We propose a model of chronic pain and anxiety disorders based on predictive coding and false inference as a formal psychopathology (Adams, Stephan, Brown, Frith, & Friston, 2013; Brown, Adams, Parees, Edwards, & Friston, 2013; Peters, McEwen, & Friston, 2017). According to the threat imminence model, interoceptive sensations with high threat value (e.g. pain, symptoms of panic) activate psychophysiological responses, which increase the amplitude of interoceptive sensations. We interpret this in terms of abnormal gain control on interoceptive signals due to inappropriately high levels of precision. In predictive coding, precision or confidence is afforded to ascending prediction errors thereby increasing their influence on higher-level expectations and beliefs encoded in the cortical hierarchy. A failure of this precision or gain control may underwrite false inference and psychopathology in many conditions and may be particularly relevant for nociception (Adams et al., 2013; Edwards, Adams, Brown, Pareés, & Friston, 2012; FitzGerald, Moran, Friston, & Dolan, 2015).

Pain and other salient sensations with high threat value are crucial for survival, because they enable the organism to avoid potential harm or danger. Therefore they are processed with high priority, while other neutral interoceptive information is afforded low weight (i.e., precision). As erring on the side of caution endows the organism with adaptive fitness, sensations that are classified as potentially harmful (high threat value) have greater salience. In other words, are signed more precision because of the implications of the sensations for behavior (i.e., affordance). Further, interoceptive precision, caused by high arousal and hypervigilance leads to the formation of unstable new patterns of beliefs (i.e., posterior probabilities) because these beliefs are more influenced by sensory evidence (in relation to prior beliefs). See (Edwards et al., 2012) for a discussion of the role of precision in hierarchical processing and functional symptoms and (Gu et al., 2015) for a treatment of pain processing in autistic subjects using this framework. The ensuing uncertainty leads to pathological priors about the embodied and enactive future.

These priors can be characterized empirically by asking participants about the expected states of their body (e.g., including ambulatory assessment methods). We present proof of principle from two studies, which illustrate this approach. In one study 394 study adults with chronic pain answered questions about their past (24 hours-recall / 7 day recall), present and future representations of pain / comfort (expected sensation in next 24 hours / next 7 days) for three weeks. In another study children aged 11 to 18 years (N = 91) assessed the probability of their pain and other sensations (tension). Participants in the first study seemed to show an optimism bias. They underestimated pain and overestimated comfort consistently. This is an interesting observation because an optimism bias is an integral part of active inference, where we try to minimize prediction errors in the future via action. Crucially, participants in the second study showed responses that reflected their type of pain. This suggests that the prior beliefs evidenced by subjects are context sensitive and may depend upon the belief structures used to explain different sorts of interoceptive signals.

We suggest that assessing the threat value of pain could be used to quantify the high-level beliefs associated with the experience of chronic pain using the formalism of active inference and predictive coding. This would entail using ratings of the probability of neutral sensations and sensations with high threat value to understand the relationship between past, present and future representations of interoceptive sensations. These investigations would be usefully complemented by longitudinal psychophysiological experiments in the lab – as well as neuroimaging studies to understand the relationship of these interactions in terms of predictive coding. This will lead to a formal understanding of the mechanisms leading to and maintaining pain disorders – and potentially offers a computational phenotyping for assessing therapeutic interventions.

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