Your Brain is Mostly for Moving, Not Thinking

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I danced my way through my degrees -- literally. As a dance major, I spent my days training in ballet, modern and West African dance and attended rehearsals that ran long into the night. But when I wasn't in the dance studio or performing on stage, I led an alternate existence. Beyond the ballet barre, you could find me soaking in lectures about brain science or running experiments on nervous freshman somewhere in a dark laboratory.

I now hold degrees in both dance and neuroscience, a fun fact that ever ceases to surprise people. I'm always asked what inspired me to pursue these divergent passions, simultaneously. For me, the connection is obvious: without our brains, human movement as we know it would be impossible. And remarkably, the opposite is also true.

Brains are Wired for Movement

The human brain pulses with electricity, every moment of every day. Within that wrinkly organ, tiny impulses send information from one cell to the next and grant us the ability to think, feel and even dream. But those signals have a much more pressing purpose: they also allow us to *move*.

At the Okinawa Institute of Science and Technology Graduate University (OIST), Dr. Marylka Yoe Uusisaari from Finland studies how the brain controls the movement of the body. Even seemingly simple movements, such as standing up from a chair, require specific groups of muscles to contract in perfect synchronization. Like an orchestral conductor, the brain coordinates all these actions, controlling which muscles contract, when and for how long.

Scientists don't yet understand how the brain pulls off this managerial feat. And though neuroscientists can observe electricity, chemicals, water and blood rushing through the brain, they have struggled to see the steps that lie between deciding to move and actually moving. If we want to stand up, walk across the room or pick a book off a shelf, those desires don't magically compel our muscles to contract. So what does?

"There has to be some place where an abstract concept, like "I want to grab a cup of coffee," is translated into a very strict sequence of impulses that will make it happen," said Uusisaari. As the principal investigator of the OIST Neuronal Rhythms in Movement Unit, Uusisaari aims to unpack the black box between our motivation to move and actualized movement. She and her researchers study a region of the brain called the olivocerebellar system, which is thought to relay tightly-timed instructions to the muscles based on input from higher regions in the brain.

A "Neural Clock" Buried Deep in the Brain

The olivocerebellar system resides near the brain stem, a structure that sits far below the iconic, crumpled cerebral cortex. The brain stem resembles the thick stem of a squash and protrudes from the base of the brain. The “cerebellar” portion of the olivocerebellar system wraps around this stem like a shawl and integrates information from the entire brain, including the inferior olive, a structure that resembles its namesake fruit and bulges off the bottom of the brain stem.

It is this system, buried at the bottom of the brain, that issues precise motor commands to the body and allows us to transform our nebulous thoughts into physical actions. But there are two big problems: the location of the olivocerebellar system makes it difficult to study, and it behaves unlike any other region of the brain.

“The neurons in the inferior olive are really special among all other neurons in the brain,” said Dr. Da Guo, a postdoctoral scholar from China now working in the Neuronal Rhythms in Movement Unit. The brain cells making up the inferior olive are coupled via many electrical connections, he said, which allow them to synchronize their activity. When they send information on to the cerebellum, the cerebellar cells seem to sync, too. This inherent rhythmicity may be critical to the timing of muscle contractions later on.

“This is an unusual mechanism compared to other brain systems.”

Venturing into Unexplored Territory with New Techniques

Guo is developing techniques to monitor calcium levels in the inferior olive, which would serve as a measure of its electrical function. But to apply brain imaging in such a deep structure, he has to navigate around many important arteries and brain regions, including those that control breathing and heart rate. Ultimately, Guo aims to use this new technique in moving animals, so he and his unit members can see how the system controls movement in real time.

“It’s quite ambitious. Whatever techniques we develop, they’re going to generate novel results,” said Dr. Bogna M. Ignatowska-Jankowska, a research fellow from Poland who is visiting OIST on scholarship from the Japan Society for the Promotion of Science. Much more research has been done in accessible structures, like the cerebral cortex, than in the olivocerebellar system, she said. She and her fellow researchers are working to fill that chasm in the literature.

In the unit, Ignatowska-Jankowska aims to combine brain imaging techniques with 3D motion capture, technology that captures 3D videos of the unit’s lab mice performing different behaviors. She places spherical markers on the mice at their hip, knee and ankle joints, whose locations are then picked up by high-speed cameras placed around the lab. Ignatowska-Jankowska specializes in training the mice to be comfortable in the spotlight, so that the animals move as they would naturally.

Once this technique is perfected, the researchers will be able to monitor their animals’ brain activity while the mice walk, run or climb through space. Eventually, they plan to manipulate the animals’ brain activity to see how specific alterations affect their behavior. The scientists have to build these techniques from the ground up, but their efforts should greatly advance our understanding of how the brain controls movement -- and how the brain works in general.

Studying Movement to Unlock the Brain's Mysteries

“The brain and nervous system evolved to create and coordinate movement,” said Uusisaari. “Everything else -- talking, thinking, making plans, having memory, dreaming -- is just a silver lining.”

The same principles that allow the brain to direct movement allow it to recall precious childhood memories, learn new skills and decide what entree to order at lunch. Many neuropsychiatric conditions, such as schizophrenia, Alzheimer’s Disease, and Autism Spectrum Disorder, have significant symptoms that affect people’s behavior and motor control. By better understanding the olivocerebellar system, scientists may also gain new insights into cognition, perception and learning processes, as well as neuropsychiatric diagnosis and treatment.

“If we want to understand the brain,” Uusisaari said, “there is nothing more relevant than studying movement.”