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How a clock can change your pain? The illusion of duration and pain perception

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ABSTRACT

The intensity of experimental pain is known to be dependent on stimulation duration. However, it remains unknown whether this effect arises largely from the actual stimulus duration or is substantially influenced by the subject's perception of the stimulus duration. In the present study, we questioned this issue by misleading the perception of the duration of pain in a population of 36 healthy volunteers stimulated with a thermode. To this aim, time was signified by a clock with rotating hands in which imperceptible differences in speed rotation had been introduced. Subjects were therefore immersed in 2 comparative conditions in which time was manipulated to provide the illusion of either long or short duration of the painful stimulus. In a first condition ("full-length" clock), participants were instructed that pain would last for a complete revolution of the clock's hands, whereas in the second condition ("shortened" clock), revolution was reduced by 25%. Although the intensity and the real duration of stimulation were identical in both conditions, the intensity of pain was significantly reduced when the perception of time was misleadingly shortened by the manipulated clock. This study suggests that the perceived duration of a noxious stimulation may influence the perceived intensity of pain.

1. Introduction

Experimental studies on pain generally deliver acute painful stimuli (i.e., brief events) to normal volunteers. Intuitively, it seems logical that pain duration could influence the intensity of pain perception in a sense that the longer is the pain stimulus, the higher should be the pain perception. By manipulating the representation of time in normal volunteers during a painful stimulation, our study aimed at investigating the time dimension as a part of pain perception.

The influence of various contexts on pain intensity has been investigated previously. Emotion (i.e., seeing unpleasant pictures during painful stimuli) was found to enhance pain ratings [12] and to decrease pain threshold [19], whereas distracting the subject from pain with a cognitive task was found to reduce pain ratings [21,31]. Anxiety [24] and anticipation of pain, particularly for expected stimuli [27] have also been found to increase pain intensity. Only a few studies assessed the relationships between pain perception and time. It is generally admitted that long-duration stimuli are perceived as more painful than short stimuli for high temperatures [18]. What has been shown is that time perception was underestimated as the subjects experienced pain [13,16,28] and that pain coping strategies integrating temporal information in children can help to decrease pain rating [6], but the reverse (i.e., the effect of time perception on pain intensity) has not been investigated so far. Time perception is known to involve contextual information, and duration estimation is known to rely, for example, on stimulus size [34], velocity and speed [17], visual information [14,15], auditory clues [9], or interaction between modalities [33]. Subjective perception of time can also be distorted by emotional context [10,19] and attention [5,16,30]; we used these properties to modify subjective duration of our painful stimulations.

In the present study, we investigated how the perception of time may influence the intensity of perceived pain: by using a misleading representation of time, participants were immersed in 2 different conditions, relative to the duration of stimulations that were delivered by a heat thermode on the left leg or on the left hand. Compared with a control context in which subjects received a "full-length" nociceptive stimulation, a second context in which they were convinced that they had received a "shortened" stimulation succeeded in modulating (i.e., minimizing) pain perception. Here we present the details of this experiment showing that believing you are suffering for a shorter period of time will decrease your pain intensity.

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2. Methods

2.1. Participants

A total of 36 right-handed subjects (18 male and 18 female, age [mean ± SD] 23.2 ± 2.85 years) were included in the main study. All were free of treatment and did not practice intensive sport. They were not paid for their participation, and all provided informed consent. Twenty-four additional subjects were included in a complementary study (12 male and 12 female, age 22 ± 2.98 years). They were paid for their participation, and all provided informed consent. The local ethics committee approved the experimental protocols.

2.2. Task and procedure

Thermal stimulations were delivered by a 3 × 3-cm thermal probe (TSA-2001, Medoc). Nociceptive thresholds were determined by methods of limits. Basal temperature, set at 32 °C, rose to individual pain threshold with a slope of 1 °C/s. Subjects had to press a button as the heat temperature reached a painful level. The measure was repeated 4 times. Mean pain thresholds were 45.2 °C ± 1.46 °C in the main study (range 40.2 to 46) and 44.1 °C ± 0.68 °C in the complementary study (range 43 to 45.5). In both studies, maximal temperature was set to 47 °C to prevent skin damage.

Subjects received a standardized instruction that there would be 2 painful conditions and that a clock would materialize the course of time. In one condition, the hands of the clock described a complete revolution, whereas in the second condition they described only three-fourths of the revolution (Fig. 1). Subjects were instructed that in this latter condition, pain duration would therefore be reduced by 25%. In the main experiment, this instruction was reinforced by the green colour of the shortened clock and by adding a happy-face emoticon, whereas the clock with a complete revolution was filled with a red colour and associated with a sad-face emoticon. The aim of this presentation was to convince the subjects that in the context with the shortened clock, the painful stimulation was shorter compared with the context with the full-length clock. Stimulation temperature was set to the individual pain threshold +1 °C with the thermode applied on the left leg for 30 s (plateau duration, slope 6 °C/s [up] and 8 °C/s [down]). Subjects were kept blinded to the fact that stimulation temperature and duration were kept constant in both conditions. Immediately after each stimulation, the subject was asked to rate the intensity of pain on a 10-cm Visual Analog Scale. To minimize memory bias in their activity of scoring pain, subjects were asked to score their pain immediately after the temperature had returned to baseline. In a first session (passive session), 4 stimulations (2 stimulations with the full-length clock and 2 stimulations with the shortened clock) were delivered to volunteers according to a predefined sequence that was randomly ordered. To minimize the known influence of pain predictability on pain perception [26] and to exclude confounds that may relate to the chosen or the forced aspects of the decision, we replicated the experiment in a second session in which subjects were asked to choose (active session) the sequence (i.e., the order of the 4 stimulations). Thus, subjects experienced a total of 8 stimulations. The order between passive and active sessions was counterbalanced.

Then, a complementary experiment was designed to exclude the effects of colours and emoticons, and therefore, both full-length and shortened clocks were similarly represented in gray colour. The ensuing experiment was then similar to what was performed in the forced session of the main study. Two different lengths of painful stimuli applied on the dorsum of the left hand were tested (either 25 or 15 s) at the individual pain threshold or at the individual pain threshold +1 °C. Although it could be interesting to investigate the effects of time representation on innocuous stimuli, we preferred not to introduce innocuous intensities of stimulation (below pain threshold) that would have required an additional scoring and would have increased the complexity of the experiment. Subjects were asked to score their pain after the temperature had returned to baseline with a variable delay (jitter) that was introduced between the end of the stimulation and the signal for rating: 2.08 ± 1.38 s) to prepare the rating conditions of the future fMRI experiment in which stimulation should be easily dissociated from scoring.

2.3. Time perception

Throughout the main and the complementary experiments, we deliberately omitted investigating explicitly the perception of time and the perception of rotation speed of the hands of the clock by the subjects. Specifically, it would probably have been interesting to assess their own perception of time representation or to compare with a real 75% reduction of stimulus duration. However, we anticipated that orienting attention toward the representation of time and the distortions introduced here would have exposed them to the risk of giving a temporal reference, and therefore possibly the key of the illusion. At the end of the session, for the same reasons, we systematically checked with a vague but standardized question ("Did you notice anything wrong or bizarre with the

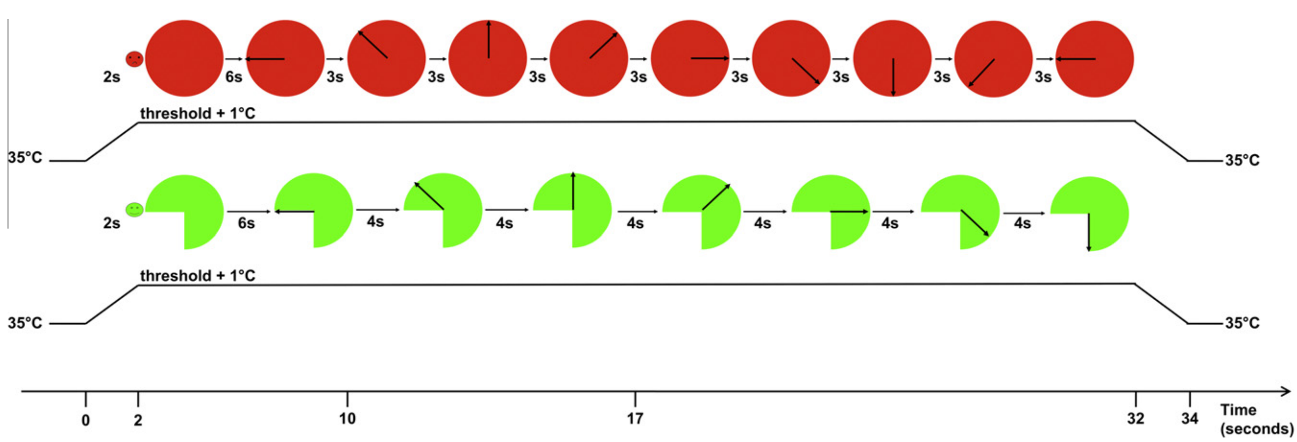

Fig. 1. Experimental design. In the 2 conditions, the clock with the emoticon was first presented for 2 s corresponding to the delay for the temperature to reach the plateau, then the first hand position on the clock was presented for 6 s. In the shortened-length condition, green clock with a happy-face emoticon, the hand moved every 4 s, in the full-length condition, red clock with a sad-face emoticon, the hand moved every 3 s. After 30 s, the temperature decreased to 35 °C (baseline) and the clock was removed.