

Remembering the dynamic changes in pain intensity and unpleasantness: A psychophysical study



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ABSTRACT

This study investigated the short-term memory of dynamic changes in acute pain using psychophysical methods. Pain intensity or unpleasantness induced by painful contact-heat stimuli of 8, 9, or 10 s was rated continuously during the stimulus or after a 14-s delay using an electronic visual analog scale in 10 healthy volunteers. Because the continuous visual analog scale time courses contained large amounts of redundant information, a principal component analysis was applied to characterize the main features inherent to both the concurrent rating and retrospective evaluations. Three components explained about 90% of the total variance across all trials and subjects, with the first component reflecting the global perceptual profile, and the second and third components explaining finer perceptual aspects (eg, changes in slope at onset and offset and shifts in peak latency). We postulate that these 3 principal components may provide some information about the structure of the mental representations of what one perceives, stores, and remembers during the course of few seconds. Analysis performed on the components confirmed significant memory distortions and revealed that the discriminative information about pain dimensions in concurrent ratings was partly or completely lost in retrospective ratings. Importantly, our results highlight individual differences affecting these memory processes. These results provide further evidence of the important transformations underlying the processing of pain in explicit memory and raise fundamental questions about the conversion of dynamic nociceptive signals into a mental representation of pain in perception and memory.

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1. Introduction

In clinical or experimental situations, the amount of pain felt is assessed by subjective reports: the patient or volunteer is asked to provide a rating that represents their current or past experience using a validated visual, numerical, or verbal scale. However, the accuracy of pain recall has been debated. Although some studies show that the recollection of pain is moderately accurate [2,8,18,28,30,32], others argue for important and systematic distortions of the remembered pain [6,17,19,31,37,38,47,48,55]. The nature of the information available in memory about past painful experiences remains unclear. One immediate problem with the

methods used in previous research is that subjects may encode, store, and/or remember an indirect measure of pain by translating the sensory information into a more stable memory representation (eg, a number or a word) rather than memorizing the actual pain experienced. A few investigators have used online continuous ratings to monitor the ongoing perceptual changes in the magnitude of experimentally induced pain [15,16] or spontaneous fluctuations in clinical pain [21]. These methods are less likely to lead to a simple conversion into a more stable format, but to our knowledge, they have not yet been used to determine how much of the dynamic pain information is actually preserved in memory.

In addition to the dynamic aspect of pain, it is generally accepted that pain can be described along sensory-discriminative (intensity) and affective-motivational (unpleasantness) dimensions [42,51,52,54,56]. Previous research has suggested that long-term pain recall largely reflects the aversive emotional context at encoding [22,23]. Few data exist, however, on the relevance of this

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distinction in short-term memory processes. One of the goals of this study was to take advantage of online continuous rating procedures to evaluate in greater depth the memory distortions affecting the recall of pain intensity and unpleasantness over a very brief time interval.

Comparing dynamic temporal profiles of continuous visual analog scale (VAS) reports, obtained in concurrent/perceptual and retrospective/memory conditions, may provide insight into possible transformations induced by the encoding, storage, and/or retrieval processes. The comparison between the 2 pain dimensions may also reveal whether specific aspects of the real-time pain experience are weighted differently throughout memory processing. Another important but neglected issue is whether individuals vary in how they memorize dynamic information about pain sensation and affect. This study was designed to address these questions by using a multivariate analysis (principal component analysis, PCA) applied to dynamic data. PCA was utilized to decompose the temporal profiles into a few components explaining most of the overall variance, thereby greatly reducing the dimensionality of the data. This allowed us to test differences related to memory, pain dimension, and individual variability in terms of independent patterns of information (components) extracted from VAS curves that might provide some insight about the inherent structure of the mental representation of ongoing changes in pain magnitude over time.

2. Materials and methods

2.1. Subjects

Ten subjects (7 men and 3 women with an average age of 26 years, 5 ± 9 years) took part in this experiment. They were recruited on the campus of the Université de Montréal. All participants provided informed consent before the beginning of the experiments. The protocol was approved by the Human Research Ethic Committee of Université de Montréal and was in accordance with the 1975 Helsinki Declaration of Human Rights. Subjects were free to withdraw from the study at any point during the experiments, but no one did.

2.2. Stimulation and procedure

Subjects were comfortably seated in a soundproof room, and thermal (heat) stimulation was applied on the volar surface of the forearm with a MEDOC TSA-2001 contact thermode of 30×30 mm. The temporal profile of the stimuli consisted of 3 phases: onset, plateau, and offset. The temperature of the stimuli started rising from 37°C , reached 47°C in 2 s (onset), and then remained at that fixed intensity during 4, 5 or 6 s (plateau), and returned back to baseline at 37°C in 2 s (offset) (Fig. 1). The total

duration of the stimuli was thus 8, 9, or 10 s. The thermal probe was moved to 1 of 4 spots on the forearm between trials to minimize the risk of sensitization.

Continuous ratings were performed using an electronic VAS (e-VAS) consisting of a 9-cm sliding potentiometer. Cursor movement along the axis of the scale was converted to a numerical scale from 0 to 100 units of pain intensity or pain unpleasantness. The 2 pain dimensions were described according to previous studies [52,54,56]. The 2 extremities of the e-VAS were labeled “No pain” and “Most intense pain imaginable,” or “No unpleasantness” and “Most unpleasant pain imaginable.” The e-VAS signal was sampled at 200 Hz, using a Biopac MP150 system, and recorded using the AcqKnowledge program 3.7.1.

The experiment was designed to investigate the effect of memory on the subjective report of the temporal profile of painful thermal stimuli after a delay of 14 s (Fig. 1). This delay was chosen on the basis of the results of our earlier study showing important memory distortions within this time frame [55]. Importantly, concurrent and retrospective ratings were obtained in separate blocks of trials to reduce the risk that subjects might memorize their motor response rather than their pain experience in retrospective rating trials. Each block of trials started with the instruction to rate pain intensity or pain unpleasantness (pain dimension effect), either concurrently or retrospectively (memory effect). In concurrent rating trials, subjects were asked to move the cursor to report the pain felt as precisely as possible throughout the sensation. In retrospective trials, the rating scale was covered with a towel during the stimulus and the delay and subjects were asked to attend to and memorize the pain experienced, and to try to reproduce the experience they felt as precisely as possible. Practice trials were performed as necessary to familiarize the subjects with the task conditions.

The experimental protocol thus consisted of 4 main conditions [memory ($2 \times$ pain dimensions (2)]], tested in separate blocks: simultaneous intensity (SI), simultaneous unpleasantness (SU), retrospective intensity (RI), and retrospective unpleasantness (RU). Each of these 4 conditions was tested in 2 separate blocks of 6 trials including 2 trials for each of the 3 stimulus duration (duration effect; pseudo-randomized within block) for a total of 8 blocks and 48 trials. Therefore, each stimulus was presented 4 times in each condition. We also investigated whether such perceptual and memory processes of the different dimensions of pain varied across individuals (subject effect).

2.3. Data analysis

The analysis was designed to summarize the VAS time courses in order to investigate the following: (1) differences between retrospective and concurrent pain evaluations (memory effect), (2)

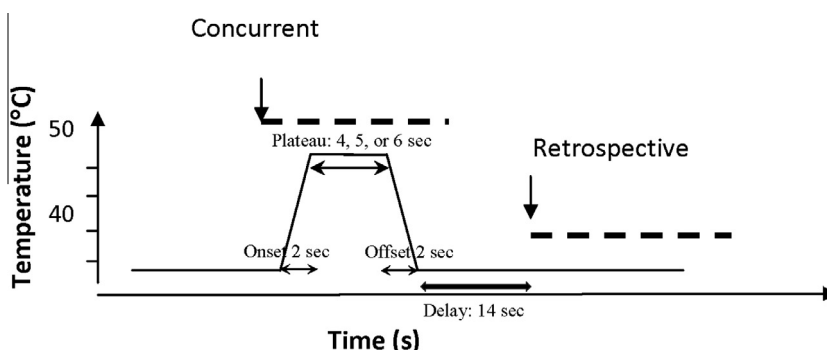


Fig. 1. Temporal profile of the actual stimulus delivered consists of 3 phases: onset, plateau, and offset. In separate trials, subjects rated the intensity or the unpleasantness of pain concurrently with the stimulus or after a 14-s delay after the offset of the stimulus. Dashed lines indicate when concurrent and retrospective ratings are produced.

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