Different areas of brain respond to belief, disbelief, uncertainty

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The human mind is a prolific generator of beliefs about the world. The capacity of our minds to believe or disbelieve linguistic propositions is a powerful force for controlling both behavior and emotion, but the basis of this process in the brain is not yet understood.

In the January issue of *Annals of Neurology*, currently online, Sam Harris, a UCLA graduate student in the lab of Mark Cohen, a professor of psychiatry at the UCLA Center for Cognitive Neuroscience and a study co-author, and Sameer Sheth of Massachusetts General Hospital, report that functional magnetic resonance imaging (fMRI) reveals clear differences in the areas of the brain involved in belief, disbelief and uncertainty.

Their results suggest that the differences among these cognitive states may one day be distinguished reliably, in real time, by techniques of neuroimaging. This finding has implications for the detection of deception, for the control of the placebo effect during drug design and for the study of any higher cognitive phenomenon in which the differences among belief, disbelief and uncertainty might be relevant.

Fourteen adult volunteers were scanned in an MRI device at UCLA's Brain Imaging Center. While inside the scanner, subjects were presented with written statements covering a broad range of topics, including mathematics, geography, factual knowledge, word definitions, religion, ethics and biographical facts about themselves. Subjects were asked to rate these statements as true, false or undecidable. The authors then

compared the brain images recorded when their subjects believed, disbelieved or could not judge the truth-value of these written propositions.

The scientists predicted that the difference between belief and disbelief would be largely mediated by activity in the frontal lobes — the part of the brain most enlarged and differentiated in humans. Indeed, when belief and disbelief were compared, the investigators saw differences principally in a region known as the ventromedial prefrontal cortex (VMPFC), near the front of the brain, along its midline.

"The involvement of the VMPFC in belief processing suggests an anatomical link between the purely cognitive aspects of belief and human emotion and reward," the authors said. "The fact that ethical belief showed a similar pattern of activation to mathematical belief suggests that the physiological difference between belief and disbelief may be independent of content or emotional associations."

The areas especially engaged in disbelief included the limbic system's cingulate areas and the anterior insula, a brain region known to report visceral sensations such as pain and disgust and to be involved largely in negative appraisals of sensations like taste and smell.

"Our results appear to make sense of the emotional tone of disbelief, placing it on a continuum with other modes of stimulus appraisal and rejection," the authors said. "False propositions might actually disgust us."

When the subjects experienced uncertainty, yet another pattern emerged. A different portion of the cingulate cortex, located closer to the front of the brain, showed a much stronger signal. This so-called "anterior cingulate" cortex frequently shows up in studies of conflict monitoring, error detection and cognitive interference. When compared to both

belief and disbelief, the state of uncertainty also showed a decreased signal in the caudate, a region of the basal ganglia, which plays a role in motor action.

Noting that uncertainty differs from both belief and disbelief by not allowing us to settle upon "a specific, actionable interpretation of the world," the authors suggest that the basal ganglia may play a role in mediating the cognitive and behavioral differences between decision and indecision.

Taken together, these data offer insight into the way in which our brains work to form beliefs about the world.

"What I find most interesting about our results is the suggestion that our view of the world must pass through a bottleneck in regions of the brain generally understood to govern emotion, reward and primal feelings like pain and disgust," Harris said. "While evaluating mathematical, ethical or factual statements requires very different kinds of processing, accepting or rejecting these statements seems to rely upon a more primitive process that may be content-neutral. I think that it has long been assumed that believing that two plus two equals four and believing that George Bush is President of the United States have almost nothing in common as cognitive operations. But what they clearly have in common is that both representations of the world satisfy some process of truth-testing that we continually perform. I think this is yet another result, in a long line of results, that calls the popular opposition between reason and emotion into question."

Harris is the author of two New York Times best-sellers, "The End of Faith" and "Letter to a Christian Nation," which have been published in more than 10 languages.

Cohen is a pioneer in the technologies and applications of MRI. He,

along with colleagues at Harvard, performed the first experiments using fMRI to localize brain activity in humans.

The full text of the report in Annals of Neurology is available at www3.interscience.wiley.com/cgi-bin/fulltext/117858891/HTMLSTART .

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