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Impaired visual perception of hurtful actions in patients with chronic low back pain ☆

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ABSTRACT

Visually presented biological motion stimuli activate regions in the brain that are also related to musculo-skeletal pain. We therefore hypothesized that chronic pain impairs the perception of visually presented actions that involve body parts that hurt. In the first experiment, chronic back pain (CLBP) patients and healthy controls judged the lifted weight from point-light biological motion displays. An actor either lifted an invisible container (5, 10, or 15 kg) from the floor, or lifted and manipulated it from the right to the left. The latter involved twisting of the lower back and would be very painful for CLBP patients. All participants recognized the displayed actions, but CLBP patients were impaired in judging the difference in handled weights, especially for the trunk rotation. The second experiment involved discrimination between forward and backward walking. Here the patients were just as good as the controls, showing that the main result of the first experiment was indeed specific to the sensory aspects of the task, and not to general impairments or attentional deficits. The results thus indicate that the judgment of sensorimotor aspects of a visually displayed movement is specifically affected by chronic low back pain.

☆ Short title: Chronic pain impairs visual judgments.

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1. Introduction

Evidence suggests that high level cortical mechanisms play an important role in the body and motor representations during pain (Lotze & Moseley, 2007; Moseley, Gallace, & Spence, 2012). For example, the motor imagery of depicted hand postures causes pain and swelling of the affected limb in patients with chronic hand or wrist pain, complex regional pain syndrome (CRPS), and non-CRPS pain patients (Moseley et al., 2008b). In patients with chronic hand pain, the manipulation of visual input using binoculars during movements can alter pain and swelling of their affected limb evoked by movements (Moseley, Parsons, & Spence, 2008a). A recent study demonstrated that bilateral and unilateral back pain is associated with less accuracy in judgment of depicted left and right trunk rotations, compared to healthy controls (Bray & Moseley, 2011). Additionally, there is an altered representation of the deep postural abdominal trunk muscle at the primary motor cortex (M1) in individuals with recurrent low back pain (Tsao, Galea, & Hodges, 2008). The cortical representation of the back at the primary somatosensory cortex (S1) in response to electrical stimuli was shifted about 2.5 cm medially in chronic back pain patients compared to controls (Flor, Braun, Elbert, & Birbaumer, 1997). Furthermore, body image was distorted and two-point discrimination threshold was increased at the affected area in patients with chronic back pain (Moseley, 2008). Additionally, tactile acuity during two-point discrimination tasks at the back was decreased and related to a worse performance of voluntary lumbopelvic positioning tasks in chronic back pain patients (Luomajoki & Moseley, 2009).

These data might be interpreted in the sense that specific cognitive tasks, such as motor imagery, and sensory and motor representations of one's own body, use similar cortical resources as the processing of (chronic) pain. Possible candidates for this processing are parts of the frontal cortex and the rostral inferior parietal lobe (Apkarian, Baliki, & Geha, 2009; Lotze & Moseley, 2007; Moseley, 2003). Following this interpretation one can hypothesize that pain should also affect the visual perception of actions that involve motion of the body region affected by the chronic pain.

The visual observation of a goal-directed movement activates a complex cortical network that involves not only visual processing regions in the occipital and temporal cortex (Grossman et al., 2000; Michels, Kleiser, de Lussanet, Seitz, & Lappe, 2009; Servos, Osu, Santi, & Kawato, 2002), but also the sensorimotor representations in the brain (Buccino et al., 2001; de Lussanet et al., 2008; Saygin, Wilson, Hagler, Bates, & Sereno, 2004) which belong to the so-called mirror neuron system (Rizzolatti & Sinigaglia, 2010). These brain regions are thought to fulfill a central role during observation of movement; it is active during action execution as well as during action recognition (Buccino et al., 2001; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti & Sinigaglia, 2010). The rostral part of the inferior parietal lobe, the lower part of the precentral gyrus, and the posterior part of the inferior frontal gyrus have been found to be part of the mirror neuron system (Fogassi et al., 2005; Rizzolatti & Sinigaglia, 2010).

Some additional brain areas, such as the insula, middle temporal gyrus, and somatosensory cortex are closely connected with the areas containing mirror neurons and are also involved in information processing for mirroring and simulation (Pineda, 2008; Rizzolatti & Sinigaglia, 2010). Thus, there is a substantial anatomical overlap between the mirror neuron system, its extended areas, and regions affected by chronic pain (Apkarian et al., 2009; Baliki, Schnitzer, Bauer, & Apkarian, 2011; Rizzolatti & Sinigaglia, 2010).

The visual perception of biological movements from moving point-light stimuli has been intensively studied since Johansson (1973). Such so-called point-light biological motion is devoid of image information but is nevertheless easily recognized. Brain imaging evidence revealed that point-light biological motion is processed by a cortical network including extrastriate visual cortical areas, ventral temporal (fusiform) areas, and the right posterior superior temporal sulcus (Grossman et al., 2000; Vaina, Solomon, Chowdhury, Sinha, & Belliveau, 2001; Michels, Lappe, & Vaina, 2005; Servos et al., 2002). Depending on the task, however, point-light biological motion may also activate premotor and parietal areas belonging to the cortical mirror-neuron system (de Lussanet et al., 2008; Saygin et al., 2004). These biological motion stimuli activate motor and somatosensory representations and