



# Brain Activity Differences Between Back Pain Patients And Healthy Subjects For Acute Thermal Pain

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## INTRODUCTION

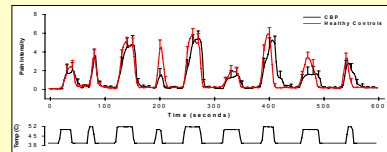
We have reported in previous studies that CBP is associated with specific cognitive, brain chemical and morphological abnormalities, all of which implicate enhanced prefrontal cortical involvement. Here we investigate brain areas underlying acute thermal pain in chronic back pain patients (CBP). We compare this brain activity to that of healthy normal subjects, and to spontaneous pain of CBP. Contrasting these different pain states might aid us in unraveling the dynamics of the major brain areas encoding chronic pain and provide a history of the progression and pathology of the disease.

## METHODS

- 6 CBP patients and 6 healthy controls (matched for age and sex) were studied with fMRI for thermal pain. All CBP patients reported a history of chronic back pain for at least 3 years.
- All volunteers were trained to use the finger-span device to rate magnitude of either their pain, or that of a moving bar (motor-cognitive control).
- In the scanner the CBP and healthy controls rated their on-line thermal pain (panel one). Each volunteer performed 2 thermal pain scans and one visual control scan.
- The signals for pain and control scans are used to search for the BOLD signal and to control for various contaminants. First and higher level analysis were performed using FSL software (fmrib, Smith et al. 2001). The end result was a cope image for each subject that accounted for both pain runs and the visual motor control. These cope images were used to generate the average activity maps (panel 2), perform the f-test (panel 3) and covariate analysis for pain intensity (panel 4).

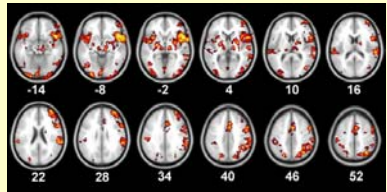
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### 1 On-line thermal pain ratings

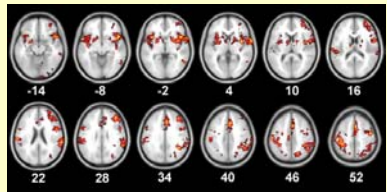


Average ratings taken for normal control subjects and CBP patients. There is no significant difference between the 2 groups. The S.E.M. is shown at intervals of 10 seconds (4 TRs) for clarity. Time profile of the thermal stimulus applied to the back of patients and healthy subjects is shown beneath the ratings.

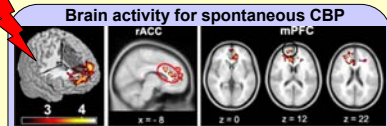
### 2 Brain activity for thermal pain



**Average group brain activity for painful thermal stimulation in normal controls.** Activity is mainly bilateral and seen in insula, basal ganglia, thalamus, cingulate cortex.

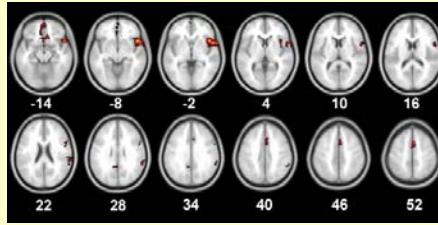


**Average group brain activity for painful thermal stimulation in CBP.** Anterior cingulate, bilateral insula and basal ganglia as well as multiple primary and secondary somatosensory and cerebellar regions are activated.



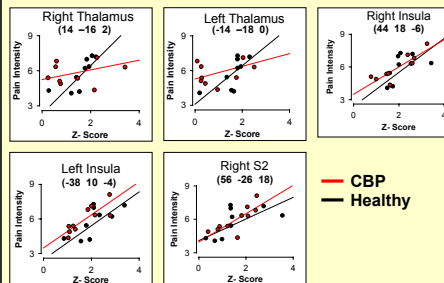
**Brain activity for spontaneous CBP**  
Average group brain activity for spontaneous pain of CBP in 13 patients is limited to the medial prefrontal cortex and rostral anterior cingulate cortex.

### 3 Brain activity differences in CBP and normals for thermal pain

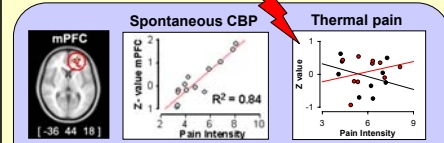


**f-test analysis between thermal pain for CBP and healthy controls.** Brain areas that exhibit differential activations for thermal pain include the left insular and mid cingulate cortices in addition to the medial prefrontal and primary sensory areas. It is worthy to note that a paired t-test analysis between the two groups did not yield any significant result.

### 4 Pain intensity vs. Brain activity

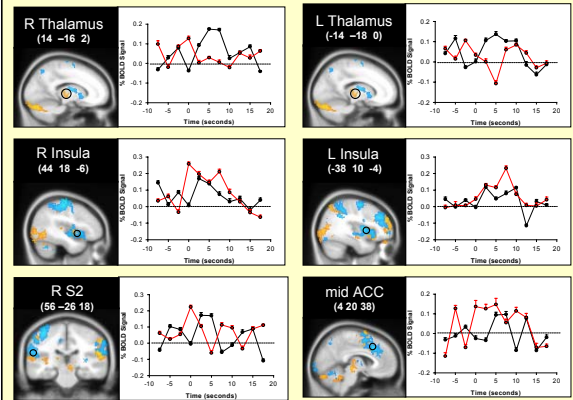


Covariate analysis between pain intensity (mean rating of heat pain during scan) and brain activity for thermal pain, across CBP (red) and normal subjects (black). Multiple brain regions show significant correlations for both groups including bilateral insular and right secondary sensory cortices. The thalamus show stronger correlation with pain for normals compared with CBP.

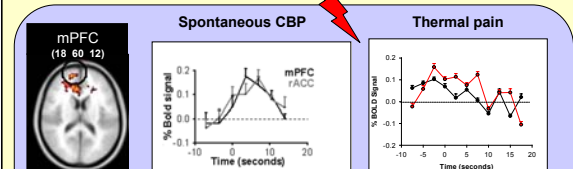


Covariate analysis between pain intensity (mean rating of pain during scan) and brain activity for spontaneous CBP results in a single cluster in mPFC

### 5 BOLD responses for thermal pain



Differences in BOLD is seen in the thalamus, where CBP shows decrease responses; and in insula and ACC, where CBP show increased responses. Normal brain activity = orange, CBP brain activity = blue. The coordinates chosen for bold is maximum foci of the intersection of the 2 maps.



The mPFC BOLD response appears to be specific for spontaneous back pain since it shows a significant increase from baseline when spontaneous pain is high. In response to thermal stimulation (right), mPFC exhibits an anticipatory response in CBP and less activity in healthy controls.

## CONCLUSION

- Brain activity for thermal pain is distinct from spontaneous pain of CBP.
- The main difference for thermal pain between CBP and controls is decreased thalamic activity, increased insular and ACC activity, and anticipatory mPFC activity in CBP.
- The differences between CBP and healthy subjects for thermal pain are striking since the stimulus ratings were not different.
- Overall, CBP activity seems to involve more affective brain regions and less sensory discriminative regions of the cortex.