Experience related changes in bioelectric brain activity of engineer-electronics at the air traffic control systems under round-o-clock service

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1. Introduction
High nervous-emotional tension, working with devices demanding continuous attention, shift regime including night and long work hours are known factors that could influence the nervous system functioning causing the specific longitudinal changes in the brain bioelectric activity.

The aim was to reveal the experience related changes in EEG of engineer-electronics under round-o-clock service.

2. Method

2.1 Subjects and procedure
Engineer-electronics aged 23-60 years (general experience 1-44 years, professional experience 1-36 years) were observed at their workplaces at the beginning (1st hour) and at the end (12th hour) of the day (8:00-20:00) and night (20:00-8:00) shifts.

2.2 Measurements
The monopolar registration of EEG activity was performed for 44 subject-shifts under eyes-closed conditions using the 10-20 system of electrode location (16 electrodes with linked ears as reference) [1, 2].

2.3 Analysis
Spectral power for delta (1-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), beta (13-35 Hz) and gamma (35-50 Hz) bands in relative units (% within the general spectral power) was analyzed in connection with general and professional experience of workers using Pearson correlation and ANCOVA (age – covariate) at p<0,05.

3. Results

3.1 General experience related changes
In workers of general experience 1-20 years some local significant correlations of EEG power and general experience were found at the day shifts end (decrease in theta-band at 1 electrode) and over-shift power change (decrease in theta at 3 electrodes, increase in gamma at 1 electrode), at the night shifts beginning (increase in delta and alpha by 1 electrode), end (increase in alpha at 1 electrode: effect of age was significant) and over-shift change (increase in delta at 2 electrodes, in gamma – at 1 electrode).

In workers of general experience 21-44 years more number of significant correlations were found: at the day shifts beginning (increase in beta at 5 electrodes) and end (increase in beta at 8 electrodes; decrease in theta at 7 electrodes: effect of age was significant at 6 electrodes), at the night shifts beginning (increase in theta at 1 electrode), end (increase in theta at 1 electrode, decrease in delta at 2 electrodes) and over-shifts change (increase in gamma at 2 electrodes, in beta - at 3, decrease in alpha - at 3 electrodes).
General Experience: 1-20 years

<table>
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<th>EEG band</th>
<th>DAY SHIFTS</th>
<th>9 h</th>
<th>19 h</th>
<th>difference</th>
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<td>🗿️</td>
<td>🗿️</td>
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<td>🗿️</td>
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NIGHT SHIFTS

<table>
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<th>NIGHT SHIFTS</th>
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<th>7 h</th>
<th>difference</th>
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<td>🗿️⁻</td>
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<td>Theta</td>
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<td>Gamma</td>
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<td>🗿️⁻</td>
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</tr>
</tbody>
</table>

Figure 1. General experience related changes in EEG power of engineer-electronics.
Designations: “difference” is equal to the [score at the end of the shift] minus [score at the beginning of the shift]. Triangle shows significant correlation between EEG power and experience (p<0.05), positive (▲) or negative (▼) one. Circle shows significant effect of age (p<0.05).

Professional Experience: 1-15 years

16-36 years
Figure 2. Professional experience related changes in EEG power of engineer-electronics. Designations see fig. 1, the same.

3.2 Professional experience related changes
In workers of professional experience 1-15 years, in the opposite, more number of local significant correlations were found compared to more experienced group: at the day shifts beginning (increase in beta at 3 electrodes, in delta – at 2 electrodes: effect of age was significant at one of them), end (increase in gamma at 1 electrode: effect of age was significant) and power over-shift change (increase in theta and alpha - by 1 electrode; decrease in beta and gamma - by 1 electrode; in delta increase at 2 and decrease at 2 electrodes: effect of age was significant for the each case at 1 electrode), at the night shifts beginning (increase in delta at 2 electrodes, decrease - at 1 electrode), end (increase in beta at 2 electrodes, decrease in theta at 1 electrode) and power over-shift change (increase in gamma at 6 electrodes, decrease in theta at 3, in delta – at 2 electrodes).

In workers of professional experience 16-36 years some significant correlations were found with power change over the day shifts (increase in alpha at 2 electrodes) and more number – over the night shifts (increase in gamma at 3 electrodes, beta (significant age effect) and delta – by 1 electrode, decrease in alpha at 8 electrodes: effect of age was significant at two of them).

4. Discussion
The leading general experience related changes in EEG are the increase in beta-band power at the beginning and the end of the day shifts in workers experienced beyond 20 years, that is associated in literature with cognitive performance, attention, nervous-emotional tension increase [3, 4] and corresponds to the work place factors of engineer-electronics. This is accompanied with the decrease in theta-band power (mainly – age caused one) that could be associated with the decrease in cognitive control [5, 6], temporal information maintenance [7, 8].

Over-shift experience related increase in gamma-band magnitude is characteristic for night shifts, especially pronounced - along with the increase in professional experience, manifesting, due to the literature data, the working memory involvement, performance under stressful conditions [7, 9-11] that also corresponds to the work load features pointing the stress character of working at night. Under increase in professional experience this is accompanied with the compensatory decrease in the delta and theta power during 1-15 years of professional experience, in the alpha-band (partially – owing to the aging effect) – during 16-36 years. Decrease in alpha-band power is associated with the increase in activation and sympathetic influences [10] due to the morning body activation against the background of fatigue. In this, sympathetic augmentation increases the risk of coronary heart diseases and hypertension development [12-14]. So, the alteration in the underlying mechanisms to maintain the required workability during night shifts with the increase in engineer-electronics professional experience after 15 years – from the over-shift decrease in cognitive control to the increase in sympathetic activation – could cause the negative health consequences, and require new facilitating work-rest regimes for this category of workers at the night shifts.

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References