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Researchers develop brain model to quantify pain beyond sensory input

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Credit: Human Brain Project

Pain is a signal of actual or potential damage to the body, so it is natural to think of it as a localized sensation: knee pain in the knee, back pain in the back and so on.

However, research has demonstrated that pain is an experience constructed in the brain. A knee doesn't "feel" anything. Instead, it sends signals to the brain. Input from the body is important, but a person's pain experience also depends on the brain's interpretation of what the input signal means.

Scientists are just beginning to study these complex cerebral processes, and in a promising step forward, University of Colorado Boulder researchers have developed a functional MRI-based model that identifies brain activity patterns involved in varied pain experience, even when the input from the body is held constant.

"Pain is more than just a passive response to stimuli. The brain actively contributes to pain, constructing it through various neural systems," said Choong-Wan Woo, lead author and a post-doctoral researcher in CU Boulder's Institute of Cognitive Science when the research was completed. "Thus, we wanted to build a brain-based model to predict pain using variables beyond the painful stimuli."

For the study, researchers began by aggregating data from six independent brain imaging studies, deliberately choosing those with differing methodologies. In all of the studies, participants had been exposed to several seconds' worth of a painful stimulus and asked to rate their pain while inside an MRI scanner that recorded brain activity.

From the data, the researchers were able to identify common markers in the brain that were predictive of a participant's different pain experiences when external stimuli are matched on intensity, resulting in fine-grained mapping of both positively correlated ("pro-pain") and negatively correlated ("anti-pain") brain sub-regions.

Comprising part of the new model, those markers several brain regions that are not classically considered important for pain. However, the regions—which include the ventromedial prefrontal cortex, nucleus accumbens, and hippocampus—are involved in the brain's assessment of the meaning of painful and non-painful events alike.

The researchers named their telltale brain pattern the Stimulus Intensity Independent Pain Signature-1 (SIIPS1), a preliminary roadmap that can now be tested and refined in future studies.

"We now have a model that can be applied to other basic and clinical pain research in the field," said Woo, who is now beginning an Assistant Professorship at Sungkyunkwan University in South Korea. "We deliberately added the number one to the name because we don't think this is the only brain signature related to pain and expect that more will be developed."

The SIIPS1 may provide researchers with a new understanding of chronic pain and hypersensitivity to pain, potentially paving the way for the development of clinical applications and more effective treatments.

"There is increasing evidence that chronic pain often involves changes in brain areas identified in our model," said Tor Wager, a professor in CU Boulder's Department of Psychology and Neuroscience and the study's senior author. "The SIIPS1 provides a template for systematic evaluation of how these areas are altered in chronic pain. We hope that it will improve our understanding of chronic pain and lead to the development of new options for preventing and treating this complex disease."

The study was published today in the journal *Nature Communications*.

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