Supplementary Materials

Methods:

Motion correction: Patients with high levels of pain invariably move during fMRI scans, and such motion degrades brain activity. To compensate for these artifacts we performed head motion correction in two steps. The first step consisted in standard correction for head motion using MCFLIRT (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl, (Jenkinson and Smith 2001;Jenkinson et al. 2002)). One subject was removed from further analysis at this stage because head motion was larger than 4 mm. In the second step, the motion corrected data was again analyzed for head motion artifacts running Independent Component Analysis, using MELODIC part of FSL implementing estimation of a Probabilistic Independent Component Analysis (PICA) model (Beckmann and Smith 2005). The first-stage head motion corrected data was masked for non-brain voxels, voxel-wise de-meaned, and normalized for voxel-wise variance. This data was then whitened and projected into a n-dimensional subspace using PICA, where the number of dimensions n is estimated using Laplace approximation to the Bayesian evidence of the model order (Beckmann and Smith 2005). The whitened observations were decomposed into a set of time-courses and spatial maps using a fixed-point iteration technique (Hyvarinen and Pajunen 1999). Estimated component maps were divided by the standard deviation of the residual noise and thresholded by fitting a mixture model to the histogram of intensity values (Beckmann and Smith 2005). We then run a regression analysis between, on the one hand, the vector of interest (*sp* or *v* task ratings convolved with canonical hemodynamic function) and each brain activity component time series, generating a task-related correlation coefficient (r_1), and on the

other hand between the head motion time series and each component time series, generating a head motion-related correlation coefficient (r_2). A specific PICA component was removed from the raw 4-dimensional brain activity data, if it satisfied two conditions: $r_2 > |0.5|$, and $r_1 <= 0$. This method allowed us to remove head motion by subtracting components highly correlated to head motion ($r_2 > |0.5|$), but not positively correlated to our vector of interest ($r_1<0$). Out of the 47 available *sp* task brain activity, only 7 necessitated PICA component removal. The *v* task data did not require PICA component removal. The new 4-dimensional data was used for statistical analysis.

Temporal filtering: High pass filtering is used to minimize low-frequency signals drifts, the origin of which remains controversial but certainly is contaminated with breathing and heart rate contributions. The properties of such filters are well defined in a block design type experiment where the on/off period of stimulus presentation defines the filter characteristics. In the current study where the patient generates fluctuations of spontaneous pain, the frequency content of the task will vary across subjects and even within a subject across sessions or scans. If we apply a fixed temporal filter then in the frequency domain the amount of signal reduction by the filter will be different across subjects. For this reason, we have instead opted to apply a filter dependent on the power spectrum of each rating. The latter then guarantees that equivalent proportions of low frequency power are removed from each scan. We have extensively tested both approaches, having a fixed filter vs. a variable filter; the overall results are very similar between the two. We opted to use the variable filter since in the frequency domain it makes the power spectra more equivalent.

Results:

The demographics of the PHN patients participating in the study are shown in STable 1. The responses of the PHN patients on the ten descriptors of Neuropathic Pain Scale are shown in STable 2 at each session, where each descriptor is rated on a 0-10 categorical intensity scale.

Brain activity for the visual control task for each session (v_1, v_2, and v_3) is shown in Sfigure 1. Note that the activity increases from session 1 to session 3. Sfigure 2 shows the brain activity for rating fluctuations of spontaneous pain (sp_1, sp_2, and sp_3). Again in general activity increases from session 1 to session 3. Sfigures 1 and 2, together with figure 3 highlight the necessity for correcting for across session variations in performance. Subtracting the visual control task from the pain-rating task achieves this. The difference between pain rating and visual rating averaged across the patients and all three sessions $(sp\text{-}v)_{all}$ is shown in Sfigure 3, with and without flipping the brains to make the PHN pain location homogeneous between subjects. The flipping does not render any brain region activity more unilateral.

Stables 3 and 4 indicate the details of activity for the group and session averaged results for rating spontaneous pain and for rating the visual task. The corresponding activations are presented on the brain in figure 2.

Reference List

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