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Investigating the affective component of pain: No startle modulation by tonic heat pain in startle responsive individuals

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ABSTRACT

Background: Experimental tonic pain has been assumed to equal clinical pain by triggering sizeable affective responses. A psycho-physiological indicator of defensive affective-motivational responses is the startle reflex. However, earlier studies have not provided unequivocal evidence for a potentiation of the startle reflex during tonic contact heat pain.

Objectives: The demonstration of modulating effects of pain on the startle reflex might require very intense tonic stimulation and investigation of subjects, who are particularly sensitive to startle potentiation by threatening cues.

Method: We investigated a sample of healthy subjects ($N = 20$), who had shown pronounced startle amplitude potentiation in response to attack pictures. Noxious stimulation was provided by hand immersion into a hot water bath, which is a tonic pain model known for intense and summated stimulation. Modulation of the startle reflex was attempted by use of two stimulation intensities (42 °C, 46 °C) and one control condition (no stimulation).

Results: Even in these favorable conditions, we did not observe startle potentiation under painful stimulation in comparison to non-painful conditions although subjects reported to be experiencing moderate to high pain.

Conclusions: Our findings indicate that tonic heat pain does not trigger defensive affective-motivational responses as measured by the startle reflex when it is applied in a predictable and thus non-threatening fashion. Future research should investigate the effects of manipulations of threat on startle responses to painful stimulation.

1. Introduction

To date it seems to be well established that pain can be described as having two dimensions, which are experienced as distinguishable and which are encoded by two separate neural networks (IASP, 1979; Price and Harkins, 1992; Rainville et al., 1997; Price, 2000). These are the sensory-discriminative dimension, which provides information about stimulus properties like intensity and site, and the affective-motivational dimension, which presents as feeling of unpleasantness associated with the experience of pain and as drive to avoid, escape and overcome noxious stimulations.

This affective-motivational dimension of pain is assumed to arise from the experience of pain as threatening. As pain is mainly identified as an evolutionarily acquired warning signal with the function to protect us from potential tissue damage, the assumption that pain is automatically associated with threat and thereby with affective-motivational responding has not been questioned so far (Eccleston and Crombez, 1999; Auvray et al., 2010; Van Damme et al., 2010).

However, many pain experiences – in everyday life or in the laboratory – may also be perceived as very low in threat and, by that, without major emotional impact. Thus, the question arises whether the affective-motivational component of pain is indeed omnipresent.

In order to answer this question, valid and specific methods of assessing the affective-motivational component are required. Commonly, self-report measures are believed to differentially target the sensory and affective components when two separate rating scales are presented (Price and Harkins, 1992). However, there is some evidence that this differentiation is often an artifact due to experimental instructions (Fernandez and Turk, 1994; Chapman et al., 2001). Additionally, subjective ratings reflect explicit affective processes, which require a certain level of self-awareness and self-verbalization, whereas basal, automatic processes are not indicated by these measures. Therefore, additional parameters, which target these automatic affective processes and capture the level of implicit processing, are important to complement self-report measures; they are also less likely to be distorted by intentional response biases. Such parameters might be found amongst the established psycho-physiological methods for

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assessing affective-motivational reactions. One promising candidate for this purpose is the startle reflex paradigm. The startle reflex is a defensive reflex which is modulated by affective cues in a way that cues signaling threat and thus, activating the motivational defense system, lead to a potentiation of the startle amplitude; whereas cues signaling reward and thus, activating the motivational approach system, lead to reflex attenuation (Lang et al., 1990; Bradley et al., 1999; Grillon and Baas, 2003). Accordingly, one might assume that amplitude potentiation occurs also during painful stimulation given that pain is thought to elicit a defensive affective-motivational reaction by signaling threat to the body (Eccleston and Crombez, 1999; Auvray et al., 2010; Van Damme et al., 2010).

Based on these considerations, we designed an experiment to investigate the modulating effect of noxious stimulation on the startle reflex (Horn et al., 2012). We decided to use a tonic stimulation paradigm because experimental tonic pain is believed to resemble clinical pain more closely than phasic pain and to trigger sizeable affective responses (Chen and Treede, 1985; Price and Harkins, 1987; Rainville et al., 1992; Lautenbacher et al., 1995). Surprisingly, we detected no potentiation of the startle reflex under painful in comparison to non-painful heat stimulation, although unpleasantness ratings for painful heat were rather high. These results provide first evidence that even on-going pain is not necessarily associated with negative affect in the sense of an automatic defensive response.

However, some limitations may have prevented to draw firm conclusions. First, the dosage of tonic pain might have been still too low in our first study. Pain was induced via a thermode, which allows for exact control of intensity but is limited with respect to spatial summation. Since further increases in intensity might have run the risk to produce intolerable levels of pain, we thought it preferable for the present study to produce more nociceptive input by enlarging the degree of spatial summation in using hot water immersion. Hot water immersion belongs to the well-established experimental tonic pain models with proven efficacy (e.g. Staud et al., 2003; Lautenbacher et al., 2002, 2008; Yarnitsky et al., 2008). Second, we might have tapped a sample with individuals, who were generally not very sensitive to activation of the motivational defense system (Cook et al., 1991; Cook, 1999). Therefore, we selected a sample of subjects, who had shown pronounced startle potentiation in response to viewing attack pictures in an affective picture viewing task.

By selecting (i) a noxious stimulation like hot water immersion, which has been shown to be powerful as tonic pain test, and (ii) individuals, who were sensitive to startle potentiation by threatening cues, we optimized the conditions for verifying startle modulation by pain. In other words, if no startle potentiation occurred under these conditions, this would indicate that tonic pain is not necessarily associated with a defensive affective-motivational reaction.

2. Materials and methods

2.1. Subjects

40 healthy volunteers (female: N = 20, male: N = 20; M = 23.62 years; SD = 3.4) were recruited by advertisement at the University of Bamberg; 10 subjects were students of psychology. None suffered from severe acute or chronic illness, mental disorders or facial paralysis. Because contacts are known to enhance blink frequency, persons wearing contacts were asked to wear their glasses instead during the experimental session. None had taken any CNS affecting medication in the last seven days. Prior to the test session, subjects gave written informed consent. After testing, some of the subjects were reimbursed for participation, the others received course credits. The experimental procedure was approved by the local ethics committee.

As our prior studies had failed to show startle potentiation in response to painful stimulation in an unselected sample, we now aimed at investigating subjects who are particularly sensitive to startle potentiation by affective cues signaling threat. Subjects were selected according to their startle reactions in an affective picture viewing task (Lang et al., 1990; Bradley et al., 1999); responses to pictures showing attack scenes (e.g. a gun pointed towards the observer) were compared to responses to neutral pictures (e.g. an umbrella). Attack pictures were chosen because this picture category has been shown to elicit particularly strong startle potentiation, probably because of their directly threatening content (Bernat et al., 2006).

Subjects who showed the highest positive difference in startle amplitude between the two picture categories (i.e. large amplitudes for attack pictures and low amplitudes for neutral pictures) were selected using median split; these 20 subjects (female: N = 14; male: N = 6; M = 23.25 years; SD = 2.92) were included into further statistical analyses for startle modulation by pain.

2.2. Materials and procedures

During the whole session, which lasted for approximately 1 h, subjects sat upright in a comfortable chair. Subjects were familiarized with all the methods to be used before the start of the experiment.

The experiment was divided into two parts: In part “A”, we measured the startle reflex during affective picture presentation; this part was designed to identify subjects who are sensitive to startle modulation by affective content (see 1.). In part “B”, we assessed the startle reflex during painful thermal stimulation. In both parts, acoustic startle probes were presented to elicit startle blinks. The sequence of the two parts was randomized across subjects; of the 20 subjects selected for further analysis, 9 subjects started with block “B” and the remaining 11 subjects started with block “A”.

2.2.1. Affective picture presentation (part “A”)

Affective pictures were selected from the IAPS (Lang et al., 2005); we decided to use four categories displaying diverse affective content, which were erotic pictures, attack pictures, pain-related pictures and neutral pictures. It is commonly observed that the startle reflex is potentiated by pictures of negative valence and attenuated by pictures of positive valence, but only when these pictures are highly arousing. Strong modulating effects are commonly observed for attack pictures (negative) and erotic pictures (positive) (Bradley et al., 2001a, 2001b; Bernat et al., 2006). These picture categories display evolutionary relevant content and are rated as highly arousing, thus presumably leading to a strong activation of the motivational defense and approach system, respectively. We also added pain-related negative pictures, i.e. pictures depicting mutilation, to assess whether this special category exerts different effects on the startle reflex in comparison to other negative pictures. For each valence category, we chose six representative pictures, resulting in a total of 24 pictures.[1] Pictures were presented in blocks of the same valence category (four blocks altogether); each picture was shown for 55 s. The sequence of pictures within each category was randomized once and then set for all subjects, while the sequence of categories was randomized across subjects.

After each picture, subjects rated picture valence and arousal as well as the perceived mean intensity of the startle noise. This rating period lasted for 10 s, resulting in a total duration of 6.5 min for each of the four blocks with affective picture viewing.

2.2.2. Tonic heat stimulation (part “B”)

To design a condition which provides intense and spatially summated tonic heat stimulation, we used a water bath. Subjects were asked to immerse their right or left hand up to 10 cm above the wrist in the water for 3.25 min. Subjects were informed that they

[1] The IAPS identification numbers were as follows: *Erotic pictures*: 4652, 4659, 4660, 4670, 4687, 4695; *Attack pictures*: 1120, 1300, 1525, 6250.1, 6300, 6510; *Pain-related pictures*: 3010, 3180, 3261, 3350, 9253, 9410; and *Neutral pictures*: 2200, 5120, 5534, 7002, 7031, 7150.