Master thesis: Individual differences across neural basis of pain

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Pain perception is a phenomenon qualified as ordinary in the mind of most people, but it is at the same time very poorly understood in a neurological point of view. Although a pain sensation is easily forgotten when felt for a short period of time, some patients are subject to different types of chronic pain, and this can indubitably lead to great discomfort in the everyday life. The neural basis of pain remain poorly known in the neuroscientific field, and each new discovery allows to make this knowledge grow.

The goal of this project was to determine whether or not different biotypes of pain co-exist. The idea is that different people correlate to pain in different manners. Thus, a large dataset grouping a total number of 433 participants coming from 13 different pain studies was constructed in order to conduct a stratification process and discover possible subgroups. For each participant individually, a pain-predictive weight map was created based on several single-trials maps, each of them associated with a pain rating given by the participant at the moment of the experiment. The weight maps were constructed with two different machine learning approaches: multivariate with PCR and univariate with OLS regression. A clustering algorithm, k-means in this project, was then applied to find four clusters in those weight maps, either directly in the maps or after some dimensionality reduction technique. The two dimensionality reduction methods leading to the best results were the application of two pain signatures patterns, NPS and SIIPS, and a dimensionality reduction using PCA, and both were better for the multivariate procedure. The different brain activation patterns associated with the clusters were then visualized using a one-sample t-test, and they in fact showed different and unique templates for each cluster. Both outcomes constitute interesting findings: the first one, based on predefined patterns (i.e. the signatures), reflects different behaviors in subjects towards the level of activation of each signature, in the idea of defining if some subjects track one signature more than the other. On the other hand, the second one exhibits different activation patterns that are more difficult to interpret.

Future studies should be dedicated to a deeper analysis of the different brain patterns discovered; in this project only their visualization is available, but it is not sufficient to draw accurate conclusions. A numerical analysis to determine statistically significant differences between them is the priority before claiming the discovery of four pain biotypes. Also, an expert’s opinion is essential for the analysis of the activation patterns discovered for each cluster, especially in the PCA reduced maps, as this topic surpasses the content of the project.
Figure 1: Clusters in the signatures responses on multivariate maps (cosine distance)

(a) First dataset  
(b) Second dataset

Figure 2: Clusters in the PCA reduced multivariate maps (cosine distance)

(a) First dataset  
(b) Second dataset
Figure 3: Cluster 1 - Signatures responses on multivariate maps

Figure 4: Cluster 2 - Signatures responses on multivariate maps
Figure 5: Cluster 3 - Signatures responses on multivariate maps

Figure 6: Cluster 4 - Signatures responses on multivariate maps
Figure 7: Cluster 1 - PCA reduced multivariate maps

Figure 8: Cluster 2 - PCA reduced multivariate maps
Figure 9: Cluster 3 - PCA reduced multivariate maps

Figure 10: Cluster 4 - PCA reduced multivariate maps