

Detect the Effect of Cognitive Function on Cerebral Blood Flow

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Hack #10

Detect the Effect of Cognitive Function on Cerebral Blood Flow

When you think really hard, your heart rate noticeably increases.

The brain requires approximately 20% of the oxygen in the body, even during times of rest. Like the other organs in our body, our brain needs more glucose, oxygen, and other essential nutrients as it takes on more work. Many of the scanning technologies that aim to measure aspects of brain function take advantage of this. Functional magnetic resonance imaging (fMRI) (“Functional Magnetic Resonance Imaging: the State of the Art” [Hack #4]) benefits from the fact that oxygenated blood produces slightly different electromagnetic signals when exposed to strong magnetic fields than deoxygenated blood and that oxygenated blood is more concentrated in active brain areas. Positron emission tomography (PET) (“Positron Emission Tomography: Measuring Activity Indirectly with PET” [Hack #3]) involves being injected with weakly radioactive glucose and reading the subsequent signals from the most active, glucose-hungry areas of the brain.

A technology called *transcranial Doppler sonography* takes a different approach and measures blood flow through veins and arteries. It takes advantage of the fact that the pitch of reflected ultrasound will be altered in proportion to the rate of flow and has been used to measure moment-to-moment changes in blood supply to the brain. It has been found to be particularly useful in making comparisons between different mental tasks.

However, even without transcranial Doppler sonography, you can measure the effect of increased brain activity on blood flow by measuring the pulse.

In Action

For this exercise you will need to get someone to measure your *carotid pulse*, taken from either side of the front of the neck, just below the angle of the jaw. It is important that only very light pressure be used—a couple of fingertips pressed lightly to the neck, next to the windpipe, should enable your friend to feel your pulse with little trouble.

First you need to take a measure of a resting pulse. Sit down and relax for a few minutes. When you are calm, ask your friend to count your pulse for 60 seconds. During this time, close your eyes and try and blank your mind.

With a baseline established, ask your friend to measure your pulse for a second time, using exactly the same method. This time, however, try and think of as many examples of animals as you can. Keeping still and with your eyes closed, think hard, and if you get stuck, try thinking up a new strategy to give you some more ideas.

During the second session, your pulse rate is likely to increase as your brain requires more glucose and oxygen to complete its task. Just how much increase you'll see varies from person to person.

How It Works

Thinking of as many animals as possible is a type of *verbal fluency* task, testing how easily you can come up with words. To complete the task successfully, you needed to be able to coordinate various cognitive skills, for example, searching memory for category examples, generating and using strategies to think up more names (perhaps you thought about walking through the jungle or animals from your local area) and checking you were not repeating yourself.

Neuropsychologists often use this task to test the *executive system*, the notional system that allows us to coordinate mental tasks to solve problems and work toward a goal, skills that you were using to think up examples of animals. After brain injury (particularly to the frontal cortex), this system can break down, and the verbal fluency task can be one of the tests used to assess the function of this system.

Research using PET scanning has shown similar verbal fluency tasks use a significant amount of brain resources and large areas of the cortex, particularly the frontal, temporal, and parietal areas [1].

Interestingly, in this study people who did best used less blood glucose than people who did not perform as well. You can examine this relationship yourself by trying the earlier exercise on a number of people. Do the people who do best show a slightly lower pulse than others? In these cases, high performers seem to be using their brain more efficiently, rather than simply using more brain resources.

Although measuring the carotid pulse is a fairly crude measure of brain activity compared to PET scanning, it is still a good indirect measure of brain activity for this type of high-demand mental task, as the carotid arteries supply both the middle and anterior cerebral arteries. They supply blood to most major parts of the cortex, including the frontal, temporal, parietal, and occipital areas, and so would be important in supplying the needed glucose and oxygen as your brain kicks into gear.

One problem with PET scanning is that, although it can localize activity to certain brain areas, it has poor temporal resolution, meaning it is not very good at detecting quick changes in the rate of blood flow. In contrast, transcranial Doppler sonography can detect differences in blood flow over very short periods of time (milliseconds). Frauenfelder and colleagues used this

technique to measure blood flow through the middle and anterior cerebral arteries while participants were completing tasks that are known to need similar cognitive skills as the verbal fluency exercise [2]. They found that the rate of blood flow changed second by second, depending on exactly which part of the task the participant was tackling. While brain scanning can provide important information about which areas of the brain are involved in completing a mental activity, sometimes measuring something as simple as blood flow can fill in the missing pieces.

See Also

1. Parks, R. W., Loewenstein, D. A., Dodrill, K. L., Barker, W. W., Yoshii, F., Chang, J. Y., Emran, A., Apicella, A., Sheramata, W. A., & Duara, R. (1988). Cerebral metabolic effects of a verbal fluency test: A PET scan study. *Journal of Clinical and Experimental Neuropsychology*, 10 (5), 565–575.
2. Schuepbach, D., Merlo, M. C., Goenner, F., Staikov, I., Mattle, H. P., Dierks, T., & Brenner, H. D. (2002). Cerebral hemodynamic response induced by the Tower of Hanoi puzzle and the Wisconsin card sorting test. *Neuropsychologia*, 40 (1), 39–53.

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