Scientists define brain network behind attention, daydreaming

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Stanford neuroscientists have for the first time traced how three brain networks mediate the mind's internal focus and its processing of stimuli from the outside world.

By stimulating neurons with electromagnets, the researchers demonstrated how the brain's executive and salience networks - crucial for cognition and decision-making - inhibit the default mode network, which centers on self-directed processes such as introspection, recall and rumination.

"As you engage in any task that's attention demanding, you activate these outside world networks - the executive and salience network - and you deactivate or turn down the default mode network," said Stanford neuroscientist and psychiatrist Dr. Amit Etkin, lead author of the study published online Monday in *Proceedings of the National Academy of Sciences*.

Dysfunction among those networks has been implicated in a broad array of psychiatric disorders, including depression, post-traumatic stress disorder, autism and schizophrenia.

Imaging studies had long ago established strong correlations among these networks, but the causal path of their interplay had been indecipherable from the data produced through functional magnetic resonance imaging, or fMRI, according to the authors.

"You don't actually know which events were responsible for which other events," said Etkin, who also works with the Veterans Administration Palo Alto Health Care System. "That is, you don't really have a sense of causality."

The researchers used trans-cranial magnetic stimulation, a technique that applies a magnetic field to alter the electrochemical signaling in neurons. It has been used for decades to test brain function, and has been approved for treatment of depression.

When applied to discreet areas in the cortex, the magnetic fields provoked responses, evident on fMRI scans, that resembled voluntary brain activity. Researchers then measured the effect of stimulating the executive and salience networks, and recorded a drop in activity in the default mode network. When they used a low-frequency magnetic field to inhibit the executive and salience network, the default mode showed heightened activity.

The study also turned up intriguing clues toward new therapies. One of the executive network nodes they stimulated was closely associated with inhibiting a specific area of the default mode that scientists believe is crucial to the antidepressant effects of magnetic stimulation and drug therapies. That could offer neurological clues to why magnetic stimulation appears to work - an effect that has remained somewhat mysterious.

"We're already starting to think about how to use this for novel treatments," Etkin said. "If the default mode were abnormal in patients - which we know to be true for a range of psychiatric disorders - and you knew how to modulate it in the right way, which is what this study provides, then you would have a very important insight into how to potentially remediate these circuits for treatment of these disorders."