament-character, alpha power and self injury

Variables	α	NS	HA	RD	P	SD	C	ST
NS	-0.31	-	-	-	-	-	-	-
HA	0.64	-0.33	-	-	-	-	-	-
RD	-0.31	0.10	-0.28	-	-	-	-	-
P	-0.15	0.08	-0.27	0.26	-	-	-	-
SD	0.19	0.22	-0.30	0.07	0.32	-	-	-
C	0.50	-0.19	0.33	-0.10	-0.28	0.25	-	-
ST	-0.46	0.07	-0.21	0.15	-0.10	-0.20	-0.18	-
SH	-0.84	0.45	-0.66	0.16	0.09	-0.07	-0.39	0.36

Table 2: Regression analysis for prediction of self injury by alpha power and temperament character

Variables	B	β	t-values	Sig.	R	R ²
α	-3.76	-0.70	9.14	0.001	-	-
NS	0.21	0.15	3.05	0.01	-	-
HA	-0.26	-0.22	3.23	0.01	-	-
RD	-0.10	-0.08	1.79	NS	-	-
P	-0.37	-0.14	2.70	0.01	0.89	0.79
SD	0.05	0.05	0.70	NS	-	-
C	0.05	0.07	0.11	NS	-	-
ST	-0.03	-0.02	0.45	NS	-	-

negative relationship between alpha power in frontal and self injuring behavior of BPD. It means that decreasing in alpha power in frontal result in more self injuring behavior in BPD patient. This finding has therapeutic importance which increasing alpha power in frontal cause to decrease in BPD symptoms, especially self injuring behaviors. Previous findings about cortical response revealed that alpha band oscillations were related to the emotional processing (Balconi *et al.*, 2009; Knyazev, 2007). In other words, alpha in frontal has critical role in emotional processing. So, according to Linehan (1993)'s biosocial theory and Crowell *et al.* (2009)'s revised model, BPD is emotion dysregulation disorder. Because self injuring is consequence of emotion dysregulation therefore it could understand that there is significant relationship between alpha power in frontal lobe and self injuring behavior of BPD.

Also according to approach-withdrawal model, frontal cortical activity specially in alpha band has important role in producing emotional responses and behavioral tendencies (approach or withdrawal tendencies) (Balconi and Pozzoli, 2007; Schupp *et al.*, 2006). For the reason that anger is most important predictor of self injury and suicidal behaviors also because anger is an approach motivation, the relationship of anger and frontal cortical activity seems logical. On the other hand, alpha power in frontal site has significant role in information processing. As Klimesch *et al.* (2007) proposed alpha is an active phenomenon but reflects a certain type of top-down process. Synchronization in the alpha, frequency range helps neurons in distributed networks to effectively activate common target cells. This timing mechanism plays an important role in the top-down control of cortical activation. Inhibition helps to establish a highly selective activation pattern. This hypothesis is in line with one of the critical hypothesis of Crowell *et al.* (2009)'s model that BPD symptoms produce by distorted information processing's which driven from emotional dysregulation.

The results revealed that NS, HA and P are the best predicting factors for self injuring behavior. Previous researches indicated some temperament-character factors can predict self injuring such as novelty seeking and harm avoidance (Joyce *et al.*, 2003; Pukrop, 2002; Korner *et al.*, 2007). These results indicated that temperamental traits like NS, HA and P could be a predictor of biopsychologic predisposition to behavioral disturbances like self injuring behavior in BPD. NS results in exploratory behaviors and approaching to novel stimuli. Cloninger (1987) postulated one of the characteristics of BPD patients is high NS, he categorized BPD patients in the borderline/histrionic type

who seeking attention, stimulation and tending toward recklessness and impulsivity. The results are congruent with Cloninger's prediction.

Negative relationship between HA and self injuring behavior is congruent with HA definition as responsible for inhibition of behaviors. As described before, HA relates with behavioral inhibition in front of potentially dangerous stimuli and to anticipate negative effects (Cloninger, 1987). Higher HA is one of the personality traits that differentiate suicide attempters (Calati *et al.*, 2008; Giegling *et al.*, 2009; Favaro *et al.*, 2008; Evren and Evren, 2006). Findings showed that serotonin neurotransmitter and its genetically roots like polymorphisms of *5-HT2A* genes have central role in patients with suicidal behaviors (Giegling *et al.*, 2006; Roggenbach *et al.*, 2002). On the other hand, research evidences revealed that serotonin as a more important neurotransmitter plays central role in fluctuations of HA (Boz *et al.*, 2007; Serretti *et al.*, 2007). Also other findings that revealed antidepressant drugs which decrease BPD negative emotions and behaviors, act on the serotonin system (Boz *et al.*, 2007).

Also P indicates hard working and stable individuals who have tendency to pursuit of desired goals (Cloninger *et al.*, 1993). Results indicated that self injuring behaviors were predicted negatively by P. This result is congruent with BPD phenomenology which BPD patients suffer from chronic feelings of emptiness, identity disturbances and occupational instabilities (Barlow and Durand, 2012). Because BPD patient can not set logical goals for themselves and P indicates persons who have sustained pursuit for reaching to their goals, the acceptable result is that P predicted BPD features negatively.

As seen in this results, none of the character traits predicted self injuring behavior. This finding is congruent with the Cloninger *et al.* (1993)'s postulations which low traits in characters are core characteristics in personality disorders. These results suggest that neurobiological based factors could predict self injuring behaviors of BPD better than environmental factors. In other words, innate aspects of personality in comparison with acquired aspects, related to self injuring behaviors of BPD.

The results of this study lend support to the importance of the interaction between psychobiological factors and neurological functions in the manifestation of BPD features. The interaction between cortical functions especially in alpha band in frontal lobe and temperamental factors of personality was a significant predictor of self injuring behaviors of BPD which is one of the most important features of this disorder. This interaction

predicted a significant amount of variance (79%) of self injuring behaviors of BPD. These results suggest that neurological factors and psychological factors with neurobiological basis are the most important factors in the manifestation of borderline personality pathology. This finding is in favor of Gunderson (2009)'s that postulated BPD is a good prognosis brain disease. The results carry a variety of implications for the conceptualization, assessment, diagnosis and treatment of BPD.

However, these results can help to develop new strategies in therapeutic procedure of BPD specially in decreasing self injuring behaviors. Evidences indicated that Dialectical Behavior Therapy (DBT; Linehan, 1993) is the most frequent treatment for BPD. Because DBT is based upon Linehan's theory of BPD, emotional dysregulation is at the core of the therapy. Treatment primarily focuses on teaching patients more effective ways of regulating their emotional states and coping with distress, instead of relying on maladaptive coping strategies such as self harm, substance abuse or other impulsive behavior. The results indicated that neurological factors are the fundamental in self injuring behaviors, in other words disinhibition and emotional dysregulation of BPD patients have biological causes. So, it is necessary to use of techniques like neurofeedback in treatment of BPD.

CONCLUSION

The present study provides support for the validity of Crowell's model of BPD as predictors of self injuring through frontal function and personality factors especially, frontal dysfunction and temperamental factors appear to have a significant influence on self injuring in BPD.

LIMITATIONS

The main limitation of this study that should be acknowledged was little sample size. These limitations first causes from the including and excluding criteria, second because the sample was recruited in a specialized research centre, patients recruited there who suffer from severe symptoms. Gender, age, education and other psychiatric disorders were controlled for in the samples and this fact could be considered strength.

ACKNOWLEDGEMENT

The researchers grateful to the patients participated in this study.

REFERENCES

- APA, 2000. Diagnostic and Statistical Manual of Mental Disorders. 4th Edn., Text Revised (DSM-IV). American Psychiatric Association, Washington, DC., USA.
- Balconi, M. and U. Pozzoli, 2007. Event-related oscillations (EROs) and event-related potentials (ERPs) comparison in facial expression recognition. *J. Neuropsychol.*, 1: 283-294.
- Balconi, M., E. Brambilla and L. Falbo, 2009. BIS/BAS, cortical oscillations and coherence in response to emotional cues. *Brain Res. Bull.*, 80: 151-157.
- Barlow, D.H. and V.M. Durand, 2012. *Abnormal Psychology: An Integrative Approach*. 6th Edn., Wadsworth/Thomson Learning, Belmont, CA.
- Beauchaine, T.P., D.N. Klein, S.E. Crowell, C.M. Derbidge and L.M. Gatzke-Kopp, 2009. Multifinality in the development of personality disorders: A biology \times sex \times environment interaction model of antisocial and borderline traits. *Dev. Psychopathol.*, 21: 735-770.
- Black, D.W., N. Blum, B. Pfohl and N. Hale, 2004. Suicidal behavior in borderline personality disorder: prevalence, risk factors, prediction, and prevention. *J. Personal Disord.*, 18: 226-239.
- Boz, C., S. Gazioglu, V. Altunayoglu and C. Hocaoglu, 2007. Effect of serotonergic antidepressant therapy on temperament and character scales in patients with chronic tension-type headache. *Psychiatry Clin. Neurosci.*, 61: 534-542.
- Brezo, J., J. Paris and G. Turecki, 2006. Personality traits as correlates of suicidal ideation, suicide attempts and suicide completions: A systematic review. *Acta Psychiatry Scand.*, 113: 180-206.
- Calati, R., I. Giegling, D. Rujescu, A.M. Hartmann, H.J. Moller, D. De Ronchi and A. Serretti, 2008. Temperament and character of suicide attempters. *J. Psychiatry Res.*, 42: 938-945.
- Cloninger, C.R., 1987. A systematic method for clinical description and classification of personality variants. *Arch. Gen. Psychiatry*, 44: 573-588.
- Cloninger, C.R., D.M. Svrakic and T.R. Przybeck, 1993. A psychobiological model of temperament and character. *Arch. Gen. Psychiatry*, 50: 975-990.
- Cloninger, C.R., T.R. Przybeck, D.M. Svrakic and R.D. Wetzel, 1994. *The Temperament and Character Inventory (TCI): A Guide to its Development and Use*. Center for Psychobiology of Personality, St. Louis, MO.
- Coid, J., M. Yang, P. Tyrer and A. Roberts, 2006. Prevalence and correlates of personality disorder in Great Britain. *Br. J. Psychiatry*, 188: 423-431.

- Coid, J.W., 1993. An affective syndrome in psychopaths with borderline personality disorder? *Br. J. Psychiatry*, 162: 641-650.
- Crowell, S.E., T.P. Beauchaine and M.M. Linehan, 2009. A biosocial developmental model of borderline personality: Elaborating and extending Linehan's theory. *Psychol. Bull.*, 135: 495-510.
- Evren, C. and B. Evren, 2006. The relationship of suicide attempt history with childhood abuse and neglect, alexithymia and temperament and character dimensions of personality in substance dependents. *Nord. J. Psychiatry*, 60: 263-269.
- Favaro, A., P. Santonastaso, P. Monteleone, L. Bellodi and M. Mauri *et al.*, 2008. Self-injurious behavior and attempted suicide in purging bulimia nervosa: Associations with psychiatric comorbidity. *J. Affect. Disord.*, 105: 285-289.
- First, M.B., M. Gibbon, R.L. Spitzer, L.S. Benjamin and J.B.W. Williams, 1997. Structured Clinical Interview for DSM-IV Axis II Personality Disorders. American Psychiatric Press, Washington DC. USA., ISBN-13: 9780880488112, Pages: 41.
- Giegling, I., A.M. Hartmann, H.J. Moller and D. Rujescu, 2006. Anger- and aggression-related traits are associated with polymorphisms in the 5-HT-2A gene. *J. Affect. Disord.*, 96: 75-81.
- Giegling, I., P. Ogiati, A.M. Hartmann, R. Calati, H.J. Moller, D. Rujescu and A. Serretti, 2009. Personality and attempted suicide. Analysis of anger, aggression and impulsivity. *J. Psychiatry Res.*, 43: 1262-1271.
- Goldin, P.R., K. McRae, W. Ramel and J.J. Gross, 2008. The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. *Biol. Psychiatry*, 63: 577-586.
- Grant, B.F., S.P. Chou, R.B. Goldstein, B. Huang and F.S. Stinson *et al.*, 2008. Prevalence, correlates, disability and comorbidity of DSM-IV borderline personality disorder: results from the Wave 2 National Epidemiologic survey on alcohol and related conditions. *J. Clin. Psychiatry*, 69: 533-545.
- Gratz, K.L. and L. Roemer, 2004. Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure and initial validation of the difficulties in emotion regulation scale. *J. Psychopathol. Behav. Assess.*, 26: 41-54.
- Guitart-Masip, M., J.C. Pascual, S. Carmona, E. Hoekzema and D. Berge *et al.*, 2009. Neural correlates of impaired emotional discrimination in borderline personality disorder: An fMRI study. *Prog. Neuropsychopharmacol. Biol. Psychiatry*, 33: 1537-1545.
- Gunderson, J.G., 2009. Borderline personality disorder: Ontogeny of a diagnosis. *Am. J. Psychiatry*, 166: 530-539.
- Jacob, G.A., C. Guenzler, S. Zimmermann, C.N. Scheel and N. Rusch *et al.*, 2008. Schema therapy for patients with borderline personality disorder: A single case series. *J. Behav. Ther. Exp. Psychiatry*, 39: 391-402.
- Joyce, P.R., J.M. McKenzie, S.E. Luty, R.T. Mulder, J.D. Carter, P.F. Sullivan and C.R. Cloninger, 2003. Temperament, childhood environment and psychopathology as risk factors for avoidant and borderline personality disorders. *Aust. N. Z. J. Psychiatry*, 37: 756-764.
- Klimesch, W., P. Sauseng and S. Hanslmayr, 2007. EEG alpha oscillations: The inhibition-timing hypothesis. *Brain Res. Rev.*, 53: 63-88.
- Knyazev, G.G., 2007. Motivation, emotion and their inhibitory control mirrored in brain oscillations. *Neurosci. Biobehav. Rev.*, 31: 377-395.
- Koenigsberg, H.W., L.J. Siever, H. Lee, S. Pizzarello and A.S. New *et al.*, 2009. Neural correlates of emotion processing in borderline personality disorder. *Psychiatry Res.*, 172: 192-199.
- Korner, A., F. Gerull, J. Stevenson and R. Meares, 2007. Harm avoidance, self-harm, psychic pain and the borderline personality: Life in a Comp. *Psychiatry*, 48: 303-308.
- Kraus, A., G. Valerius, E. Seifritz, M. Ruf, J.D. Bremner, M. Bohus and C. Schmahl, 2010. Script-driven imagery of self-injurious behavior in patients with borderline personality disorder: A pilot fMRI study. *Acta Psychiatr. Scand.*, 121: 41-51.
- Kunert, H.J., H.W. Druecke, H. Sass and S.C. Herpertz, 2003. Frontal lobe dysfunctions in borderline personality disorder? Neuropsychological findings. *J. Personal Disord.*, 17: 497-509.
- Lieb, K., M.C. Zanarini, C. Schmahl, M.M. Linehan and M. Bohus, 2004. Borderline personality disorder. *Lancet*, 364: 453-461.
- Linehan, M.M., 1993. *Cognitive Behavioral Treatment of Borderline Personality Disorder*. Guilford, New York, USA.
- Millon, T., S. Grossman, C. Milon, S. Meagher and R. Rmnath, 2004. *Personality Disorders in Modern Life*. John Wiley and Sons Inc, New Jersey.
- Minzenberg, M.J., J. Fan, A.S. New, C.Y. Tang and L.J. Siever, 2008. Frontolimbic structural changes in and borderline personality disorder. *J. Psychiatr. Res.*, 42: 727-733.
- Morey, L.C., 1991. *The Personality Assessment Inventory: Professional Manual*. Psychological Assessment Resources, Odessa, FL.

- Paris, J., 2007. The Nature of borderline personality disorder: Mdimensions, multiple symptoms, but one category. *J. Personal Disord.*, 21: 457-473.
- Paris, J., H. Zweig-Frank, N.M. Kin, G. Schwartz, H. Steiger and N.P.V. Nair, 2004. Neurobiological correlates of diagnosis and underlying traits in patients with borderline personality disorder compared with normal controls. *Psychiatry Res.*, 121: 239-252.
- Pukrop, R., 2002. Dimensional personality profiles of borderline personality disorder in comparison with other personality disorders and healthy controls. *J. Personal Disord.*, 16: 135-147.
- Roggenbach, J., B. Muller-Oerlinghausen and L. Franke, 2002. Suicidality, impulsivity and aggression-is there a link to 5HIAA concentration in the cerebrospinal fluid. *Psychiatry Res.*, 113: 193-206.
- Russ, M.J., S.D. Roth, A. Lerman, T. Kakuma, K. Harrison, R.D. Shindedecker and J. Hull, 1992. Pain perception in self-injurious patients with borderline personality disorder. *Biol. Psychiatry*, 32: 501-511.
- Samuels, J., W.W. Eaton, O.J. Bienvenu, C.H. Brown, P.T. Costa Jr. and G. Nestadt, 2002. Prevalence and correlates of personality disorders in a community sample. *Br. J. Psychiatry*, 180: 536-542.
- Schmahle, C., W. Greffrath, U. Baumgartner, T. Schleretha and W. Magerla *et al.*, 2004. Differential nociceptive deficits in patients with borderline personality disorder and self-injurious behavior: Laser-evoked potentials, spatial discrimination of noxious stimuli and pain ratings. *Pain*, 110: 470-479.
- Schupp, H.T., T. Flaisch, J. Stockburger and M. Junghofer, 2006. Emotion and attention: Event-related brain potential studies. *Prog. Brain Res.*, 156: 31-51.
- Serretti, A., R. Calati, I. Giegling, A.M. Hartmann, H.J. Moller and C. Colombo, 2007. 5-HT2A SNPs and the temperament and character inventory. *Prog. Neuropsychopharmacol. Biol. Psychiatry*, 31: 1275-1281.
- Skodol, A.E., J.G. Gunderson, B. Pfohl, T.A. Widiger, W.J. Livesley and L.J. Siever, 2002. The borderline diagnosis I: Psychopathology, comorbidity and personality structure. *Biol. Psychiatry*, 51: 936-950.
- Soloff, P.H., C.C. Meltzer, C. Becker, P. Greer and T.M. Kelly, 2003. Impulsivity and prefrontal hypometabolism in borderline personality disorder. *Psychiatry Res.*, 123: 153-163.
- Zanarini, M.C., F.R. Frankenburg, J. Hennen, D.B. Reich and K.R. Silk, 2004. Comorbidity in patients with borderline personality disorder: 6-year follow-up and prediction of time to remission. *Am. J. Psychiatry*, 161: 2108-2114.