International Journal of Psychophysiology 74 (2009) 139–148

Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

Effects of affective pictures on pain sensitivity and cortical responses induced by laser stimuli in healthy subjects and migraine patients

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ARTICLE INFO

Article history:
Received 5 February 2009
Received in revised form 25 June 2009
Accepted 17 August 2009
Available online 25 August 2009

Keywords:
Pain
Affective pictures
Laser evoked potentials
Migraine

ABSTRACT

Visually induced analgesia has been correlated with the affective content of pleasant, neutral or unpleasant pictures. The aim of the present study was to assess the effect of affective images vision on laser evoked potentials and pain perception, in a cohort of healthy subjects and migraine patients. Twenty-two healthy subjects and 24 migraine without aura patients (recorded during the inter-critical phase) participated in the study. Eighty-four colour slides, arranged in two blocks, each consisting of 14 pleasant, 14 unpleasant and 14 neutral images, in random presentation, were chosen from the International Affective Picture System. The CO_2 laser stimuli were delivered on the dorsum of the right hand and supra-orbital zone at 7.5-watt intensity and 25-ms duration, in basal condition and during the viewing of affective pictures. Migraine patients expressed higher scores of valence and arousal for pleasant and unpleasant pictures, compared to controls. In both groups, a late positive potential in the 400–700 ms time range was clear for pleasant and unpleasant pictures, but its amplitude was significantly reduced in migraine patients. The pain rating and the N2 component were reduced in both groups during the visual task compared to basal condition. In migraineurs and controls the P2 wave was reduced during the vision of pleasant pictures, compared to basal condition. This indicates that stimulation by images with different affective content reduces subjective pain for a cognitive mechanism of attentive engagement, while a special inhibition of later LEPs is produced by a positive emotional impact. In migraine, affective images are able to modulate pain perception and LEPs, differently from other modalities of distraction, suggesting a possible emotive elaboration of painful stimuli.

1. Introduction

Pain is a complex function of the human brain, involving attention and emotions (Rainville, 2002; Villemure and Bushnell, 2002). The process of distraction appears to involve competition for attention between a highly salient sensation (pain) and consciously directed focus on some other information processing activity. Attention, expectation and reappraisal are three basic mechanisms that are important for the cognitive modulation of pain (Wiech et al., 2008). The International Affective Picture System (Lang et al., 2005), a standardized set of affective picture stimuli varying on the emotional dimensions of valence and arousal, can be used for affect induction. According to the motivational priming hypothesis (Lang, 1995), an organism's emotional state will modify responses to significant stimuli. Responses triggered by aversive stimuli are facilitated in the context of a negative emotional state and inhibited in the context of a positive emotional state. This prediction was verified repeatedly on the basis of the acoustic startle reflex in animals (e.g., Lang et al., 2000) and humans (e.g., Vrana et al., 1988). Accordingly, visually induced analgesia has also been correlated with the affective content of pleasant, neutral or unpleasant pictures and pain tolerance has been reported to depend on primal and appraisal processes (de Wied and Verbatena, 2001). It has recently been shown that event related brain potentials (ERPs) elicited by painful and nonpainful electrical stimuli are modified by the affective valence of pictures, with the maximum distractive effect on pain coming from images with positive affective content (Kenntner-Mabiala and Pauli, 2005). In that study, electrical stimuli were employed to evoke cortical pain responses, which are only indirectly related to nociception. The later positive component was reduced during the vision of pictures with positive affective content, compared with the neutral ones (Kenntner-Mabiala and Pauli, 2005). The same authors have recently provided neurophysiological evidence that attention and affect have distinct effects on pain processing, being the earlier SEP component modulated by picture valence, the later one by picture arousal (Kenntner-Mabiala et al., 2008).

Brief radiant heat pulses generated by a laser (infrared CO_2, argon, or thulium-YAG) can be used to elicit an evoked potential. Scalp potentials may be evoked by selective activation of Aδ (laser evoked potentials (LEPs) and C (ultra-late LEPs) mechano-thermal

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doi:10.1016/j.ijpsycho.2009.08.004

nociceptors in the superficial layers of the skin (Beydoun et al., 1993). In clinical studies, only the late LEP components, named N2 and P2 are routinely evaluated. These components are maximal between the vertex Cz and the midline parietal lead Pz vs.linked earlobes or nose. An early component, named N1, may be recorded by a temporal electrode, controlateral to the stimulated site, referred to Fz (T3–T4/Fz) (Treede et al., 2003). LEPs have been found to be useful for selective evaluation of nociceptive pathways in experimental pain models, as well as in central and peripheral neurological diseases (Treede et al., 2003). The LEP waveform also appears to be influenced by factors other than nociceptive input. Peak amplitude of the LEP is known to vary as a function of the level of attention, arousal (Beydoun et al., 1993) and anxiety (Gibson et al., 1991). The psycho-physiological properties of LEPs have been recently employed to test complex mechanisms of pain modulation, such as the resonant effect of empathy (Valeriani et al., 2008) induced by the vision of others' pain, and the placebo effect (Colloca et al., 2008). No study is available about the effect of emotive impact induced by the International Affective Picture System (Lang et al., 2005), a standardized set of affective picture stimuli varying on the emotional dimensions of valence and arousal, on cortical responses and pain sensitivity induced by laser stimuli. Yet, it is known that the vision of affective images induces a late positive potential (LPP, 400–700 ms) and a larger positive slow wave (1–6 s) over centro-parietal regions. These two components may provide an objective measure of affective arousal (Pastor et al., 2008). In a recent study, we evaluated the LEPs modulation, induced by the vision of artistic pictures, in healthy subjects, and found that beautiful images induced a P2 wave reduction, together with a decrease in laser pain perception (de Tommaso et al., 2008a,b,c). In that study we suggested, in accord with Zeki (2001), that the aesthetic perception should be a cognitive resource with a peculiar effect on pain perception, not comparable in all its aspects to the affective involvement. The affective content of images seems unconnected to aesthetic judgement in visual arts (Ishai et al., 2007). There is neurophysiological evidence supporting the different neuronal basis of aesthetic vs affective involvement in images vision. The late ERP component, linked with the vision of IAPS images, was reported to have maximal amplitude for the vision of affective rather than neutral images, irrespective of their positive or negative valence (Cuthbert et al., 2000). In fact, pictures with negative affective valence cause a strong attentive attraction (Waters et al., 2006), differently from the ugly images (de Tommaso et al., 2008b). The distractive effect from pain experience exerted by beauty should not be inferred by the results obtained through affective images since there is no evidence of an overlapping of the aesthetic appraisal and the pure affective reaction. (de Tommaso et al., 2008c).

A complex and invalidating form of pain of neuro-vascular origin is represented by migraine. Many studies of LEPs in migraine have supported abnormal modulation of the cortical areas involved in pain circuitry (de Tommaso, 2008). Normal amplitude of basal LEPs with reduced habituation and altered attentive modulation seems to express a general dysfunction of cortical pain processing, which may contribute, other than to predispose, also to the persistence of migraine (de Tommaso, 2008). In previous studies, distraction induced by a mental arithmetic task suppressed LEPs amplitude in non-migraine subjects. However, in migraine patients, especially in chronic cases, the N2–P2 complex was not modified by engagement in mental computation (de Tommaso et al., 2003, 2008a). The lack of suppression of the later N2–P2 LEPs complex suggested a deficit in attentive modulation of pain, for a prevalence of cortical arousal and emotive reaction against nociceptive stimuli (de Tommaso et al., 2003, 2008a,b,c). For both chronic and acute pain, the sufferer's mood and emotional state has a significant impact on resultant pain perception and ability to cope. (Tracey, 2008). In migraine, pain seems a high involving experience, mainly processed in the cortical zones devoted to the emotive and affective aspects of nociception (de Tommaso et al., 2005). Stress and maladaptive coping strategies are associated with poor migraine outcome (Radat et al., 2008).

Understanding the emotional stimuli interference on pain processing may improve the knowledge on migraine pathophysiology. Considering the strong emotional involvement of migraine patients in pain processing, we can argue that affective stimuli may exert a significant effect on subjective pain rating and cortical elaboration of nociceptive inputs, differently from cognitive engagement (de Tommaso et al., 2008a). In line with this notion, we assessed the effect of affective images vision on laser evoked potentials and pain perception, in a cohort of healthy subjects and migraine patients.

2. Methods

2.1. Subjects

Twenty-two healthy, right-handed subjects (16 females) in the 21- to 40-year-age range (mean 35.2 ± 2.9) participated in the study. The migraine group consisted of 24 migraine without aura patients (18 females), right-handed, aging 21 to 45 (mean 36.6. ± 4.3), diagnosed according to the ICHD II criteria (cod. 1.1) (Headache Classification Committee, 2004) and recorded during the inter-critical phase, at least 72 h after the last attack and 48 h before the next one, ascertained by a telephonic interview. In any case, exclusion criteria were the assumption of preventive treatment for migraine or of any drug acting on the SNC in the previous three months, and of any analgesic drug in the last 72 h, the co-morbidity for general medical and neurological diseases, other than psychiatric diseases, as coded by the DSMIV. Patients and controls were similar for age (ANOVA $F = 0.23$ n.s.) and education (mean number of education years in patients: 12.1 ± 0.8 years; in controls 12.8 ± 0.5 years ANOVA $F = 0.12$ n.s). The selected migraine patients, reported a mean 3.4 ± 1.2 days with headache monthly frequency, computed in the last three months.

The experimental protocol was approved by the ethics committee of the Neurological and Psychiatric Sciences Department of Bari University and informed consent was obtained for all participants.

3. Materials

3.1. IAPS images

Eighty-four colour slides were chosen from the International Affective Picture System (Lang et al., 2005), depicting 28 unpleasant, 28 pleasant, and 28 neutral objects or scenes, resulting in three different picture content categories.[1] Pictures were presented on a 19-in computer screen. They were arranged in two blocks, each consisting of 14 pleasant, 14 unpleasant and 14 neutral images, randomly presented. Each presentation lasted 10 s, and a black panel with a central white point was interposed between the images for 5 s. Subjects were initially invited to look at the central white point, and to pay attention to the different images.

[1] Criteria for the choice of the pictures were normative ratings (Lang et al., 2005) on the dimensions of affective valence and arousal (on a scale ranging from 1 to 9, with low scores indicating low arousal and low pleasure and high scores indicating high arousal and high pleasure). Negative and positive pictures had comparable arousal ratings (6.13 vs. 6.09, respectively). Neutral pictures had low arousal (2.57) and intermediate valence ratings (5.09). The slide numbers were as follows: positive: 1440,2040,2030,2080, 2154,2209,2260,2332,2360,2550,2660,4220,4235,4279,4290,4610,4626,4660, 5626,5833,7270,7502,8080,8170,8185,8190,8370, 8501; neutral: 1616,4520,5533, 7000,7004,7052,7057,7058,7060,7100,7140,7150,7170,7207,7238,7242, 7490,7493,7495,7504,7506,7546,7620,7820,7830,8160,8241,8645. and negative: 1050, 1052,1111,1220,1274,1280,1300,2053,2095,2120,2141,2205,2455,2703,2730,2799, 2800,2811,3010,3120,3180,3215.3220,3530,9570,9250,9910,9921.).