1. Introduction

The affective picture viewing paradigm has been used to study the emotion-pain relationship. Electrical pain is highest while viewing unpleasant pictures and lowest while viewing pleasant pictures (Kenntner-Mabiala et al., 2008). These findings show that cortical processing of trigeminal nociception is modulated by emotion. We explain our findings in terms of the effects of picture viewing on attention.

To investigate whether cortical processing of trigeminal nociception is modulated by emotion, we assessed the N2 and P2 components of the pain-related evoked potential (PREP) recorded in response to noxious stimulation of the supraorbital nerve while participants viewed neutral, pleasant, and unpleasant pictures. The nerve was stimulated at 125% of pain threshold via a nociceptive-specific concentric electrode to selectively activate A-delta pain fibres. The N2 and P2 pain-related evoked potentials were similarly influenced by emotional priming: the amplitude of both potentials decreased monotonically from viewing neutral to pleasant to unpleasant pictures. These findings show that cortical processing of trigeminal nociception is modulated by emotion. We explain our findings in terms of the effects of picture viewing on attention.

We refer to the second negative and positive peaks, respectively, of the corticospinal response to a noxious stimulus and represent the central processes associated with nociception. The most commonly studied PREPs are the N2 and P2, which refer to the second negative and positive peaks, respectively, of the corticospinal response to a noxious stimulus and represent the central processes associated with nociception. The second negative and positive peaks, respectively, of the corticospinal response to a noxious stimulus and represent the central processes associated with nociception.
N2 and P2 during affective picture viewing. Given discrepancies among previous studies, we made no explicit predictions.

2. Methods

2.1. Participants

Ninety-six (48 males, 47 females) healthy adults (M = 21 years) who played competitive team sport participated.

2.2. Noxious stimulation

The noxious electrical stimulus comprised two 500 µs rectangular wave pulses separated by 100 µs delivered via a Digitimer constant current stimulator and nociceptive-specific concentric electrode (Katsarava et al., 2006; Kaube et al., 2000) secured over the supraorbital nerve above the left eye. It was perceived as a single pinprick-like pain.

2.3. Pain threshold

The pain threshold was determined using an ascending method of limits followed by an up–down staircase (Kavussanu, Willoughby, & Ring, 2012). The mean (SD) pain threshold was 1.34 (0.86) mA.

2.4. Pain-related evoked potential

The electroencephalogram (EEG) and electrooculogram were recorded using a BioSemi ActiveTwo system (for details see Kavussanu et al., 2012). The EEG was recorded at 512 Hz and re-referenced to average earlobe electrodes offline when the data were scored using EEGLAB (Delorme & Makeig, 2004). To score the PREPs, the EEG was high-pass filtered using a finite impulse response windowed-sinc filter with a half-amplitude cut-off at 1 Hz and a 0.4 Hz transition band. Artifact rejection comprised removal of epochs containing excessive noise or paroxysmal artifact followed by independent components analysis. N2 and P2 amplitudes at Cz were calculated as the average of seven data-points around the peak 100–200 ms and 200–300 ms post-stimulation, respectively, relative to a 100 ms pre-stimulus baseline (Inui & Kakigi, 2011). Peak latencies were also determined.

2.5. Picture viewing task

The task comprised 3 habituation pictures, randomly followed by 20 neutral (e.g., players standing or moving), 20 pleasant (e.g., players celebrating, semi-naked players), and 20 unpleasant (e.g., players being hurt, badly injured players) pictures (for previous valence and arousal ratings see Stanger, Kavussanu, Willoughby, & Ring, 2012). Each picture was presented on a monitor for 5 s with a 16–20 s inter-picture interval. A noxious electrical stimulus (125% of pain threshold) was delivered 3–5 s after picture onset on 90% and 8–10 s after picture offset on 10% of trials.

2.6. Manipulation checks

Participants used a Self Assessment Manikin (Bradley & Lang, 1994) to rate each picture for valence (1, very unpleasant; 9, very pleasant) and arousal (1, very calming; 9, very exciting). The Late Positive Potential (LPP), at Pz with 0.1 Hz high-pass filtering, assessed sustained positivity in the cortical response to picture viewing (Hajcak, MacNamara, & Olvet, 2010; Palomba, Angrilli, & Mini, 1997).

Table 1

| Amplitude        | Neutral pictures | Pleasant pictures | Unpleasant pictures | ANOVA |
|------------------|------------------|-------------------|---------------------|-------|
|                  | M    | SD  | M     | SD  | M     | SD  | F(2, 93) | p    | η²   |
| N2 (µV)          | -16.21| 9.29| -15.39 | 9.26| -13.62 | 8.86| 14.63    | .001 | .24  |
| P2 (µV)          | 21.69 | 10.72| 20.75  | 10.66| 19.14  | 10.26| 11.44    | .001 | .20  |
| LPP (µV)         | 10.69 | 6.23 | 12.01  | 7.26| 15.51  | 6.54| 36.21    | .001 | .44  |
| Latency          |       |     |       |     |       |     |         |      |      |
| N2 (ms)          | 128.62| 17.76| 129.38 | 16.95| 127.08 | 17.58| 3.20     | .05  | .06  |
| P2 (ms)          | 255.53| 30.21| 256.09 | 31.00| 249.49 | 30.20| 1.02     | .36  | .02  |
| Ratings          |       |     |       |     |       |     |         |      |      |
| Valence          | 5.26  | 0.68 | 7.15   | 0.66| 2.46   | 0.68| 1022.37  | .001 | .96  |
| Arousal          | 4.33  | 0.88 | 6.42   | 0.85| 6.16   | 1.20| 216.31   | .001 | .82  |

Note: Letters n and p denote significant (p < 0.05) differences from the neutral and pleasant categories, respectively.
Finally, an ANOVA yielded category effects for the LPP (Table 1): Pz activity 400–1000 ms after picture onset was more positive for unpleasant than pleasant and neutral pictures and more positive for pleasant than neutral pictures.

3.2. Control analyses

We analyzed the EEG uncorrected for ocular activity to determine whether the aforementioned effects were an artefact of the eye-movement and blink correction procedure. All category effects remained significant, confirming that effects of picture viewing on N2 and P2 were not an artifact of ocular activity (cf. Cuthbert, Schupp, Bradley, McMamis, & Lang, 1998).

4. Discussion

Our primary purpose was to investigate whether cortical processing of trigeminal nociception is modulated by emotion. That both N2 and P2 amplitudes were smaller while viewing unpleasant compared to pleasant neutral pictures indicates a global inhibitory effect of affective picture processing on pain-related cortical processing of trigeminal nociceptive stimulation.

Our N2 findings agree in part with a study that used intra-cutaneous electrical stimulation: Mini et al. (1995) found that baroreceptor activation produced smaller N2 amplitudes while participants viewed unpleasant compared to pleasant and neutral pictures. Our findings are also in line with studies showing that PREPs are similarly affected when attention is diverted from a painful stimulus (Lorenz & García-Larrea, 2003; Miltnner, Johnson, Braun, & Larbig, 1989). However, these findings contrast with reports that N2 was greater for unpleasant than pleasant pictures (Kenntner-Mabiala et al., 2008; Kenntner-Mabiala & Pauli, 2005). Our P2 findings are broadly consistent with previous studies showing that P2 was smaller for unpleasant than neutral (Kenntner-Mabiala et al., 2008) and smaller for pleasant than neutral pictures (Kenntner-Mabiala et al., 2008; Kenntner-Mabiala & Pauli, 2005).

These small discrepancies could be explained by methodological factors. First, we stimulated the supraorbital nerve at low currents using a nociceptive-specific electrode to selectively examine cortical processing of trigeminal nociception. Second, we did not collect subjective pain ratings, which may have affected relative depth of processing of the electrical and visual stimuli or amount of attention paid to these two modalities. Finally, our pleasant pictures grabbed more attention and were processed more deeply than the pleasant pictures which, in turn, were more attention grabbing than the neutral pictures. Accordingly, the present modulation of PREPs may be explained best in terms of changes in emotion-dependent attentional focus.

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