Earthquake Related Startle Reaction and Its EEG Correlates

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Key Words
Acute Stress Reaction
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Startle Response

ABSTRACT

The acute effect of traumatizing events on the human brain has long been studied. The major obstacles to this endeavor have been the severity and the delay from time of exposure to the traumatizing events. To avoid these issues, EEG and clinical examinations of 18 healthy, drug-free subjects were performed 2 weeks after an earthquake occurred in Turkey in 1999. It was found, for the first time to our knowledge, that EEG parameters can predict startle response in acute stress reaction correctly in 100% of the cases. EEG measures of the reactivity to eyes opening were especially important in this regard.

INTRODUCTION

Startle reactions and hypervigilance were the predominantly observed symptoms of victims of an earthquake that occurred in Turkey in 1999. Meltzer et al.[1] stated that, among the post-disaster symptoms, hypervigilance and startle are unique. Startle reaction is a rapid, generalized motor response to a sudden, surprise stimulus. Hoy et al.[2] concluded that the startle response is a phylogenetically universal behavioral act of avoidance provoked by any kind of intense, unexpected stimuli. It has been reported that interruption of descending cortical inhibitory influences can release exaggerated startle reflexes. In general, findings suggest that the excitatory and inhibitory systems of the central nervous system at least partially have some significance in eliciting abnormal startle response.[3,4]

Excitability changes of the CNS as a function of electroencephalographic (EEG) characteristics have been investigated in several studies. Findings during eyes open are: diminished "blocking" of the background alpha rhythms in the occipital regions,[5] decreased delta genesis and a potentiation of the faster rhythms' relative power,[6] asymmetric functional changes assessed with EEG,[7] closely related with the hyperexcitability in CNS.[8] EEG indicators of excitability have been thought to be related to both thalamic and cortical neurones.[6]

We hypothesized that startle reaction can be predicted with EEG reactivity to eyes opening and closing measured reliably from the occipital leads. A possible relationship should be of value in introducing an easy diagnostic, research and screening tool for startle reaction.

From the methodological point of view, the degree and timing of exposure to the traumatizing events have been considered important obstacles when studying the effect of psychic trauma on the human brain.[9] In this study, we have taken advantage of identical timing, duration and intensity of the earthquake on all subjects to study the acute stress reaction.

MATERIALS AND METHODS

Eighteen subjects were studied 2 weeks after the earthquake (12 males, 6 females), aged 21-51 years (mean 32.7 ± 9.3). They gave informed consent for the study. All subjects were right handed, had normal visual functioning, and no previous neuropsychiatric or medical history of disease. The earthquake had physically affected none of them. Each subject had a normal routine EEG. Clinical examinations were conducted, and the diagnosis of acute stress reaction was made on the basis of DSM-IV criteria. None of the subjects met any other diagnostic category of DSM-IV. A scale for post-traumatic stress reaction was not used because the experiment was not done at least 6 months after the traumatizing event. Subjects were asked if they are startled by unexpected sounds, and/or motions of objects in their environment. Their responses were coded either yes (12 subjects), or no (6 subjects), without any further analysis.

Scalp EEGs were performed using silver chloride electrodes applied with collodion at O1 and O2 according to the International 10-20 System. Referential linked ear electrodes were used. Impedances were kept below 5kOhm. The activity derived from the occipital leads was recorded in a shielded room (highpass filter 2 Hz, sampling rate: 128 Hz, gain: 16000, notch filter on, 50 micro V/cm). A room temperature of 23° C was maintained to avoid excessive perspiration. Special attention to the possible negative effect of the severe stress on nocturnal sleep was given during recordings and the EEG examination. During the recordings, the subjects were supine, and their vigilance level was kept as constant as possible by verbal commands. The EEGs were recorded for

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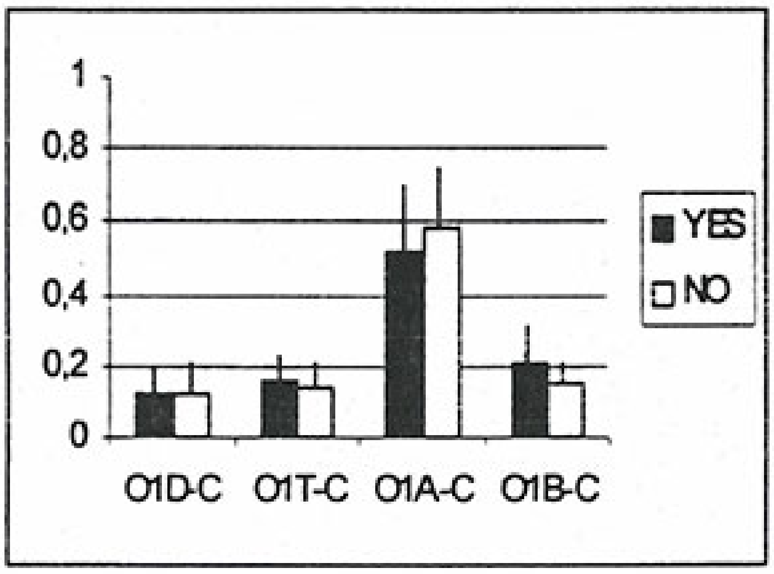

Figure 1
t-statistics of eyes closed data O1; positive and negative startle history.

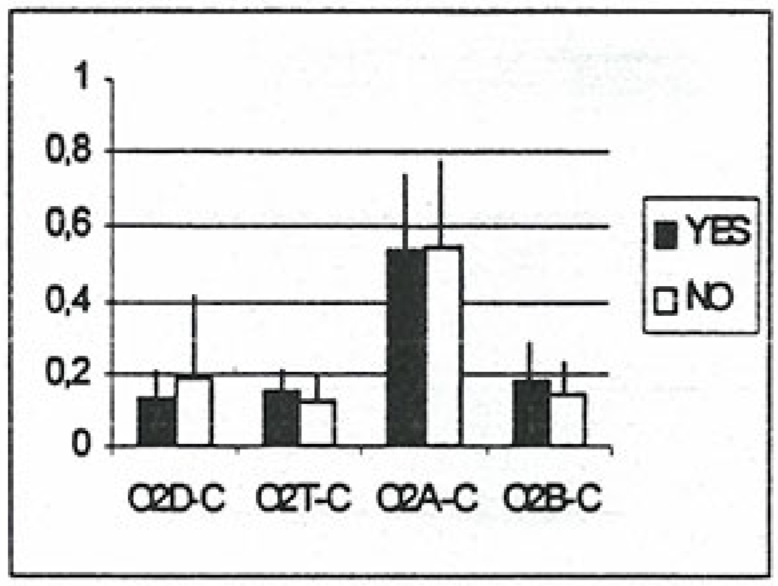

Figure 2
t-statistics of eyes closed data O2.

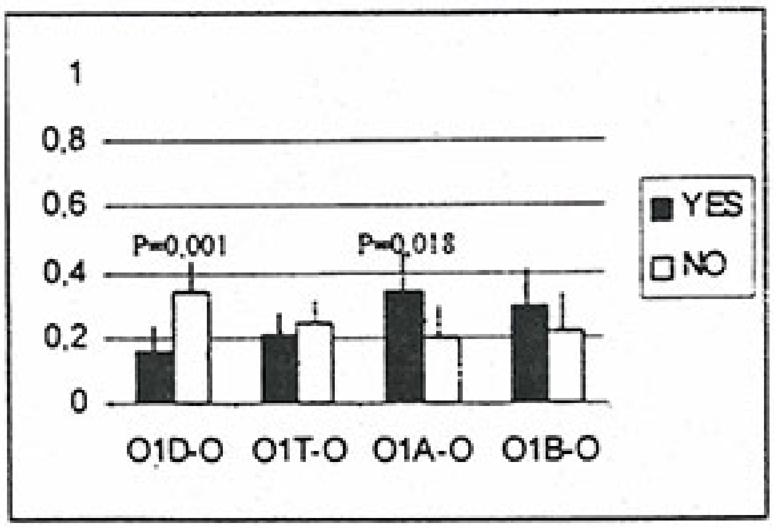

Figure 3.
t-statistics of eyes open data O1.

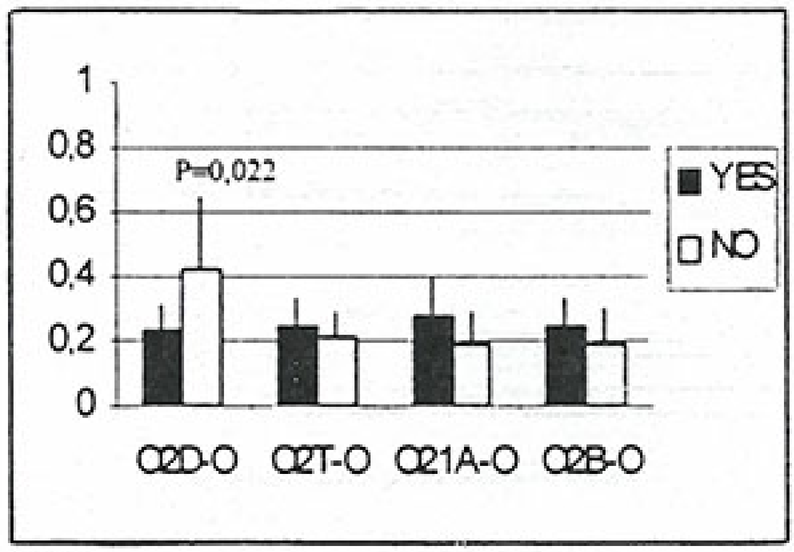

Figure 4.
t-statistics of eyes open data O2.

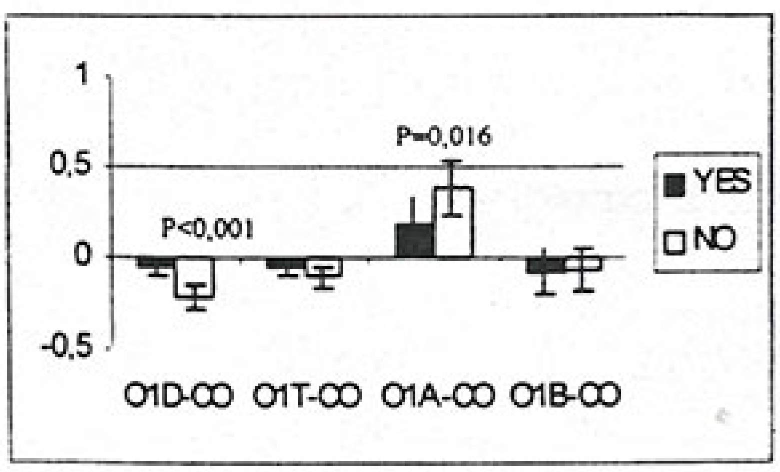

Figure 5.
t-statistics of eyes CO (closed-open) data O1.

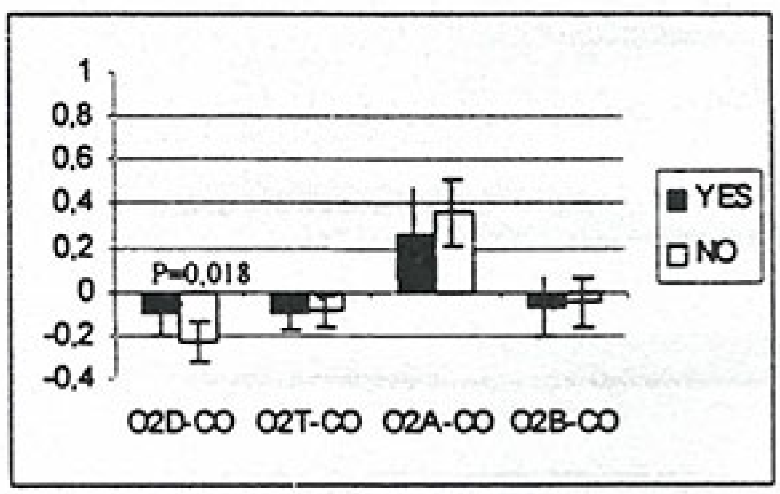

Figure 6.
t-statistics of eyes CO (closed-open) data O2.

Note: vertical corrdinates show percent powers; horizontal coordinates show bands. O: eyes open; C: eyes closed; CO: closed-open; D: delta; T: theta; A: alpha; B: beta.

50 epochs with eyes closed, 50 epochs with eyes open; epoch length was 2 seconds. Fast Fourier Transformation applied to artifact free epochs.

The mean power spectrum was obtained from each subject in each different eyelid condition (open-O; or closed-C). Data obtained from each channel was stored for further analysis. The following frequency bands of the mean power spectra were considered: delta (abbreviated as D) (2-4 Hz), theta (abbreviated as T) (4-8 Hz), alpha (abbreviated as A) (8-12 Hz), beta (abbreviated as B) (12-16 Hz). Activity below 2 Hz was excluded to avoid misleading results due to eye movements. EEG percent power data of each frequency band (delta, theta, alpha, beta) obtained from O1 and O2 leads under open (O) or closed (C) eyelid conditions and

Table 1
Paired samples t statistics for YES responses

		Mean	N	Std. Dev.	t	p
Pair 1	O1_DC	.1200	12	0.07553	-2.231	.047
	O2_DC	.1310	12	0.07500		
Pair 2	O1_TC	.1567	12	0.07139	1.103	.293
	O2_TC	.1488	12	0.06093		
Pair 3	O1_AC	.5163	12	.1799	-1.224	.247
	O2_AC	.5398	12	.1946		
Pair 4	O1_BC	.2096	12	.1044	1.674	.122
	O2_BC	.1775	12	.1058		
Pair 5	O1_DO	.1638	12	0.07279	-2.465	.031
	O2_DO	.2324	12	0.07724		
Pair 6	O1_TO	.2058	12	0.07159	-1.799	.100
	O2_TO	.2432	12	0.08669		
Pair 7	O1_AO	.3388	12	.1100	5.138	.000
	O2_AO	.2731	12	.1127		
Pair 8	O1_BO	.2892	12	.1150	1,232	.244
	O2_BO	.2493	12	0.08180		
Pair 9	O1D_CO	-0.043833	12	0.04947	2.330	.040
	O2D_CO	-.1014	12	0.09848		
Pair 10	O1T_CO	-0.049000	12	0.04715	2.306	.042
	O2T_CO	-0.094333	12	0.07539		
Pair 11	O1A_CO	.1775	12	.1514	-3,308	.007
	O2A_CO	.2668	12	.2064		
Pair 12	O1B_CO	-0.079667	12	.1241	-.342	.738
	O2B_CO	-0.071750	12	.1331		

their differences (abbreviated as CO) were used as the alternative models for stepwise discriminant analysis.

RESULTS

Among the models, only the data of arithmetical differences between the percent powers of the frequency bands of closed and open eyes satisfied the obligatory statistical criteria of sample size sufficiency, homogeneity of variance for conducting the discriminant analysis (Box's M: $F = 0.585$ $p = 0.445$; Wilks' Lambda $X^2 = 18.734$ $p < 0.001$). The results of the stepwise discriminant analysis showed that the model was able to discriminate between the startle positive group and the negative group 100% correctly. Changes in delta rhythm in the O1 lead had a predictive value. We conducted several Student's t tests to evaluate the differences between the percent powers of the frequency bands obtained during different conditions.

No significant difference was found under resting and eyes-closed conditions between the startle positive and negative groups. Differences in delta and alpha bands in O1 appeared when the subjects opened their eyes. Even the significance of the differences was magnified when the quantitative changes in percent powers due to the eyes opening and closing were taken into the analysis.

It is clearly seen in Figures 1-6 that subjects with positive startle history have fewer changes due to eyelid status in their alpha and delta rhythms. Findings in delta powers were not asymmetric. O1 and O2 leads show the same significant differences. However, in terms of alpha reactivity only the left occipital alpha power shows a significant change. Startle positive subjects have less alpha power during eyes-closed conditions with no significant reactivity, and high delta power particularly during eyes-open states without significant changes. Although a significant level was not reached, data showed increased beta activity in both leads in each condition.

Paired t tests were conducted for each frequency band of each lead on the two groups of startle positive and negative subjects. Subjects with a positive startle history showed significant asymmetric changes only in delta power during the eyes-closed condition. The left occipital region had less power than the right. Significant lateralization in alpha and delta powers occurred during the eyes-open condition. Delta had less power in the left side than that seen during the eyes-closed status. Alpha had less power in the right side. The difference between those two different states showed in delta, theta and alpha powers in the occipital leads. Left occipital delta, theta and alpha powers appeared less reactive to the eyes opening and closing procedure (Table 1). There was no asymmetry in the startle negative population (Table 2). According to the independent t tests, there was no significant gender difference found in any EEG parameters in any conditions.

Table 2

Paired samples t statistics for NO responses

		Mean	N	Std. Dev.	t	p
Pair 1	O1_DC	.1232	6	0.08120	-.809	.455
	O2_DC	.1870	6	.2283		
Pair 2	O1_TC	.1383	6	0.06699	1.109	.318
	O2_TC	.1213	6	0.07101		
Pair 3	O1_AC	.5848	6	.1617	.644	.548
	O2_AC	.5505	6	.2260		
Pair 4	O1_BC	.1552	6	0.05569	.638	.552
	O2_BC	.1395	6	0.08564		
Pair 5	O1_DO	.3365	6	.1018	-1.404	.219
	O2_DO	.4168	6	.2332		
Pair 6	O1_TO	.2422	6	0.06771	.870	.424
	O2_TO	.2072	6	0.08551		
Pair 7	O1_AO	.2012	6	0.08919	.578	.588
	O2_AO	.1882	6	0.09955		
Pair 8	O1_BO	.2182	6	.1143	.945	.388
	O2_BO	.1868	6	.1094		
Pair 9	O1D_CO	-.2133	6	0.06634	.461	.664
	O2D_CO	-.2298	6	0.09520		
Pair 10	O1T_CO	-.1038	6	0.06183	-.581	.586
	O2T_CO	-0.085833	6	0.07170		
Pair 11	O1A_CO	.3837	6	.1547	.373	.724
	O2A_CO	.3623	6	.1537		
Pair 12	O1B_CO	-0.063000	6	.1126	-.840	.439
	O2B_CO	-0.047333	6	.1133		

DISCUSSION

This study indicates that the subjects with a positive startle history after an earthquake showed the following EEG changes: 1. Subtracted percent powers of frequencies obtained during eyes closed and eyes open was the only data set that fit statistically perfectly to conduct discriminant analysis. Reduced delta-power response to eyes opening was the predictor to discriminate the startle positive group from the negative group. The classification power of reduced delta change in the O1 lead was 100%. To our knowledge, this has been observed for the first time. 2. There was decreased delta power in the O1 lead in eyes closed and open conditions, with less response to eyelid changes. 3. Less alpha reactivity occurred in the open eyes/eyes closed procedure. 4. The left occipital region showed less asymmetric delta and alpha powers, and less response to eyes opening in delta, theta and alpha frequencies.

These findings support the idea that startle reaction can be predicted with EEG reactivity to eyes opening and closing recorded from the occipital leads. Although the EEG changes observed in the group with startle reaction symptoms may theoretically indicate the hyperexcitability in CNS,[3-8] the underlying neurophysiological mechanisms remain to be clarified.

These data indicate that simple open-eyes, closed-eyes EEG recording is a useful tool for understanding the mechanisms of startle response, for screening the survivors for possible psychiatric complications of disasters in general, and for possible complications of the startle reactions in particular. Screening is strongly recommended to prevent severe and chronic post-traumatic stress reactions.[10] Screening might also prevent exaggerated startle reaction related injuries. The procedure seems to have its own advantage of screening reliably and economically a large population in a short time.

This study also indicates that alterations of brain function are highly correlated with the self-reported clinical finding of the startle response. Therefore, EEG might also be used as a confirmatory tool in clinical practice when examining the startle reaction of the survivors of disasters.

Since the study involved only one pair of leads, our results concerning possible alterations of spatial organization in startle response positive subjects should be cautiously accepted as evidence of hemispheric lateralization. Although the study design is relatively satisfactory for the conditions of a serious disaster,[9] lack of control subjects who are not affected by the earthquake, and lack of eye-blink startle measurements might be considered as other shortcomings of this study. Before applying these findings to the startle reactions occurring in other states, further studies in different conditions are needed.

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