Cortical responses to a rectal balloon pain paradigm

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Background: The barostat balloon rectal distension paradigm is a gold standard in clinical settings for investigating visceral hypersensitivity, a widespread problem in gastrointestinal diseases such as Irritable Bowel Syndrome and Diverticular Disease. Visceral hypersensitivity occurs either because patients are peripherally sensitized by prior inflammation or because patients are hypervigilant. The relative contribution of these peripheral versus central factors is controversial and has implications for patient management. Several fMRI studies have investigated cortical activation in response to rectal distension, demonstrating that this elicits a widespread network of brain activity [1,2]. The clinical barostat paradigm comprises 30 to 40 s “ON” and “OFF” periods, in which the barostat balloon is applied at stepped pressure thresholds. However, the stimulus does not follow a classic box-car, as it takes a few seconds for the balloon to achieve the desired pressure in the rectum, meaning that the “ramp on” and “ramp off” times are slow. It is unclear which part of this varying distension curve is most relevant to the physiology. To date most fMRI studies have modelled the data using a simple “ON” box car stimulus waveform but cortical responses may better correlate with “ramp on” and “ramp off” periods. Here, the experiment was performed in fMRI to investigate the nature of the haemodynamic response, and repeated using magnetoencephalography (MEG) to provide neuromagnetic data which, given its direct nature, may provide further information on the cortical response to visceral sensation.

Materials and Methods: 15 healthy female volunteers (age 29.2±10.9 yrs) participated. A G&J Electronics Distender Series II barostat was used. The distension balloon was inserted rectally and the threshold of moderate pain determined using a tracking paradigm. The barostat paradigm comprised four stimuli: no stimulus, subliminal stimulus, perceived stimulus (first sensation) and painful stimulus (determined because patients are peripherally sensitized by prior inflammation or because patients are hypervigilant. The relative contribu

Discussion: The fMRI data analysis shows the complexity of the barostat rectal distension stimulus, and that the cortical response occurs primarily during the ramps of the rectal distension. The paradigm detects activity in regions conventionally associated with sensory, cognitive and affective aspects of pain processing [4]. The brain areas identified with MEG largely matched those identified by fMRI. Given that no fMRI priors were used in MEG source localisation, this spatial agreement is compelling. The direct nature of MEG also gives it potential to provide insight into the timescale of electrical power changes in the cortical areas of interest identified using fMRI.


Fig. 1: Barostat distension paradigm modelled with 40 s “ON” barostat distension (a) or 5 s “ramp on” (b). fMRI maps for 40 s “ON” (c) and for the 5 s “ramp on” (d). FIG. 2: Average fMRI time courses from anterior cingulate for each stimulus level. FIG. 3: MEG activations with anterior insula cortex location of a ERD peak in α band (a), and insula cortex location of a ERD peak in β band (b).