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EEG ABNORMALITIES IN DIFFERENT TYPES OF CRIMINAL BEHAVIOR

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Abstract

Electroencephalographic abnormalities in psychopathic personalities and in forensic population were reported in many EEG studies but at this time the problem presents still unresolved question. Within this context aim of this study is to present findings of several EEG abnormalities in different types of criminal behavior in comparison to healthy controls. Studied sample included four groups. The first group (n=20) included offenders of violent criminal activity evaluated as impulsive, non-deliberate, affectively motivated and affectively aggressive. The second, control group (n=20) included individuals who committed no criminal activity and has no mental disorder. The third group (n=20) included violently deliberately behaving delinquents and the fourth group (n=20) included delinquents performing property criminal activities, non-violent and non-impulsive.
An EEG abnormality was found in 70 % of subjects. Multiple abnormalities were found in 35% of the subjects. In non-impulsive delinquents higher rate of EEG abnormalities were found (30 % and multiple abnormalities in 5 %). Other groups i.e. thefts and the control group show no significant EEG changes. In summary, the results show the highest occurrence of EEG abnormalities in the group of impulsive criminals. The results are in agreement with previous findings that did not find specific EEG signs in different types of criminal behavior exception of impulsive aggressive criminals.

Key words: EEG abnormalities; criminal behavior; impulsivity

INTRODUCTION

Electroencephalographic abnormalities in psychopathic personalities and in forensic population were reported in many EEG studies but at this time the problem presents still unresolved question (Mednick et al., 1982; Patrick, 2008; Loeber & Pardini, 2008). There are many studies evaluating EEG in criminals, personality disorders and violent offenders (Ellingson, 1954; Hare, 1970; Driver et al., 1974; Syndulko, 1978; Mednick et al., 1981; Blackburn, 1983; Veneables & Raine, 1988; Hsu et al., 1985; Pillman, Rohde, 1999; Pillmann et al., 1999; Bars &Heyrend, 2001; Frierson & Finkenbine, 2004; Petersen et al., 2007). The findings, however, were mainly nonspecific and the studies suffered from methodological problems. The significance of these EEG abnormalities is thus far a matter of debate (Lindberg et. al., 2005; Patrick, 2008; Loeber & Pardini, 2008; Pilman et al., 1999).

Still most of available studies show that the frequency of EEG abnormalities is much higher in offenders than in non-delinquent population. Hill and Pond (1952) explored hundreds of offenders and noted EEG abnormality in nearly 50% of cases. This finding is presently seconded by other studies in murderers, violent, but also non-violent offenders (Mednick et al., 1981; Petersen et al., 2007). Similarly, Petersen (2007) shows that among EEG characteristics found in non violent offenders are different non-specific changes, e.g.:

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paroxysmal activity during sleep, slow alpha activity and spectral-analytical measurements corresponding to lower EEG ages than the individuals' actual ages. In other study Pillmann et al. (1999) assessed the relationship of EEG abnormalities and violent criminal behavior in 222 defendants. They did not find connection between the number of violent offenses and EEG abnormalities in general. Further they reported that focal abnormalities, however, especially of the left hemisphere, were related to a significantly higher number of violent offenses. The findings suggest that impairment of left hemisphere functions may enhance the propensity for violent behavior in a subgroup of offenders (Pillmann et al., 1999).

In this context it is needed to note that several authors emphasized that subjects with personality disorders and criminal behavior have the same occurrence of EEG abnormalities as other mental disorders (Volavka, 1990; Small, 1993).

In our previous studies we have reported different EEG abnormalities and P 300 changes in different types of criminal behavior (Zukov et al. 2008) which correspond to results of other studies (e.g. Mednick, 1982 etc.). Following the previous results the aim of the present study is to find specific changes in EEG in persons with three types of criminal behavior without psychiatric history in comparison to healthy controls.

METHODS

Participants

Four groups of subjects were compared in the study. The first group (n=20) (hereinafter referred to as “I” – impulsive) included offenders of violent criminal activity evaluated as impulsive, non-deliberate, affectively motivated and affectively aggressive. This regarded delinquent behavior in the framework of the uncontrolled affect without forensic influence for the examined subjects. Impulsively aggressive individuals in no case behaved in the framework of pathological affect related to a qualitative disturbance of consciousness. The second, control group (n=20) (“N” – norms) included individuals who committed no criminal activity and has no mental disorder. The third group included violently deliberately behaving delinquents (n=20) (“NI”– non-impulsive). The fourth group included delinquents performing property criminal activities, non-violent and non-impulsive (n=20) (“T”– thieves). All subjects included in the first group were forensically examined in 2002 – 2007 by one of the authors. The examined subjects were assessed for a period of max. 1 year from criminal act commitment The control group consists of healthy subjects from non-clinical and non-criminal population. The controls were psychiatrically healthy according to DSM IV criteria. IQ and age of the studied groups are in the Table 1. It shows high level of inter group equitableness caused by careful pairwise selection. Subjects in all groups were normal and had no psychiatric or neurologic disorders in their anamnesis with exception of personality disorders in groups of impulsive and non impulsive criminals. The study compared individuals pairwise.

Table 1. Age and IQ in all groups.

Group	Age		IQ	
	AVG	*SD*	*AVG*	*SD*
I	40,25	9,32	106,05	8,17
NI	40,75	9,20	105,85	8,46
T	40,35	9,44	106,05	8,48
N	40,65	9,36	105,95	8,83

EEG examination

EEG examination was performed using the system 10 – 20 with 18 channels imbedded in EEG cap with Pz reference electrode. In the EEG examination the following parameters according to current guidelines (Abou-Khalil & Misulis, 2006) were evaluated: abnormalities of basic activity (abnormalities of alpha activity; evaluated only frequency 7.5 – 8 Hz PO), abnormality of beta activity, abnormal slow activity theta, delta waves, and epileptiform graphoelements. EEG examination consited of 20 min recording, including rest conditions (10 min) and hyperventilation phase (HD) used as activation method (4 minutes; 2 minutes by mouth and 2 minutes by nose). After the end of HD, EEG was continuously recorded for another 2 minutes (dynamic of pathological changes was evaluated, how promptly the HD fades away). All examinations were performed at the Psychiatric Clinic of 1st Faculty of Medicine in Prague and evaluated by the authors.

Statistical analysis was performed by using the Statistica software package. Because the analyzed data were not normally distributed, group differences were tested with the nonparametric tests (Kruskal-Wallis. ANOVA and Median test) for statistical significance.

RESULTS

Table 2 presents EEG findings of the present study. Only abnormalities that were unambiguously present were rated. For analysis, EEG abnormalities were coded according to usual criteria that include focal abnormalities and nonfocal abnormalities (diffuse slowing of background rhythm, intermittent theta or delta slowing, paroxysmal activity). These abnormalities were clasified into four groups including alpha abnormality, theta abnormality, delta abnormality, epileptoform abnormality. Multiple abnormalities (more than one clasified abnormality) were treated as a specific cathegory.

Table 2. Count and type of EEG findings in all groups (Note: I– impulsive; N– norms; NI– non-impulsive; T– thieves).

EEG findings	Group I	NI	T	N
	(n=20)	*(n=20)*	*(n=20)*	*(n=20)*
Alpha abnormality	8	2	2	0
Theta abnormality	2	2	0	2
Delta abnormality	1	2	0	0
EPI abnormality	6	1	1	1
Combined EEG abnormality	7	1	0	0
Total subjects with EEG abnormality	14	6	3	3

The table shows the highest occurrence of all abnormalities in the group of impulsive criminals – 70% of subjects show an EEG abnormality and multiple abnormalities were found in 35%. Non-impulsive delinquents still show higher rate of EEG abnormalities incidence - 30% and multiple abnormalities in 5%. Other groups – thefts and control group show no significant EEG changes.

Table 3. **Statistical significance between all groups.**

EEG findings	Between group differences		
	2	*df*	*p*
Alpha abnormality	14,11	3	,0027*
Theta abnormality	2,16	3	,5394
Delta abnormality	3,80	3	,2828
EPI abnormality	9,38	3	,0245*
Total count of abnormalities	14,46	3	,0004*

Table 3 presents results of statistical significance analysis. Total count of abnormalities was found as the most significant differentiating parameter among studied groups (^{2}*=14,46, df=3, p<,0004*). Further alpha abnormalities are found as very significant sign (^{2}*=14,11, df=3, p<,0027*). Theta and delta abnormalities were not determined as differentiating parameters among all groups. Different statistical significance in delta or theta abnormality was not found even between groups of impulsive criminals and control group by Mann-Whitney U test – theta abnormality (*z=0;U=200;p=1,00*) delta abnormality (*z=,27;U=190;p=,03173*). The results are presented in Table 4 where still the most significant difference is found in total count of EEG abnormalities and alpha abnormalities.

Table 4. Statistical significance between impulsive criminal and normal group.

EEG findings	U	Z	adjusted p
Total count of EEG abnormalities	85,50	3,10	0,0001*
alpha abnormality	120,00	2,16	0,0304*
theta abnormality	200,00	0,00	1,0000
delta abnormality	190,00	0,27	0,7994
EPI abnormality	150,00	1,35	0,1812

The group of impulsive aggressive offenders shows the most significant difference in EEG abnormalities in comparison to healthy controls. The difference is represented mainly by the total count of EEG abnormalities (*p< ,0027*) and alpha abnormalities (*p< ,0245*). Evidence for a specific EEG patterns in other groups of criminals were not unambiguously determined.

DISCUSSION

The results show significant EEG abnormalities only in the group of impulsive criminals. From this we can conclude that previously reported findings of a general increase in nonspecific EEG abnormalities associated with violent recidivism in general (Pillman et al., 1999) were not confirmed by our investigation. Several recent studies have also failed to replicate these findings (Krakowski et al., 1989; Pillmann et al., 1999). According to several authors (Pillman et al., 1999) more advanced recording techniques, higher numbers of electrodes placed, and better artifact control may be responsible for the differences from earlier results. However, our findings are in accordance with recent studies (e.g.: Pillman et al., 1999; Frierson & Finkenbine, 2004) that confirm neither specific nor non specific EEG findings as predictors of criminal behavior in general. It brings information about significantly higher occurrence of specific and non-specific EEG changes in offenders of violent criminal activity evaluated as impulsive, non-deliberate, affectively motivated and affectively aggressive. These results show that impulsive agresive behavior may have a different neurophysiological corelates and therefore from the clinical and forensic point of view represent a totally different category from non-impulsive aggressive behavior.

These findings corespond to our previous results of P 300 in impulsive aggressive criminals (Zukov el al., 2008) as also to other studies (e.g.: Mednick, 1981; Matayo, 2008). The results suggest a presence of cognitive deficits and/or attentional system deficits, and likely the existence of a specific sensory system in individuals with impulsively aggressive behavior (Patrick, 2008). This points to possible existence of a neurophysiologic correlate for impulsively aggressive delinquent behavior in the framework of the "uncontrolled affect".

In this context it is likely that the cognitive deficit related to impulsive forms of aggressive behavior could be located in a single cortical area (Lindberg et. al., 2005; Patrick, 2008; Loeber & Pardini, 2008). Regarding specific cognitive deficits, there are also questions how much "uncontrolled" affect relates to other phenomena – as especially to dissociation or whether triggers of uncontrolled behavior may be related to neurobiological consequences of traumatic or stress events (Bob, 2008).

This assumption seems to be also confirmed by neuropsychological testing indicating the presence of cognitive deficits in these individuals, e.g. in speech areas or in areas designed for identification of emotional status or the incapability to learn from previous mistakes. Furthermore, disorders of automatic sensory functions (reactions), which are damaged in impulsively aggressive individuals, is probable (Best et al., 2002). Likewise, the administration of cocaine or other amphetamines results in a decrease of the amplitude and increase of readiness to perform impulsive acts (Moeller et al., 2002). Cloninger describes the correlation of increased impulsiveness and hypofrontality in individuals in the second stage of alcoholism, in relation of which, the significant hereditary element is described (Cloninger et al., 1981). Expert evaluation of criminal activity in the framework of the "uncontrolled affect" is thus the subject of extensive discussions by experts (Loeber, Pardini, 2008).

Further studies in this field are needed to pay attention especially to modern a detailed evaluation of brain activity in the group of impulsively aggressive perpetrators – for example use nonparametric methods of evalution or low resolution brain electromagnetic tomography could bring interesting information. Further work should also distinguish between changes in brain activity due to actual emotional (Esch & Stefano, 2007) or cognitive (Petrek, 2008) changes and due to relatively constant basal personality traits that may correspond with "uncontrolled" affect. New and more detailed findings in this area may bring very important information to the current debates about forensic assessment of uncontrolled affect with violent manifestation and other important questions in the field of forensic sciences (Garland & Glimcher, 2006).

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