Detection of Pain Caused By A Thermal Stimulus Using EEG and Machine Learning

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Introduction

Pain is known for being a vital but unpleasant sensation that demands immediate attention, disrupts ongoing behavior and distortions the thought. It is interesting how pain affects each of us taking in count the history, sexuality, and sociocultural context besides the physiological response, but this increases the problem of how to detect or quantify it.

Nowadays the most common way to assess if a person is experiencing pain is with self-report pain scales, which are unreliable.

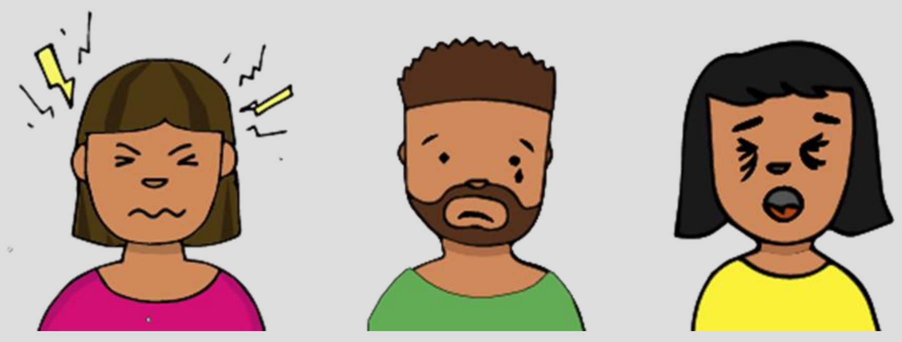

Fig. 1. Pain is a subjective experience as it depends on the history, sexuality and sociocultural context of each subject.

This is a big opportunity for computational novel methods to detect and quantify pain using biosignals and machine learning methods as a solution.

Objective

Characterize the brain response associated with pain/sensibility caused by a thermal stimulus using electroencephalography (EEG).

Related Work

Most of the works that study the relationship between EEG and pain are intended to detect and quantify it because it is a problem to communicate it verbally, and for people in a state of unconsciousness or with some speech problem, it is almost impossible. In 2021, Sun, G. found 8 regions of interest (insula, acc, postcentral and precentral gyrus) [1].

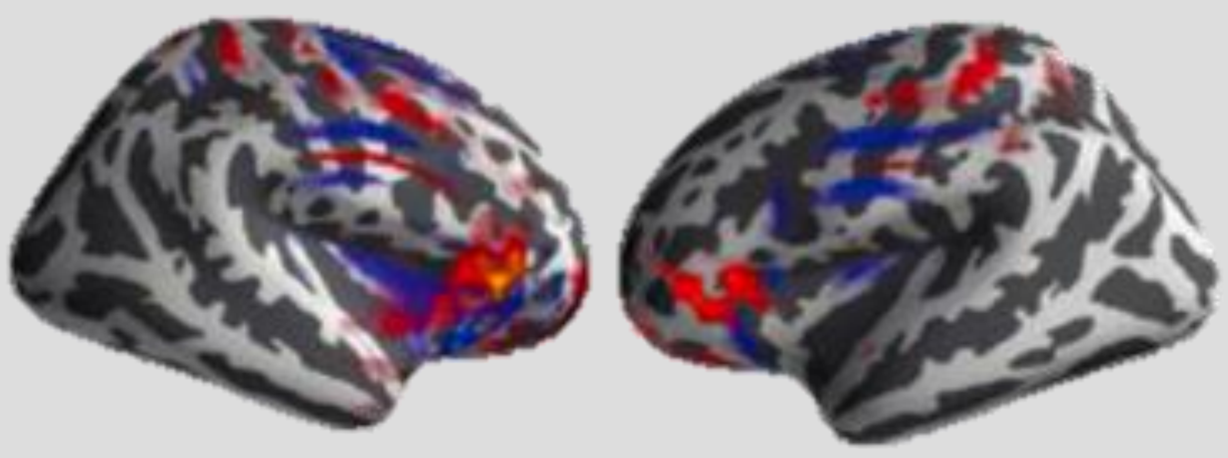

Fig.2. Illustration of localized sources on the cortical surfaces in two hemispheres. Warm color indicates high activation activity [1].

Another study found that the nociceptive pain reflex occurs approximately 450 - 750 ms after applying the stimulus [2]. Finally, other works have mentioned a decrease of alpha waves (8-12 Hz) and an increase of beta waves (12-32 Hz) in almost all sensors [3-4]. Most of these studies have also succeeded in classifying EEG signals between pain and non-pain states.

Hypothesis

It is believed that nociceptive pain, as it passes from the tissues to the spinal cord in order to reach the brain to process this information, can be detected using electroencephalography and classify the EEG signal between baseline, no pain and pain. A thermal stimulus (ice block) will be used to generate replicable nociceptive pain that does not leave trauma to the skin of the participants.

Methodology

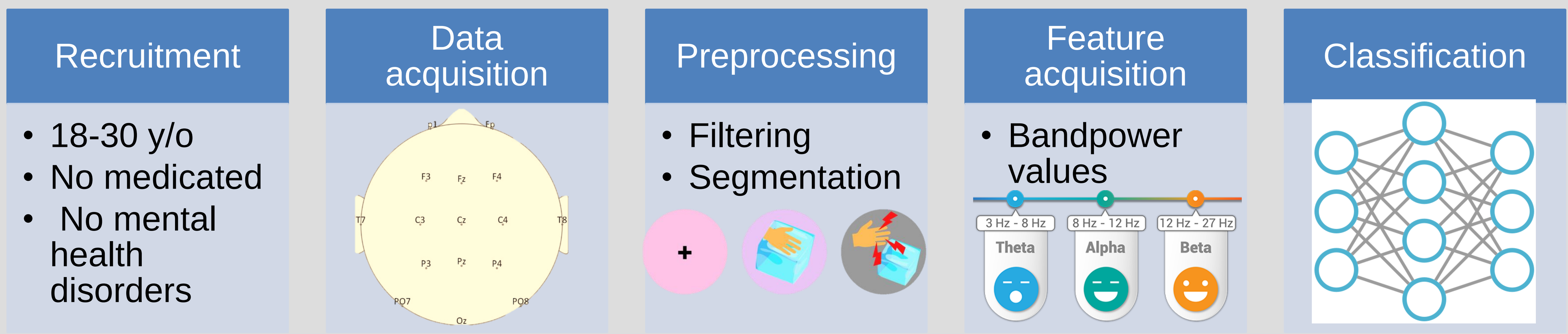

Fig. 3. Experiment methodology

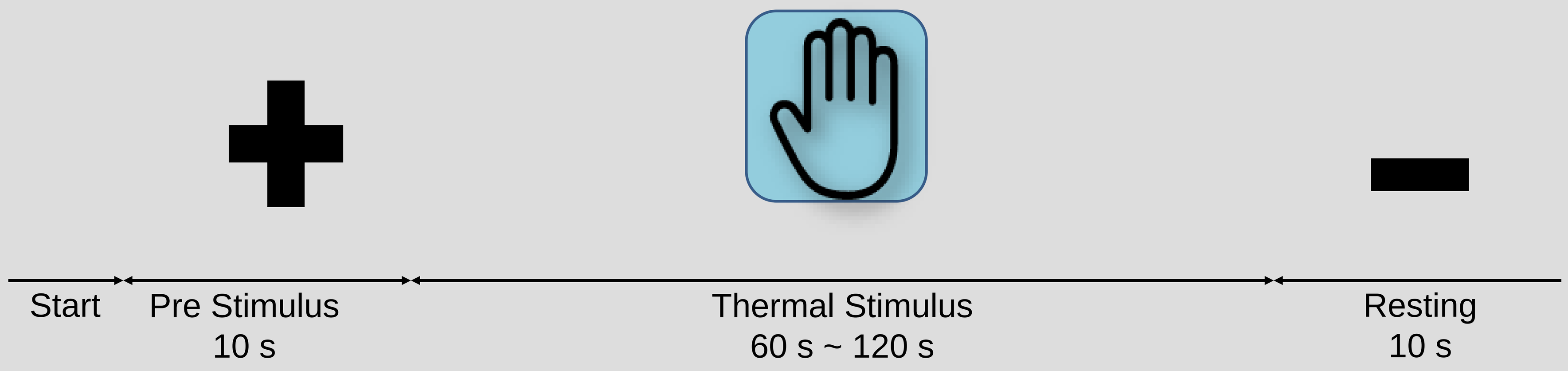

Fig. 4. Data acquisition protocol timeline

Results

Subjects	Cond 0	Cond 1	Cond 2	Accuracy	Model
1 (Left)	82.2%	53.3%	50%	64.8%	SVM
1 (Right)	65.8%	86.7%	56.7%	69.4%	NNs
1 (Both)	89.2%	63.3%	45%	68.5%	SVM
3 (Left)	78.6%	96.4%	86.7%	87.2%	NNs
3 (Right)	75%	89.3%	80%	82.1%	NNs
3 (Both)	58.3%	98.2%	88.3%	82.9%	SVM
4 (Left)	82.1%	75.9%	83.8%	80.6%	SVM
4 (Right)	70.3%	89.7%	73.7%	77.1%	NNs
4 (Both)	73.7%	82.8%	83.3	79.4%	SVM
6 (Left)	78%	85.7%	50%	71.7%	NNs
6 (Right)	63.4%	77.8%	70%	69.4	NNs
6 (Both)	77%	85.7%	60%	74%	SVM

Conclusions

The study conducted at the NTLab have shown that is possible to discriminate between 3 conditions using band power features and machine learning algorithms such as NN´s and SVM. Also, the results showed that women are more resistant to the sensation of nociceptive pain caused by ice than men. As future work, it is necessary to continue obtaining signals with this protocol in order to be able to analyze this type of data more completely.

References

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