EVOKED POTENTIALS

The Jump From Creative Vision to Strategic Plan

The essence of science is the formulation and execution of strategies designed to answer questions, and in this month's "Neuroscience Today, Neurology Tomorrow" (page 8), we are given considerable insight into the sequential neurophysiological nature of the intention to act (formulation) and the act itself (execution). Whether the question is how to prevent Alzheimer's disease, use genetic tests effectively, or make Medicare sustainable, we first formulate a plan that we will then carry out. Therefore, our April issue provides a wonderful context in which to continue our discussion of creativity by turning to the step of strategic formulation, the first step in action.

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Howard Gardner, Ph.D., in his 1983 book, "Frames of Mind," first proposed the theory of multiple intelligences. He derived a set of six (at that time) noncoinciding intellectual competencies from rigorous and overlapping neurological, psychological, and developmental observations. The original six intelligences included linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, and personal intelligence. According to Gardner, any form of intelligence has a creative aspect in which a desired goal is envisioned and a plan for attaining it is formulated and then executed (What is intelligence? in "Frames of Mind" [New York: Harper Collins, 1983, pp. 59-70]).

Translating a creative vision, an idea, into a creative achievement requires a strategic plan, as illustrated by the scientist writing a grant or the architect drafting blueprints. I have an idea that age-related memory decline may be a manifestation of subclinical Alzheimer's disease, but formulating an experiment to test that idea is a nontrivial subsequent step. The generation of ideas and the formulation of a strategic action plan to realize those ideas are not wholly separate processes because both require mental imagery, but they might be likened to Mihály Csíkszentmihályi's model of creativity where the idea represents a low-threshold, low-effort thought while the plan is a more effortful and deliberate formulation to give the idea "legs" ("Creativity: Flow and the Psychology of Discovery and Invention" [New York: Harper Collins, 1996]).

Strategic planning requires the ability to perceive and weigh the importance of multiple pieces of information that accommodate the needs of the individual to the circumstances of the situation. Working memory, the cognitive process that underlies multitasking, involves holding all relevant pieces of information in our conscious thought while we generate an action plan.

Physiologically, dorsolateral prefrontal neurons become active during the period when information must be retained before a response can be enacted (Curr. Opin. Neurobiol. 2004;14:163-8). The activation of neurons in this region may reflect holding online the relevant information itself, or another aspect such as its intended future use in the action plan. We perceive various stimuli around us, and learn to associate certain ones with specific outcomes (for example, the sound of a dinner bell means dinner is served). Such stimulus-outcome relationships may be simple (single and immediately paired) or complex and removed from the salient outcome by multiple steps, but all act through activation of the same reward systems we have discussed.

But what about when a solution arrives in an "aha moment," a sudden burst of insight that does not seem to derive from strategic planning? These moments, which are possibly analogous to the unintended, sudden spontaneous generation of a mental image, are unexpected, and generally do not occur during a time of deliberate conscious (or externally provoked) analysis (Trends Cog. Sci. 2005;9:322-8). Mind wandering provides fertile ground for aha moments. It is a state of spontaneous thought that is not deliberate and that occurs when there is a lull in external demands, such as in the shower. Sudden insights that arise during states of mind wandering can be quite relevant solutions for unfinished problems, just as if the working memory state of systematic analysis had been temporarily paused and then suddenly restarted, bringing an important missing piece of the puzzle into conscious awareness.

Functional MRI studies of insight-oriented problem solving and mind wandering have revealed that both involve enhanced activity of the anterior cingulate cortex, the same general region that is first activated when our behavior changes in response to altered reward (Proc. Natl. Acad. Sci. U.S.A. 2009;106:8719-24). The anterior cingulate is part of a "default network," a series of brain structures that, paradoxically, become maximally active when we are at rest. When individuals are unaware of their mind wandering (and so least aware of internal and external distractions), working memory regions (including the dorsolateral prefrontal cortices) increase their activity together with the default network. This possibly provides a neural substrate for spontaneous "aha" insights that arise during periods of mind wandering.

The prefrontal cortex is a multimodal region where information about bodily states, surrounding circumstances, and semantic knowledge converge. All this information is used to develop an appropriate plan of action. Prefrontal neurons project to the locus ceruleus, the origin of cortical noradrenergic projections that influence our level of alertness and attention. Norepinephrine released from the locus ceruleus facilitates the transmission of incoming sensory signals, making it more likely that we will detect, attend to, and be influenced by environmental sensory stimuli. Parietal sensory association cortices also contain neurons with working memory type properties, so that multiple sources of perceptual information can be held "online" while a plan is being formulated (J. Neurosci. 2002;22:8720-5).

These sensory association cortices perhaps contribute perception and mental imagery to the formulated plan and constitute a working memory network designed for strategic thought. The potential rewarding and aversive values of a stimulus influence prefrontal neuronal activity, as well as other stages of the perceptual and planning networks, and thereby affect what we perceptually notice and choose to contemplate in the strategic planning process (Curr. Opin. Neurobiol. 2004;14:139-47). We are more likely to attend to higher-reward and higher-risk stimuli than to those with little potential consequence.

Next month we will consider what happens when we execute a plan of action. ■

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Brain Glucose Metabolism Raised Near Cell Phone's Antenna

BY MARY ANN MOON

FROM JAMA

Short-term use of a cell phone increased brain glucose metabolism in a region of the brain adjacent to the device's antenna in controlled study.

This brain region received the highest amplitude of radiofrequency-modulated electromagnetic fields (RF-EMFs) from the model of cell phone used in this study, given its position relative to the head during use. The finding suggests that brain absorption of RF-EMF energy emitted by cell phones "may enhance the excitability of brain tissue," wrote Dr. Nora D. Volkow, director of the National Institute on Drug Abuse, and her associates.

They studied brain glucose metabolism in 47 healthy volunteers using PET imaging with the injection of fluorodeoxyglucose-18. The volunteers wore devices that held cell phones in place simultaneously over both ears. As a part of the study's randomized, crossover design, the investigators scanned the individuals on separate days, once with one cell phone activated but the sound turned off (the "on" condition) and once with both cell phones deactivated (the "off" condition).

The researchers used both ears "to avoid confounding effects from the expectation of a signal from the side of the brain at which the cell phone was located" (JAMA 2011;305:808-14).

After 50 minutes of exposure to radiation emitted during the on condition, there was a significant 7% increase in glucose metabolism (35.7 micromol/100 g per minute), compared with the off condition (33.3 micromol/100 g per minute). This occurred only in the right orbitofrontal cortex (OFC) and the lower part of the right superior temporal gyrus – areas that corresponded to the location of the cell phone antenna.

Moreover, there was a linear relation between cell phone–related increases in metabolism and the estimated rate of radiofrequency energy absorption expected in various brain regions.

A 7% rise in regional metabolism is similar in magnitude to that reported after suprathreshold transcranial magnetic stimulation of the sensorimotor cortex, the investigators noted.

"The question that remains to be studied into the future is 'Could there be potential long-term consequences from repeated stimulation?' " Dr. Volkow said in a press teleconference. Previous PET imaging studies of cell phone use have been substantially smaller – 14 subjects in the largest – and may not have had the statistical power to detect small, but significant, signals. Those studies also measured brain activation via cerebral blood flow rather than the more sensitive method of measuring brain glucose metabolism.

It is important to note that these findings "provide no information as to their relevance regarding potential carcinogenic effects (or lack of such effects) from chronic cell phone use," the researchers added. ■

Jeff Evans contributed to this report.

LETTERS

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