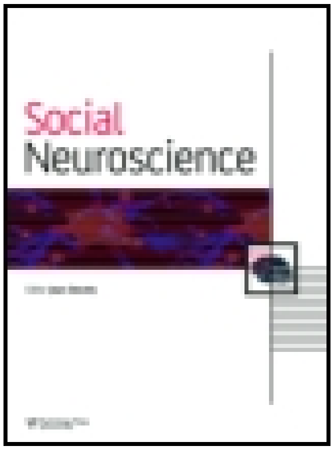

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Emotional processing in Colombian ex-combatants and its relationship with empathy and executive functions

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Emotional processing in Colombian ex-combatants and its relationship with empathy and executive functions

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In this work, the neural correlates of emotional processing in Colombian ex-combatants with different empathy profiles were compared to normal controls matched for age, gender and educational level. Forty ex-combatants and 20 non ex-combatants were recruited for this study. Empathy levels as well as executive functions were measured. Empathy level was used to create three groups. Group 1 (G1) included ex-combatants with normal empathy scores, and Group 2 included ex-combatants with low scores on at least one empathy sub-scales. In control group (Ctrl), participants with no antecedents of being combatants and with normal scores in empathy were included. Age, gender, educational and intelligence quotients level were controlled among groups. event-related potentials (ERPs) were recorded while individuals performed an affective picture processing task that included positive, neutral and negative emotional stimuli, which elicit an early modulation of emotion categorization (Early Posterior Negativity (EPN)) and late evaluative process (LPP). EPN differences were found among affective categories, but no group effects were observed at this component. LPP showed a main effect of category and group (higher amplitudes in ex-combatants). There was an inverse correlation between empathy and executive

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functions scores and ERPs. Results are discussed according to the impact of emotional processing on empathy profile.

Keywords: Empathy; ERPs; EPN; LPP; IAPS; Executive functions; Ex-combatants.

Armed conflicts are naturalistic settings where human behaviour can display abnormal and exacerbated expressions of aggression and violent behaviours, as shown in war veterans (Gallaway, Fink, Millikan, & Bell, 2012; Jakupcak et al., 2007; Taft, Vogt, Marshall, Panuzio, & Niles, 2007). These behaviours are the result of psychological and biological adaptations to emotional processing, oriented to handle highly stressful conditions, and can be explained by changes in emotional processing leading to dispositional empathy impairment. The Colombian conflict has several characteristics that make it a special scenario to test human behaviour. Combatants have ideological preconceptions bent by the political influence of the group they belong to (McCarroll et al., 2000; Slep, Foran, Heyman, & Snarr, 2010). This produces a lack of empathy for the enemy. In addition, the presence of drug trafficking, kidnapping and terrorism leads the combatants to commit acts of extreme violence, such as murder and torture (Maguen et al., 2009). These conditions can interact with their cognitive profile, leading some combatants to adapt better to the war environment.

The assessment of emotional processing in this population, along with measurements of empathy and executive functions, is thus important to understand how these social factors shape violent behaviour. The purpose of this study is to examine whether dispositional empathy levels are related to differences in the modulation of event-related potentials (ERPs) evoked by emotional stimuli of positive, neutral or negative hedonic valence in Colombian ex-combatants. In addition, we assessed the influence of executive functions in the different groups.

An important factor in individuals with low remorse and poor emotional expression control is the lack of empathy (Mcphedran, 2009). These features have been associated with a violent environment and sociocultural deprivation (Silva, Derecho, Leong, Weinstock, & Ferrari, 2001). Empathy deficits are related to inadequate identification of emotional expressions (Marsh et al., 2008; Petroni et al., 2011), reward-oriented behaviour without concern for the consequences (Brazil et al., 2011) and deficits in executive functions such as inhibitory control and working memory (Heilbrun, 1982; Nelson & Trainor, 2007; Paschall & Fishbein, 2002). Furthermore, theory of mind, an empathy-related process (Ibanez et al., 2013), has effects on behavioural, emotional and moral judgement control in violent individuals (Ragsdale, Foley, & Lauwereyns, 2011). Therefore, individual differences in empathy in violent persons can be involved in the modulation of emotional information.

In addition, impairments in executive functions are another important factor in individuals with deficiencies in social interactions (Brazil et al., 2011; Heilbrun, 1982; Nelson & Trainor, 2007; Paschall & Fishbein, 2002). Moreover, in populations with antisocial personality disorder and psychopathic behaviour, impairments in executive function have often been observed (Brazil et al., 2011; Salnaitis, Baker, Holland, & Welsh, 2011). This raises the possibility that individual differences in executive functions could be involved in the modulation of other cognitive-affective process.

The use of emotional pictures from the International Affective Picture System (IAPS) combined with ERP measures is a powerful approach to assess cortical dynamics of emotional processing (Ferri, Weinberg, & Hajcak, 2012; Herrmann et al., 2008; MacNamara, Ferri, & Hajcak, 2011; Weymar et al., 2010). ERP and IAPS stimuli have documented middle and late ERP modulation of valence (Dufey, Hurtado, Fernández, Manes, & Ibáñez, 2011; Ibanez et al., 2012). The Early Posterior Negativity (EPN, more enhanced in the right hemisphere) is a middle latency component associated with an early discrimination and response selection processes from valence of stimulus (Schupp, Junghöfer, Weike, & Hamm, 2004). The Late Positive Potential (LPP), a late component typically present around 300–700 ms, is associated with processing cognitive evaluation of emotional stimuli (Pastor et al., 2008). In emotional discrimination, time window for LPP has been described between 300 and 500 ms (Frantzidis et al., 2010; Stanford, Vasterling, Mathias, Constans, & Houston, 2001), in this case the frontal topography is the most dominant (Cunningham, Espinet, DeYoung, & Zelazo, 2005; Dufey et al., 2011). EPN and LPP can be used as markers of early emotional discrimination and late evaluation of emotional salience, respectively.

In this study, we examined the neural correlates of emotional processing in Colombian ex-combatants with different profiles of dispositional empathy, compared to normal controls matched for age, gender and educational level. We also compared executive functions among groups and their possible association with ERPs. We expected group differences in EPN modulation of stimuli valence (positive, negative and neutral). In LPP, different amplitude modulation triggered by dissimilar patterns of emotional salience was also expected. Finally, in order to document individual differences in cortical processing of emotion, we evaluated the association of ERPs amplitude with scores of empathy and executive functions. To our knowledge, this is the first study that explores whether individuals with different empathy dispositions involved in aggressive conducts present differential cortical processing of emotions.

MATERIALS AND METHODS

Participants and group selection

Participants were selected from a pool of 564 ex-combatants form a project to assess empathy profiles of this population. In this study, empathy was assessed with the Spanish version of the Interpersonal Reactivity Index (IRI; Davis, 1980). The IRI was administered by self-report to people with 5 or more years of education and by interview for people with less than 5 years of education or with reading impairments. The IRI included 28 items with four sub-scales, that is, Fantasy (FS), Perspective Taking (PTS), Empathy Concern (ECS) and Personal Distress (PDS) (Davis, 1980). This instrument has been designed to measure at least two components of empathy: cognitive and emotional. Empathy could be considered as an emotionally related measure when it refers to the tendency to feel concern towards others, or to feel anxiety and discomfort, as a result from observing negative emotional experiences of others (Eslinger, 1998). Empathy could be considered as a cognitive dimension when it refers to the tendency to take the perspective of others, or when subjects can understand and identify the feelings of the characters of a fiction picture or novel. Both emotional and cognitive dimensions have to be taken into account when the concept of empathy is measured with a rating scale (Davis, 1980; Perez-Albeniz & De Paul, 2004).

For normal values in IRI scores, we used a latent class analysis. Latent class cluster analysis (LCCA) aims at constructing discrete categories from a set of responses (e.g. as IRI for empathy), thus grouping participants who share similar response patterns. It would be expected that the multiple groups that are derived exhibit independent symptom profiles. Therefore, the independence between items and derived groups is an inherent assumption of this kind of analysis (Hudziak et al., 1998; Neuman et al., 2001). Using Latent GOLD 4.0 (Statistical Innovations, Belmonts, MA, USA), we analysed 1 to 10 models of LCCA. With expectation/maximization and Newton–Raphson algorithms, the Latent Gold 4.0 estimated the maximum likelihood for each model (Vermunt & Magidson, 2002). The model with better adjustment to L^2 or LL indices, the lowest Bayesian information criteria, the lowest number of parameters, the bootstrap p-values <.005, the lowest number of bivariates residuals and the best distribution of plausible prevalence’s in cluster, was selected as the best model of analysis.

The best model included three clusters: Cluster 1 included participants with higher possibilities of mean scores in four dimensions of IRI (normal population). Cluster 2 higher possibilities of mean scores in EC, FS and PT but higher possibilities to low scores in PD. Finally, Cluster 3 included participants with higher possibilities of lower scores in all dimensions of IRI.

For ERPs assessment, a sub-group of 40 ex-combatants (8 females, M = 32.85 years, SD = 7.13) and 20 (4 females, M = 31.50 years, SD = 6.15) non ex-combatant, ranging between 19 and 54 years of age, were included. Since empathy profile is a good predictor of impairments in social interactions, according to previous studies and literature reports (Brook & Kosson, 2013; Dinsdale & Crespi, 2013; Klimecki, Leiberg, Ricard, & Singer, 2013), this element was used to arrange the groups. Individuals were divided into three groups according to their combatant status and empathy disposition in clusters. Participants with average to high scores on the four IRI sub-scales were considered as presenting normal empathy (Cluster 1), and participants with low scores on any of four sub-scales (FS, PTS, ECS and PDS) were included in the poor empathy group (Cluster 2 and 3). For ERP study, Group 1 (G1, n = 20) included ex-combatants with close to normal empathy scores, Group 2 included (G2, n = 20) ex-combatants with poor empathy scores, and the control group (Ctrl, n = 20) included non-ex-combatants with normal empathy scores.

After the groups were created, we analysed age, gender and educational level differences in order to ensure consistency across groups for those variables. No age (F(6, 110) = 0.75, p = .77), gender (F(6, 110) = 0.75, p = .74) or educational level (F(6, 110) = 0.75, p = .25) differences were found (demographic information is provided in Table 1).

An analysis of variance was performed to assess the discriminative competence of the latent class

TABLE 1
Demographic information

	G1 (*n* = 20)	*G2* (*n* = 20)	*Ctrl* (*n* = 20)	*p*
Age (years)	M = 32.70 SD = 1.37	M = 33.00 SD = 1.82	M = 31.5 SD = 1.38	0.77
Gender (F:M)	5:15	3:17	4:16	0.74
Educational level (years)	M = 10.95 SD = 0.72	M = 10.50 SD = 0.69	M = 9.35 SD = 0.66	0.25

components on empathy measures and to outline the dimension that better distinguished them. As expected, the three groups presented differences in empathy scores. A main effect of PD (F(2, 56) = 131.49, p < .001), with post hoc comparisons (MS = 34.63, df = 56.00), revealed that Ctrl ratings were significantly higher than G1 (p < .001) and G2 (p < .001), and G1 scores were higher than G2 (p = .06). There were no group differences in FS (F(2,56) = 1.38, p = .26), PTS (F(2,56) = 1.16, p = .32) or ECS (F(2,56) = 0.45, p = .64). PD subscale was the main variable to distinguish groups. This group selection allowed us to evaluate the impact of emotional empathy on behavioural profile in ex-combatants. Unlike empathic concern, the PDS involves self-oriented feelings of personal unease when exposed to the suffering of others (Davis, Luce, & Kraus, 1994). Moreover, discomfort may produce a self-centred motivation to reduce the PDS, whereas empathic concern may instigate an altruistic motivation to help the other. Thus, it seems that reduced levels of personal discomfort (when exposed to the suffering of others) may constitute the core of empathy impairments observed in ex-combatants.

Ex-combatants were recruited through the Colombian National Integration Program (*Alta Consejería para la Reinserción de la Presidencia de la República*—ACR). Individuals were screened to exclude neurological or psychiatric conditions or drug consumption that may affect any of the target variables. For psychiatric criteria, the MINI Neuropsychiatric interview 6.0 was applied and participants with positive current anxiety, depression or drugs addictions were excluded. All participants could read and gave written informed consent, according to the Declaration of Helsinki before the beginning of the study. The Universidad de Antioquia's Ethics Committee approved the study.

All ex-combatants enrolled in the databases of the Alta Consejería para la Reinserción (ACR) had explicitly declared having participated in an illegal armed group as part of the ACR programme requirements. Those declarations include illegal arms use and armed group participation. For the non-ex-combatants group, the criminal records of all participants were screened and they were excluded if they belonged or had belonged to any armed group.

Neuropsychological assessment

To evaluate intelligence quotients (IQ), an abbreviated version of the Weschler Adult Intelligence Scale (WAIS-III) was used. The IQ score was estimated from Block Designs, vocabulary for verbal IQ, performance IQ and total IQ (Donders & Axlerod, 2002).

The INECO Frontal Screening (IFS, Torralva, Roca, Gleichgerrcht, López, & Manes, 2009) was used to evaluate executive functions. The IFS is a very sensitive tool for clinical assessment in neuropsychiatry, so impairments in this task can be interpreted as clinical impairments (Baez et al., 2014; Gleichgerrcht, Roca, Manes, & Torralva, 2011; Torralva et al., 2009). This battery test is made up of eight subtests (motor programming, conflicting instructions, Go-No-Go, backward digit span, verbal working memory, spatial working memory, proverb interpretation and verbal inhibitory control) with a total score of 30 points. The total score was used to assess and control the influence of executive functions on the analysed variables.

Experimental paradigm

The stimuli presented in the affective picture processing task were obtained from the IAPS and classified according to their valence scores (Lang, Bradley, & Cuthbert, 2005). The selected images of the IAPS, according to previous standardization, showed test–retest reliability coefficients and internal consistencies of r = 0.99, α = 0.94 in valence and of r = 0.97 and α = 0.93 in arousal (Gantiva Diaz, Guerra Muñoz, & Vila Castellar, 2011; Lang et al., 2005). We used an ERP Spanish version of IAPS task previously reported (Dufey et al., 2011).

EEG was recorded while subjects completed the IAPS. Following previous research protocols (Dufey et al., 2011; Schupp et al., 2000), 57 images conveying neutral (n = 19), negative (n = 19) and positive (n = 19) scenes were presented for 1500 ms each, and the trials were preceded by a fixation point at the centre of the screen for 200 ms. Images were selected representing people in different social situations: for the positive category: children playing, couples in romantic situations; for the neutral category: people walking on the street, inside a house or standing up; and for the negative category: people crying, situations of violence and obfuscation, drugs and alcohol consumption. Images were presented four times each, with a total of 228 trials, having no stimuli presented more than twice for the same affective valence on each sequence.

Participants were instructed to look at each image and rate its valence (positive, neutral or negative) once it disappeared from the screen, using three keys on a response keyboard. They were also instructed to avoid movements that could interfere with the recordings (e.g. eyeblinks and eye or head movements). The affective task was run on a computer monitor situated approximately 24 inches away from the participant.

EEG acquisition and processing

EEG signals were recorded online using a Medicid (Neuronic s.a., La Habana, Cuba), 36-channel system from Neuronic s.a. with a DC coupling Amplifier, 16-bit A/D converter and EPWorkstation software. Analogue filters were 0.05 and 100 Hz. A digital band pass filter between 0.5 and 30 Hz was applied offline to remove unwanted frequency components. Signals were sampled at 200 Hz. The reference was set by default to link mastoids, but then was re-referenced offline to average electrodes. Two bipolar derivations were employed to monitor vertical and horizontal ocular movements electrooculogram. Stimulus-locked epochs were selected from the continuous data, from 200 ms before and 800 ms after the stimulus onset. A baseline from −200 to 0 ms correction was applied. All epochs with eye movement contamination were removed from further analysis using an automatic (Gratton, Coles, & Donchin, 1983) method for removing eyeblink artefacts and visual procedures. Artefact-free epochs were averaged to obtain the ERPs. The analysis was done separately based on group (G1, G2 and Ctrl), category (positive, negative and neutral) and electrodes. ERP waveforms were averaged separately for each experimental condition. The EEGLAB Matlab toolbox was used for EEG offline processing and analysis.

Data analysis

The demographics, neuropsychological and experimental data were compared among the groups using ANOVA. When analysing categorical variables (e.g. gender), chi-square tests were applied.

A mixed repeated-measures ANOVA was conducted for the behavioural data obtained from offline recordings, with a between-subject factor (Group: G1, G2 and Ctrl) and a within-subject factor (category: positive, neutral, negative). Electrodes were used to represent and analyse the scalp topography of the ERP components. The ERP analysis was carried out based on the electrodes chosen by visually checking each component: EPN (right: P4; central: Pz; left: P3) and LPP (right: Fp2; central: FPz; left: Fp1). Although the figures show the ERPs grand averages for each group, all statistical calculations were done using each participant's individual data. ERP amplitudes were quantified as the mean average around the peak deflection occurring within a 180–240 ms (EPN) (Franken, Gootjes, & Van Strien, 2009; Nordström & Wiens, 2012; Schupp, Schmälzle, Flaisch, Weike, & Hamm, 2012; Smith, Weinberg, Moran, & Hajcak, 2012) and 370–520 ms (LPP) temporal window (Bradley, Hamby, Löw, & Lang, 2007; Hurtado, Haye, González, Manes, & Ibáñez, 2009; Key, Jones, & Dykens, 2013; Parvaz, MacNamara, Goldstein, & Hajcak, 2012). For each component, mixed repeated-measures ANOVA of group (3), category (3) and electrodes (left and right for EPN; left, central and right for LPP) was performed. All post hoc comparisons for both the behavioural and electrophysiological data were performed with Tukey's HSD tests.

Spearman ranks order correlations were performed to evaluate the relationship between the ERPs, empathy and executive functions (IFS Total score). Based on significant results, we selected PDS (for empathy), total IFS (for executive functions) and ERP conditions and regions to be used as scores. EPN and LPP total amplitude, as well as emotion category subtraction (negative–minus–neutral and positive–minus–neutral), were included in correlations.

RESULTS

Neuropsychology and scales

No IQ differences ($F(2, 56) = 1.52$, $p = .23$) were observed among groups. The analysis of executive functions showed a main effect for IFS total score ($F(2, 56) = 3.16$, $p < .05$). Post hoc analysis (MS = 17.83, df = 56.00) revealed that Ctrl yielded higher scores than G1 ($p < .05$), but not than G2 ($p = .79$). No differences between G1 and G2 were observed ($p = .19$). Table 2 provides performance in IFS subtests and total score.

TABLE 2
INECO frontal screening scores

	G1		*G2*		*Ctrl*	
	M	*SD*	*M*	*SD*	*M*	*SD*
Motor programming	2.55	0.82	2.73	0.56	2.95	0.22
Conflicting instructions	2.50	0.95	2.58	0.84	2.70	0.92
Go-No-Go	2.15	1.08	2.05	1.35	2.40	1.14
Backward digit span	2.35	0.88	2.73	1.24	2.70	1.17
Verbal working memory	1.00	0.91	1.42	1.34	1.60	0.75
Spatial working memory	1.75	0.71	2.21	1.08	2.25	0.97
Proverb interpretation	1.90	0.64	2.34	0.67	2.25	0.91
Verbal inhibitory control	4.30	1.63	4.68	2.00	4.90	1.37
Total score	18.55	2.86	20.92	4.81	21.80	4.73

Affective picture processing task

Behavioural data

Significant accuracy differences for category were observed (*F*(2, 57) = 23.06, *p* < .001). Post hoc analysis (MS = 252.24, df = 114) showed that positive stimuli were better classified than negative (*p* < .05) and negative better than neutral ones (*p* < .001). No significant effects for group (*F*(2, 57) = 1.13, *p* = .33) or category × group interaction (*F*(4, 114) = 1.24, *p* = .29) were found.

Reaction times (RTs) yielded no effect for category (*F*(2, 57) = 0.56, *p* = .57), group (*F*(2, 57) = 1.61, *p* = .21) or interactions. (Table 3 provides accuracy and RTs.)

ERPs

Figures 1 and 2 illustrate the EPN and LPP effects.

EPN. A main effect of category (*F*(2, 114) = 30.43, *p* < .001) followed by post hoc analysis (MS = 0.81, df = 114.00) evidenced that the positive category presented a greater amplitude (M = −1.09, SD = 0.26) followed by the neutral (M = −0.60, SD = 0.26) and finally by the negative category (M = −0.19, SD = 0.24) (all pairwise comparisons *p* < .001). No main effect of electrode site was observed (*F*(1, 57) = 0.08, *p* = .77). A category × electrode interaction (*F*(2, 114) = 24.19, *p* < .001) indicated that the greatest differences between categories were observed on the right region.

To compare possible category differences between groups, a restricted ANOVA was conducted on the right electrode. A main effect of category (*F*(2, 114) = 39.92, *p* < .001) was observed, but no interaction of category × group (*F*(4, 114) = 1.83, *p* = .13). Post hoc comparisons (MS = 0.71, df = 114.00) showed that the positive category presented higher amplitudes than the negative one (*p* < .001) and neutral ones (*p* < .001). Figure 3A illustrates the main relevant valence effects at EPN.

LPP. A main electrode effect (*F*(2, 114) = 21.99, *p* < .001) followed by post hoc interactions (MS = 7.09, df = 114.00) showed significant different values for the central versus right (*p* < .001) and left (*p* = < .001) LPP. No differences between right and left (*p* = .74) were found.

TABLE 3
Accuracy and reaction time

		G1		*G2*		*Ctrl*	
		M	*SD*	*M*	*SD*	*M*	*SD*
Accuracy	Negative	39.90	4.29	52.35	3.33	46.90	4.79
	Positive	48.85	4.52	57.90	4.14	53.85	5.18
	Neutral	32.25	4.19	31.50	5.51	38.45	4.92
Reaction time	Negative	630.91	63.78	616.47	76.10	782.60	81.11
	Positive	651.66	81.06	582.75	76.93	840.14	137.66
	Neutral	633.46	64.28	589.82	74.88	784.06	111.16

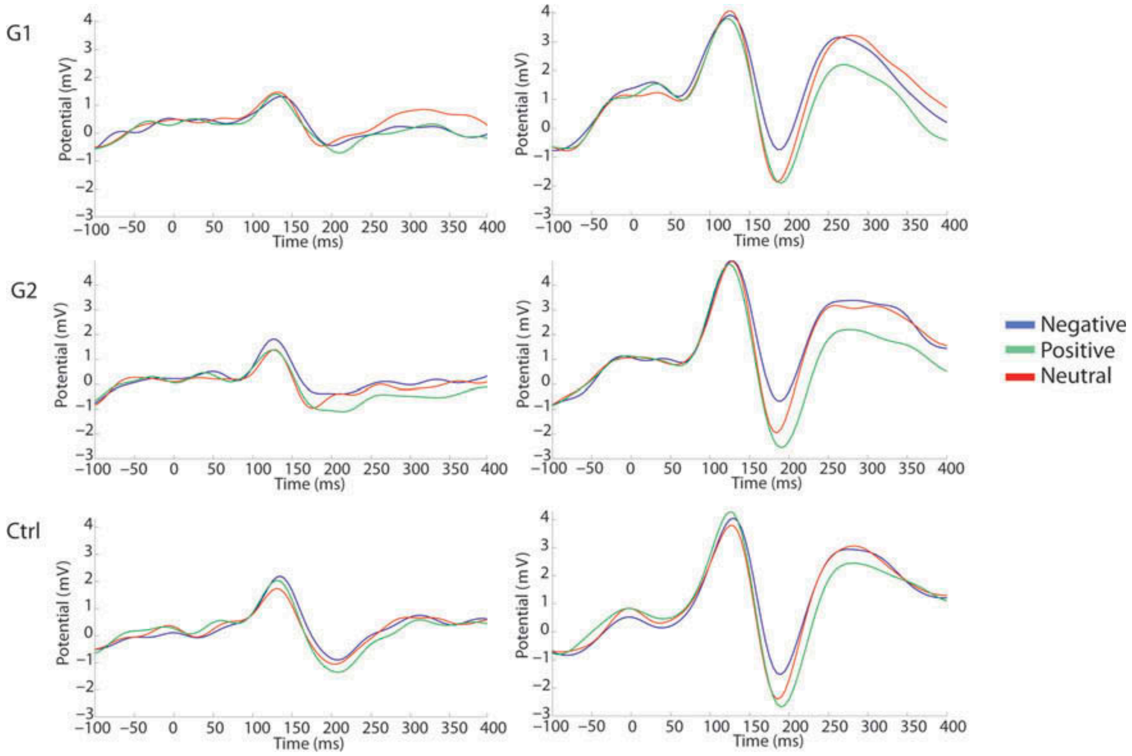

Figure 1. Early Posterior Negativity (EPN) effects. Average waveforms in the left (P3) and right (P4) electrodes for each group. Average waveforms were generated by taking the mean of each participant's waveform for each category (positive, negative and neutral).

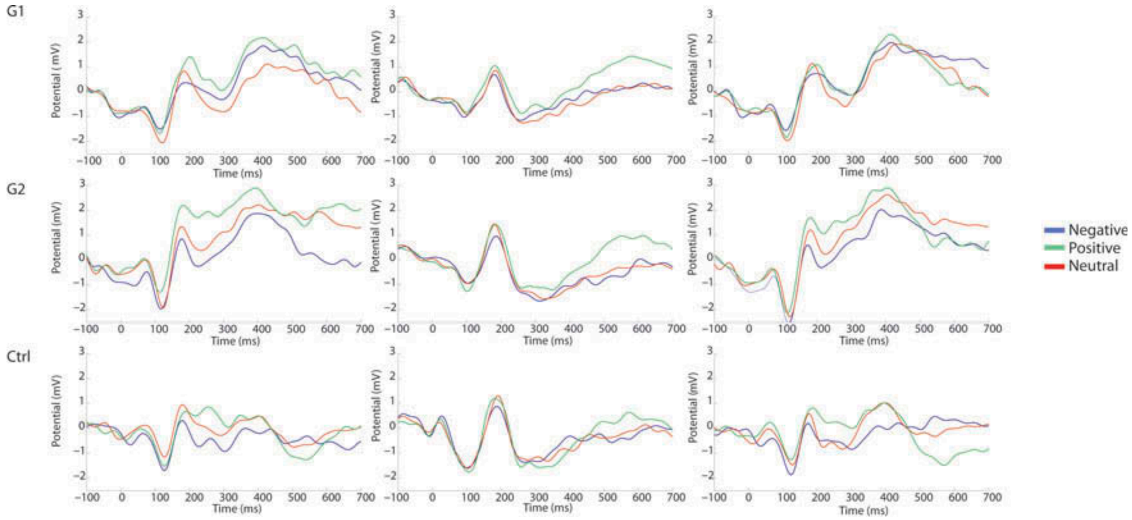

Figure 2. Late Positive Potential (LPP) effects. LPP component distribution on the left (Fp1), central (Fz) and right (Fp2) electrodes for each category and each group of participants.

There was a group effect ($F(2, 57) = 7.35$, $p < .001$), with the control group (M = −0.11, SD = 0.24) obtaining lower amplitudes compared to the G1 (M = 0.99, DE = 0.24) and G2 (M = 1.05, SD = 0.24). The post hoc analysis (MS = 10.41, df = 57) confirmed these differences between Ctrl group versus G1 ($p < .01$) and Ctrl group versus G2 ($p < .005$). Figure 3B illustrates the relevant group effects at LPP.

Also, a category effect was observed ($F(2, 114) = 4.41$, $p < .05$). Post hoc comparisons

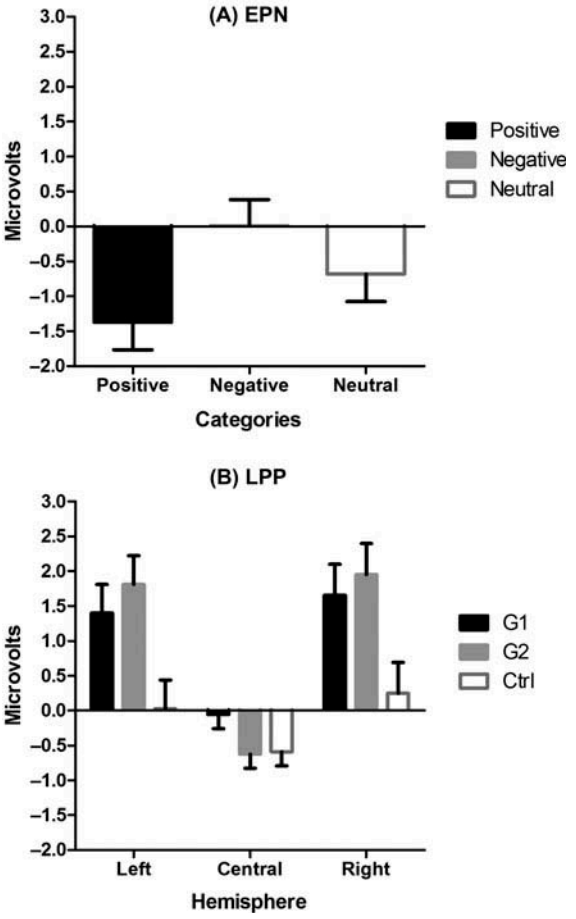

Figure 3. (A) Mean amplitude value for each category in EPN window. (B) LPP mean amplitude in left, central and right electrodes in each group.

(MS = 1.42, df = 114.00) revealed that only the negative category differed from the positive category ($p < .05$), but not from the neutral category ($p = .96$).

Finally, no electrode × category interaction ($F(4, 228) = 1.11$, $p = .35$) or electrode × category × group interaction ($F(8, 228) = 0.38$, $p = .93$) were observed on LPP.

In brief, ERPs modulation by category in EPN and LPP components were observed, but only LPP showed significant differences between groups. Right hemisphere facilitation was observed in emotional processing, especially in EPN component.

Correlations

EPN, IRI and IFS. No correlations between the scores of EPN and IRI or for IFS scores were observed.

TABLE 4
Correlations

	PDS	*IFS*
EPN-NN	−0.09	0.024
EPN-PN	0.12	−0.09
EPN	−0.08	−0.04
LPP-NN	0.15	**−0.28***
LPP-PN	−0.13	**−0.32***
LPP	**−0.37***	−0.16

Note: *$p < .05$.

LPP, IRI and IFS. A negative correlation between the PDS dimensions of IRI and LPP was found. Total score in IFS also had a negative correlation with LPP amplitude for negative and positive categories (see Table 4).

DISCUSSION

In this study, we assessed the relationship between ERPs responses to emotional pictures and dispositional empathy levels in Colombian ex-combatants. The valence EPN modulation was preserved in both controls and ex-combatant participants. Conversely, group differences were observed for the LPP. Both ex-combatant groups (G1 and G2) presented higher frontal LPP amplitudes than controls, suggesting enhanced reactivity to emotional salience. The inverse correlation between brain responses and behavioural scores (empathy and executive functions) suggests that higher reactivity in LPP is related to a reduced PDS and poor executive function. To our knowledge, this is the first study combining neurophysiological and behavioural markers of emotional processing in Colombian ex-combatants.

The EPN component

A large number of studies have found a modulation in EPN in response to neutral, and both emotional (pleasant and unpleasant) categories of pictures (Dufey et al., 2011; Ibanez et al., 2012; Junghofer, Bradley, Elbert, & Lang, 2001; Weinberg & Hajcak, 2010). Information processing in EPN window seems to reflect early affective discrimination and its modulation by perceptual features that facilitate further evaluation of salient stimuli (Di Russo, Taddei, Apnile, & Spinelli, 2006; Schupp et al., 2004). At the neurophysiological level, limbic and occipital structures have been implicated in early processing of emotional information indexed with the EPN (Herrmann et al., 2008). Emotional content triggers specific responses in the amygdala, which in turn activates sensory cortical areas and therefore allows for a more accurate perceptual processing when affective stimuli are presented (Bobes et al., 2012; Sabatinelli, Lang, Keil, & Bradley, 2007). Studies of sensory cortex activity in ex-combatants with posttraumatic stress disorders (PTSD) have shown perceptual adaptations to facilitate emotional discrimination, principally oriented to threat stimuli (Hendler, Rotshtein, & Hadar, 2001).

In our study, category (emotional versus neutral) effects reflected a preserved discrimination in ex-combatants, and no group differences were found. Although unexpected, this result suggests that an intact valence modulation in ex-combatants could be necessary as an adaptation to a violent environment. In a war environment, participants need to identify risky situations quickly. Alterations in early cortical discrimination of emotional stimuli may result in a poor adaptation and result in disadvantages for survival. Consistent with this hypothesis, the literature reports that combat veterans have more accuracy than non-combatants in identifying fear and anger expressions (Anaki, Brezniak, & Shalom, 2012; Miller & Litz, 2004).

The LPP component

The LPP has been associated with evaluation of motivational relevance of stimuli and is related with neural networks that modulate emotional engagement (Foti, Hajcak, & Dien, 2009; Ibanez et al., 2012; Pastor et al., 2008). This component is generated by visual, temporal and orbitofrontal cortices, as well as the amygdala and insula (Liu, Huang, McGinnis-Deweese, Keil, & Ding, 2012). Using simultaneous fMRI-ERP recordings, positive pictures showed more LPP-BOLD coupling in occipito-temporal junction, medial prefrontal cortex, amygdala and precuneus. Unpleasant pictures presented LPP-BOLD coupling in ventrolateral prefrontal cortex, insula and posterior cingulate cortex (Liu et al., 2012). The participation of parieto-occipital areas suggests that emotionally salient content enhances visual stimulus processing by attracting attentional resources (Lang & Bradley, 2010). Following these antecedents, the LPP activation could be considered as an index of stimuli evaluation oriented to enhance or inhibit behaviours.

We found a group effect in LPP amplitude, with higher values for ex-combatants (G1 and G2) than for controls. These results can be interpreted as biases in the effect of emotional information on subsequent cognitive processes. Similar effects have been described in war veterans with and without PTSD (Attias, Bleich, Furman, & Zinger, 1996; Stanford et al., 2001). Individuals with PTSD present an attentional bias reflected in an attenuated frontal P3 response to neutral target and increased response to trauma-relevant combat stimuli (Stanford et al., 2001). Another study with Israeli combat veterans, evaluated the modulation of ERPs (N1, N2, P2 and P3) in response to domestic animal pictures (targets), emotionally neutral pictures of furnishings (non-targets) and combat-related pictures (non-target probes) (Attias et al., 1996). An enhanced P3 and N1 amplitudes in the PTSD patients in non-target combat-related pictures and prolonged P3 latencies and RTs were found. These results support our preliminary speculation regarding perceptual bias in evaluation of emotional stimuli.

Moreover, the inverse correlation between LPP amplitude and executive functions and empathy (PDS dimension) found in our study suggest that higher cortical reactivity would be related both to poor empathy and executive function. These arguments are consistent with the hypothesis that armed conflict and war environment produce a biological adaptation represented in exaggerated responses to incoming stimuli (Jatzko, Schmitt, Demirakca, Weimer, & Braus, 2006; Tillman et al., 2012).

Hostility has been associated with higher arousal for displeasure (negative) IAPS pictures (Heponiemi, Ravaja, Elovainio, & Keltikangas-Järvinen, 2007). Both exaggerated and attenuated responses to emotional stimuli have been documented in generalized anxiety disorder (Weinberg & Hajcak, 2011), depression (Jaworska et al., 2012) and stress conditions (Weymar, Schwabe, Löw, & Hamm, 2012). Modulations in prefrontal regulation of emotional processing have been associated with aggressive and violent behaviour (Calzada-Reyes, Alvarez-Amador, Galán-García, & Valdés-Sosa, 2013; Reyes & Amador, 2009; Taft et al., 2007). In this sense, although speculative, combat environment could produce a high reactivity to emotional salience, for all positive, negative and neutral valences, which results from a perceptual bias in processing information. This would bias the result of biological adaptations to deal with the stressing conditions of war environment. Also, high reactivity could facilitate changes in responses to social situations, affecting empathy processes. These are very hypothetical conclusions that will require further assessment in the following studies.

Empathy, executive functions and individual differences in ex-combatants

Behavioural, ERP and correlational results suggest subtle differential neurocognitive processing among groups. The G1 (ex-combatant with normal empathy) showed impairments in executive function that could index impulsive behaviour. Impairments in these components could be reflected in non-planning actions, poor consequence evaluation and reward-oriented behaviour (Criaud, Wardak, Ben Hamed, Ballanger, & Boulinguez, 2012). In line with the inverse correlations found, higher reactivity in LPP would produce poor self-regulation in actions and exaggerated responses in social situations (Nelson & Trainor, 2007).

Empathy profile in G2 suggest that participants could understand the pain and feelings of others (normal cognitive empathy), but they did not feel high discomfort for others' suffering (abnormal PDS). Impairments to evaluate consequences of actions may be associated with their poor PDS. Studies in populations with instrumental aggression exhibit similar patterns of poor or normal executive functions but low PDS (Barratt, Stanford, Dowdy, Liebman, & Kent, 1999; Lane, Kjome, & Moeller, 2011). Similar to G1, in this group, higher reactivity in LPP would be indexing a poor self-regulation.

In synthesis, G1 may exhibit poor executive functioning and high cortical reactivity as a possible consequence of general lenient impairments in frontal functions. In turn, the G2 would be characterized by empathy abnormalities and high cortical reactivity to emotional processing information.

Limitations and further research

The sample size of our study, as in similar reports (Attias et al., 1996; Cunningham et al., 2005; Stanford et al., 2001), was modest. Neuropsychological assessment combined with ERPs in illegal ex-combatants is extremely difficult and uncommon. Nonetheless, future research should try to include more detailed measures for empathy and executive functions. Also, using individual aggression scores for a better characterization at behavioural level would be helpful in further assessment.

The selected stimuli used in this report, as detailed by the original reported parading, have moderate arousal levels (Dufey et al., 2011). This was decided in order to 1. steer clear of excessive ERP artefacts elicited by facial muscle reactions to negative stimuli with high arousal and 2. avoid posttraumatic stress reactions in ex-combatants. Nevertheless, although challenging, the inclusion of high arousal pictures could be an important strategy to evaluate the emotional processing in ex-combatants.

CONCLUSION

In this study, ex-combatants showed adequate early cortical responses to affective stimuli (EPN) but presented a higher reactivity of LPP. Moreover, we found poor executive functioning and high cortical reactivity in G1, and empathy impairments and high cortical reactivity to emotional processing information in G2. These features could be involved in the biological adaptations to the stressing conditions in a war environment. These findings, although preliminary, open new opportunities to conceive cognitive-behavioural interventions. Furthermore, they aid in the understanding of the neurophysiological basis of emotional processing and their relationship with empathy and executive functions.

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