Pure Novelty Spurs The Brain

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Neurobiologists have known that a novel environment sparks exploration and learning, but very little is known about whether the brain really prefers novelty as such. Rather, the major "novelty center" of the brain--called the substantia nigra/ventral tegmental area (SN/VTA)--might be activated by the unexpectedness of a stimulus, the emotional arousal it causes, or the need to respond behaviorally.

The SN/VTA exerts a major influence on learning because it is functionally linked to both the hippocampus, which is the brain's learning center, and the amygdala, the center for processing emotional information.

Now, researchers Nico Bunzeck and Emrah Duzel report studies with humans showing that the SN/VTA does respond to novelty as such and this novelty motivates the brain to explore, seeking a reward. The researchers of University College London and Otto von Guericke University reported their findings in the August 3, 2006, issue of Neuron, published by Cell Press.

In their experiments, Bunzeck and Duzel used what is known as an "oddball" experimental paradigm to study how novel images activate the SN/VTA of volunteer subjects' brains. In this method--as the subject's brains were scanned using functional magnetic resonance imaging--they were shown a series of images of the same face or outdoor scene.

However, the researchers randomly intermixed in this series four types of different, or "oddball," faces or scenes. One oddball was simply a

different neutral image, one was a different image that required the researchers to press a button, one was an emotional image, and one was a distinctly novel image.

In fMRI, harmless radio signals and magnetic fields are used to measure blood flow in brain regions, which reflects activity in those regions.

With this experimental design, the researchers could compare the subjects' response to the different kinds of oddball images to distinguish the brain's reaction to pure novelty itself from the other possible sources of brain activation, such as emotional arousal.

In a second set of oddball experiments, the researchers sought to determine whether the SN/VTA encodes the magnitude of novelty. In those experiments, the researchers measured activation of the region by images of different levels of familiarity or novelty. In yet other studies, the researchers assessed whether the subjects' memory of familiar images was better when presented along with novel images or very familiar images.

The researchers found that the SN/VTA does, indeed, respond to novelty, and these response scales according to how novel the image was. They concluded that their data provide evidence for "a functional hippocampal-SN/VTA loop" that is driven by novelty rather than other forms of stimulus salience such as emotional content or the need to respond to an image.

The researchers said their finding that the SN/VTA is more activated by greater novelty is compatible with models of brain function "that see novelty as a motivating bonus to explore an environment in the search for reward rather than being a reward itself."

Also, Bunzeck and Duzel found that novelty enhanced learning in the

subjects. "Thus, the human SN/VTA can code absolute stimulus novelty and might contribute to enhanced learning in the context of novelty," they concluded.

Finally, they said their findings raise the possibility that selective brain injury to the hippocampus could eliminate the positive effects of novelty in such patients and constitute one source of reduction in recognition memory in the patients.