Understanding Human Pain Perception and Analgesia through Advanced Neuroimaging
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The ability to experience pain is old and shared across species. It confers an evolutionary advantage and provides a warning of harm or impending threat. As far back as Hippocrates, it was understood that the brain was key to a person experiencing pain. Fortunately, these days we now have many techniques available to explore the human central nervous system in vivo from a functional, structural and chemical perspective in both patients and healthy subjects. Relating specific neurophysiologic measures to perceptual or non-perceptual changes induced by peripheral or central sensitisation, behavioural, psychological or pharmacological mechanisms and identifying their site of action within the CNS has both value and has been a major goal for scientists, clinicians and the pharmaceutical industry. Identifying non-invasively where functional and structural plasticity, sensitisation and other amplification or attenuation processes occur along the pain neuraxis for an individual and relating these neural mechanisms to specific pain experiences, measures of pain relief, persistence of pain states, degree of injury and the subject's underlying genetics, has neuroscientific relevance and potential diagnostic value.

With the advent of functional neuroimaging methods, such as Blood Oxygen Level Dependent (BOLD) functional magnetic resonance imaging (FMRI), Arterial Spin Labelling (ASL) quantitative perfusion imaging, positron emission tomography (PET), electroencephalography (EEG) and magnetoencephalography (MEG) this has been made feasible. These read-outs of varying physiological types provide a sophisticated non-invasive ‘behind the scenes’ measure of the nociceptive processing that underpins the subjective experience and mechanisms relevant to the development and maintenance of chronic pain states. They can be powerfully used to aid explanation of a subject’s multidimensional pain experience or analgesia. As the measures can be related to what the subject describes and what we can additionally measure about the subject (psychological, personality, physiological), it enables us to disentangle for an individual how or whether factors like anxiety, depression, attention, central sensitization, etc., mechanistically might influence nociceptive processing at the brain level to alter the pain experience. Further, these technologies have contributed to a better understanding of the consequences on the human CNS of patients left with poorly managed chronic pain. Current work focuses on identifying what aberrant CNS mechanisms might make an individual resilient or vulnerable to developing a chronic pain condition. It is my expectation that ‘pain neuroimaging’ will play an increasing role in pain neuroscience, clinical decision-making and analgesic drug development in the coming decade.