frontiers FOR YOUNG MINDS

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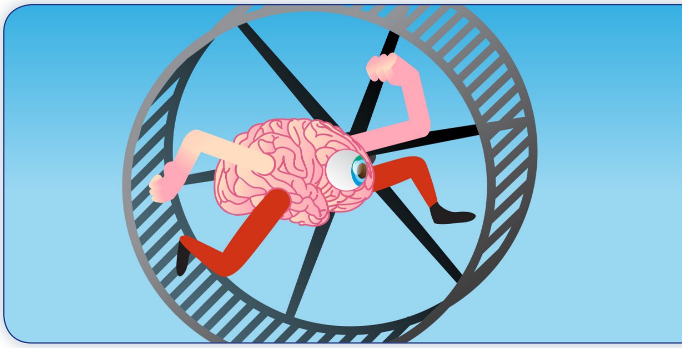

The brain never stops

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Reviewed by:

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15 years old

Your brain is doing a lot of work when you are engaged in activities such as sports, playing a game, or watching a movie. Your brain is also a master of associating one thought with another and making your mind wander. But what does your brain do when you are not engaged in particular thoughts or actions? Interestingly, similar to the heart that always keeps beating, the brain never stops its activity. For example, your brain is highly active even when you are fast asleep. In fact, brain cells are working hard even in the absence of thoughts, such as during anesthesia (a state in which drugs block sensation, consciousness, and movement).

THE BRAIN IS SPONTANEOUSLY ACTIVE

Surprisingly, the brain uses about 20% of the body's energy at all times. That's right: about one-fifth of everything you eat is for your brain. Figure 1 shows the energy consumption of the upper body and head. The dark areas show body parts that use a lot of energy while resting without movement. The brain uses a lot of energy, so it appears very dark in the image. This is also true of the heart, which needs a lot of energy to continuously keep beating. Nevertheless, the brain appears darker and thus uses more energy than the heart, the skeletal muscles, or any other organ. The brain's high energy needs show that it is very active at all times.

The brain's high energy needs largely come from "ongoing brain activity." "Ongoing" in this context means independent of sensory input or task. Researchers have found that most of the brain's activity is occurring spontaneously. Spontaneous or ongoing brain activity is a neural activity that is not directly related to specific processes such as seeing, tasting, smelling, movement planning, or thinking.

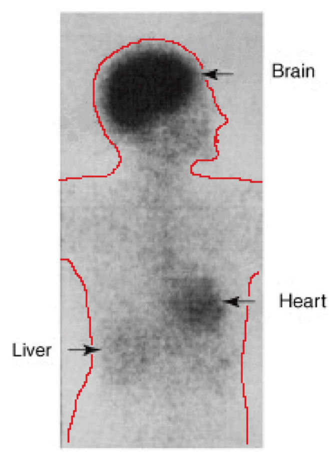

FIGURE 1 - Energy consumption in the body while resting [1, 2].

In other words, brain activity persists, whether or not the brain is engaged in a particular task.

To better understand ongoing brain activity, picture the surface of a lake as shown in Figure 2A. When a drop of water falls into the lake, it causes ripples or small waves that move throughout the lake. However, Figure 2A is a simplified picture. In reality, lakes resemble more the picture shown in Figure 2B. The surface of a lake is never completely still, even before the drop of water hits it. A lake's surface has movement caused by wind, previously fallen water drops, and many other factors (see Figure 2B). Other ripples on the surface of the lake interact with the new ripples, causing the new ripples to change shape. When a drop falls in, the new ripples are not completely smooth and do not spread evenly in different directions. The ripples caused by a drop will therefore depend on the waves already present on the lake at that moment.

Imagine that neural activity in the brain corresponds to movement on the surface of the lake. Now, imagine that sensory information, such as a sound, corresponds to each drop of water. When information reaches the brain through the senses, it is like a drop of water falling into the lake. The brain activity occurring in response to the incoming signal resembles the ripples caused by a drop of water. Like the restless surface of a lake (Figure 2B), the brain is always full of ongoing activity, even before the sensory information comes in. Just like previous drops changing the surface of the lake, our previous experiences alter the ongoing brain activity. In turn, ongoing brain activity changes the neural response to new incoming signals. This means that, depending on what is going on inside your brain, you might perceive the same signal in different ways.

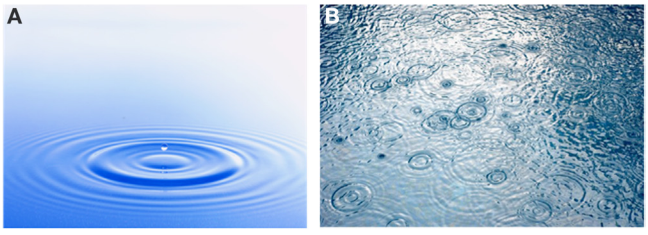

FIGURE 2 - Brain activity can be compared to the ripples and waves on the surface of a lake, never completely still and affecting each other.

ONGOING BRAIN ACTIVITY CHANGES THE WAY WE SEE

Our perception varies from one time to another. For an example, look at Figure 3A for a while. What do you see?

At one moment, you may see two faces (the black area), while at other times, you may see a vase (white area). This is an example of an ambiguous figure, because it can be seen in more than one way. What determines whether you see two faces or a vase? To study this question, researchers showed the ambiguous figure to participants for a very brief time, only 150 ms. The participants immediately indicated whether they saw faces or a vase. While participants performed this task, researchers looked at their brain activity using a machine called magnetic resonance imaging scanner, commonly called MRI. This machine can "scan" the brain and record how much brain activity occurs in each part of the brain at a given time. Figure 3B highlights brain activity in an area called the "fusiform face area." This area can be seen when looking at the brain from the bottom. The fusiform face area processes visual information from all kinds of objects, including faces and vases, but it is most important for seeing faces (see article on "specialization of functions in the human brain"). Figure 3C shows brain activity from the fusiform face area when participants saw the ambiguous figure. If activity in this area had a large peak, participants saw the faces (red curve). If the activity peak was smaller, they saw the vase instead (blue curve). The yellow shaded oval area in Figure 3C highlights ongoing brain activity just *before* the viewer saw the image. Interestingly, brain activity *before* the image was shown determined what figure people saw (faces or a vase) when they looked at the image. Very much like a restless lake, the effect of the incoming signal on the brain depends on the ongoing activity (waves) that is already present. Ongoing activity changes our perception of the world.

FIGURE 3 - Activity in response to the faces–vase ambiguous figure in the fusiform face area, specialized for processing faces [3].

ONGOING BRAIN ACTIVITY CHANGES WHAT WE HEAR

Let us look at another example in which our perception varies from one time to the other. Imagine your mom is calling you from downstairs. But while you may have heard her call and reacted the day before, you may not hear her this time round. When investigating hearing, researchers found that ongoing brain activity contributes to this variability and is one of the reasons why you may not hear your mom's voice.

Figure 4 shows brain activity measured with the MRI scanner during a hearing experiment. In this experiment, a very low-volume sound was played about twice a minute at random times. The participants' task was to press a response button as soon as they heard the sound. The sound was so faint that the participants could hear it certain times, and not others. Figure 4A shows a view from the right side of the brain. When people hear a sound through their ears, an area of the brain called "auditory cortex" becomes active (highlighted in Figure 4A). The curve in Figure 4B illustrates brain activity from the auditory cortex during 180 s. The speakers and arrows mark brain activity at the moments when a sound was heard. Because the curve peaks at these particular moments, we know that the auditory cortex responds to the sounds. Interestingly, there are a lot of other ups-and-downs in the activity curve. These come from ongoing brain activity. Note that activity peaks in response to the sounds look different each time, even though the sound did not change. One of the primary reasons for this was the ongoing brain activity at that time. Figure 4C directly compares auditory cortex activity in response to the sounds that the participants heard (red curve) and the sounds that they did not hear (blue curve). As expected, when the auditory cortex responded with a high peak of activity, the sound was heard. Take a close look at the ongoing activity level before the sound was played (oval area shaded in yellow). When the person heard the sound, the auditory cortex activity was high, even *before* the sound was played. The level of ongoing activity just before the sound determines whether or not the sound will actually be heard. This means that what is going on inside your brain before your mom calls has an effect on how your brain processes your mom's voice. And this affects whether or not you hear her call.

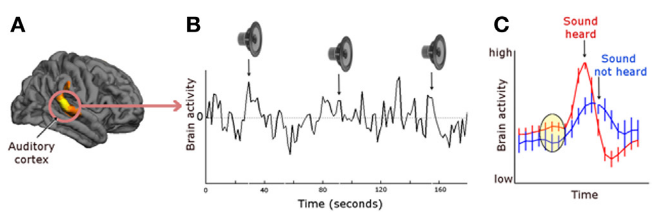

FIGURE 4 - Activity in response to the faint sounds in the auditory cortex, specialized for hearing [4].

To summarize, brain cells are continuously active, even when they are not busy with specific signals, thoughts, or actions. This ongoing brain activity is shaped by our past experiences and, in turn, influences the way we act and perceive the world around us at every moment.

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I am a freshman in high school. My favorite classes are physics and history because I love figuring out why things are the way they are. That fascination began when I was little and my mom, who is a neurosurgeon, set up experiments for me to do in her lab. When I am not busy with school, I spend my free time riding my horse and hanging out with my friends.

AUTHOR

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I am fascinated by the brain's ability to focus on the current moment or task and to control its own activity. I do brain research to help understanding how the brain achieves this control. Apart from studying brains, I am really happy when I windsurf, do yoga, or paint.