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The effect of eye orientation on slowly increasing pain

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Abstract

The present study investigated the influence of eye orientation upon the experience of pain. Quasi continuous electrocutaneous stimuli which slowly increased in intensity were delivered to 32 healthy females volunteers. Participants were instructed to direct the eyes at locations that were ipsilateral or contralateral to the stimulated hand. Unpleasantness threshold and pain threshold were significantly higher when the eyes were oriented ipsilateral towards the stimulated hand. In a second experiment phase, the pain intensity increased until tolerance. There was no effect of eye orientation upon pain threshold and tolerance. Results of the first experimental part are in line with the counterintuitive idea that selective monitoring reduces pain distress. The lack of significant results in the second experiment phase is discussed in terms of statistical power and a change in coping induced by the expectation of high intensity pain.

Keywords: Pain; Attention; Eye orientation

1. Introduction

The fact that attention improves the ability to perceive and to discriminate has been much investigated in experiments using non-painful stimuli. These perceptual effects have often been demonstrated by experiments focusing upon covert attention, i.e., the ability to attend to objects that are not in line with gaze (see Posner, 1980 for review). However, in most natural situations the eyes are directed towards information that is relevant for ongoing behaviour (Kahneman, 1973). By directing the eyes towards visual information, information is brought into the fovea, which is the retinal region with the highest acuity. Therefore, orienting the eyes towards information can be considered as one of the major components of overt visuospatial attention. In support of this idea, is the neurophysiological finding that areas underlying attention and ocular activity, such as saccades and fixation, are tightly related (Corbetta et al., 1998; Kustov and Robinson, 1996; Petit et al., 1995, 1999).

There is growing evidence that the effects of visual attention are not limited to the visual modality, but also extends to other perceptual modalities such as the somatosensory one. First, Groh and Sparks (1996) demonstrated that a vibrotactile stimulus attracts foveating saccades. Second, and of more relevance, orienting the eyes towards the location of somatosensory information, facilitates the detection and the discrimination of non-painful cutaneous stimuli (Bradshaw et al., 1988; Honoré et al., 1989; Naveteur and Honoré, 1995; Pierson et al., 1991). In the study of Naveteur and Honoré (1995), participants were instructed to orient the eyes towards visual information at the ipsilateral or contralateral side of a non-painful electrocutaneous stimulus. It was found that the cutaneous threshold was lower when eyes were oriented to ipsilateral visual information.

The idea of heightened perceptual sensitivity when attention is directed towards somatosensory informa-

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tion has also been applied in pain research. It is assumed that attending towards pain amplifies the experience and that attending away from pain results in less pain (Johnson and Petrie, 1997; Tan, 1982). In line with this reasoning, McCaul and Malott (1984) argued that attending away from pain may therefore be used as a coping strategy to improve pain control. According to these authors, the most effective distraction tasks are those that consume the most attentional resources, and, therefore, reduce the attentional resources that can be allocated to pain. Some experimental evidence supports the hypothesis that attending away from discrete pain stimuli, impairs the detection of pain and lowers the reported intensity and unpleasantness of pain (Dowman, 2001; Miron et al., 1989; Spence et al., 2002; Van Damme et al., 2002). However, in an extensive review of distraction studies, Eccleston (1995) has argued that it is yet unclear how and when distraction works. He pointed at several methodological limitations, such as differences in tasks, demand characteristics and instructions between and even within experiments that make any firm conclusions about the efficacy of distraction premature.

The assumption that attending towards pain amplifies pain is intuitive appealing, but has also been contested by Cioffi (1991) and Leventhal (1992). These authors argued that an attentional focus upon pain may result in less affective responses to pain. In two experiments of Ahles et al. (1983), participants were instructed to closely monitor the experienced sensations during a cold water test or to attend away from them. It was found that participants from the sensory monitoring condition, reported less distress (Experiment 1) and better tolerated the cold water (Experiment 2). Also, Sokolov (1963) demonstrated that the instruction to orient to pain stimuli may inhibit defensive responses as cephalic vasoconstriction and the verbal report of unpleasantness. The counterintuitive use of selective monitoring has also proven to be clinically useful (Baron et al., 1993; Logan et al., 1995).

To further the understanding of attentional processes upon pain, the manipulation of eye orientation, as discussed above in studies using non-pain stimuli, may be worthwhile. First, in these procedures there is no explicit instruction to attend towards or attend away from pain, making demand effects less likely. Second, effects can be directly attributed to processes of spatial attention (see Spence et al., 2002). Honoré et al. (1995) were one of the first to apply this procedure using pain stimuli. This study provided only limited evidence of modulation in pain sensitivity: no clear effects of eye orientation upon pain threshold and pain tolerance were found. However, only brief (50 ms) electrocutaneous stimuli were used. It is possible that the temporal characteristics of that pain stimulus were not optimal for observing an effect of eye orientation effect. Indeed, it has been shown that the efficacy of attentional strategies vary as a function of pain duration (Barber and Cooper, 1972; McCaul and Haugvedt, 1982). It has also been shown that ongoing slowly ramped pain triggers more prefrontal activity, which is related to pain modulation (Lorenz et al., 2003).

The objective of this study was, then, to investigate the effect of spatial attention upon the unpleasantness threshold (the lowest stimulus intensity at which a participant perceives unpleasantness), pain threshold (the lowest stimulus intensity at which a participant perceives pain) and pain tolerance (the highest intensity that a participant is willing to accept). In contrast to the study of Honoré et al. (1995), we used a quasi-continuous electrocutaneous stimulus with a slow slope and long duration. It was also reasoned that the temporal characteristics of this stimulus are more clinical relevant. During each electrocutaneous stimulus, eye fixation was maintained ipsi- or contralaterally to the stimulated hand by the instruction to detect increases in intensity of a fixated light. In Experiment Phase 1, the stimulation stopped when pain threshold was reached. Unpleasantness and pain thresholds were measured. In Experiment Phase 2, participants stopped when the stimulus reached tolerance. Unpleasantness threshold, pain thresholds and pain tolerance were measured. As anxiety has been demonstrated to modulate the effects of attention upon pain (Arntz et al., 1991; Goubert et al., 2004), participants were selected based upon their high or low scores for trait anxiety. In sum, this study was designed to explore the effects of ipsi and contralateral orientation of the eyes upon the experience of long-duration pain in high and low trait anxious students.

2. Methods

2.1. Participants

There were 32 paid female volunteers ($M = 19.44$ years, $SD = 1.50$, range = 18 to 24 years), of which 16 high trait anxious participants, and 16 low trait anxious participants. They were selected from a large pool of students from University of Lille I based upon their trait anxiety scores as assessed by the Cattel's self-analysis sheet (1962). Low trait anxiety was defined as a decile score lower than 3. High trait anxiety was defined as a decile score higher than 7. An exclusion criterion was moderate or severe depression as measured by Beck Depression Inventory (1984). A further exclusion criterion was the presence of any disease or medical disorder (i.e., diabetes) that could modify pain sensitivity. This was checked by a physician during a medical interview. All participants were right-handed as tested by the Hécaen's laterality test (1984).

Before the start of the experiment, the participants were invited to the laboratory and given information

about the experimental procedure. Participants were informed about the possibility of leaving the experiment at any time. A written informed consent was obtained. The protocol was approved by the regional ethical committee.

2.2. Electrocutaneous stimuli

Electrocutaneous stimuli were generated by a constant current stimulator. They were delivered through two pairs of electrodes (6 mm diameter), that were filled with a conducting jelly. Electrodes of each pair were attached 1.5 cm apart to the dorsal side of the first metacarpus. The cathode was in proximal position. Each electrocutaneous stimulus consisted of a series of 50 ms trains, which was composed of 17 rectangular monophasic pulses, 1 ms in duration (330 Hz). Trains were presented at 2.5 Hz, in order to induce a quasi-continuous sensation. Every three trains the intensity was increased by 2% until the pain threshold. In Experiment Phase 2, the intensity, thereafter, increased by 4% until pain tolerance.

2.3. Procedure

Upon arrival, jewellery was removed and electrodes attached. The participants were requested to take place at the experimental table (see Fig. 1), which was equipped with a device to maintain the participant's head in a median position. The eyes were about 40 cm above the table. The forearms were positioned symmetrically on the table. There was a response box for each hand. Six centimetres above the table, the table was perpendicularly surmounted by a 50-cm-high curved screen. There were five LEDs at the base of the screen: a yellow one in the centre and four red ones, at 10° and 20° on either side. All LEDs were about 50 cm from the participant's eyes. The hands were placed behind the screen in such way that the electrodes appeared exactly at the position of the 20° LEDs. The screen was black, except for the lower 10 cm, which was translucent. That way, the participant could see her hands and the labels on the response boxes.

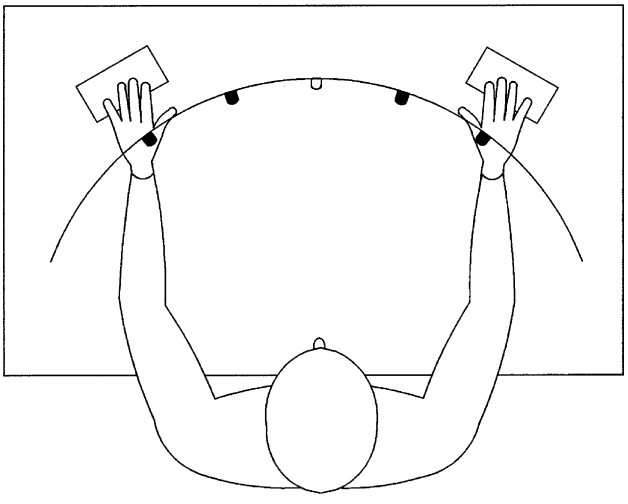

Fig. 1. Schematic representation of the apparatus (upper view).

The experiment consisted of four phases: a training of the electrocutaneous task, a training of the visual task, a first experiment phase and a second experiment phase. Instructions were tape-recorded.

During the *training of the electrocutaneous task* the participants experienced two electrocutaneous stimuli on each hand. Presentation order was counterbalanced. Participants had to indicate by a key press on the response box, when the electrocutaneous stimulus became unpleasant, but not painful (unpleasantness threshold), and when it became painful (pain threshold). The electrocutaneous stimulus was stopped once the pain threshold was reached. The aims of this training phase were: (1) to familiarize the participant with the electrocutaneous stimuli and (2) to obtain a value for the pain threshold, which was used in both experiment phases as a parameter to increase intensity.

During the *training of the visual task* the participants were trained to detect brief increases (50 ms) in the light intensity of the LED stimuli. Participants were asked to orient the eyes towards the lit LED and to keep gaze at it. Only the 20° red LEDs were used and an increase in light intensity occurred on average every 6 s. The participants had to indicate its occurrence by a key press on the response box. A criterion of eight consecutive hits at each location was required. A pilot study had revealed that during this task the detection of increase in light intensity of the LED required a sustained fixation upon the lit LED.

During *Experiment Phase 1* the participants had to perform both tasks simultaneously. They had to press a corresponding response key: (1) when the electrocutaneous stimulus became unpleasant, (2) when the electrocutaneous stimulus became painful and (3) when there was a brief increase in light intensity of the LED. There were 10 trials. The first two trials (one for each hand) were practice trials and were not included in the statistical analysis. There were eight experimental trials, presented in a counterbalanced order. Each trial consisted of the following sequence. First, an experimenter indicated which hand would be stimulated. Next, the central yellow LED light up. When the yellow LED was switched off, one of the four red LEDs switched on and the electrocutanoeous stimulus began on one of the two hands. There were four trials for each hand. Of these four trials, there are two trials during which the eyes were in the ipsilateral hemispace of the stimulated hand (one trial with the 10° LED and one trial with the 20° LED), and there are two trials during which the eyes were in the contralateral hemispace of the stimulated

hand (one trial with the 10° LED and one trial with the 20° LED). The use of these four LEDs allows to test whether the attentional effect is limited to a condition of strict convergence or is rather hemispatial. An increase in light intensity of the lit LED occurred only on average every 12 s. The electrocutaneous and visual stimulus ended when the pain threshold was indicated by the participant. There was a short break after six trials. Mean trial duration was 33.1 s (SD = 10.9).

Experiment Phase 2 was similar to Experiment Phase 1, except for the following. First, next to the unpleasantness and pain threshold, also pain tolerance was assessed. A trial ended when a participant indicated not willing to tolerate the electrocutaneous stimulus anymore. Second, there were only trials with the 20° LEDs. This limitation was motivated by the ethical consideration to lower the number of painful stimuli. There were only five trials, of which the first one was a practice trial and, therefore, discarded for statistical analysis. There were two trials for each hand. Of these two trials, there was one trial during which the eyes were in the ipsilateral hemispace of the stimulated hand, and there was one trial during which the eyes were in the contralateral hemispace of the stimulated hand. There was a short break after three trials. Mean trial duration was 66.1 s (SD = 19.6).

At the end of the experiment, participants rated retrospectively their level of state anxiety. Overall anxiety was assessed by 10 anxiety-laden adjectives taken from Bonis and Lebeaux's Q-sort (1975) using a 7-point scale (see Honoré et al., 1995). The participant rated whether the adjective matched with the overall emotional experience during the experiment. Next, state anxiety during the Experiment Phase 1 and the Experiment Phase 2 was assessed separately by a single 5-point scale (0 = absent, 4 = at maximum intensity). A full session lasted about 2 h.

3. Results

3.1. Self-reported state anxiety

Using the 10 adjectives list, high trait anxious participants ($M = 27.7$, SD = 13.5) had a significantly higher overall anxious state than low trait anxious participants ($M = 18.6$, SD = 5.9, $t(23) = 2.48$, $p < 0.05$. A 2 (Trait-anxiety: High vs Low) × 2 (Experiment Phase: 1 vs 2) ANOVA was performed upon the 1-item state-anxiety scale. There was no main effect of Trait, $F(1, 30) = 1.35$, nor an interaction between Trait-anxiety and Experiment Phase, $F(1, 30) = 0.09$. However, state-anxiety was significantly larger during Experiment Phase 2 ($M = 1.72$, SD = 1.14) than during Experiment Phase 1 ($M = 1.25$, SD = 0.92), $F(1, 30) = 21.23$, $p < 0.001$).

3.2. Performance of the visual task during the experiment

The increases in light intensity during the visual stimuli were correctly detected in 87.1% (SD = 7.9) of the cases. The detection rate was similar for Experiment Phase 1 and Experiment Phase 2. Although the performance is less than the 94.3% reported by Honoré et al. (1995) using short electrocutaneous stimuli, it is sufficient to conclude that participants have followed the instructions to keep the gaze at the lit LED. The detection rate did not differ between ipsi- and contralateral trials (Fs < 1).

3.3. Unpleasantness and pain thresholds during Experiment Phase 1

The effect of eye orientation upon threshold were analyzed using a 2 (Trait anxiety: High vs Low) × 2 (Hand: Left vs Right) × 2 (Hemispace: Ipsilateral vs Contralateral) × 2 (LED position: 10° vs 20°) ANOVA. All except the first variable were within-subject. A first ANOVA was performed upon the intensity (mA) of the electrocutaneous stimuli that the participant indicated to become unpleasant (Unpleasantness Threshold). This analysis revealed a main effect of Hand, $F(1, 30) = 24.75$, $p < 0.001$, indicating a higher Unpleasantness Threshold for the right hand ($M = 0.77$ mA, SD = 0.49) than for the left hand ($M = 0.50$ mA, SD = 0.30). Of more importance to this study was the significant main effect of Hemispace, $F(1, 30) = 4.93$, $p < 0.035$. The Unpleasantness Threshold was higher when the eyes were oriented in the ipsilateral hemispace than when the eyes were oriented in the contralateral hemispace (see Table 1). No other effects were significant (Hand × Hemispace: $F(1, 30) = 2.34$; Trait anxiety × Hemispace: $F(1, 30) = 3.86$, all other Fs < 1).

A similar analysis was performed upon the Pain Threshold, i.e., the stimulus intensity that the participants indicated to become painful. This analysis revealed again a main effect of Hand, $F(1, 30) = 21.47$, $p < 0.001$, indicating a higher Pain Threshold for the right hand ($M = 1.00$ mA, SD = 0.65) than for the left

Table 1
Mean intensity (SD) in mA for the electrocutaneous variables, as a function of eye orientation relatively to the stimulated hand

	Ipsilateral	Contralateral
Experiment Phase 1		
Unpleasantness threshold	0.64 (0.45)	0.63 (0.45)
Pain threshold	0.84 (0.59)	0.82 (0.59)
Experiment Phase 2		
Unpleasantness threshold	0.64 (0.42)	0.63 (0.42)
Pain threshold	0.84 (0.54)	0.82 (0.56)
Pain tolerance	1.46 (1.06)	1.45 (1.09)
Pain range	0.63 (0.65)	0.62 (0.69)

hand ($M = 0.66$ mA, SD = 0.1). Of more importance to this study was the significant main effect of Hemispace, $F(1, 30) = 4.63$, $p < 0.05$. The Pain Threshold was higher when the eyes were oriented in the ipsilateral hemispace than when the eyes were oriented in the contralateral hemispace (see Table 1). No other effects were significant (LED Position: $F(1, 30) = 1.06$; Hand × Hemispace: $F(1, 30) = 2.00$; Group × Hand × LED position: $F(1, 30) = 1.06$, all other Fs < 1).

3.4. Unpleasantness, pain thresholds and pain tolerance during Experiment Phase 2

The effect of eye orientation were analyzed using a 2 (Trait Anxiety: High vs Low) × 2 (Hand: Left vs Right) × 2 (Hemispace: Ipsilateral vs Contralateral) ANOVA. Analyses were performed upon the Unpleasantness Threshold. This analysis revealed a main effect of Hand, $F(1, 30) = 19.15$, $p < 0.001$, indicating a higher Unpleasantness Threshold for the right hand ($M = 0.75$ mA, SD = 0.47) than for the left hand ($M = 0.51$ mA, SD = 0.31). Although in the expected direction (see Table 1), the effect of Hemispace, $F(1, 30) = 1.07$, was not significant. There was a significant effect of Trait Anxiety × Hand × Hemispace, $F(1, 30) = 7.89$, $p < 0.001$. All other effects were non-significant (Fs < 1). The Newmann–Keuls post hoc test was used to explore the potential effects of Hemispace within the significant interaction. This test revealed only a significant effect of Hemispace (Ipsilateral: $M = 0.75$ mA, SD = 0.49; Contralateral: $M = 0.71$ mA, SD = 0.47) for the Right Hand in the group of the High Trait Anxious participants.

Similar ANOVAs were performed upon the Pain Threshold and the Pain Tolerance. They only revealed a significant effect of Hand for Pain Threshold, $F(1, 30) = 21.41$, $p > 0.001$, (right hand: $M = 0.98$ mA, SD = 0.63; left hand: $M = 0.68$ mA, SD = 0.42) and Pain Tolerance $F(1, 30) = 15.32$, $p < 0.001$ (right hand: $M = 1.66$ mA, SD = 1.17; left hand: $M = 1.24$ mA, SD = 0.92). The eye orientation effects never reached significance in these analyses (Pain Threshold $F(1, 30) = 2.19$; Pain Tolerance $F(1, 30) = 1.28$). All other effects were also not significant (all Fs < 1). A complementary ANOVA performed upon the difference between tolerance and pain threshold, called pain range (see Cubelli et al., 1984) did also not provide any significant effect (Eye orientation effect: $F(1, 30) = 0.64$).

4. Discussion

This study was designed to explore the effects of ipsilateral and contralateral orientation of the eyes upon the experience of pain induced by a quasi-continuous electrocutaneous stimulus which slowly increased in intensity. The results can be readily summarized. In the first part of the experiment, orienting the eyes ipsilateral towards the stimulated hand, resulted in a higher unpleasantness threshold and a higher pain threshold than orienting the eyes contralateral towards the stimulated hand. In the second part of the experiment, the pain intensity increased until tolerance. The previous main effects of eye orientation upon unpleasantness and pain threshold were not replicated. There was also no effect of eye orientation upon pain tolerance and pain range.

Overall, the results of Experiment Phase 1 corroborate the idea that orienting the eyes ipsilateral or contralateral towards pain stimuli affects the processing of pain. However, the effects of eye orientation upon pain seem to be different from the effects of eye orientation upon non-painful information. Indeed, the detection and discrimination of non-painful information is generally better when attention is directed towards that information. In Experiment Phase 1, we found the reverse pattern: the unpleasantness and pain thresholds were higher instead of lower. There are at least two explanations for this divergence. A first explanation is related to the idea of a dynamic interaction between orienting and defensive systems. Sokolov (1963) has repeatedly shown that the instruction to orient to pain inhibits defensive responses and negative affect otherwise elicited by painful stimuli (see also Donaldson et al., 2003). Second, the instigation of attentional coping strategies may have modulated the pain experience. It has been demonstrated that a selective monitoring of painful information reduces pain distress (Ahles et al., 1983; Leventhal et al., 1979). As suggested by McCaul and Haugvedt (1982) selective monitoring may be effective with stressors of long duration, whereas distraction may be more efficacious with stressors of short duration. Furthermore, Lorenz et al. (2003) revealed ongoing slowly ramped pain triggers prefrontal activity that is related to pain modulation.

Of further interest to this study was the finding that the effects of eye orientation were not restricted to a strict spatial convergence between eye orientation and stimulated site. Neither unpleasantness nor pain threshold did differ between 10° and 20° of eccentricity. A similar hemispatial feature has also been reported in previous studies using non-painful and painful stimuli (Honoré et al., 1995; Naveteur and Honoré, 1995). These results are in line with the attentional model of Kinsbourne (1975) which postulates that a lateral shift of attention results in a relatively large activation of the contralateral hemisphere and a corresponding more efficient information processing. However, studies investigating overt and covert attention using reaction times found a strict spatial convergence effect (see Driver and Spence, 1998 for covert attention; see Honoré et al., 1989 for overt attention). It is plausible that the spatial feature of the effect may depend upon the task context.

In case of threshold determination when only 10° separated the hand and the LED, attention may have been strategically shared between the electrocutaneous and visual task without obvious costs.

Counter to expectations, the effect of eye orientation upon unpleasantness threshold and pain threshold could not be replicated in the second part of the experiment. There was also no effect upon pain tolerance and pain range. Although the number of experimental trials in the second part was lower than in the first part of the experiment, it is unlikely that the failure is only owing to a lack of statistical power since an almost identical procedure was used by Honoré et al. (1995) who reported a significant effect upon pain range. It is possible that the experimentally induced eye orientation was too weak for competing with the strong attentionally demanding nature of a high-intensity pain stimulus of long duration (see Eccleston and Crombez, 1999 for a review). Nevertheless, it is also clear that in the current study, sustained and divided attention was highly solicited in order to performed both tasks simultaneously. Indeed, as compared to the previous experiments, participants were continuously sharing attention between both types of stimuli for a long period of time, as they had to deal with the on-line rating of the electrocutaneous stimuli and the uncertainty about the occurrence of a visual target. These task characteristics may have been detrimental to cope with pain of high intensity. It is also possible that the introduction of a stimulus that increases in intensity until pain tolerance has profoundly affected the meaning of unpleasantness and pain thresholds. They may have become strong and valid signals of impending, almost unbearable pain. It has already been demonstrated that signals for pain also become threatening and demand attention (Van Damme et al., 2002, 2004). This process of expectation may have increased the anxiety level and may have overruled the selective monitoring style, and therefore prevented the improvement of pain control (see Ahles et al., 1983).

There was no clear effect of trait anxiety in this study. There was only an effect of trait anxiety upon the unpleasantness threshold for the right hand in the second part of the experiment. An explanation for the lack of effects of trait anxiety is not yet clear. A possibility is that the effects of anxiety upon pain are largely mediated by attentional processes (Arntz et al., 1991; Crombez et al., 1999; Goubert et al., 2004). In particular, one of the functions of anxiety may be to facilitate the detection of threat by means of attentional processes. Whenever attentional processes are controlled or manipulated as in our study, the role of trait anxiety may be minimal (Arntz et al., 1991).

Finally, thresholds were repeatedly higher on the right hand as compared to the left hand in the two experimental phases. This asymmetry supports the idea of a higher left hand–right hemisphere sensitivity which has been reported previously in right handed normal individuals with various painful stimuli (Brennum et al., 1989; Haslam, 1970; Murray and Safferstone, 1970; Pauli et al., 1999) but also with non pain stimuli (Kaplan-Solms and Saling, 1988; Weinstein, 1978).

There are a number of issues to be considered that arise from this research. First, although there are several studies that have investigated the effects of eye orientation upon the processing of somatosensory information, there is not a lot of research about its effects upon pain. Therefore, further research is needed to show the robustness of our results. Also the actual registration of eye movements may be useful to document the manipulation of eye orientations and to further explore its effects. Second, this study was conducted in pain free students within a context of understanding the interrelationships between attention and pain (Eccleston, 1995; Leventhal, 1992; McCaul and Malott, 1984). Therefore, one should be cautious in generalizing these results to both other non-clinical populations and clinical populations until these effects are studied more extensively. Third, we did not obtain any self-report about pain distress, anticipatory anxiety and coping mode as a function of eye orientation that may further corroborate our interpretations. Fourth, our study reveals that the effects of eye orientation upon pain seem to be dynamic and dependent upon stimulus and context variables. For example, in Experiment Phase 2 the effect of eye orientation upon the unpleasantness threshold was only present for the right hand in persons with high trait anxiety. Indeed, the effect of eye orientation from Experiment Phase 1 was not replicated in Experiment Phase 2, and our interpretation of the change in the pattern of results, although plausible, remains to be tested.

To conclude, the present study provides evidence that orienting the eyes towards electrocutaneous stimulation of long duration may increase the threshold at which the stimulus is reported to be unpleasant and to be painful. We argued that this effect can be usefully understood as the result of sensory monitoring as a way of coping with pain. This benefit was however not observed when the stimulus intensity passed beyond pain threshold. Our study illustrates that the manipulation of eye orientation as an experimental method for investigating the effects of attention on pain, has several advantages, and can be easily adapted to further investigate the role of spatial attention upon pain.

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References

Ahles TA, Blanchard EB, Leventhal H. Cognitive control of pain: attention to the sensory aspects of the cold pressor stimulus. Cogn Ther Res 1983;7:159–78.

Arntz A, Dreessen L, Merckelbach H. Attention, not anxiety, influences pain. Behav Res Ther 1991;29:41–50.

Baron RS, Logan H, Hoppe S. Emotional and sensory focus as mediators of dental pain among patients differing in desired and felt dental control. Health Psychol 1993;12:381–9.

Barber TX, Cooper BJ. Effects on pain of experimentally induced and spontaneous distraction. Psychol Rep 1972;31:647–51.

Beck AT. Beck Depression Inventory: revised. In: Wetzel JW, editor. Clinical handbook of depression. New York: Gardner Press; 1984. p. 324–7.

Bonis M de, Lebeaux MO. Une technique de mesure de type ipsatif, le Q-sort: son intérêt en pharmacologie. Psychol Med 1975;7:265–75.

Bradshaw JL, Bradshaw JA, Pierson-Sauvage JM, Nettleton NC. Overt and covert attention and vibrotactile reaction times: gaze direction, spatial compatibility and hemispatial asymmetry. Can J Psychol 1988;42:44–56.

Brennum J, Kjeldsen M, Jensen K, Jensen TS. Measurements of human pressure-pain thresholds on fingers and toes. Pain 1989;38:211–7.

Cattel RB. Handbook for the I.P.A.T. anxiety scale. Champain: I.P.A.T.; 1962. French translation Paris: C.P.A., 1962.

Cioffi D. Sensory awareness versus sensory impression: affect and attention interact to produce somatic meaning. Cogn Emot 1991;5:275–94.

Corbetta M, Akbudak E, Conturo TE, Snyder AZ, Ollinger JM, Drury HA, et al. A common network of functional areas for attention and eye movements. Neuron 1998;21:761–73.

Cubelli R, Caselli M, Neri M. Pain endurance in unilateral cerebral lesions. Cortex 1984;20:369–75.

Driver J, Spence C. Crossmodal attention. Curr Opin Neurobiol 1998;8:245–53.

Donaldson GW, Chapman CR, Nakamura Y, Bradshaw DH, Jacobson RC, Chapman CN. Pain and the defense response: structural equation modeling reveals a coordinated psychophysiological response to increasing painful stimulation. Pain 2003;102:97–108.

Dowman R. Attentional set effects on spinal and supraspinal responses to pain. Psychophysiology 2001;38:451–64.

Eccleston C. The attentional control of pain: methodological and theoretical concerns. Pain 1995;63:3–10.

Eccleston C, Crombez G. Pain demands attention: a cognitive-affective model of the interruptive function of pain. Psychol Bull 1999;125:356–66.

Goubert L, Crombez G, Van Damme S. The role of neuroticism, pain catastrophizing and pain-related fear in vigilance for pain: a structural equations approach. Pain 2004;107:234–41.

Groh JM, Sparks DL. Saccades to somatosensory targets. I. Behavioral characteristics. J Neurophysiol 1996;75:412–27.

Haslam DR. Lateral dominance in the perception of size and of pain. Q J Exp Psychol 1970;22:503–7.

Hécaen H. Les gauchers: Etude Neuropsysiologique. Paris: P.U.F.; 1984.

Honoré J, Sparrow L, Bourdeaud'hui M. Reduction of cutaneous reaction time by directing eyes towards the source of stimulation. Neuropsychologia 1989;24:367–71.

Honoré J, Hénon H, Naveteur J. Influence of eye orientation on pain as a function of anxiety. Pain 1995;63:213–8.

Johnson MH, Petrie SM. The effects of distraction on exercise and cold pressor tolerance for chronic low back pain sufferers. Pain 1997;69:43–8.

Kahneman D. Attention and effort. Englewood Cliffs, NJ: Prentice-Hall; 1973.

Kaplan-Solms KL, Saling MM. Lateral asymmetry and tactile sensitivity. Percep Mot Skills 1988;76:55–62.

Kinsbourne M. The mechanism of hemispheric control of the lateral gradient of attention. In: Rabitt PMA, Dornic S, editors. Attention and performance, vol. V. New York: Academic Press; 1975.

Kustov AA, Robinson DL. Shared neural control of attentional shifts and eye movements. Nature 1996;384:74–7.

Leventhal H. I know distraction works even though it doesn't!. Health Psychol 1992;11:208–9.

Leventhal H, Brown D, Shacham S, Engquist G. Effects of preparatory information about sensations, threat of pain, and attention on cold pressor distress. J Pers Soc Psychol 1979;45:688–714.

Logan HL, Baron RS, Kohout F. Sensory focus as therapeutic treatment for acute pain. Psychosom Med 1995;57:475–84.

Lorenz J, Minoshima S, Casey KL. Keeping pain out of mind: the role of the dorsolateral prefrontal cortex in pain modulation. Brain 2003;126:1079–91.

McCaul KD, Haugvedt C. Attention, distraction and cold pressor pain. J Pers Soc Psychol 1982;95:154–62.

McCaul KD, Malott JM. Distraction and coping with pain. Psychol Bull 1984;95:516–33.

Miron D, Duncan GH, Bushnell MC. Effects of attention on the intensity and unpleasantness of thermal pain. Pain 1989;39:345–52.

Murray FS, Safferstone JF. Threshold and tolerance of right and left hands. J Comp Physiol Psychol 1970;71:83–6.

Naveteur J, Honoré H. Cutaneous thresholds and anxiety: influence of eye orientation and lateral asymmetry. Percept Mot Skills 1995;80:707–16.

Pauli P, Wiedemann G, Nickola M. Pain sensitivity, cerebral laterality, and negative affect. Pain 1999;80:359–64.

Petit L, Tzourio N, Orssaud C, Pietrzyk U, Berthoz A, Mazoyer B. Functional neuroanatomy of the human visual fixation system. Eur J Neurosci 1995;7:169–74.

Petit L, Dubois S, Tzourio N, Dejardin S, Crivello F, Michel C, et al. PET study if the human foveal fixation system. Hum Brain Map 1999;8:28–43.

Pierson JM, Bradshaw JL, Meyer TF, Howard MJ, Bradshaw JA. Direction of gaze during vobrotactile choice reaction time task. Neuropsychologia 1991;29:925–8.

Posner MI. Orienting of attention. Q J Exp Psychol 1980;32:3–25.

Sokolov EN. Perception and the conditioned reflex. Oxford: Pergamon Press; 1963.

Spence C, Bentley DE, Phillips N, McGlone FP, Jones AKP. Selective attention to pain: a psychophysical investigation. Exp Brain Res 2002;145:395–402.

Tan SY. Cognitive and cognitive-behavioral methods for pain control: a selective review. Pain 1982;12:201–28.

Van Damme S, Crombez G, Eccleston C. Retarded disengagement from pain cues: the effects of pain catastrophizing and pain expectancy. Pain 2002;100:111–8.

Van Damme S, Lorenz J, Eccleston C, Koster EHW, De Clercq A, Crombez G. Fear-conditioned cues of impending pain facilitate attentional engagement. Neurophysiol Clin Clin Neurophysiol 2004;34:33–9.

Weinstein S. Functional cerebral hemispheric asymmetry. In: Kinsbourne M, editor. Asymmetrical function of the brain. Cambridge UK: Cambridge University Press; 1978. p. 17–48.