Research Article

Psychophysiological Characteristics of Burnout Syndrome: Resting-State EEG Analysis

Krystyna Golonka, Magda Gawlowska, Justyna Mojsa-Kaja, and Tadeusz Marek

Institute of Applied Psychology, Faculty of Management and Social Communication, Jagiellonian University, Łojasiewicza 4, 30-348 Kraków, Poland

Correspondence should be addressed to Krystyna Golonka; krystyna.golonka@uj.edu.pl

Received 17 May 2019; Accepted 10 July 2019; Published 29 July 2019

Guest Editor: Gabriela Topa

Copyright © 2019 Krystyna Golonka et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Introduction. The consequences of chronic work-related stress are related to various emotional, cognitive, and behavioral symptoms. Occupational burnout as a complex syndrome is characterized by exhaustion, cynicism, and lower professional efficacy. Moreover, the growing amount of research on the neural correlates of burnout broadens the existing knowledge on the mechanisms underlying this syndrome. Aim of the Study. The aim of the study is to explore possible differences in brain activity between burnout and non-burnout employees. Frequency-specific EEG power analyses in a resting-state condition in burnout subjects and controls are presented. Materials and Methods. Burnout employees (N=46; 19 men) were matched with the control group (N=49; 19 men; mean age: 36.14 years, SD=7.89). The Maslach Burnout Inventory—General Survey (MBI-GS) and the Areas of Worklife Survey (AWS) scale were used to measure burnout symptoms and work conditions, respectively. A 256-channel EEG (EGI System 300) was used to collect psychophysiological data. A repeated measures ANOVA was performed with condition (eyes-open vs. eyes-closed) and region (6 levels: extracted scalp regions) factors; burnout (2 levels: burnout vs. no burnout) was the grouping factor. Results. A significant difference was observed only in the alpha frequency band: the burnout group revealed significantly lower alpha power in the eyes-open condition compared to the controls (p<0.05). The correlation analysis revealed that gender may significantly change the pattern of relations between EEG spectral characteristics and burnout symptoms. Conclusions. Reduced alpha power in burnout individuals suggests cortical hyperactivity and may be related to greater mental effort and the possible development of compensatory mechanisms by burnout subjects.
in the general population of employees; (2) significant individual and organizational consequences; and (3) important scientific dispute on its etiology and the symptomatic characteristics that differentiate it from other diseases, especially from depression [9, 28]. Regarding methodology in burnout studies, objective methods and research outcomes are particularly needed to answer the question of whether severe burnout syndrome may be a separate entity, or whether it is a form of depression or anxiety-depression disorder induced by long-term work-related stress.

Neuroimaging research revealed that burnout or prolonged occupational stress correlated with specific anatomical and functional brain characteristics [22, 23, 25, 26]. For example, Jovanovic et al. [23] showed that subjects with chronic work-related stress revealed functional disconnection between the amygdala and the medial prefrontal cortex (mPFC), including anterior cingulate cortex (ACC). Moreover, they observed that receptors which are involved in the HPA regulation (5-HT1A receptors) were reduced in the ACC, the insular cortex, and in the hippocampus. These results indicate significant structural and functional brain changes and may suggest impaired top-down regulation of stress in subjects with prolonged work-related stress [23]. Similarly, Blix, Perski, Berglund, & Savic [26] analyzing the sample with chronic occupational stress observed reduction in the grey matter volumes of the ACC and the dorsolateral prefrontal cortex (dPFC), and reduced volumes of caudate and putamen. Savic [25] observed that burnout patients demonstrated significantly thinner mesial frontal cortex and selective changes in subcortical volumes: their amygdala volumes were bilaterally increased and caudate volumes were decreased. Golkar et al. [22] observed weaker activation of the functional network between the right amygdala and the anterior cingulate cortex in burnout subjects what may explain difficulties in controlling and coping with negative emotions. These studies give a solid basis for further exploration of neural correlates of burnout and search for its neurophysiological indicators.

In previous psychophysiological studies using electroencephalography (EEG), cognitive impairments in burnout subjects, accompanied by a changed pattern of selected Event-Related Potentials (ERP), were observed [29–33]. In our earlier study, we observed altered ERP pattern of processing of emotion-related stimuli in burnout subjects, which may explain one of the core burnout components: depersonalization/cynicism [15]. Additionally, Luijtelaar and colleagues [29] analyzed frequency-specific EEG power and revealed that lower alpha peak frequency and reduced beta power were observed in burnout subjects. Frequency-specific EEG power analyses may be an interesting perspective in exploring burnout and may bring additional insights in the characteristics of burnout syndrome. These explorations in relation to burnout may be particularly interesting in terms of such burnout characteristics as mental fatigue, depletion of energy, and a state of exhaustion [1, 7, 34–38]. Some studies clearly showed that burnout subjects demonstrate specific arousal patterns such as lower energy levels and higher levels of tension [39, 40]. In this context, the indexes of arousal levels and reactivity may be of particular interest.
study sample (N=95) consisted of the burnout group (N=46; 19 men), which was matched with the control group (N=49; 19 men) in terms of gender and age characteristics (mean age: 36.14 years, SD=7.89).

The study protocol was approved by the Bioethics Commission of Jagiellonian University and was carried out in accordance with the recommendations of the APA Ethics Code. Participants were paid for their contribution in the project. Each subject gave written informed consent.

The burnout group consisted of participants who had high scores on burnout measure and who reported their job-related context as stressful. Burnout and job context were assessed using Polish versions of the Maslach Burnout Inventory–General Survey (MBI-GS) [3] and the Areas of Worklife Survey scale (AWS) [50].

The MBI-GS consists of 16 items rated on a 7-point scale ranging from 0 “never” to 6 “every day.” The instrument measures three dimensions of burnout: exhaustion (5 items), cynicism (5 items), and professional efficacy (6 items). Cronbach’s α coefficients based on the sample are αexhaustion = 0.922, αcynicism = 0.9101, and αefficacy = 0.889.

The AWS consists of 29 items which relate to work conditions and assess employees’ perceived alignment between their work environment and individual preferences. Six areas of worklife are analyzed: workload (6 items), control (3 items), reward (4 items), community (5 items), fairness (6 items), and values (5 items). They are rated on a 5-point scale ranging from 1 “strongly disagree” to 5 “strongly agree.” Cronbach’s α coefficients were αworkload = 0.848, αcontrol = 0.803, αreward = 0.839, αcommunity = 0.894, αfairness = 0.864, and αvalues = 0.757.

The burnout group comprises participants who scored high (>3) on the two burnout dimensions of exhaustion and cynicism, and low scores (<3) in at least three AWS scales; this indicated higher burnout symptoms and more stressful work-related context, as assessed by a lower degree of matching between the individual’s workplace and preferences.

2.2. Experimental Procedure. The EEG data was recorded for 3 minutes for the eyes-open and 3 minutes for the eyes-closed condition. Subjects were asked to sit still and focus on the fixation point; when their eyes were closed, they were asked to sit still with closed eyes.

2.3. EEG Analysis. Continuous dense-array EEG data (HydroCel Geodesic Sensor Net, EGI System 300; Electrical Geodesic Inc., OR, USA) was collected from a 256-channel EEG at a sampling rate of 250 Hz (band-pass filtered at 0.01–100 Hz with a vertex electrode as a reference) and recorded with NetStation Software (Version 4.5.1, Electrical Geodesic Inc., OR, USA). The impedance for all electrodes was kept below 50 kΩ. The offline data analysis was conducted with the open-source EEGLAB toolbox [51]. Before the preprocessing steps, facial electrodes were removed; thus, further analysis was performed on 224 channels. Data was digitally filtered to remove frequencies below 0.5 Hz and above 35 Hz. Average reference was recomputed, and bad channels were automatically removed by kurtosis measures with a threshold value of 5 standard deviations. Next, continuous data was visually inspected in order to manually remove channels or time epochs containing high-amplitude, high-frequency muscle noise, and other irregular artifacts.

Independent component analysis was used to remove artifacts from data. Due to the large number of channels, decomposition of EEG data with the Infomax algorithm was preceded with Principle Component Analysis. Fifty independent components were extracted and visually inspected for each subject. On the basis of the spatiotemporal pattern [52, 53], components recognized as blinks, heart rate, saccades, muscle artifacts, or bad channels were removed. Missing channels were interpolated, and ICA weights were recomputed. Data was divided into the eyes-open (EO) and eyes-closed (EC) conditions. Spectral decomposition was performed using the Welch window, followed by Fast Fourier Transform (FFT). Mean power spectra for alpha (8–13 Hz), beta (14–35 Hz), delta (1–3 Hz), and theta (4–7 Hz) were extracted for every participant from the electrode clusters localized at the left and right anterior, left and right central, and left and right posterior scalp sites.

3. Results and Discussion

The statistical analyses were performed for each frequency band separately. There was no significant effect between the groups for the beta, delta, and theta bands; thus, the statistical analyses will be presented only for the alpha frequency band.

The repeated-measures ANOVA was performed with condition (EO vs. EC) and region (6 levels: extracted scalp regions) factors; burnout (2 levels: burnout vs. no burnout) was the grouping factor. As expected, there was a main effect of condition (F(1.93)=341.82, p < .001, ηp2 = 0.786), and alpha power was significantly higher for closed eyes. Moreover, an interaction effect of group and condition was observed (F(1.93)=5.43, p < .05, ηp2 = 0.055). The post hoc analysis revealed that there was a significant difference in the OE condition (p<.05), with a lower alpha power for the burnout vs. no burnout group (see Figure 1). Finally, there was a significant main effect of scalp region (F(5,465)=82.04, p < .001, ηp2 = 0.469) and an interaction effect of condition and scalp region (F(5,465)=52.51, p < .001, ηp2 = 0.361). However, these effects were not modulated by burnout occurrence; thus, we neither explored nor interpreted these effects. No significant differences were observed in alpha individual peak frequency between the studied groups.

Thus, we observed significantly lower alpha power in the burnout group in the eyes-open condition. Our results do not support hypothesis 1, which relates to lower alpha peak frequency, or hypothesis 2, which relates to lower beta power in burnout subjects. No significant group or interaction effect was observed. Our results support hypothesis 3, i.e., frontal alpha asymmetry is not observed in burnout subjects. This is in line with Luijtelaar et al.’s [29] observations.

Although to the best of the authors’ knowledge higher alpha power has not been observed in any burnout group,
this tendency could be expected as burnout reveals some symptomatological similarities to fatigue and depression, for which elevated alpha power has been reported [29, 49]. Thus, the presented results show a novel characteristic in burnout subjects, indicating cortical hyperactivity rather than hypoactivity, which is typical of depression and fatigue.

In further correlation analysis, in the eyes-open (Table 1) and eyes-closed (Table 2) conditions, we observed a significant relation between alpha power and two burnout symptoms: exhaustion and cynicism. For exhaustion, a significant negative correlation was revealed in the eyes-open condition for the anterior, central, and posterior areas. This was observed as global effect for each region and for all left and right areas. In the eyes-closed condition, a significant correlation was observed only for the anterior (globally and hemispheric), central left, and posterior global and left areas. In the eyes-closed condition, the correlation coefficients were weaker compared to the eyes-open condition. For cynicism, significant negative correlations were observed in the eyes-open condition for the global anterior and posterior areas and for both the left and right sides. Weaker correlations were observed for the central global and central left regions.

Further alpha power analysis took gender into account as an important characteristic which may reverse the pattern of relations between alpha power and burnout symptoms [49]. In line with Tement et al.’s findings [49], we observed that alpha power significantly correlated with burnout only in the male subjects (N=38). In females (N=57), although the tendency for negative correlation remains, the relations between alpha power and burnout symptoms in most areas failed to reach significance. The only significant negative correlation between exhaustion and alpha power was observed in the anterior right in the eyes-open condition (r=0.32, p=0.049). Male subjects, a significant negative correlation was observed between alpha power and cynicism for all areas in the eyes-open condition. These relations were observed for global analyses for the anterior (r=-0.37, p=0.021), central (r=-0.37, p=0.023), and posterior (r=-0.35, p=0.032) areas, as well for hemispheric analyses (anterior left: r=-0.41, p=0.011; right: r=-0.34, p=0.036; central left: r=-0.37, p=0.021; right: r=-0.35, p=0.029; posterior left: r=-0.35, p=0.033; right: r=-0.35, p=0.033). Interestingly, for male subjects, additional significant correlations were found between alpha power and efficacy; all these correlations were positive and were noticed only in the eyes-open condition (anterior left: r=0.33, p=0.042; central global: r=0.39, p=0.016, left: r=0.42, p=0.009, and right: r=0.36, p=0.028; posterior global: r=0.32, p=0.048, and left: r=0.34, p=0.035). These analyses reveal that gender may significantly change the pattern of relations between spectral EEG characteristics and burnout symptoms, thus supporting the findings and conclusions of Tement et al. [49].

Further analysis is based on the index of alpha power in the eyes-open condition, referenced to the eyes-closed resting condition, which is defined as the task-related power decrease/increase (TRPD/TRPI). This index is calculated as TRPD/TRPI% = (EO-EC)/EC x 100 [54–56] and is described as a valuable measure of cortical reactivity. A task-related power decrease (TRPD) of EEG alpha rhythms at about 8–12 Hz reflects cortical activation, while a task-related power increase reflects cortical deactivation [54]. Our analyses on the TRPD index revealed significant differences between the study groups in the central right (F(1,93)=6.78, p<0.05, $\eta^2_p=0.068$) and the posterior area (F(1,93)=5.86, p<0.05, $\eta^2_p=0.059$), indicating a higher TRPD index in burnout subjects. We also noticed a significant positive correlation between TRPD in the central right region and cynicism (r=0.27, p=0.009). This may suggest that burnout correlates with the
Table 1: Correlation coefficients between alpha power and burnout symptoms in the eyes-open condition (N=95).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Region</th>
<th>Site</th>
<th>MBI-GS: Exhaustion</th>
<th>MBI-GS: Cynicism</th>
<th>MBI-GS: Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes-open</td>
<td>Anterior</td>
<td>Global</td>
<td>-0.2952</td>
<td>-0.2761</td>
<td>0.1425</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>-0.2872</td>
<td>-0.2831</td>
<td>0.1380</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>-0.2897</td>
<td>-0.2586</td>
<td>0.1424</td>
</tr>
<tr>
<td></td>
<td>Central</td>
<td>Global</td>
<td>-0.2598</td>
<td>-0.2084</td>
<td>0.1229</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>-0.2754</td>
<td>-0.2265</td>
<td>0.1384</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>-0.2374</td>
<td>-0.1833</td>
<td>0.1058</td>
</tr>
<tr>
<td></td>
<td>Posterior</td>
<td>Global</td>
<td>-0.3050</td>
<td>-0.2722</td>
<td>0.1576</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>-0.3186</td>
<td>-0.2818</td>
<td>0.1768</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>-0.2899</td>
<td>-0.2583</td>
<td>0.1402</td>
</tr>
</tbody>
</table>

Table 2: Correlation coefficients between alpha power and burnout symptoms in the eyes-closed condition (N=95).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Region</th>
<th>Site</th>
<th>MBI-GS: Exhaustion</th>
<th>MBI-GS: Cynicism</th>
<th>MBI-GS: Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes-closed</td>
<td>Anterior</td>
<td>Global</td>
<td>-0.2130</td>
<td>-0.1282</td>
<td>0.1248</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>-0.2176</td>
<td>-0.1444</td>
<td>0.1316</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>-0.2044</td>
<td>-0.1214</td>
<td>0.1189</td>
</tr>
<tr>
<td></td>
<td>Central</td>
<td>Global</td>
<td>-0.1933</td>
<td>-0.0931</td>
<td>0.0920</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>-0.2184</td>
<td>-0.1212</td>
<td>0.1186</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>-0.1627</td>
<td>-0.0620</td>
<td>0.0643</td>
</tr>
<tr>
<td></td>
<td>Posterior</td>
<td>Global</td>
<td>-0.2139</td>
<td>-0.1336</td>
<td>0.1258</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>-0.2250</td>
<td>-0.1390</td>
<td>0.1324</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>-0.1967</td>
<td>-0.1151</td>
<td>0.1149</td>
</tr>
</tbody>
</table>

TRPD index, showing that greater cynicism is related to a higher TRPD index, which reflects lower cortical activation in the right central brain areas. Furthermore, we found a weaker but significant positive correlation between the TRPD index in the left anterior area and efficacy \((r=0.24, p=0.017)\), which may suggest that greater efficacy is related to lower cortical activity in the anterior left-brain area (indexed by higher TRPD).

Most of the studies of structural and functional brain changes in burnout included subjects who had severe and long-lasting symptoms and sometimes required at least 50% sick leave for stress-related symptoms for a minimum of 6 months before the study [23]. In the presented study, although it was conducted on a nonclinical burnout sample, the results confirm different brain characteristics in burnout subjects. We observed significantly lower alpha power in...
the burnout group in the eyes-open condition, which was not reported by previous EEG studies on burnout [29, 49]. This might be associated with the sample characteristics because Luijtelaar et al. [29] tested subjects with more severe burnout symptoms that led to a reduction of their work time of up to 50% for at least 3 months. It seems that the consequences of work-related stress and/or other health problems in their study sample were greater than in our sample of healthy and currently employed full-time workers. Therefore, it seems that burnout severity may be manifested by differences in the EEG power spectrum; however, further comparative analysis conducted among individuals with different burnout levels is required to draw clear conclusions. Referring to Tement et al.’s [49] study, their sample comprised students aged between 19 and 29 with no distinctive burnout outcomes, and their analysis was based on the eyes-closed condition only. Thus, the sample characteristics in all previously presented findings differ significantly, which may result in different study outcomes and lead to inconclusive findings.

4. Conclusions

The EEG power spectrum, regulated by anatomically complex homeostatic systems in the various frequency bands, is generally stable in healthy individuals but can be abnormal in some psychiatric disorders due to the dysfunction of this regulation [57]. The presented power analysis showed that in the eyes-open condition the alpha power was lower in the burnout group than in the controls, suggesting that power density might even be sensitive to differences between the healthy and the nonclinical burnout samples.

From the perspective of functional meaning, the reduced alpha power in burnout individuals suggests cortical hyperactivity and may be related to the greater mental effort and possible compensatory mechanisms developed by burnout subjects, as we pointed out in our previous findings [30]. The decreased alpha power is a novel characteristic of burnout syndrome and may indicate different mechanisms compared to depression and fatigue. However, further studies are required to verify these findings in other nonclinical and clinical burnout samples.

Finally, our findings indicate that gender may change the pattern of relations between spectral EEG characteristics and burnout symptoms; therefore, in future studies on burnout, gender should be considered as an important moderating factor.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

The authors would like to thank Katarzyna Popiel for her valuable contributions to data acquisition. The preparation of this paper was supported by a grant from the National Science Centre [Research project no. 2013/10/E/HS6/00163].

References


