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Original Article

Comparisons between recidivists and non-recidivists on affective, behavioral, and P300 brain activity

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Abstract

The evidence from previous studies showed that frequent exposure to violent media or circumstances affects an individual's desensitization to violence, aggression, remorse, and leads to psychopathy in adult life. However, studies of a recidivist's brain activity have not been much explored. Thai male students (N=43) aged 18–35 years were included. The male recidivist group participated in violent circumstances of two or more times. Both recidivists (n=21) and non-recidivists (n=22) were undergone ERP recording while conducting the three series of tasks. The target ERP generated in these tasks were the P300 wave recorded over Pz electrode sites. The recidivists showed significantly smaller P300 amplitude than the non-recidivists when responding to target stimuli in three series of tasks. In addition, the recidivists had significantly higher score of physical aggression, uncaring, and callousness than the non-recidivists. Reduced P300 amplitude correlated to high physical aggression, uncaring, and callousness on the recidivist group.

Keywords: aggression, callous-unemotional traits, EEG, P300, recidivism

1. Introduction

School, campus, and university crimes have been critical problems in various countries (Clark, 2019). According to previous studies, juvenile crime rates have increased in youth and university students in Thailand (Panezai, Panezai, Wassan, & Saqib, 2019; Suradanai, 2018). Juvenile crime, especially, gang attack of university students is notorious in Bangkok, which is the capital city of Thailand (Daily news, 2019). The university gangs carry weapons such as guns, knives, and others. In consequence, some opponents were shot, seriously injured, or become disabled. These university gang attacks occur repeatedly. These events often involve recidivism: the tendency to relapse a convicted offend. Mejovsek, Budanovac, and Sucar (2001) suggested that recidivists were more physically aggressive compared to non-recidivists. Individuals with high trait aggression show deficits in response to inhibition, especially, facing angry expressions (Sun *et al*., 2020) and poor response to fear recognition (Gao, Raine, Venables, Dawson, Mednick, 2010), as a result, reduces their empathy to a victim's suffering.

As we mentioned above, our research was conducted to assess the differences between recidivists and non-recidivists in the aspects of brain activity, affective, and behavior correlates, in order to understand the national recidivism problem of gang attacks in Thailand.

1.1 Brain activity correlates of recidivists

The P300 event-related potential (ERP), is a time-locked measure of the electrical potential activity of the cerebral surface representing a distinct phase of cortical processing extracted from the electroencephalogram (EEG) (Kropotov, 2016; Luck & Kappenman, 2011). This method was applied to assess the neural activity of cognitive processes and memory-updating (Picton, 1992; Polich, 2007). Positive deflection can be observed at approximately 200–800 ms after stimulus onset (Picton, 1992). The P300 ERP (as known as a

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classic P300) is elicited by using oddball paradigm: a target stimuli discrimination paradigm that comprises two different stimuli (rare target vs. frequent standard (non-target) stimuli), randomly distributed in a sequence. The P300 amplitude that elicited from target stimuli is obviously demonstrated over the parietal area site (Polich, 2003), i.e., Pz, P3, P4.

The P300 ERP facilitates this current study to assess a relationship between attentions to different kinds of target stimuli in recidivists compared with non-recidivists. Results from previous studies showed that reduction of the P300 amplitude in response to target stimuli was one of the brain impairment indicators in individuals with aggression, antisocial behaviors (Beech, Carter, Mann, & Rotshtein, 2018), and violent inmates (Bernat, Hall, Steffen, & Patrick, 2007). Reduced P300 responses were associated with disinhibition or inhibitory deficit (Patrick *et al*., 2006). In studies with adult samples, reduced parietal P300 amplitude predicted the development of externalizing disorders such as conduct disorder, antisocial behavior, disinhibitory personality (Pasion, Fernandes, Pereira, & Barbosa, 2018; Patrick *et al*., 2006).

Typically, P300 amplitude is larger when responding to high-arousal affective pictures presented in both passive viewing and active tasks (Pasion *et al*., 2018). Nonetheless, previous studies showed smaller P300 responses to violent pictures among violent game players (Bartholow, Bushman, & Sestir, 2006; Engelhardt, Bartholow, Kerr, & Bushman, 2011). Therefore, recidivists who were frequently exposed to violent circumstances might have poor active responses to violent target stimuli.

Previous studies showed the relationships between P300 and affective stimuli. Deficit emotional processing was found in psychopaths in which they had the smaller P300 amplitude when they were responding to affective stimuli than non-psychopaths (e.g., Briggs & Martin, 2009; Williamson, Harpur, & Hare, 1991).

Studies on violent recidivists, especially in the non-inmate groups, still limited. It might be a crucial problem to take a closer look at this group in order to provide psychological treatments to them when it should be necessary in order to prevent further criminal acts.

1.2 Callous-unemotional traits (CU traits) correlates of recidivists

The CU traits comprise 3 subscales including Unemotional, Callousness, and Uncaring. These traits refer to individuals who lack of empathy, guilt or remorse, and have a shallow affect (Frick, 2003). These affective components are prominent in the psychopath. CU traits are also indicators in psychopathy checklists (PCL-R) (Hare, 1991). CU traits significantly correlate with aggression, antisocial, delinquency, psychosocial impairment, and conduct problems (Ansel, Barry, Gillen, & Herrington, 2015; Essau, Sasagawa, & Frick, 2006). Furthermore, the uncaring and callousness subscales of CU traits can decrease the attention of others' fearful faces and positively related to bullying and lack of empathy for victims (Ciucci & Baroncelli, 2014; Pardini, 2006; Pasion *et al*., 2018; White & Delk, 2017). Studies of Juvenile justice settings suggested that youths with CU traits were likely to repeat wrongdoing behaviors due to the lack of fears and punishment concerns (Pardini, 2006; Viljoen, McLachlan, & Vincent, 2010).

1.3 Aggression and recidivists

According to neurobiological research, increased violence and instrumental aggression could be explained through damages of physiological characteristics that indicate the social brain including the amygdala, the orbital prefrontal cortex, the anterior cingulate cortex, and the insula (Mitchell & Beech, 2018) following this notion we investigated more electrodes in Fp1, Fp2, T7, T8. Frequent exposure to violent activities could lead individuals to become desensitized to violence and more aggressive (Bartholow *et al*., 2006; Engelhardt, Hilgard, & Bartholow, 2015). Males are more likely to return to prison due to aggressive feelings, criminal associations, carrying weapons, and alcohol abuse (Benda, 2005). Furthermore, early-onset of substance abuse found associations with psychopathy, aggression, and recidivism (Gustavson *et al*., 2007). Recidivists had higher aggression scores on physical aggression (Archer, 2004).

The present study aims to compare P300 amplitudes to target stimuli between recidivists and non-recidivists at Pz site. Furthermore, the P300 amplitude and latency of recidivists were compared to find their affective process toward violent and pleasant animal pictures.

2. Materials and Methods

2.1 Participants

The criteria for participant inclusion in the study were men who were right-handed without visual or hearing impairment. The snowball technique of sampling was used to recruit volunteering subjects via social media (e.g., Facebook, and Line applications) including public announcements. The criteria to be excluded were having non-healthy states, having a history or in a process of psychiatric medical treatments, having substance abuse at any time, having a history of brain concussion or brain surgery, and being able to come to the experiment room. Thus, forty-three healthy males ranging in age from 18 to 35 years were 21 recidivists and 22 non-recidivists. This study was approved by the Chulalongkorn University Institutional Review Board, no. 047.1/61.

2.2 Measures

2.2.1 Recidivism

For inclusion of recidivists in this study were male students who had a history of the violent situation (i.e., physical attack, using weapons, or gang attack). The history was recorded by the student affair of the institution or by police for two times or more during their college study. The recidivist group had average of recidivism acts 2.24±0.54 times, whereas non-recidivists were typical university students who had no record of misconduct acts.

2.2.2 Callous-unemotional traits

The inventory of callous-unemotional traits (ICU) (Frick, 2003; Frick & White, 2008) is a 24-item self-report questionnaire containing three subscales; unemotional (5

items), callousness (11 items), and uncaring (8 items). Responses were made on Likert-scale at 0 (not at all true) and 3 (definitely true). In a pilot study (n=772), a back-translation method from English to Thai language was applied (Poonyakanok, 2016) with Cronbach's α at 0.486, 0.789, and 0.786, respectively. In the present study, the unemotional subscale in CU traits was excluded due to low Cronbach's α on this subscale. A recent meta-analysis revealed that the unemotional subscale showed low internal consistency than the callousness and uncaring subscales (Ray & Frick, 2018).

2.2.3 Aggression

Individual differences in aggression were assessed by using the aggression questionnaires (29 items) (Buss & Perry, 1992). The questionnaires contain four subscales, labeled physical aggression (9 items; α=.700), verbal aggression (5 items; α=.529), anger (7 items; α=.712); and hostility (8 items; α=.624). A back-translation method from English to Thai language was applied. Participants were asked to rate items on a Likert-scale at 1 (extremely uncharacteristic of me) and 5 (extremely characteristic of me).

2.2.4 Electrophysiological recording

The EEG signals were recorded by 32 active electrodes attached to an elastic EEG Biosemi's head cap. The electrode placement was set according to the international 10-20 system. The 6 flat-type active electrodes; two pairs of electrodes were placed at the most widely used locations for electrooculography (EOG) recording over the left and right eyes for detecting eye movement, approximately 2 cm away from the eyes. The reference electrodes were attached at the left and right mastoids. The ground electrodes were placed on a cap between Cz (common mode sense; CMS and driven right leg; DRL). The electro gel was inserted into the electrode holder and all electrodes were attached. The continuous EEG data were recorded by using an ActiveTwo biosignal system. Signals were amplified and digitized at 512 Hz with a 24-bit A/D conversion with a sampling rate of 2,048 Hz. An online filter was set to a bandpass with a 100 Hz low pass and a 0.16 Hz high pass. A notch filter was opened at 50 Hz. An electrode offset was kept between ±40 μV. The impedance of all electrodes, CMS, and DRL electrodes was kept below 5 kOhm. The continuous EEG signal was stored in an off-line file for data analysis in BESA 6.0.

2.2.5 Stimulus viewing task

Regarding picture condition, the pictures were selected from the *International Affective Picture System* (IAPS) (Lang, Bradley, & Cuthbert, 2005). In the pilot study, male undergraduates (n=30) had rated the valence of each pictures using scales ranging from 1 (low pleasure) to 9 (high pleasure), and the arousal of each picture by using scales from 1 (low arousal) to 9 (high arousal). Mean of the valence and arousal ratings are presented in Table 1.

Table 1. Mean ±SD of valence and arousal ratings for the IAPS pictures used in this study.

Picture types	Valence ratings	Arousal ratings
Violence	3.21±0.54	6.40±0.62
Animal	6.24±0.56	4.67±0.51
Neutral	4.37±0.37	3.24±0.24

The identification number (IAPS) in this study

Violent picture: 6415, 9265, 9253, 9254, 6022, 9420, 9426, 9400, 9252, 6560, 6550, 6540, 9427, 9425, 6530, 6350, 9423, 6315, 6313, 6021, 9402, 6510, 9424, 6570.1, 6571, 6312, 6821, 6211, 3530, and 6260

Animal picture: 1441, 1440, 1710, 1463, 1721, 1750, 1460, 1722, 1920, 1610, 1601, 1947, 1720, 1740, 1811, 1640, 1419, 1900, 1812, 1500, 1942, 1510, 1603, 1604, 1333, 1602, 1660, 1810, 1540, and 1661

Neutral picture: 5220, 5849, 5020, 5030, 5200, 7188, 5395, 7190, 7192, 7490, 7186, 7041, 7900, 5740, 7036, 7185, 6150, 7100, 7504, 7038, 7170, 7187, 7710, 7053, 7207, 7211, 7175, 7179, 7491, and 7205

1) Procedure

Recidivists and non-recidivists participated in the same procedure. Before the experimental day, participants were asked to confirm the appointment and follow the instructions (e.g., get enough sleep, avoid drinking alcohol within 24 hrs, wash your hair and avoid using hair gel or mousse). All experiments were conducted in a quiet room with an ambient temperature of 25 °C. The experiment was performed between 9 a.m.–12 p.m. and 1 p.m.–4 p.m.

Participants were told that the study involved the effects of visual perception and reaction time. After obtaining informed consent, a researcher attached all electrodes for EEG recording and then explained to participants about the tasks' procedures, for example, "your task is to press the number '1' button as soon as possible when you see the letter 'A' with your index finger". Afterward, the researcher re-checked EEG setting before leaving the experiment room. Participants followed each step of the tasks through an instruction shown on the monitor. After completing the tasks, participants cleaned up their hair and then returned to complete all self-report questionnaires. Finally, participants were interviewed for their suspicions, debriefed, and received for 500 THB each to participate.

2) Tasks

The tasks used in this study were derived from the classic oddball paradigm: methods for assessing how electric brain patterns vary among conditions (Polich, 2007). Our visual oddball paradigm was created by using E-prime 2.0. Two different stimuli were distributed randomly in a sequence. Target stimuli (rare) appeared at 1/4 times ratio, and non-target stimuli (frequent) appeared at 3/4 times ratio. This current study consisted of the three series of tasks. Each task comprises 150 trials of two different stimuli on distributed randomly in a sequence.

The first task was the letter 'A-B'. The second task was violent-neutral pictures, and the third task was animal-neutral pictures. For the letter 'A', violent pictures, and animal pictures were set as the target stimulus, respectively. In picture conditions, target stimuli were shown at a single time with non-repeated. All participants performed the first task, while a counterbalancing was applied for the second and the

third tasks. Participants responded by quickly pressing the number '1' button on a keyboard within 1 second when the target stimulus was presented and ignored responding to non-target stimulus.

The stimulus was presented at the center of the monitor sized 15x20 cm for the pictures and size 4x5 cm for the letters. The stimulus was displayed for 1,000 ms each, separated by a 2,400 ms inter-stimulus interval and fixation. The fixation '+' appears to prepare participant to be ready for the next stimulus (Figure 1). Participant sat in a padded recliner chair at a distance of 70 cm from a 21-inch computer screen, placed directly in front of them. Participant was asked to read and follow the instructions on the monitor screen step by step. Each task takes approximately 8 minutes and 2 minutes breaks after each task. The overall time to finish the three series of all the tasks was 30 minutes.

3) ERP analysis

The analysis of ERP was performed offline. The ERP waveform was analyzed by using BESA research 6.0 (Graefelfing, Germany). A bandpass filter was obtained by using both lower cut off at 0.3 (type: forward slope 12 dB/oct) and high cut off at 30 Hz (type: zero phase slope: 24 dB/oct) with a sampling rate of 250 Hz. All EEG and EOG records were visually inspected to reject gross artifacts, such as those involving with movements. Eye blinks and eye movements were corrected and rejected based on the artifact correction. Data were segmented into 1,000 ms epochs including the 400 ms (baseline) prior to the stimulus onset. EEG and EOG exceeding ±100 μV were discarded from further processing. Trials with response times more than 1 second were considered error responses. These responses were rejected. Only those trials with correct responses at Fp1, Fp2, Pz, P3, P4, T7, and T8 sites to the target stimuli were averaged and analyzed. The P300 ERP waveform was identified as the most prominent positive peak occurring between 200 and 600 ms after stimulus onset (Bernat *et al*., 2007).

4) Statistical analysis

Data were reported with means ± standard deviation. The SPSS statistical package version 22 was used for data analysis. The repeated measures ANOVA was applied to analyze the data. Data from three participants with a high proportion of EEG artifacts were discarded. In total, data from 43 individuals (21 recidivists and 22 non-recidivists) were analyzed.

3. Results and Discussion

Results of the study consistent with the previous research, individuals who had exposed to violent offenses were strongly associated with increased aggression (Bartholow *et al.*, 2006; Engelhardt *et al.*, 2015; Sommer *et al.*, 2017) especially physical aggression compared to non-recidivists. Also, callousness and uncaring subscales of recidivists were significantly higher than non-recidivists (Table 2).

When comparing the average of the valence and arousal ratings for the violent, animal, and neutral pictures

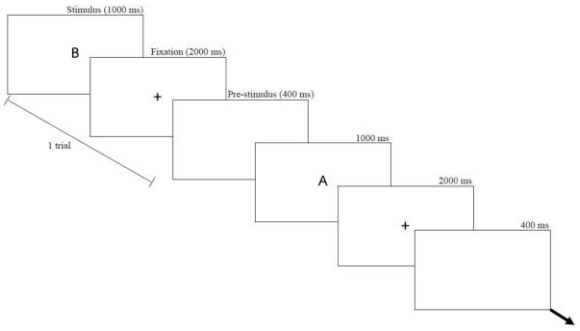

Figure 1. Example of visual oddball paradigm in 1 trail

between two groups, results showed insignificance between groups. The average of latency, the reaction time, and the error rate in comparison with the two groups showed insignificance but the average of the correct hits on target stimuli (violent pictures $t(41)=2.072$, $p<.05$, and animal pictures $t(41)=2.464$, $p<.05$) of non-recidivists showed significantly higher than recidivists (Table 3 and 4).

We conducted 2 (groups; non-recidivists, recidivists) x 3 (target stimuli; letter 'A', violent pictures, animal pictures) repeated measures ANOVA at the Pz site to respond to our objective. Results showed the significant differences, between groups ($F(1,41)=72.819$, $p<.001$), and target stimuli ($F(2,82)=7.278$, $p<.01$), however, no significant difference of the targets × groups interaction was found (see Figure 2-4). Post hoc test at the Pz electrode site showed that recidivists had fewer amplitude responses to all target stimuli than non-recidivists, especially violent pictures.

When compared between stimuli within each group, we found that non-recidivists responded more significantly to violent and animal pictures than the letter 'A'. In contrast, recidivists had similar responded in all stimuli.

Additional results from the parietal electrode sites (i.e., P3,P4). We conducted 2 (groups) × 2 (sites; P3, P4) × 3 (target stimuli) repeated measures ANOVA. We found the significant interaction differences of groups × sites ($F(1,41)=12.152$, $p<.01$) and sites × targets ($F(2,82)=6.610$, $p<.01$). For the target of the violent pictures, we found the differences between recidivists and non-recidivists. Both recidivists and non-recidivists had significant differences between P4 and P3.

The related electrode sites were also analyzed (i.e. Fp1,Fp2,P3,P4,T7,T8) by the 2 (groups) × 3 (target stimuli) repeated measures ANOVA. We found the significant main effects of groups and targets in nearly all electrode sites (except the target at T8) in which they had a similar trend as at Pz. Recidivists had significant differences between the letter 'A' and the other stimuli. Interestingly, we found the significant interaction of targets x groups at Fp2 ($F(2,82)=4.909$, $p<.05$). Therefore, apart from Pz, Fp2 could be another electrode site to be considered regarding recidivism.

In the present study, the three series of the visual oddball task were presented to participants while brainwave activity was recorded when responding to each target stimulus as an indicator of attention. The present study aimed to compare P300 amplitude to target stimuli between recidivists and non-recidivists.

Table 2. Mean ±SD of CU traits and aggression and mean difference between two groups

Measures	Self-reports		*p*
	non-recidivists (n=22)	recidivists (n=21)	
Callousness	0.77±0.33	1.01±0.36	.029*
Uncaring	0.48±0.31	0.88±0.36	<.001*
Anger	2.23±0.82	2.51±0.66	.231
Hostility	2.84±0.96	2.66±0.62	.466
Physical Aggression	2.32±0.77	2.90±0.58	.008*
Verbal Aggression	3.21±0.76	2.88±0.71	.146

* $p < .05$ was considered significance.

Table 3. Mean ±SD of reaction time, correct hits, and errors of commission and mean difference between two groups

Measures	non-recidivists (n=22)	recidivists (n=21)	*p*
Reaction time (ms)			
Letter 'A'	434.73±45.19	440.86±52.18	.682
Violent pictures	479.96±82.42	497.82±73.04	.457
Animal pictures	466.22±80.50	481.13±72.45	.527
Percentage of correct hits			
Letter 'A'	98.36±5.25	98.14±2.92	.866
Violent pictures	97.55±4.78	91.38±13.07	.045*
Animal pictures	99.18±1.40	95.29±7.12	.022*
Errors of commission			
Letter 'B'	0.27±0.77	0.33±0.66	.783
Neutral 1	0.50±0.86	0.14±0.48	.100
Neutral 2	0.28±0.50	0.30±0.33	.411

* $p < .05$ was considered significance.

Table 4. Mean ±SD of P300 wave generated in three series of tasks and mean difference between two groups.

Measures	non-recidivists (n=22)	recidivists (n=21)	*p*
Amplitude at Pz (μV)			
Letter 'A'	4.51±1.56	2.76±1.17	<.001*
Violent pictures	5.71±1.32	3.11±0.97	<.001*
Animal pictures	5.31±0.85	3.27±0.94	<.001*
Latency (ms)			
Letter 'A'	348.82±47.76	353.10±61.14	.803
Violent pictures	358.68±74.87	379.43±91.64	.430
Animal pictures	343.86±100.59	358.67±86.26	.608

* $p < .05$ was considered significance.

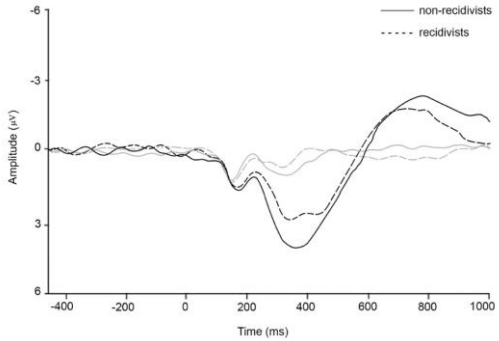

Figure 2. P300 amplitude elicited by the letter 'A' (dark lines) as target stimuli compared to the letter 'B' (light lines) as non-target stimuli.

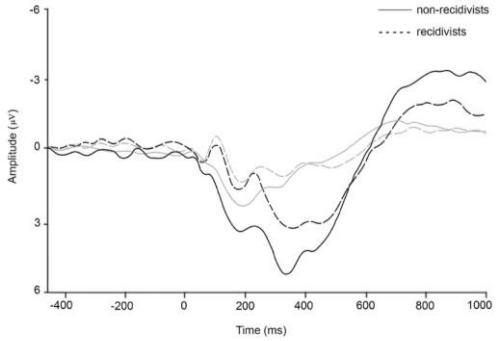

Figure 3. Mean of the P300 amplitude elicited by the violent pictures (dark lines) as target stimuli compared to the neutral pictures (light lines) as non-target stimuli.

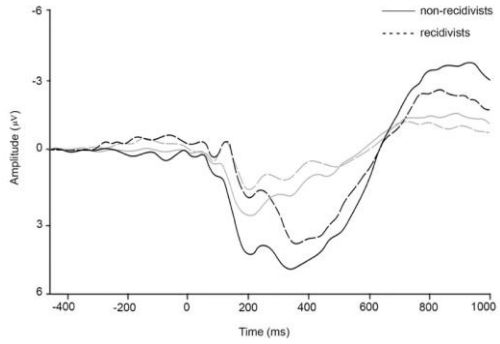

Figure 4. Mean of the P300 amplitude elicited by the pleasant animal pictures (dark lines) as target stimuli compared to the neutral pictures (light lines) as non-target stimuli.

In the cognitive domain, EEG was applied to measure neural activities of P300 amplitude to test recidivists and non-recidivists' attention to each target stimulus (i.e., letter 'A', violent pictures, and animal pictures). In line with our hypothesis, P300 amplitudes in recidivists were significantly smaller for every target stimulus; letter 'A', violent, and animal pictures, when compared to non-recidivists. Recidivists when compared to non-recidivists elicited significantly smaller P300 amplitude toward violent pictures. This P300 reduction was a neurobiological marker of information processing brain impairment that decreases performance on various cognitive tests (Dinteren, Arns, Jongsma, & Kessels, 2014; Kropotov, 2016; Pasion *et al*., 2018). A decrease of the P300 amplitude as a neurobiological correlate of emotional-affective tasks may be particularly relevant to the conceptualization of the CU traits of psychopathy (Pasion *et al*., 2018). In our college student sample, the lack of empathy, especially, callousness, and uncaring concern for others found in the recidivist group. The higher callousness had correlated with low desensitization to something relevant to the violent situation that affects the P300 differently. Thus, callousness and uncaring may be the characteristics that should be concerned. Also, the blunted P300 amplitude in the recidivist group in our study may be considered as a neurobiological marker of the externalizing behavior such as physical aggression.

Recidivists, as expected, showed high physical aggression scores on behavioral domain. While in the callous-unemotional traits on affective domain, recidivists showed higher scores on callousness and uncaring subscales than non-recidivists. This implies that the recidivists do not only lack of concern about others' welfare or suffering, but they also behave aggressively toward others. Results of this present study were consistent with the several previous studies that adult male inmates who committed violent acts showed higher aggression and desensitization in real-life violence (i.e., voluntarily participating in violent offenses or gang attacks). After recidivists prolonged exposure to violent circumstances, they reduce inhibition against aggression and become less responsive to the rival gangs or victims' pain and suffering (Bernat *et al*., 2007; Engelhardt *et al*., 2011; Littman & Paluck, 2015). According to previous studies, individuals with higher callousness tend to lack of concern about being punished after committing aggressive acts and behaving in an aggressive way (Pardini, 2006). Furthermore, callous-aggressive individuals tend to repeat unpleasant behaviors in rule-breaking and drug addiction.

Based on our results, recidivists showed more physical aggression, more callousness and uncaring, and less P300 amplitude activation in every stimulus. These mean psychological treatments that could motivate their attention and activation of the P300 amplitude or caringness for others would be investigated. Future research needs to be done to explore such treatments.

4. Conclusions

This present study emphasizes the link between recidivism, exposure frequency to violent circumstances and smaller P300 amplitudes. University students who were exposed to two or more offenses tended to show a reduction in the P300 responses to violent circumstances and had tendency to commit more crimes. Students who offended crimes do not only show reduced brain activity associated with desensitized violent situations/objects/daily basics, but they also show an increase in physical aggression, callousness, and uncaring.

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