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Site-specific visual feedback reduces pain perception

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ABSTRACT

One of the most common forms of chronic pain is back pain. Until now, nothing has been known about the influence of visualizing one's own back on pain perception at this site. We tested 18 patients with chronic back pain and 18 healthy controls, by implementing online video feedback of the back during painful pressure and subcutaneous electrical stimuli over the trapezius muscle. Pain threshold and pain tolerance were assessed. Pressure pain stimulation intensity was set to 50% above the pain threshold. Subcutaneous stimulation intensity was set to 70% above the pain threshold. Subjects had to rate pain intensity and unpleasantness after each stimulation block on an 11-point numerical rating scale. Visual feedback of the back reduced perceived pain intensity compared to feedback of the hand in both patients and controls. These findings suggest novel intervention modes for chronic back pain based on visualization of body parts by augmented reality applications.

1. Introduction

Chronic back pain (CBP) is a frequent debilitating and often treatment-resistant disorder. Compared to the proportion of the body, the back occupies only a small representation in the somatosensory and motor areas of the brain [30,32]. In contrast to other body areas, one's own back cannot be seen directly, unlike, for example, the hands, which are very familiar. Often the back is only perceived when it causes trouble. In most patients the exact localization of their pain is often difficult. This diffuseness of pain and its shifting locations are central to musculoskeletal pain syndromes, and there is evidence that their body image has become disrupted [25]. This begs the question as to whether manipulating the body image can in turn influence pain perception. In patients with complex regional pain syndrome (CRPS) watching an enlarged view of the limb during movement significantly increased the pain and swelling evoked by movements, whereas shrinking the view of the limb decreased pain and swelling. These observations were interpreted as being due to a top-down effect of body image on the integration of incoming sensory information [28]. In chronic back pain patients, it could be shown that seeing the back during repeated lumbar spine movements reduces movement-evoked pain [39].

In healthy controls (HC), the focusing of attention on a tactile stimulus leads to changes in the organization or activation of the primary somatosensory cortex (SI) [23,34]. Seeing the skin of the body part being stimulated decreases 2-point discrimination thresholds [6,23], which are further decreased if the visual input of the skin is enlarged [16]. Patients with CRPS had lower 2-point discrimination thresholds after sensory discrimination training while looking in the direction of the affected hand and seeing the mirror image of the unaffected hand [29]. A mirror at the reflection of one's own hand versus the reflection of a neutral object reduced pain perception and evoked potentials [20]. This suggests that visual feedback influences sensory discrimination and cortical organization. For non-painful tactile stimuli, visual feedback of the hand produces small effects on detection thresholds [14], whereas visual feedback can improve tactile detection on the neck, a body site normally not seen without a mirror [35]. So far we do not know how seeing one's own back during painful stimulation influences pain perception. We implemented online video feedback of the back and the hand as well as enlarged and downscaled feedback of the back. To induce relevant pain, we applied nociceptive pressure at myofascial trigger points, where repetitive stimulation can induce central sensitization and enhanced pain perception [19,40]. As a control condition, we used electrical stimuli. We

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Table 1
Demographic, psychometric and clinical data for chronic back pain patients (CBP) and healthy controls (HC).

	CBP	HC
Age [M (SD) range in years]	53.93 (9.18) 39.57-76.99	54.20 (9.16) 42.22-63.69
CESD [M (SD)]	16.41 (9.83)*	6.69 (8.18)*
Chronic pain grade[a] [M (SD)]	2.12 (1.11)	
Pain medication:		
N opioid/N nonsteroidal anti-inflammatory	0/1	0/0
Pain-related self-statements scale[b]		
Catastrophizing [M (SD)]	2.12 (0.86)	
Active coping [M (SD)]	3.32 (0.58)	
MPI	CBP patients	Pain comparison sample[c]
Pain severity [M (SD)]	3.10 (1.47)	3.55 (1.23)
Interference [M (SD)]	2.54 (1.47)	2.76 (1.27)
Life control [M (SD)]	4.46 (0.94)	3.80 (1.22)
Affective distress [M (SD)]	2.31 (1.33)	3.55 (1.23)
Support [M (SD)]	2.92 (2.29)	3.20 (1.84)
Punishing responses [M (SD)]	0.95 (1.53)	1.03 (1.20)
Solicitous responses [M (SD)]	2.90 (1.51)	2.76 (1.49)
Distracting responses [M (SD)]	3.02 (1.85)	2.19 (1.49)
General activity level [M (SD)]	2.99 (0.77)	2.62 (0.92)

CBP = chronic back pain, HC = healthy controls; M = mean, SD = standard deviation; CESD = German version of the Center for Epidemiological Studies Depression Scale (9)
* = $p < .01$.
[a] von Korff et al. (7)
[b] Flor et al. (6); MPI = West Haven-Yale multidimensional pain inventory (Kerns et al. (4), German version: Flor et al. (5)
[c] values of a German reference group of $n = 250$ patients with chronic musculoskeletal pain.

hypothesized that seeing the stimulated site compared to a control site would reduce pain intensity, and that an enlarged video feedback of the back would lead to higher and downscaled video feedback to lower pain ratings. We assumed that the pressure pain condition would be more effective than the electrical stimulation condition, as this may favor the sensitization of trigger points.

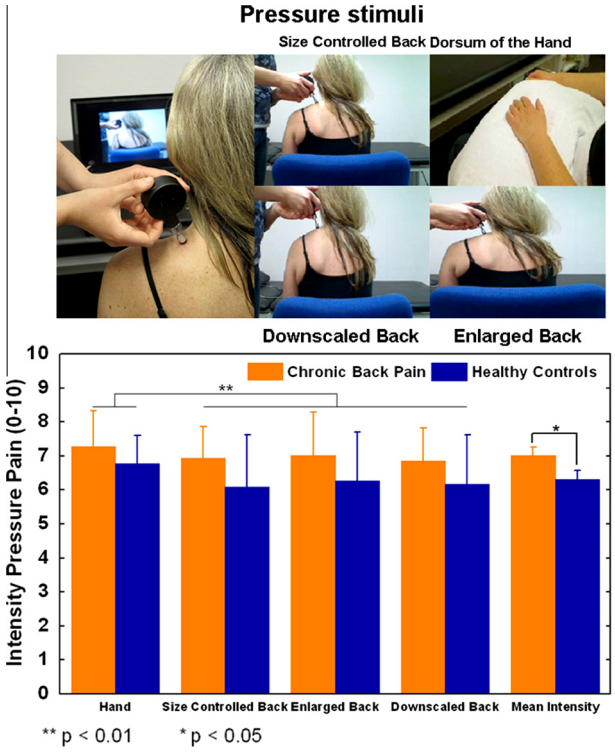

Fig. 1. (Top row) Experimental setup. Stimuli were applied to the upper back while subjects watched the image taken by a video camera placed behind them. The image showed a size control, a downscaled or an enlarged representation of their back, or the dorsum of their hand. (Bottom row) Pain intensity ratings for the pressure pain stimulation in all conditions and the mean intensity across conditions.

2. Methods

2.1. Participants

We tested 18 patients with chronic bilateral upper back pain (aged 54.74 ± 9.14 years, 5 male) and 18 HC (aged 54.69 ± 9.09 years, 6 male), matched for age and education. Table 1 lists demographic and clinical characteristics of the samples. The participants were mainly recruited through a joint case management unit established by several pain research centers in southern Germany. All patients and controls underwent medical examination. There was no significant difference between the groups with respect to age ($t_{33} = -0.016$, $P = .99$). The CBP patients had been experiencing pain for a minimum of 12 months, 9 patients for more than 10 years, and 9 for less than 10 years. None of the CBP patients took opioid medication; 1 patient took a nonsteroidal anti-inflammatory drug (NSAID); and all other subjects were medication free. We might thus have a less affected but more homogeneous sample. The patient with the NSAID was asked not to take any pain medication for 3 days before the measurement. Six of the CBP patients met the criteria for an anxiety disorder, whereas none of the CBP patients met the criteria for a current major depression or any other axis I or II mental disorder as assessed by the Structured Interview for the *Diagnostic and Statistical Manual of Mental Disorders IV* (*DSM-IV*) [2,9,10]. The HC did not fulfill any criteria for a *DSM-IV* axis I or II mental disorder. Exclusion criteria for all subjects were neurological complications, pregnancy, psychosis, use of a cardiac pacemaker, allergy to plaster, drug abuse, and current opioid intake. Informed consent was obtained, and the study was approved by the ethics committee of the Medical Faculty Mannheim, Heidelberg University and adhered to the Declaration of Helsinki.

2.2. Psychological assessment

To describe the sample in terms of clinical variables, the CBP patients completed the German Version of the West Haven–Yale Multidimensional Pain Inventory (MPI) [13,17], the Pain-Related Self-Statements Scale (PRSS) [11], and the Chronic Pain Grade (CPG) [37]. The assessment for all participants included the Center for Epidemiological Studies Depression Scale (CESD) [15,33]. The