# The Influence of Emotional States In Pain Perception

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## Abstract

Pain is a highly subjective and complex phenomenon. Current methods measure pain mostly rely on the patient's description, which may not always be possible. Thus, pain recognition systems based on body language and physiological signals have emerged. As the emotional state of a person can also influence the way pain is perceived, in this work, a protocol for pain induction with previous emotional elicitation was conducted. Eletrocardiogram (ECG), Electrodermal Activity (EDA), and Eletromyogram (EMG) signals were collected during the protocol. Besides the physiological responses, perception was also assessed through reported-scores (using a numeric scale) and times for pain tolerance and threshold. In this protocol, three different emotional elicitation sessions (negative, positive and neutral) were performed.

The results showed that during the negative emotional state, pain reported-scores were higher and pain threshold and tolerance times were smaller when compared with positive. As expected, the physiological response to pain remain similar despite the emotional elicitation.

## 1 Introduction

Pain is a subjective phenomenon that depends on the past experiences of each individual and the circumstances of the moment [1].

Currently, the methods used to quantify pain are mainly visual or numeric scales [4]. However, patients with limited communication skills cannot report their pain experience, these may include infants and children, adults with cognitive damage or intellectual disability, and unconscious people [1]. Thus, an objective measurement of pain could be beneficial. To achieve this goal, there has been some research devoted to the development of pain recognition systems, which are based on the detection of characteristics provoked in the human body by pain, such as facial expressions, sounds, gestures, or even some physiological signals.

Pain is not only a physical experience as the emotional state of the individual can influence the pain experience [4].

This work addresses the influence of emotional states on pain responses. Firstly, the participants are subjected to the elicitation of different kinds of emotions (negative, positive, and neutral) through the visualization of different excerpts of terror, comedy, and documentary movies, respectively, while, thereafter, pain induction is attained through the Cold Pressor Task (CPT) test. Throughout each entire session, ECG, EMG, EDA and pain associated measures are collected.

The aim of this work is to understand if emotion elicitation has an influence in pain perception and response. According to the state of the art, it is expected that emotional elicitation will not have an influence on the physiological response to pain, while it is supposed that perception depends on the elicited emotional state. Negative emotions (in this case, fear) should exacerbated pain, increasing the perception and lowering the tolerance to pain. On the other hand, positive emotions (happiness) should attenuate the perception of pain.

## 2 Related Works

There have been several studies developing pain recognition systems with different approaches, to analyze pain and to study the influence of emotions on pain perception.

Zhang *et al*. [3] used emotion-related questionnaires to assess negative emotions and a CPT at the temperature of 2°C to induce pain. Pain threshold was determined as the time the subject began to feel pain after immersing the hand on the water and pain tolerance as the total time from immersing the hand in the water to the time the participants withdrawn it. They found that the males presented statistically significant higher pain threshold and tolerance. Further analysis showed that differences in pain sensitivity were mediated by pain-related negative emotions. Srisopa *et al*. [5] found that emotion regulation strategies produced significant improvements in decreasing pain intensity during labor. The individuals submitted to mindfulness intervention and distraction techniques showed a significantly reduced pain intensity during the active phase of labor.

Silva and Sebastião [2] studied the ECG during pain induction under emotional contexts. The participants were subjected to a CPT while watching an emotional inducing video. The protocol consisted of two sessions, one using a fear emotion-inducing video and a second using a neutral one. Several machine learning algorithms were used to classify pain, and the results support that ECG response remain similar along both sessions.

These works support that emotions can have a crucial role in pain perception, driving the motivation for the present work in studying the influence of emotions on pain perception.

## 3 Protocol

The protocol used for data collection is schematized in Figure 1.

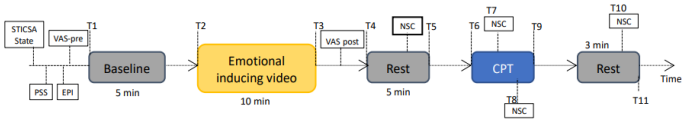


Figure 1: Scheme of the protocol applied.

Before the procedure, informed consent with all the information about the process was given to the participants. The protocol begins with the participant answering several questionnaires with the purpose of assessing some psychological traits of the participant, as well as the emotional, arousal and valence states.

The ECG, EMG of the trapezius and triceps muscles, and EDA signals were recorded during the entire protocol. EDA was collected on the palm of the dominant hand and ECG electrodes were placed on the rib cage.

In Baseline and Rest epochs, the participant was just sat in a comfortable position without any stimuli during 5 minutes. The emotional inducing video can be: an neutral emotional inducing video, which is composed of excerpts of documentaries, a negative emotional inducing video (Fear), which is composed of excerpts of terror movies, or a positive emotional inducing video (Happiness), which is composed by excerpts of comedy movies. In order to assess valence and arousal states, the Visual Analogue Scale (VAS) was answered before and after watching the video.

In the CPT, with a maximum duration of 2 minutes, the participant immersed his non-dominant hand in water at a temperature of approximately 7°C± 1°C. The participant reported the pain level three times, using a numerical pain scale (NPS) ranging from 0 to 10: before immersing the hand in the water; as soon as they feel any pain (Pain Threshold) and right before withdrawing the hand (Pain Tolerance) and after 3 minutes of removing the hand off the water. If they reach the point where they can no longer tolerate the pain, they were instructed to report to the pain level to researchers before withdrawing the hand. Each participant repeated this protocol three times, with an interval of approximately 1 week, where each session differs from the type of emotion-induced through the video. The order of the videos was randomized.

This study was approved by the Ethics and Deontological Council of the University of Aveiro (CED-UA-12-CED/2023).

## 4 Data Analyses

After the acquisition, the physiological data was filtered and divided into epochs according to the triggers given and processed.

Only Baseline and CPT epochs were used in this work, since the aim is to evaluate if the emotion elicitation had some influence on physiological response to pain and in pain perception. The signals were pre-processed using Neurokit2[1] in Python.

After the filtering, several important features of the signals were extracted. From the ECG, ultra-short Heart Rate Variability (HRV) features, mean of the Heart Rate (HR), and features concerning the peaks and waves of the signal were extracted. From both EMG signals, the variance of the signals, the median and mean of the envelops, and the root mean square errors of the signals and envelops were computed. Regarding to the EDA, the mean of both tonic and phasic components, the number of peaks of the phasic component, and its mean values of amplitude, height, recovery time, and rise time were also computed. Moreover, to minimize inter-participant variability, the features were scaled by the ratio between those extracted from CPT and the respective extracted from Baseline 1, for each participant.

In order to investigate if the extracted features differed significantly regarding the emotion elicitation, statistical tests were performed. First, the normality of all the features was tested using the Shapiro-Wilk test. The features that fail the Shapiro-Wilk test (the data does not meet the assumption of normality) were submitted to a non-parametric Friedman test. Those who passed the Shapiro-Wilk test (the data is likely to follow a normal distribution) were submitted to the parametric repeated measures ANOVA test. Both Friedman and ANOVA tests were used to evaluate if the features could differentiate between sessions with different emotion elicitation (F: Fear, H: Happiness, N: Neutral). Afterwards, post-hoc tests were performed to evaluate, for those features, which pairs of emotional states differed.

Only the participants that lasted at least 30 seconds in the three sessions with the hand immersed in the cold water were considered for physiological data analysis.

## 5 Results and Discussion

A total of 56 volunteers (28 females) with ages between 18 and 30 y.o. (mean of 22.46 and standard deviation of 2.04 y.o.) participated in the study (2 participants did not undergo the last session due to personal reasons).

Figure 2 presents the violinplots for the reported pain scores (top) and for the times (in seconds) of pain threshold and tolerance (bottom).

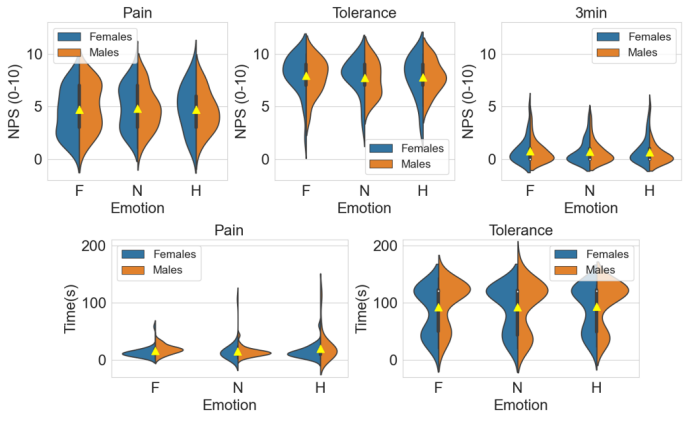


Figure 2: Violinplots of the NPS scores reported by participants (top) and of the pain threshold and tolerance, expressed in seconds (bottom). The ▲ stands for the mean of the scores and times within each emotion.

Considering the negative state, the scores reported at pain tolerance and at the 3 minutes after taking the hand off the water, were greater than those reported when in neutral and positive states. With respect to the scores reported at pain threshold, the values are similar across emotional sessions, specially for negative and positive inducing sessions (4.70±2.20 and 4.71±2.05, respectively). However, with regard to time, both pain threshold and tolerance were lower for the negative state (15.76±9.29 and 92.11±39.76, respectively) when compared with the positive induced condition (19.74±21.94 and 93.23±38.71, respectively).

Regarding the scores and tolerance time, when comparing the violins for each emotion, it can be noted that they are very similar to each other. Only smaller differences, regarding gender, can be found, as females tend to report highest scores than males. Concerning pain threshold's time, the violins are also very similar but the values are more dispersed for Positive and Neutral states than for Negative, and, in general, females tend to report pain sooner than males.

Concerning the physiological response to pain, within the 52 features analysed, only two, which did not meet the normality assumption, showed statistically differences between emotional states when applying the Friedman test, namely the mean distance between Onsets and Offsets of the R peak (R_OnOffDist) and the mean height of Skin Conductance Response (SCR_height). Therefore, the Nemenyi post-hoc test was used to evaluate, which pairs of emotional states differed. R_OnOffDist and SCR_height differentiated Fear VS Neutral and Fear VS Happy, respectively, with both p-values<0.05. These results support our hypothesis that emotion elicitation influence pain perception but not physiological response to pain.

The results of our work can be influence by the small number of participants. A larger dataset could improve the results.

## 6 Conclusions and Further Research

In this work, a protocol for pain induction with previous emotional elicitation was conducted.

The state of the art shows that the emotional state of a person influences the way pain is perceived but has no influence on physiological pain response.

The results showed that the protocol seems not clearly elicit emotions, since the pain perception was slightly modified despite the emotional video visualized, which may be due to the time elapsed between the emotional elicitation and the pain induction. On other hand, as expected, the results showed emotional states pose no influence on the physiological response to pain.

Considering the encouraging results, further research should be concerned with the design of a protocol to specifically attain the emotional elicitation in order to ensure that emotional states still elicited during pain induction.

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