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Chairs, Houses & Visual Clutter: Watching The Brain At Work

A brief overview of research into the brain's mechanisms for processing visual stimuli.

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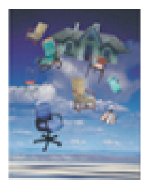
Watching the Brain at Work

Is the brain hard-wired for houses?



When NIMH neuroscientists Dr. James Haxby and colleagues flashed pictures of faces, houses and chairs in front of subjects while their mental activity was being visualized by an MRI scanner*, each category of object seemed to activate its own distinct circuitry in the brain's visual system. [1] But the researchers were skeptical. Except for certain biologically relevant objects, such as faces, which emerge through evolution, how could the brain have evolved specific circuits for such relatively modern objects? So they analyzed their data in a different way; they looked at the pattern of response to each stimulus category across the three regions that were ostensibly specialized—paying particular attention to areas of secondary activation. In each case, they found that even though a particular region might respond *maximally* to one category, it also responds to a lesser degree—but still significantly—to objects in the other categories as well.

Since this pattern of activation is widely distributed, the brain's visual circuitry appears to process what it sees based on *features* of objects, suggest the researchers. Information most characteristic of objects within a single category clusters together, thus giving the appearance of object-specific circuitry.

Still, faces appear to be an exception to the rule. Brain areas activated by faces were not as widely distributed as those for houses and chairs, adding to evidence that there may indeed be face-specific circuitry. Also, a task in the study that required subjects to pay greater attention to the stimulus had more effect on responses to houses and chairs than to faces, hinting that face perception is more automatic.

Keeping those blinders on

We simply can't become conscious of and remember everything that we see. Multiple representations of objects in our visual field are constantly competing with each other for our brain's limited visual processing capacity. What's more, they mutually cancel each other out; visual clutter actually suppresses the brain's ability to respond; it reduces its activity. So how does the brain cope?

An NIMH research team led by Dr. Robert Desimone had a hunch: by focusing its attention on just one stimulus, the brain cancels out this suppressive influence of nearby stimuli—enhancing information processing of the desired stimulus.[2] They first measured the suppression of brain activity caused by a cluttered scene, using fMRI to visualize activity in the cerebral cortex. Subjects were scanned while distracted away from the scene. The researchers compared the cortical response to four complex pictures presented at the same time, i.e., the "cluttered" condition, to the cortical response to the same four pictures presented one at a time, i.e., when the cortex could fully process each picture individually. This comparison confirmed that the cluttered scene caused a suppression of activity in a circuit critical for the recognition of objects, which explains why it is not possible to recognize objects in a complex scene without focusing your attention.

The clincher came when subjects were asked to fix their eyes on a corner of the screen, while shifting their attention to one of the four pictures. It is well known that we can attend to things we're not looking at. The researchers found the effect of attention was to counteract the suppression caused by the other distracting pictures on the screen. In other words, with attention, the cortex could devote all of its processing to the single most important picture, filtering out distraction. The results point to the modulation of suppression in the cortex as a critical mechanism of attention.

"I just saw it. Now where is it?"

Where does the human brain hold information momentarily about where things are located? This specialized circuitry for spatial working memory keeps track of, for example, the ever-changing locations of other cars while you're driving. Working memory—what we're aware of from one moment to the next—bridges time and is the content of our consciousness. After a decade of following blind alleys—led astray by its location in the monkey brain—neuroscientists recently discovered that the elusive circuitry has been displaced rearward and upward through evolution, as areas serving more distinctly human functions emerged. These newer areas mediate cognitive abilities, such as abstract reasoning, complex problem solving and planning for the future—functions impaired in some severe mental disorders, such as schizophrenia.

While other researchers focused on the human *anatomical* counterpart to the area in the monkey, a region in the middle of the frontal lobe, NIMH's Dr. Leslie Ungerleider and colleagues took their clue from a *functional* landmark.[3] They hypothesized that, as in the monkey, they would find the human spatial working memory circuits just in front of an area specialized for controlling eye movements. Brain imaging studies hinted that this circuitry had evolved into a higher and more rearward location in the human frontal cortex.

Using fMRI, they saw high activity, during an eye movement task, in the middle upper part of the frontal cortex, confirming location of the eye movement circuits. Just in front of this area they discovered an area that showed sustained activity during a pause in a spatial working memory task, confirming that it harbors the circuits for that function.

References

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