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ORIGINAL ARTICLE

Attention-affect interactions and triarchic psychopathy: New electrophysiological insights from the late positive potential

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Abstract
One of the most prominent characteristics of psychopathy is a reduced processing of emotionally relevant information. However, it is still unclear how attentional mechanisms may modulate this deficit. The current study aimed to examine the impact of attentional focus on emotion processing in relation to the triarchic constructs of boldness, meanness, and disinhibition. Participants performed two tasks in which pleasant, neutral, and unpleasant framed pictures were presented. In the first task, participants were required to indicate the color of the frame (alternative-focus task), whereas in the second task they were instructed to indicate the emotional category of the image (affect-focus task). The Late Positive Potential (LPP) was used as an index of sustained engagement of attention to affective material. Confirming a successful task manipulation, we observed reduced LPP amplitudes, particularly for affective relevant material, in the alternative-focus task compared to the affect-focus task. Most interestingly, our results evidenced that trait meanness scores were associated with blunted elaborative processing of affective material (both appetitive and aversive) when this information was task-relevant (affect-focus task), but not when it was task-irrelevant (alternative-focus task). These findings indicate that high mean individuals are characterized by blunted elaborative processing of affective stimuli when their motivational relevance is determined in a top-down manner (i.e., when it is task-relevant). Our results highlight the need for further studying of the bottom-up and top-down dynamics of emotional attention in psychopathy.

KEYWORDS
attention, emotion, event-related potentials, late positive-potential, meanness, psychopathy

Pablo Ribes-Guardiola and Carlos Ventura-Bort contributed equally to this manuscript (co-first authorship).

1 | INTRODUCTION

Psychopathy is a multifaceted personality disorder encompassing distinct clusters of affective, interpersonal, and behavioral deviance features (Cleckley, 1976; Hare, 2003; Skeem et al., 2011). Some of the most prominent characteristics of psychopathy that distinguish it from other externalizing-related disorders are deficient empathy and lack of remorse, overconfidence of oneself, and bold and venturesome traits. Compelling empirical evidence indicates that psychopathic individuals present distinctive overarching impairments in the processing of emotionally relevant information, including deficits in threat detection and responsiveness, aversive conditioning, and emotion recognition (Brook et al., 2013; Dawel et al., 2012; Hoppenbrouwers et al., 2016, for reviews and meta-analyses). However, existing theoretical models differ on the mechanisms that lead to the affective deficits observed in psychopathic individuals. On the one hand, some theoretical accounts have emphasized deficits in emotional processing and responsiveness as the cause of psychopathy (i.e., emotion dysfunction accounts), with prominent models emphasizing either specific deficits in the processing of fear/threat cues (e.g., the Low fear model; Lykken, 1957, 1995), or more general impairments in neurobiological systems (e.g., amygdala and orbital/ventrolateral frontal cortex) underlying a wider range of affective processing deviations (Blair, 2005).

On the other hand, other theoretical perspectives, such as the response modulation hypothesis (RMH; Hamilton & Newman, 2018; Newman, 1998), state that the emotional and behavioral deficits linked to psychopathy are the result of impaired cognitive-attentional mechanisms. According to the RMH, the reduced responsiveness towards emotionally relevant material reflects attentional abnormalities (i.e., an attentional bottleneck; see Baskin-Sommers & Brazil, 2022, for a recent review) that preclude the processing of any type of information (irrespective of their emotional relevance) when it is not the current focus of attention (for an in-depth discussion on the relevance of the RMH and its comparison to other theoretical accounts of psychopathy, see Lilienfeld et al., 2016; Newman & Baskin-Sommers, 2016; Smith & Lilienfeld, 2015). In support of this model, some studies have found that well-replicated correlates of emotional processing deficits linked to psychopathy, such as a deficient aversive startle potentiation (Oskarsson et al., 2021, for a review), are more evident when threat cues are not the primary focus of attention (Baskin-Sommers et al., 2011; Newman et al., 2010).

One important aspect that has contributed to the heterogeneity of explanations for the affective deficits associated with psychopathy is the understanding of the disorder as a unitary vs. multi-faceted construct. While many of the etiological models were formulated conceiving psychopathy as a unitary construct (e.g., Low fear model [Lykken, 1995] and RMH [Newman, 1998]), increasingly accumulating empirical evidence indicates that the affective/interpersonal and the behavioral deviant (impulsive/antisocial) features of psychopathy show divergent associations with criterion measures in multiple measurement modalities, leading to the idea that different developmental and neurobiological mechanisms contribute to these two symptom components (dual-process models of psychopathy; see Fowles & Dindo, 2009; Patrick & Bernat, 2009, for reviews). From a neurobiological standpoint, deficits in defensive (fear) reactivity have been posited to underlie the affective/interpersonal features of psychopathy, whereas impairments in executive control processes are believed to contribute more to impulsive/antisocial features (Patrick & Bernat, 2009).

Emphasizing the multifaceted nature of psychopathic personality, the triarchic model (Patrick et al., 2009) has been proposed as an integrative conceptual framework for the differing historical and contemporary perspectives of psychopathy. This model characterizes psychopathy in terms of three distinct trait dispositions, namely disinhibition, boldness, and meanness, with separate developmental precursors and neurobiological correlates (Patrick, 2022; Patrick & Drislane, 2015, for reviews). According to the model, the trait of disinhibition, manifested in impulsiveness, nonplanfulness or weak behavioral restraint tendencies, reflects general proneness to externalizing problems, and is believed to correspond to the low pole of a neurobehavioral dimension of inhibitory control capacity (Venables et al., 2018), reflecting impairments in frontocortical systems that mediate executive control functions (Patrick et al., 2012). Consequently, highly disinhibited individuals show poorer performance in inhibitory control tasks and reduced neural reactivity to performance errors and target stimuli in cognitive tasks (Delfin et al., 2020; Paiva et al., 2020; Ribes-Guardiola, Poy, Patrick, & Moltó, 2020; Venables et al., 2018).

The affective/interpersonal features of psychopathy are represented in two different constructs in the triarchic model: boldness—encompassing features such as social dominance, venturesomeness, and emotional stability—and meanness—reflecting low social connectedness, callousness, and lack of empathy. Trait boldness is thought to be related to a neurobehavioral dimension of threat sensitivity (Yancey et al., 2016), entailing reduced reactivity of the brain's defensive motivational system to threat and punishment cues. Following this idea, trait boldness-related scores have been found to predict deficits in fear/threat potentiated startle (Esteller et al., 2016), reduced fear/threat conditioning (López et al., 2013; Paiva et al., 2020), reduced elaborative processing of aversive vs. neutral stimuli (Ellis et al., 2017), as well as a deficient inhibition of punished responses (Ribes-Guardiola, Poy, Segarra, et al., 2020). Recent evidence also points out to a role of boldness in downregulating emotional responses to affective stimuli (Perkins et al., 2022), and in lessening threat-related interference in the implementation of cognitive control mechanisms (Yancey et al., 2019). Finally, trait meanness is posited to reflect the low pole of a neurobehavioral dimension of affiliative capacity (Palumbo et al., 2020), potentially involving widespread cortical and subcortical brain networks related to emotional empathy and pain processing (see Blair et al., 2018; Decety, 2011, for reviews). In this line, meanness-related traits predict deficits in emotional face recognition (Brislin & Patrick, 2019; Brislin et al., 2018; Gillespie et al., 2019; Mowle et al., 2019), increased pain tolerance (Brislin et al., 2016, 2022; Miller et al., 2014), and lower ratings of perceived pain and elaborative processing of painful scenarios (Brislin et al., 2022) and aggressive situations (van Dongen et al., 2018).

In this regard, the triarchic model of psychopathy has emerged as a unifying framework that can help to better delineate the unique contribution of the proposed three trait dispositions to the cognitive and affective processing deviations associated with psychopathy. In the present study, we aimed to advance our understanding of psychopathy-related deficits in affective processing under different attentional instructions using the triarchic model of psychopathy as a reference point. Correlates of affective processing were extracted using event-related potentials (ERPs) derived from electroencephalographic (EEG) recordings. EEG is a non-invasive technique suitable for tracking neural responses to stimuli with excellent temporal resolution, including the temporal dynamics of affective processing. Its high temporal precision may further allow to disentangle emotion-cognition interactions and its alterations in psychopathology and individual differences research (for a review, see Hajcak et al., 2012). In the present study, we focused on the late positive potential (LPP; Cuthbert et al., 2000; Schupp et al., 2000), as one of the most robust ERP components of affective processing. The LPP is a positive slow wave, maximal at central-parietal electrode sites, that is reliably enhanced following both negative and positive stimuli, compared to neutrals (Cuthbert et al., 2000; Schupp et al., 2000). This enhancement has been theorized to reflect the sustained engagement of attention to motivationally significant cues, with the extent of amplitude increase reflecting the degree to which affective stimuli activate the brain's aversive or appetitive motivational systems (Bradley, 2009; Hajcak & Foti, 2020). Furthermore, the LPP has been shown to be particularly suitable for investigating attention-affect interactions. Studies assessing how top-down (i.e., allocation of attentional resources towards stimuli as determined by their relevance to the task at hand) and bottom-up (i.e., the 'automatic' capture of attention determined by the intrinsic salience of stimuli) attentional processes modulate the temporal dynamics of affective processing revealed unique interactive effects between task-relevance and affect on LPP amplitudes. Concretely, LPP amplitudes for affective stimuli, compared to neutral stimuli, have been found to be particularly enhanced when they are part of an individual's task goal (Schindler & Kissler, 2016; Schindler & Straube, 2020; Schupp et al., 2007). These findings have been interpreted as increased activation of motivational systems that may be the result of synergistic effects from both emotional feedback from the amygdala and top-down signaling from frontoparietal attentional networks (cf. Schindler & Straube, 2020).

Another line of research has shown that the LPP can be considered a reliable correlate of the psychopathic deficits in affective processing. A recent systematic review covering EEG research in psychopathy (Clark et al., 2019) indicated that one of the most pronounced differences between individuals high and low in psychopathic traits during the processing of affective stimuli was evident for the LPP response, with a majority of studies showing lower LPP amplitudes in high psychopathic individuals. Corroborating this observation, a recent meta-analysis found a significant reduction of LPP amplitudes for affectively relevant (especially unpleasant) stimuli in individuals with psychopathic traits (Vallet et al., 2020). However, due to the wide variety of task designs and assessment tools used, as well as differences in the conceptualization of psychopathy (unitary vs. multidimensional), it is difficult to draw conclusions about the modulatory role of attentional processes, and the unique contribution of each of the dimensions of psychopathy to deficits in affective processing, as indexed by reduced LPP amplitudes.

To date, only a few studies have examined the interactive effects of attentional processes on the affective elaboration of visual stimuli (as indexed by the LPP amplitudes) in relation to psychopathy. In one study, Howard and McCullagh (2007) compared the LPP responses of high-psychopathic and low-psychopathic inmates elicited by two different versions of a three-stimuli oddball paradigm: a "vigilance task" in which affective stimuli were presented infrequently and never served as targets, and a "categorization task" in which affective stimuli were presented infrequently but served as targets. Compared to low-psychopathic inmates, high-psychopathic inmates showed smaller LPP amplitudes for affective stimuli in the categorization task only, indicating diminished elaborative processing of affective cues when they were task relevant. Correlational analyses revealed that blunted

LPP amplitudes for affective stimuli were negatively correlated with both deficient affective experience and impulsive and irresponsible lifestyle features of psychopathy. Unfortunately, the categorization task in this study did not involve explicit judgments as to the affective quality of the emotional stimuli serving as targets, but merely a discrimination between pictures of man-made objects and living things. Overcoming this limitation, Anderson and Stanford (2012) employed a group design in a community sample that performed the two versions of a three-stimuli oddball task on which neutral and emotional pictures were presented infrequently. In one version, participants had to discriminate between photographs and abstract designs (implicit task), while in the other version, they had to categorize the photographic stimuli as emotionally evocative or neutral (categorization task). The results showed that in the implicit task, the high psychopathic group, contrary to the low psychopathic group, failed to demonstrate an affective modulation of the LPP response, which may support attentional-deficit models of psychopathy, positing that deficits in emotion processing should emerge only when emotional information is not task-relevant (see also Carolan et al., 2014, for evidence of blunted LPP amplitudes for affective stimuli under implicit processing conditions). However, the fact that the low psychopathic group still showed greater emotional modulation of the LPP than the high psychopathic group in the categorization task, suggests that attentional mechanisms alone cannot account for the reductions in affective processing found in this study.

One limitation of the abovementioned studies is that affective information during the implicit processing conditions never competed for resources with task-relevant aspects within the same trial. Overcoming this limitation, a recent study by Scheeff et al. (2021) examined differences in the processing of affective information between violent offenders with psychopathic traits and a non-incarcerated control sample in a task that required participants to determine the orientation of rectangles superimposed to positive, neutral, and negative pictures while ignoring the affective stimuli (task 1), or to rate the valence and arousal of these stimuli (while ignoring the rectangles; task 2). Control participants tended to show greater affective modulation of the LPP than violent offenders in task 2, but not in task 1, thus suggesting that differences between groups were more readily observed when affective stimuli were the focus of attention. However, from this study it is difficult to ascertain the extent to which psychopathic traits were driving the between groups differences on LPP amplitudes. First, participants in the control group were not assessed or screened for psychopathic traits. Furthermore, inter-rater reliability of psychopathy scores in the violent offender group was not reported, which might be especially low—particularly for the core affective-interpersonal features of psychopathy—in field settings (see Edens et al., 2010).

Remarkably, the majority of the above reviewed studies examining attention-affect interactions employed group designs comparing either controls vs. inmates, or high vs. low psychopathy groups, which does not allow for robust inferences about the differential contribution of the distinct facets of psychopathic personality in the diminished affective modulation of the LPP. In order to shed further light on the relationship between psychopathic traits and affective processing in interaction with attentional processes, the present study examined the relationship between the triarchic trait dispositions—boldness, meanness, and disinhibition—and LPP amplitudes evoked by pleasant, neutral, and unpleasant pictures while directly manipulating the focus of attention towards (affect-focus task) or away (alternative-focus task) from affective information. It is important to note that this study design allows us to test more directly whether the expected reduced affective modulation of the LPP in relation to psychopathic traits occurs independently of the attentional resources dedicated to the processing of affective material, as would be expected based on emotion-dysfunction accounts of psychopathy (i.e., blunted affective modulation of the LPP under both affect-focus and alternative-focus instructions), or only when affective information is not the current focus of attention (i.e., blunted affective modulation of the LPP when attentional instructions are directed away from affective material), as the RMH would predict.

In addition to LPP amplitudes, we will also examine behavioral performance measures (i.e., interference of foreground affective stimuli in the alternative-focus task and categorization accuracy of affective stimuli in the affect-focus task). While neurophysiological measures such as the LPP allow to characterize information processing deviations at processing stages that are not directly measurable by overt behavioral responses, routinely evaluating behavioral alongside neurophysiological measures can help to better understand psychopathy-related impairments in affective processing. It may further allow to better ascertain the validity of different behavioral and neurophysiological measures as indicators of psychopathic traits (e.g., see Brook et al., 2013).

Based on the foregoing evidence, and considering prior work conducted within the triarchic model framework linking reduced affective modulation of the LPP during passive viewing conditions to either boldness (Ellis et al., 2017) or meanness traits (Brislin et al., 2022; van Dongen et al., 2018), we hypothesized that a deficient affective modulation of the LPP would be preferentially related to trait boldness or meanness scores. We did not anticipate any specific hypothesis regarding trait disinhibition, given that this triarchic construct has been most consistently linked to processing impairments during cognitive tasks (Patrick, 2022). Finally, considering the methodological differences between our study and prior research in assessing affective processing in interaction with attentional processes behaviorally (e.g., valence and arousal ratings, oddball categorization errors; see Anderson & Stanford, 2012; Howard & McCullagh, 2007; Scheeff et al., 2021), we did not advance any specific hypothesis regarding the behavioral outcomes of this study.

2 | METHOD

2.1 | Participants

A total of one hundred and forty-seven healthy students (117 women, 30 men), between the ages of 18 and 44 years, from the University Jaume I of Castellón participated in the current experiment as part of a broader investigation about psychophysiological correlates of psychopathy. Participants had normal or corrected-to-normal vision and were not undergoing psychiatric or pharmacological treatment at the time of the experiment. The experimental research procedures were approved by the Ethical Committee of the Universitat Jaume I, and all participants provided written informed consent and were compensated with academic credits for their participation.

From the initial sample of 147 participants, one participant (0.68%) who quit the experiment before ending, and two additional participants (1.36%) who did not complete the self-report personality assessment, were excluded from all analyses. Twelve additional participants (8.16%) were excluded from the behavioral analyses due to technical problems with the response pad (i.e., no responses were recorded and response triggers were not sent to the acquisition software). Therefore, behavioral analyses are reported for the 132 participants (104 females, *M* age = 19.86, *SD* = 3.68) who had available behavioral data, whereas analyses for the LPP response were based on 144 participants (114 females, *M* age = 19.86, *SD* = 3.59).

2.2 | The triarchic psychopathy measure

In the current study, we used the Spanish version (Poy et al., 2014) of the Triarchic Psychopathy Measure (TriPM; Patrick, 2010) to assess psychopathic traits. The TriPM (Patrick, 2010) is a self-report measure constructed specifically to assess the three trait dimensions of boldness, meanness, and disinhibition proposed by the triarchic model of psychopathy (Patrick et al., 2009). It consists of 58 items answered using a 4-point Likert scale (0 = "false"; 1 = "somewhat false"; 2 = "somewhat true"; 3 = "true"), that differently assess manifestations of boldness (19 items; I'm a born leader), meanness (19 items; I enjoy a good physical fight), and disinhibition (20 items; I often act on immediate needs) dimensions. Cronbach's alpha reliability coefficients for the TriPM Boldness, Meanness, and Disinhibition scale scores in the final study sample ($n = 144$) were .78, .83 and .83, respectively, indicating good internal consistency. Consistent with theoretical predictions and empirical evidence (see Patrick et al., 2009; Sleep et al., 2019), in the current study sample TriPM Boldness and Meanness scores showed modest overlap (r (144) = .18, p = .032), high overlap was observed between Meanness and Disinhibition scores (r (144) = .55, p < .001), whereas Boldness and Disinhibition scores were negligibly correlated (r (144) = .07, p = .429). Prior work has demonstrated the construct validity of the TriPM scales in relation to normal-range and psychopathological problems and traits (see Patrick, 2022; Sleep et al., 2019 for reviews and meta-analyses). TriPM Boldness scores show strong negative associations with measures of anxiety, negative emotionality and internalizing problems, as well as positive associations with measures of narcissism, risk-taking, and social dominance. TriPM Meanness mainly assess aspects of high antagonism, low empathy and aggression, and strongly relates to antagonistic-externalizing forms of psychopathology (e.g., aggressive antisocial behavior). Finally, TriPM Disinhibition scores relate to measures of impulsivity and low conscientiousness, and predicts general externalizing problems (e.g., antisocial behaviors, substance abuse), as well as higher levels of negative affect. Evidence for the construct validity of TriPM scale scores in the current study sample is provided in the Supporting Information.

2.3 | Experimental tasks

In the present experiment, 360 scenes from the *International Affective Picture System* (IAPS; Lang et al., 2008) were used, consisting of 120 pleasant (e.g., erotic, adventure, babies, small animals), 120 unpleasant, (e.g., mutilation, attack, disgust, accident) and 120 neutral (e.g., nature landscapes, buildings, neutral faces, objects) images. Pictures were selected based on their normative ratings on affective valence and arousal (Spanish norms: Moltó et al., 1999, 2013; Vila et al., 2001). Mean (SD) valence and arousal ratings were, respectively, 7.23 (0.52) and 6.05 (0.91) for pleasant pictures, 2.72 (0.74) and 6.11 (0.79) for unpleasant pictures, and 5.29 (0.54) and 3.62 (0.53) for neutral pictures. The three picture categories matched in their physical characteristics (i.e., complexity, brightness, and contrast; all ps > .13) and differed in terms of valence (unpleasant vs. neutral: t (238) = 30.76, $p < .001$; unpleasant vs. pleasant: t (238) = 54.6, $p < .001$; pleasant vs. neutral: t (238) = 28.32, $p < .001$). Pleasant and unpleasant pictures did not differ in arousal ($t < 1$), but both emotional categories showed significantly higher arousal ratings than their neutral counterparts (unpleasant vs. neutral: t (238) = 28.49, $p < .001$; pleasant vs. neutral: t (238) = 25.31, $p < .001$). Pictures were grouped into two different sets of 180 pictures (i.e., 60 from each category) carefully matched for physicality and affective ratings across sets and categories ($ps > .18$).

The experiment consisted of two blocks lasting 12 min each. In each block, 180 pictures were presented (60 pleasant, 60 unpleasant, and 60 neutral) surrounded by a yellow, red, or blue color frame (horizontal and vertical visual angle of 9.29° and 6.91° for picture, and of 11.18° and 8.82° for picture/frame combination). Each picture category was equally paired with each of the color frames. Picture/frame combinations were presented in the center of the screen for 2 s, followed by a jittered inter-trial interval varying from 1500 to 2400 ms. The picture presentation order was pseudorandomized with no more than two pictures of the same category presented consecutively.

In the first block, participants underwent the so-called alternative-focus task in which the focus of attention was drawn to the non-affective characteristics of the stimuli. Here, participants had to indicate the color of the frame in which the images were embedded by pressing a "red", "yellow" or "blue" button on a response pad, after the framed picture offset. In the second block, participants performed the affect-focus task in which attention was directed to affectively relevant features of the stimuli. Here, participants had to indicate the category of the picture presented on the screen by pressing a "pleasant", "neutral" or "unpleasant" button on a response pad, after the picture/frame offset.

2.4 | Procedure

The experimental tasks took place individually in a sound-attenuated and dimly lit room. Presentation v. 14.5 software. (Neurobehavioral Systems, Inc. Albany, CA, USA), installed on a PC Pentium Core 2 Duo (Intel), was used to control the order and timing of stimulus presentation and to record behavioral responses, performed using an SRBox 200A serial response device (EGI). After the electrodes were attached, participants first performed the alternative-focus task and, after a short break, the affect-focus task. To avoid potential contamination of the affect-focus on the alternative-focus task, the order of the tasks was kept fixed across participants. The total duration of the experimental procedure was about 30 min.

2.5 | Psychophysiological recording and data reduction

EEG signals were recorded continuously from 257 electrodes using an Electrical Geodesics (EGI) HydroCel high-density EEG system with NetStation software on a Macintosh computer. The EEG recording was digitized at a rate of 250 Hz, using the vertex sensor (Cz) as recording reference. Scalp impedance for each sensor was kept below 50 kΩ. All channels were band-pass filtered online from 0.1 to 100 Hz. Offline reduction was performed using *ElectroMagneticEncephaloGraphy Software* (EMEGS; Peyk et al., 2011), a well-suited software for EEG analyses in dense arrays studies (Junghöfer et al., 2000), which included low-pass filtering at 40 Hz, blink and eye movement removal, artifact detection, sensor interpolation, baseline correction, and conversion to the average reference. Stimulus-synchronized epochs were extracted from 200 ms prior to 1800 ms after onset of the picture/frame combination and baseline corrected (using 200 ms epochs prior to stimulus onset as baseline). Extracted epochs were corrected for eye movement and blink artifacts using the MATLAB-based toolbox BioSig (Vidaurre et al., 2011).

For each participant, separated ERP averages were computed for each sensor and condition. The LPP was scored as the mean amplitude in a 400–700 ms time window following stimulus onset, sampled over centro-parietal sites using a 14-sensor cluster (EGI sensors: 45, 79, 80, 81, 89, 90, 100, 101, 129, 130, 131, 132, 143, and 257; for electrode configuration, see inset in Figure 1a). The scoring window for the LPP was based on previous work indicating that interactions between task-relevance and emotion are restricted to early portions of the LPP response (Schindler & Kissler, 2016; Schindler & Straube, 2020), on prior research examining LPP amplitude modulations in psychopathy (Sadeh & Verona, 2012) and on visual inspection of the grand averaged waveforms indicating maximal activity within this time window (see Figure 1).[1]

Following prior research examining the internal consistency of the LPP (Moran et al., 2013), split-half reliabilities

[1]In order to fully characterize effects of attention on affective processing as indexed by the LPP, and given that prior studies have examined interactions between affect and task relevance on LPP amplitudes up to 1000 ms (e.g., Schindler & Straube, 2020), we undertook supplemental analyses testing for attention-affect interactions on the later part of the LPP (700–1000 ms). As detailed in the Supporting Information, our results still evidenced significant interactions between attentional focus and affect on the later portion of the LPP, albeit with smaller effects sizes than those found for the earlier (400–700 ms) time window. Results from exploratory analyses testing for the moderating role of triarchic dimensions on the attention-affect interactions for the later portion of the LPP are also reported in the Supporting Information.

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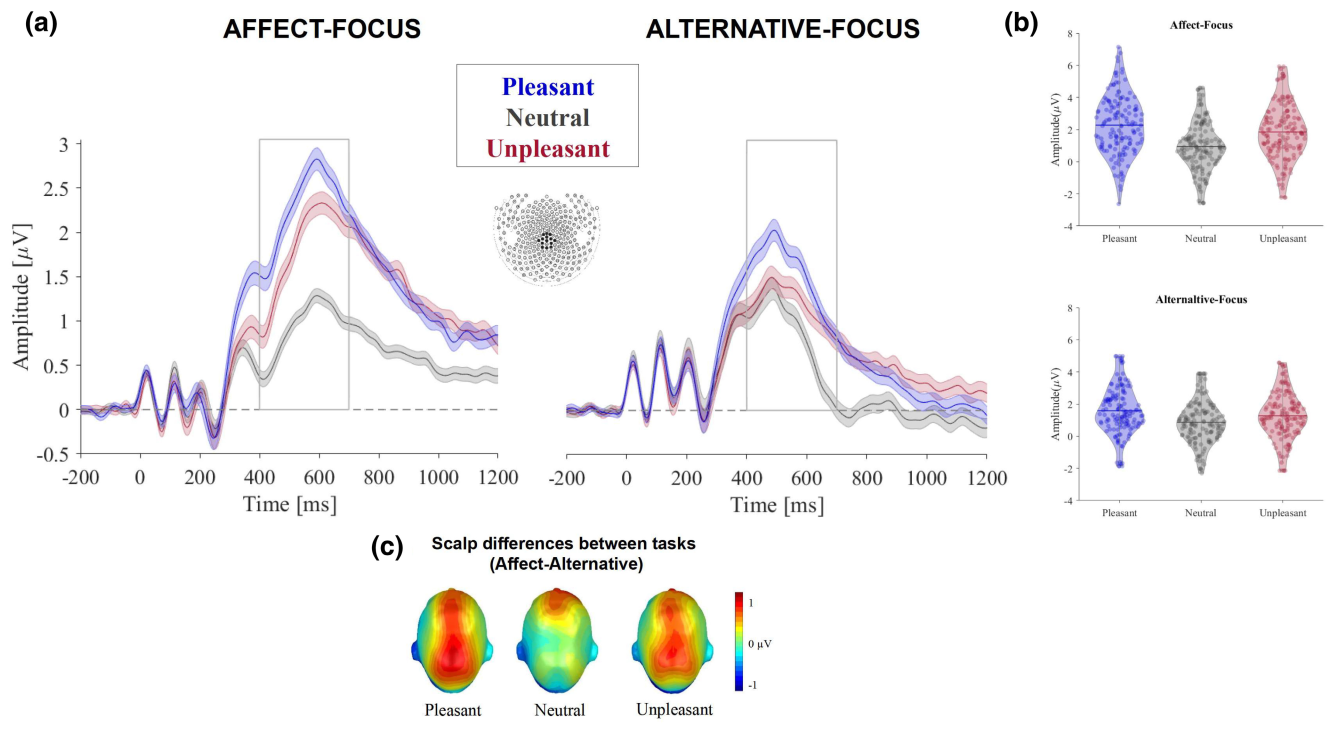

FIGURE 1 Affect modulation in LPP amplitudes for affect-focus and alternative-focus tasks. (a) Grand averaged ERPs in response to pleasant, neutral, and unpleasant images in the affect-focus (left) and alternative-focus (right) tasks. ERPs are averaged across electrodes within a centro-parietal cluster (see inset). (b) Violin plots of the mean LPP amplitudes for the affect-focus (above) and alternative-focus (below) tasks. Thick horizontal line represents the mean amplitude across participants. (c) Topographical maps of the LPP differences (400–700 ms) between tasks for each of the emotional categories.

of LPP amplitudes were computed for each task and condition as the correlation between the ERP average amplitude for even and odd numbered trials, corrected for attenuation using the Spearman-Brown prophecy formula (r_{SB}). In line with prior findings (Moran et al., 2013), corrected split-half reliabilities of the LPP for each task and condition were moderate-to-high in all cases; in the Alternative-focus task: LPP Pleasant (r_{SB} = .88), LPP Neutral (r_{SB} = .89), LPP Unpleasant (r_{SB} = .89); in the Affect-focus task: LPP Pleasant (r_{SB} = .80); LPP Neutral (r_{SB} = .84); LPP Unpleasant (r_{SB} = .79).

2.6 | Data analysis

Data analysis was performed using SPSS software (version 28; IBM). First, descriptive statistics (Mean, SD, range) were computed for the TriPM scale scores, and for the behavioral and ERP variables in each task. Prior to conducting all analyses, the effects of demographic variables (age, gender) were tested. Age showed no significant correlation with TriPM scale scores ($rs < |.13|$, $ps > .118$), nor main or interaction effects on LPP amplitudes ($Fs < 0.63$, $ps > .523$), and thus was omitted from all analyses. However, male participants scored significantly higher than females on the TriPM-Boldness and Meanness scales. Given that modulatory effects of gender on LPP amplitudes were found (detailed below; see also Table 1), gender was included as a between-subjects factor in all reported analyses.

Behavioral accuracy as a function of picture content was evaluated for each task separately by conducting a repeated-measures General Linear Model (GLM) with *Affect* (pleasant, neutral, unpleasant) as the within-subjects factor and the hit rate as the dependent variable. In the alternative-focus task, hit rates were computed as the percentage of responses correctly identifying the color of the frame when the background emotional content was pleasant, neutral, or unpleasant. In the affect-focus task, hit rates were computed as the percentage of responses correctly categorizing emotional content in agreement with the researchers' expectations and of the IAPS picture content category classification. Subsequently, the effects of triarchic psychopathy scores on the hit rate were examined by including each TriPM scale score separately as a continuous between-subjects factor in the GLMs.

To evaluate the effects of attentional focus on emotion processing, as indexed by the LPP response, a 3×2 repeated measures GLM was conducted with *Affect* (pleasant, neutral, unpleasant) and *Task* (alternative-focus,

TABLE 1 Descriptive statistics for TriPM scale scores, behavioral accuracy and LPP amplitudes for the overall sample and for women and men separately

	All participants			Women			Men			Women vs. men comparison		
Variable	**M**	**SD**	**Range**	**M**	**SD**	**Range**	**M**	**SD**	**Range**	***t***	***p***	***d***
Self-report Data	(*n* = 144)			(*n* = 114)			(*n* = 30)					
TriPM Boldness	28.44	7.90	7 to 48	27.72	7.45	7 to 45	31.2	8.98	13 to 48	**2.18**	**.031**	**0.42**
TriPM Meanness	10.50	6.82	0 to 30	9.52	6.05	0 to 30	14.2	8.31	4 to 30	**3.36**	**.001**	**0.64**
TriPM Disinhibition	16.36	8.67	0 to 40	15.75	8.60	0 to 40	18.7	8.69	3 to 39	1.67	.097	0.34
Behavioral Data	(*n* = 132)			(*n* = 104)			(*n* = 28)					
Alternative Focus Task												
Hit Rate Pleasant (%)	98.33	2.12	90 to 100	98.33	2.19	90 to 100	98.33	1.87	93.33 to 100	0.00	1.00	0.00
Hit Rate Neutral (%)	98.56	2.27	83.33 to 100	98.43	2.41	83.33 to 100	99.05	1.60	95 to 100	1.28	.203	0.27
Hit Rate Unpleasant (%)	98.08	2.81	81.67 to 100	97.95	3.08	81.67 to 100	98.57	1.33	95 to 100	1.04	.300	0.22
Affect Focus Task												
Hit Rate Pleasant (%)	75.41	15.40	26.67 to 98.3	74.81	15.52	33.33 to 98.3	77.68	14.99	26.67 to 98.3	0.88	.383	0.19
Hit Rate Neutral (%)	79.22	12.15	40 to 98.3	79.04	12.22	48.33 to 98.3	79.88	12.06	40 to 96.67	0.33	.746	0.07
Hit Rate Unpleasant (%)	84.57	12.60	11.67 to 100	86.03	10.62	35 to 100	79.17	17.37	11.67 to 98.3	**2.61**	**.010**	**0.55**
ERP Data	(*n* = 144)			(*n* = 114)			(*n* = 30)					
Alternative Focus Task												
LPP Pleasant (μV)	1.60	1.50	−1.80 to 4.99	1.75	1.41	−1.80 to 4.99	1.05	1.71	−1.81 to 4.72	**2.29**	**.023**	**0.47**
LPP Neutral (μV)	0.88	1.36	−2.27 to 3.89	1.03	1.33	−2.06 to 3.89	0.30	1.31	−2.27 to 2.10	**2.70**	**.008**	**0.56**
LPP Unpleasant (μV)	1.28	1.50	−2.17 to 4.60	1.50	1.42	−2.17 to 4.60	0.46	1.52	−2.17 to 3.40	**3.52**	**.001**	**0.72**
Affect Focus Task												
LPP Pleasant (μV)	2.31	1.81	−2.65 to 7.14	2.55	1.65	−1.13 to 6.76	1.40	2.10	−2.65 to 7.14	**3.21**	**.002**	**0.66**
LPP Neutral (μV)	0.97	1.56	−2.56 to 4.56	1.24	1.50	−2.56 to 4.56	−0.07	1.35	−2.56 to 2.37	**4.35**	**.001**	**0.89**
LPP Unpleasant (μV)	1.89	1.76	−2.22 to 5.91	2.17	1.61	−1.06 to 5.91	0.77	1.89	−2.22 to 5.45	**4.09**	**.001**	**0.84**

Abbreviations: LPP, Late Positive Potential amplitudes; TriPM, Triarchic Psychopathy Measure. Significant gender differences are highlighted in bold font.

TABLE 2 Bivariate and partial correlations between TriPM scale scores and LPP affective modulation scores for the overall sample ($n = 144$)

	Alternative focus task		Affect focus task		Affective modulation differences (affective–neutral LPP scores) across tasks	
	Affective–neutral LPP		Affective–neutral LPP		Affect-focus – Alternative-focus	
	Difference scores	Residualized scores	Difference scores	Residualized scores	Difference scores	Residualized scores
	r/Partial *r*	*r*/Partial *r*	*r*/Partial *r*	*r*/Partial *r*	*r*/Partial *r*	*r*/Partial *r*
TriPM Boldness	−.14/−.13	−.15/−.14	−.06/−.03	−.06/−.04	.05/.07	-.04/−.01
TriPM Meanness	.00/.03	−.00/.04	−.23**/−.18*	−.24**/−.17*	−.20*/−.17*	−.24**/−.18*
TriPM Disinhibition	.01/.01	.00/−.00	−.17*/−.06	−.18*/−.06	−.16/−.05	−.18*/−.06

Note: Partial r = partial correlations for each TriPM scale score controlling for gender and the overlap with the other two TriPM scales scores. TriPM = Triarchic Psychopathy Measure. Difference scores reflect LPP affective modulation scores computed by subtracting mean LPP amplitudes pooled across both affective categories (pleasant/unpleasant) from the neutral category. Residualized scores were computed as the unstandardized residuals saved from a regression model on which affective (pleasant/unpleasant average) LPP amplitudes served as the criterion and LPP amplitudes from the neutral category as the predictor. Residualized scores in the rightmost column reflect the unique variance on residual LPP amplitudes from the affect focus task after partialling out variance shared with the residual scores from the alternative focus task.

**$p < .01$; *$p < .05$.

affect-focus) as within-subjects factors. Significant effects involving the *Affect* factor were further decomposed through the use of quadratic (arousal) and linear (valence) contrasts, for which we expected significant quadratic trends reflecting higher amplitudes for both pleasant and unpleasant picture contents relative to neutrals (e.g., Cuthbert et al., 2000). For all repeated measures analyses, Greenhouse–Geisser corrections were implemented when applicable. Partial eta square (η_p^2) values were also reported as indexes of effect size. In addition, follow-up post-hoc comparisons were performed to test the significance of pair-wise contrasts, applying the Bonferroni correction ($\alpha < .05$/number of contrasts). The effects of triarchic psychopathy scores on the LPP response were examined by including each TriPM scale score separately as a continuous between-subjects factor in the GLM. Effects of interest involving significant interactions between *Affect* and *Task* with TriPM scale scores were further decomposed by conducting separate GLMs in each task (alternative-focus, affect-focus). Significant *Affect* × *TriPM scale* interactions were followed up by conducting correlational analyses between LPP amplitude difference scores (affective – neutral) and TriPM scale scores; partial correlational analyses were also conducted to test for the unique contribution of each triarchic dimension after controlling for the other two triarchic dimensions and gender. Although it is common in LPP studies to isolate neural reactivity to affective pictures by computing subtraction-based difference scores (affective – neutral), the use of regression-based residualized scores has been recently advocated as an alternative approach (Meyer et al., 2017). Following this, we computed the unstandardized residuals from separate linear regressions for each task on which LPP amplitudes for affective pictures were used as the criterion measure and LPP amplitudes for neutral pictures as the predictor, and correlated these measures with TriPM scale scores (see Table 2).[2]

To avoid a disproportionate influence of outliers on the relationship between TriPM scores and LPP amplitudes, a winsorization procedure was applied (comprising 4.05% of all scores): values below the 25th percentile minus 1.5 times the interquartile range, or above the 75th percentile plus 1.5 times the interquartile range of the distribution were replaced with the minimum or maximum values within these ranges (Wilcox, 2012).

3 | RESULTS

Descriptive statistics for the sample as a whole, and for gender subgroups separately, along with independent samples *t*-test evaluating gender differences in TriPM

[2]In the current study, corrected split-half reliabilities for both difference and residual scores were poor, but somewhat lower for difference ($r_{SB} = .14$ for the alternative-focus task; $r_{SB} = .25$ for the affect-focus task) than for residualized scores ($r_{SB} = .31$ for the alternative-focus task; $r_{SB} = .32$ for the affect-focus task). Although these reliability estimates were somewhat lower to those found for LPP amplitudes in prior research (Moran et al., 2013), they are nonetheless comparable to other difference-score psychophysiological measures widely used in individual differences research (see e.g., Levinson et al., 2017; Perkins et al., 2017; Yancey et al., 2016).

scale scores and behavioral (hit rate) and LPP amplitudes are presented in Table 1.

3.1 | Behavioral results

3.1.1 | Task effects

In the alternative-focus task, no main effect of *Affect* was observed for behavioral accuracy, $F\ (2, 260) = 2.39$, $p = .093$, $\eta_p^2 = .018$, and gender showed no significant main or interaction effects (Fs < 1.16, $ps > .316$). As can be seen in Table 1, overall accuracy in this task was high for all affective conditions (average across affective conditions: $M = 98.32\%$, $SD = 2.05\%$), thus suggesting that participants could successfully pursue the instructed goal of this task (i.e., identify the color of the frame) with little interference from background emotional information.

In the affect-focus task, behavioral accuracy was modulated by *Affect*, $F\ (2, 260) = 5.02$, $p = .010$, $\eta_p^2 = .037$, $\varepsilon = .872$. Post-hoc t-tests revealed that participants were overall more accurate in identifying unpleasant than pleasant or neutral pictures (unpleasant vs. pleasant: $t\ (131) = 6.46$, $p < .001$, $d = 0.56$; unpleasant vs. neutral: $t\ (131) = 3.35$, $p = .003$, $d = 0.29$), with no significant differences between pleasant and neutral pictures ($t[131] = -1.99$, $p = .145$, $d = -0.17$). No main effect of gender was evident in this task ($F\ [1, 130] = 0.40$, $p = .530$, $\eta_p^2 = .003$), but a significant *Gender* × *Affect* interaction was observed, $F\ (2, 260) = 3.28$, $p = .046$, $\eta_p^2 = .025$, with women being significantly more accurate than men when categorizing unpleasant pictures, but not pleasant or neutrals (see Table 1).

3.1.2 | Psychopathy effects

In the alternative-focus task, neither TriPM Boldness, Meanness or Disinhibition scale scores showed significant main nor interaction effects with *Affect* ($Fs < 2.50$, $ps > .116$, $\eta_p^2\text{s} < .019$). In the affect-focus task, a significant main effect of TriPM Meanness scale scores was detected, $F\ (1, 129) = 9.17$, $p = .003$, $\eta_p^2 = .066$; the interaction *Affect × TriPM Meanness* was not significant, $F\ (2, 260) = 2.14$, $p = .127$, $\eta_p^2 = .016$, $\varepsilon = .866$. Inclusion of TriPM Boldness and Disinhibition scale scores did not reveal significant main effects or interactions with *Affect* in this task (Fs < 2.57, $ps > .086$, $\eta_p^2\text{s} < .020$).

Follow-up correlational analyses revealed a significant negative bivariate association between overall accuracy in the affect-focus task and TriPM Meanness scores, $r\ (132) = -.26$, $p = .002$, indicating that participants scoring high in meanness showed lower accuracy in categorizing the affective category of the pictorial stimuli. This association remained significant even after controlling for gender and TriPM Boldness and Disinhibition scores in partial correlational analyses, partial $r\ (127) = -.23$, $p = .008$. Exploratory analyses revealed that the main effect of meanness was largely attributable to high mean individuals, showing reduced accuracy in the categorization of unpleasant pictures, $r\ (132) = -.35$, $p < .001$ (rs $= -.10$ and $-.02$, for pleasant and neutral pictures, respectively,[3] $ps > .257$), an association that remained significant after controlling for gender and TriPM Boldness and Disinhibition scores, partial $r\ (127) = -.30$, $p < .001$.

3.2 | ERP results: LPP

3.2.1 | Task effects

Repeated measures GLM results assessing the impact of attentional focus on the emotional modulation of the LPP response revealed a significant main effect of *Affect*, $F\ (2, 284) = 135.74$, $p < .001$, $\eta_p^2 = .489$, $\varepsilon = .916$. The linear (valence) effect was significant, $F\ (1, 142) = 69.73$, $p < .001$, $\eta_p^2 = .329$, and a more robust quadratic (arousal) effect was also observed, $F\ (1, 142) = 174.05$, $p < .001$, $\eta_p^2 = .551$, indicating larger overall amplitudes for pleasant picture contents and larger amplitudes for pleasant and unpleasant picture contents than for neutral ones. A significant main effect of *Task* was also observed, $F\ (1, 142) = 6.39$, $p = .013$, $\eta_p^2 = .043$, with larger overall LPP amplitudes in the affect-focus task than in the alternative-focus task. Most interestingly, a significant *Affect* × *Task* interaction was observed, $F\ (2, 284) = 19.03$, $p < .001$, $\eta_p^2 = .118$, $\varepsilon = .947$. A robust quadratic trend effect for the *Affect* × *Task* interaction was observed, $F\ (1, 142) = 31.94$, $p < .001$, $\eta_p^2 = .184$, while the linear contrast was non-significant, $F\ (1, 142) = 0.60$, $p = .440$, $\eta_p^2 = .004$.

Follow-up repeated-measures GLMs demonstrated robust main effects of *Affect* in both tasks: in the alternative-focus task, $F\ (2, 284) = 40.78$, $p < .001$, $\eta_p^2 = .224$; in the affect-focus task, $F\ (2, 284) = 117.68$, $p < .001$, $\eta_p^2 = .453$, $\varepsilon = .872$. The post-hoc *t*-test revealed significant differences between all affective contents in both tasks, with smaller effect sizes found in the alternative-focus task (Pleasant-Neutral: $t\ (143) = 10.24$, $p < .001$, $d = 0.85$; Unpleasant-Neutral: $t\ (143) = 6.18$, $p < .001$, $d = 0.52$; Pleasant-Unpleasant: $t\ (143) = 4.98$, $p < .001$,

[3]Follow-up analyses using Steiger's z statistic indicated that the association between TriPM Meanness scores and the hit rate for unpleasant pictures was significantly greater than that observed for pleasant ($z = -2.64$, $p = .008$) and neutral ($z = -2.63$, $p = .009$) pictures.

d = 0.42), than in the affect-focus task (Pleasant-Neutral: t (143) = 15.68, p < .001, d = 1.31; Unpleasant-Neutral: t (143) = 12.17, p < .001, d = 1.04; Pleasant-Unpleasant: t (143) = 7.09, p < .001, d = 0.59; see Figure 1b). To further elucidate the nature of the observed interaction effects, paired samples t-tests were carried out comparing both tasks in each of the emotional categories. Neutral pictures evoked comparable LPP amplitudes in both tasks, t (143) = 0.81, p = .421, d = 0.07. However, both pleasant and unpleasant picture contents evoked greater LPP amplitudes in the affect-focus compared to the alternative-focus task: t (143) = 5.54, p < .001, d = 0.46, for pleasant pictures; t (143) = 5.05, p < .001, d = 0.42, for unpleasant pictures. To illustrate these effects, Figure 1a shows grand averaged waveforms for each affective category and task across the whole sample; the accompanying scalp maps show the differences between emotional categories across tasks (Figure 1c; see Table 1 for descriptive statistics).

Finally, participant's gender evidenced a robust main effect, F (1, 142) = 15.61, p < .001, η_p^2 = .099, indicating higher overall LPP amplitudes for women than for men, but did not interact with either *Affect*, *Task*, or *Affect* × *Task* (Fs < 2.70, ps > .074); see Table 1 for descriptive statistics and independent samples t-test evaluating gender differences on LPP amplitudes.

3.2.2 | Psychopathy effects

To test for effects of triarchic psychopathy traits on the emotional modulation of the LPP response as a function of attentional focus, the same 3 (*Affect*) × 2 (*Task*) repeated-measures GLMs were conducted including gender as a between-subjects factor and each TriPM scale score separately as a continuous between-subjects factor. A significant *Affect* × *Task* × *TriPM Meanness* was evident, F (2, 282) = 4.31, p = .016, η_p^2 = .030, ε = .954. This interaction was qualified by a significant quadratic (arousal) effect, F (1, 141) = 7.49, p = .007, η_p^2 = .050, (F for linear contrast = 0.02, p = .899). No other main or interaction effects were found for TriPM Meanness scores (Fs < 2.54, ps > .085). Inclusion of TriPM Boldness and Disinhibition as separate continuous between-subjects factors revealed no significant main or interaction effects for either trait (Fs < 2.41, ps > .094).

In order to decompose the significant three-way interaction found for TriPM Meanness scores, separate repeated-measures GLMs were conducted with *Affect* as within-subjects factor, participant gender as a between-subjects factor, and TriPM Meanness scores as a continuous between-subjects factor in each task. In the alternative-focus task, neither main nor interaction effects with *Affect* were discernible (Fs < .16, ps > .691). However, a significant *Affect* × *TriPM Meanness* interaction was evident in the affect-focus task, F (2, 282) = 6.03, p = .004, η_p^2 = .041, ε = .884, which was qualified by a significant quadratic arousal effect for TriPM Meanness scores on LPP amplitudes in this task, F (1, 141) = 9.19, p = .003, η_p^2 = .061 (F for linear contrast = 0.00, p = .999). Follow-up correlational analyses evidenced a significant negative correlation between TriPM Meanness scores and LPP affective modulation scores (pleasant/unpleasant – neutral) in the affect-focus task, r (144) = −.23, p = .005 (see Figure 2a and Table 2). This association remained significant in partial correlational analyses after controlling for gender and TriPM Boldness and Disinhibition scores, partial r (139) = −.18, p = .036, reflecting reduced affective differentiation for the LPP response in high mean individuals in this task. Figure 2b illustrates this finding, showing the grand averaged waveforms for participants scoring in the upper and lower quartiles on TriPM Meanness scores in the affect-focus task. Supplemental analyses revealed significant associations between TriPM Meanness scores and pleasant-neutral (r (144) = −.19, p = .024) and unpleasant-neutral (r (144) = −.25, p = .003) LPP difference scores, which did not differ significantly from each other, Steiger's z = 0.96, p = .336.

For comprehensiveness, Table 2 shows the bivariate associations found for the LPP affective modulation scores—in terms of both difference (affective – neutral) and residualized scores—and each TriPM scale score in both tasks, as well as the difference between the LPP amplitude modulation scores (affective-neutral) found across tasks; the results of the partial correlational analysis testing for the unique contribution of each TriPM scale score, after controlling for gender and the other two triarchic scales are also reported.

4 | DISCUSSION

The present study was conducted to advance our understanding of the impact of attentional focus on affective processing in relation to psychopathic personality traits, as described by the triarchic model of psychopathy. We focused on the LPP component as a well-validated electrocortical indicator of sustained attentional engagement to affective material. Confirming a successful task manipulation, we observed reduced LPP amplitudes, particularly for affective relevant material, in the alternative-focus task compared to the affect-focus task. Most interestingly, our results evidenced that trait meanness scores were associated with blunted elaborative processing of affective material (both appetitive and aversive) when this information was task-relevant (affect-focus task),

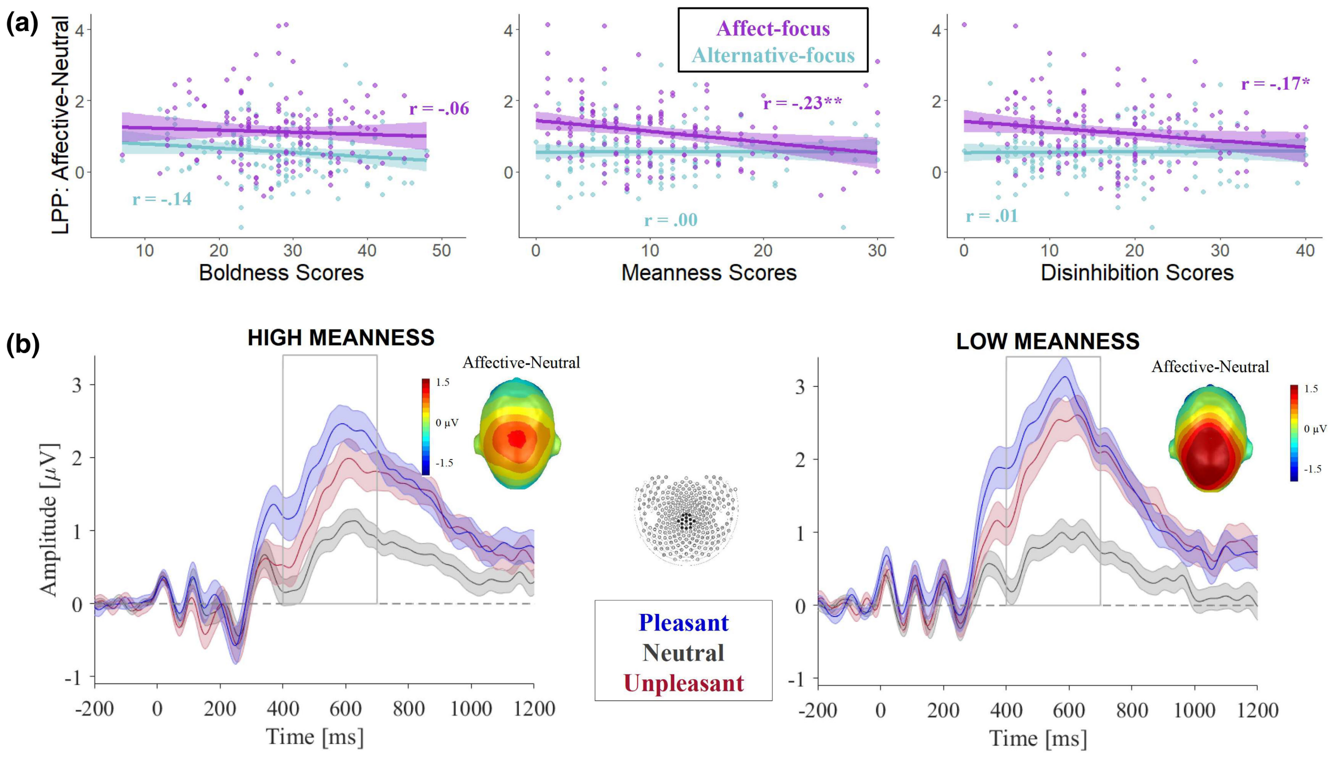

FIGURE 2 Emotional affect modulation effects in LPP amplitudes across tasks in participants classified as low or high as a function of TriPM meanness scores (highest and lowest quartile values). (a) Scatterplots illustrating the associations between LPP difference scores (affective – Neutral) and TriPM boldness, meanness, and disinhibition scores in each task. (b) Grand average ERPs in response to pleasant, neutral, and unpleasant images for high and low TriPM meanness groups in the affect-focus task.

but not when it was task-irrelevant (alternative-focus task). Furthermore, trait meanness scores also predicted lower accuracy in categorizing affective stimuli (especially, unpleasant ones). These results highlight the importance of examining the interaction between bottom-up and top-down attentional dynamics and affective processing in psychopathy.

In the overall sample, we found modulatory effects of task and affect category on LPP amplitudes. More specifically, the affective modulation of the LPP was enhanced when affective material was task-relevant, compared to when attention was explicitly directed to non-affective information (i.e., picture frame). Although larger LPP amplitudes were found in the alternative-focus task for affectively relevant material, compared to neutral material, supporting the idea that LPP is sensitive to bottom-up processes engaged during the processing of affective stimuli (Schindler & Straube, 2020), the LPP enhancement for relevant information was potentiated when the relevance of affective stimuli was manipulated in a top-down manner (i.e., when it became task-relevant). These results replicate past research showing interactions between task-relevance and affect on LPP amplitudes (Schindler & Kissler, 2016; Schindler & Straube, 2020; Schupp et al., 2007) and suggest that the LPP can be considered a reliable component for investigating attention-affect interactions (Schindler & Straube, 2020).

Furthermore, we observed that triarchic psychopathy scores modulated the task-affect interactions observed in the LPP, as indicated by a reduced LPP enhancement during the affect-focus task in participants scoring high in trait meanness. Some theoretical models, such as the RMH, have emphasized the moderating role of cognitive attentional mechanisms in the affective deficits associated to psychopathic traits (Baskin-Sommers & Brazil, 2022; Hamilton & Newman, 2018, for reviews). In particular, abnormalities in top-down attentional focus make psychopathic individuals more prone to ignore emotionally relevant information when it is not their current focus of attention or goal-directed behavior (see Baskin-Sommers et al., 2011; Larson et al., 2013; Newman et al., 2010). From this perspective, the lack of affective modulation of the LPP response should have been more prominent in the alternative-focus task than in the affect-focus task. Our results, however, point in the opposite direction, with trait meanness scores predicting reduced affective modulation of the LPP response in the affect-focus task only. This finding seems more readily interpretable from emotional dysfunction accounts of psychopathy, which would predict diminished engagement of attention to emotional material in high psychopathic individuals (e.g., Blair, 2005; Lykken, 1995). In this regard, a deficient "emotional attention" mechanism (see Blair & Mitchell, 2009, for a review) linked to psychopathic meanness should have also been manifested in a reduced interference from distracting emotional stimuli in the alternative-focus task in our study, similar to the reduced behavioral (RT) interference linked to meanness-related traits recently found by Snowden et al. (2022) using an emotional distraction task. The fact that we were unable to capture individual differences in attentional mechanisms when affective stimuli served as distracting information might be related to the low difficulty of our alternative-focus task (e.g., ceiling effects at the behavioral level and overall smaller LPP amplitudes), despite the evidence for the affective modulation of the LPP in this task.[4]

Our results dovetail well with those reported in previous studies assessing attention-affect interactions in psychopathy, which have mainly reported evidence for blunted affective modulations of the LPP in high psychopathic individuals when affective material is task-relevant (Anderson & Stanford, 2012 [task 2]; Howard & McCullagh, 2007; Scheeff et al., 2021—but see, Anderson & Stanford, 2012 [task 1]; Carolan et al., 2014, for evidence of blunted LPP amplitudes during implicit processing conditions). However, these studies have employed unitary conceptualizations of psychopathy, which do not allow to evaluate the differential contribution of distinct facets of psychopathy to this deficit. In this regard, a novel contribution of our work was to further show that this blunted affective elaboration is particularly related to core psychopathic features such as callousness, lack of empathy, and exploitativeness (i.e., trait meanness).

In the present study we observed blunted elaborative processing of both positive and negative valence material, which seems to be at odds with some theoretical models emphasizing deficient emotional responding towards aversive material only (e.g., Low fear model; Lykken, 1995). In this regard, it is worth noting that while previous empirical (Ellis et al., 2017; Medina et al., 2016; Sadeh & Verona, 2012; Venables et al., 2015), and meta-analytic work (Vallet et al., 2020), has demonstrated stronger negative associations between LPP amplitudes to negative stimuli and psychopathic traits, most of these studies have employed aversive and neutral stimuli only (but see Medina et al., 2016; Venables et al., 2015), devoting comparatively limited attention to the elaborative processing of positive stimuli (as indexed by the LPP) in individuals varying in psychopathic traits.

Indeed, and although research has generally documented greater impairments in emotional processing and responsiveness to negative affective material, there is also evidence for deviations in the processing of positive/appetitive stimuli (Brook et al., 2013; Dawel et al., 2012, for reviews and meta-analyses). For instance, psychopathic individuals have been shown to exhibit reduced behavioral and LPP amplitude differentiation between emotional (both positive and negative) and neutral words in a lexical decision task (Williamson et al., 1991), reduced affective-neutral modulation of the LPP while viewing familiar—but not novel—pictures (Baskin-Sommers et al., 2013), and reduced skin conductance responses to both positive and negative sounds, compared to neutral ones (Verona et al., 2004). Furthermore, evidence also exists for diminished medial prefrontal cortex activity while viewing positive and negative film clips in individuals scoring high in callous-unemotional traits (Fanti et al., 2016), as well as reduced emotional distraction (for both positive and negative material) in participants scoring high in meanness and associated traits specifically (Snowden et al., 2022). In this regard, some theoretical perspectives (see Blair, 2005, 2008, for reviews) have highlighted the role of the amygdala in the formation of both aversive (which seem to be specially compromised in psychopathy) and appetitive stimulus-reinforcement associations, and that impairments in these processes in psychopathic individuals could underlie their lack of responsiveness to aversive material and others' distress, as well as their reduced attachment (Blair, 2008). Some aspects of our data seem broadly consistent with these reports, given that while we found evidence of blunted affective reactivity (for both positive and negative material) at the electrophysiological level, behavioral results indicated stronger associations between trait meanness and reduced accuracy in categorizing unpleasant stimuli.

Our results also seem to be in line with recent findings from studies conducted within the triarchic model framework using face recognition paradigms. For example, Brislin and Patrick (2019) reported impairments in fear face recognition only in relation to trait meanness scores, while also finding blunted LPP responses for fearful and sad facial expressions. Similarly, Gillespie et al. (2019) reported, in a sample of incarcerated male offenders,

[4]The low reliability of LPP affective modulation scores is another important factor that might have limited our ability to detect effects in the alternative-focus task. While low reliability of difference (or residualized) scores is a concern that can limit their validity as individual differences measures, these scores may still be useful for individual differences research, to the extent that a sufficient portion of their reliable variance relates to relevant criterion measures (see Patrick et al., 2019; Perkins at el., 2017 for a discussion on these issues and strategies for addressing it). In the current study we were able to replicate results from prior published work linking psychopathic traits to LPP modulation scores when affective cues are task-relevant despite low reliability comparable to scores from the alternative-focus task, thus providing evidence for the criterion validity of LPP difference and residualized scores in the affect-focus task.

meanness-related impairments only to fear face recognition at the behavioral level, but reduced pupil reactivity to happy, sad, and fearful facial expressions—but see Burley et al. (2020) for null associations for triarchic psychopathy traits on pupil reactivity towards more complex affective pictures in a community sample, using a similar design to that used in the present study. This evidence suggests that different psychophysiological and behavioral measures might provide varying levels of discriminating power to detect psychopathy-related deviations in affective processing (Brook et al., 2013). The results from the present study further highlight the role of task context in uncovering meanness-related deviations in the processing of affective information, suggesting that tasks taxing top-down attentional resources towards affectively relevant material might provide more sensitivity in revealing general impairments in the elaborative processing of affective information in high callous individuals, at least at the processing stages indexed by the LPP response. In support of this, higher levels of callousness have been found to relate to blunted LPP amplitudes to fear face stimuli in face recognition tasks—which require participants to attend to and categorize face stimuli (Brislin & Patrick, 2019)—but not during standard viewing trials in a binocular rivalry task (Brislin et al., 2018).

Collectively, findings from the current study indicating preserved bottom-up, but impaired top-down processing of affective information provides novel insights into the processing style of high-callous individuals. Considering that the amplitude of the LPP is modulated by the motivational significance of the stimuli (Hajcak & Foti, 2020), our results suggest that high-callous individuals show motivational deficits in purposely allocating processing resources towards affective material. This might reflect an overall lack of interest in affective information, which could be related in part to the lack of acquisition of experience-based associations with affective material alluded earlier (Blair, 2005, 2008). An interesting question arising from these results would be to test whether this motivational deficit relates more specifically to particular facets embodied in the construct of meanness or callous-unemotional traits—for example, to aspects assessing uncaring attitudes towards tasks and other's feelings (Frick & Ray, 2015; Frick & White, 2008, for reviews).

Another aspect that warrants mention was the lack of significant associations between trait boldness scores and the affective modulation of the LPP. As reviewed in the introduction, trait boldness has been consistently related to several indicators of reduced emotional reactivity, particularly for aversive stimuli. One study in particular found that boldness scores predicted diminished aversive-neutral LPP differentiation while passively viewing emotional pictures, but showed negligible effects on trials asking to increase or decrease their emotional experience while viewing aversive pictures (Ellis et al., 2017). A recent study by Perkins et al. (2022) found instead that trait boldness scores were associated with greater downregulation of the LPP to affective pictures. Our task design differed in some aspects from these studies, given that we did not examine LPP amplitude modulations under different emotion regulation instructions, and our affect-focus task required explicit categorization of emotional stimuli, which might have increased the salience of affective stimuli to greater degree than task conditions including only passive viewing trials. In this regard, it seems possible that individual differences in boldness might preferentially impact 'baseline' reactivity to aversive stimuli (Ellis et al., 2017) and the ability to effortfully downregulate emotional responses to affective stimuli (Perkins et al., 2022), but are less relevant to explain individual differences in top-down elaborative processing of affective stimuli with immediate relevance for the task at hand.[5]

The results of this study should be considered in light of some limitations. First, the present study used a predominantly female (~79%) undergraduate test sample, unselected for triarchic psychopathy scores, which might have restricted the full range of scores and potentially limited our ability to detect smaller effects of psychopathic traits, especially in the alternative-focus task. Further studies with larger community samples exhibiting greater heterogeneity in age, educational level, and triarchic psychopathy scores would be needed to establish the generalizability of our findings. Also related to this, it would be necessary to extend our results to incarcerated populations to gain insight on the consistency and continuity of affective deficits in psychopathy across different populations with different levels of involvement in criminal behavior. Second, the order of the task was not counterbalanced, which did not allow us to rule out that the observed effects of meanness in the affect-focus task might also reflect a progressive disengagement from affective information over the course of the experiment. The rationale for presenting the affect-focus task first

[5]In the present study, trait boldness scores only showed a trend-level association with the affective modulation of the LPP in the alternative-focus task ($r = -.14$, $p = .096$ for difference scores, and $r = -.15$, $p = .075$, for residualized scores; see Table 2). Exploratory analyses for pleasant and unpleasant picture contents separately revealed a significant association between boldness and LPP unpleasant-neutral amplitude modulation scores ($r = -.17$, $p = .041$, for difference scores, and $r = -.18$, $p = .034$, for residualized scores), but a non-significant association for pleasant-neutral modulation scores ($r = -.08$, $p = .347$, for difference scores, and $r = -.09$, $p = .295$, for residualized scores). Although these results should be interpreted with caution given the exploratory nature of these analyses, our data suggests diminished bottom-up processing of aversive stimuli specifically when they are incidental to the task in high bold individuals.

was based on previous research that had also presented the implicit affect-processing conditions first to have a baseline measurement of incidental affective processing not influenced by prior explicit exposure to affective information (see also Anderson & Stanford, 2012; Scheeff et al., 2021). Future studies could test whether changing the order of the tasks would yield similar results. A third limitation of the current work is that we did not examine LPP responses to specific picture contents, and it is possible that some of the observed effects of trait meanness scores might be driven by stimuli of specific nature. For example, recent work suggests that trait meanness scores predict blunted LPP responses to pictures depicting violent situations (Van Dongen et al., 2018) and painful scenarios (Brislin et al., 2022), so it might be possible that picture contents involving victims were driving trait meanness associations with unpleasant-neutral LPP amplitudes in the current study. Similarly, trait boldness might be more relevant to explain individual differences in psychophysiological responses to direct threatening scenarios (e.g., Esteller et al., 2016; Perkins et al., 2022). It is also possible that pictures of an affiliative nature (e.g., babies, small animals) were more strongly driving meanness-related impairments in elaborative processing of pleasant stimuli, while other contents more related to thrill-seeking experiences (e.g., adventure pictures) could be more relevant to boldness-related traits. Future studies assessing LPP responses under more balanced designs in terms of pictures of different contents may prove to be useful to increase our understanding about affective deficits in psychopathy.

Finally, and pertaining to the implications of our findings to current etiological models of psychopathy, we would like to stress that our results, while difficult to reconcile with the predictions from the RMH, are difficult to compare with past research that has served as a foundational basis for this theory. On the one hand, the RMH was developed mainly from studies conducted in incarcerated male populations conceiving psychopathy as a unitary construct, which differs from the triarchic model approach employed in this study with a predominantly female undergraduate test sample. Furthermore, and although the LPP is a well-validated ERP component indicative of sustained engagement of attention towards motivationally significant cues, it might be that this ERP response is not sensitive to attentional abnormalities—or its downstream consequences—relevant to the RMH. In this line, Sadeh and Verona (2012) showed that, consistent with an attentional bottleneck account, psychopathic individuals showed deficits in aversive startle potentiation while viewing more complex, but not simple, aversive pictures. However, they also showed blunted LPP amplitudes to aversive pictures regardless of picture complexity, thus showing dissociable psychopathy-related effects on the LPP and the startle responses. Similarly, Baskin-Sommers et al. (2013) reported blunted aversive startle potentiated responses in psychopathic individuals during novel, but not familiar pictures, whereas they found the opposite pattern for the LPP response (i.e., reduced affective modulations of the LPP during familiar, but not novel, pictures in psychopathic individuals). Thus, different psychophysiological measures, such as the LPP (Vallet et al., 2020, for a meta-analysis) or aversive startle potentiation (Oskarsson et al., 2021, for a review), might provide non-redundant information about the affective processing deviations linked to psychopathic personality. In this regard, future studies using similar paradigms such as the one used in the present study could aim to collect diverse psychophysiological indicators to better characterize psychopathy-related alterations in the processing of affective material.

Notwithstanding these limitations, the present study provides new evidence for diminished elaborative processing of affective material (both positive and negative) in relation to trait meanness, particularly for task contexts in which affective material is task relevant. In light of recent findings which indicate that trait meanness relates to blunted elaborative processing—as indexed by reduced LPP amplitudes—of stimuli evoking emphatic sensitivity, such as fearful and sad facial expressions (Brislin & Patrick, 2019), aggressive situations (van Dongen et al., 2018), or painful scenarios (Brislin et al., 2022), the results from the current study further suggest that a more general blunted affective experience might also underlie this triarchic trait disposition. Thus, our results highlight the utility of the LPP response to further study the bottom-up and top-down dynamics of emotional attention to better understand the nature of the cognitive and affective processing deviations linked to the distinct facets of psychopathy, and highlight the utility of the triarchic model of psychopathy, and a multifaceted construct perspective, to further advance our understanding of this personality disorder in neurobehavioral terms (Patrick, 2022).

AUTHOR CONTRIBUTIONS

Pablo Ribes-Guardiola: Conceptualization; formal analysis; investigation; methodology; writing – original draft; writing – review and editing. **Javier Moltó:** Conceptualization; funding acquisition; investigation; methodology; project administration; writing – review and editing. **Rosario Poy:** Conceptualization; investigation; methodology; writing – review and editing. **Carlos Ventura-Bort:** Conceptualization; formal analysis; investigation; methodology; writing – original draft; writing – review and editing. **Victoria Branchadell:** Writing – review and editing. **Pilar Segarra:** Conceptualization; investigation; methodology; writing – review and editing.

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CONFLICT OF INTEREST

The authors have no conflict of interest to report.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding authors upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Table S1 Relationships between TriPM scale scores and criterion measures of personality in the overall study sample (N = 144): Bivariate correlations (r) and standardized beta weights (β) from multiple regression analyses

Table S2 Descriptive statistics for LPP amplitudes in the late time window (700-1000 ms)

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