Brain 'zips and unzips' information to perform skilled tasks

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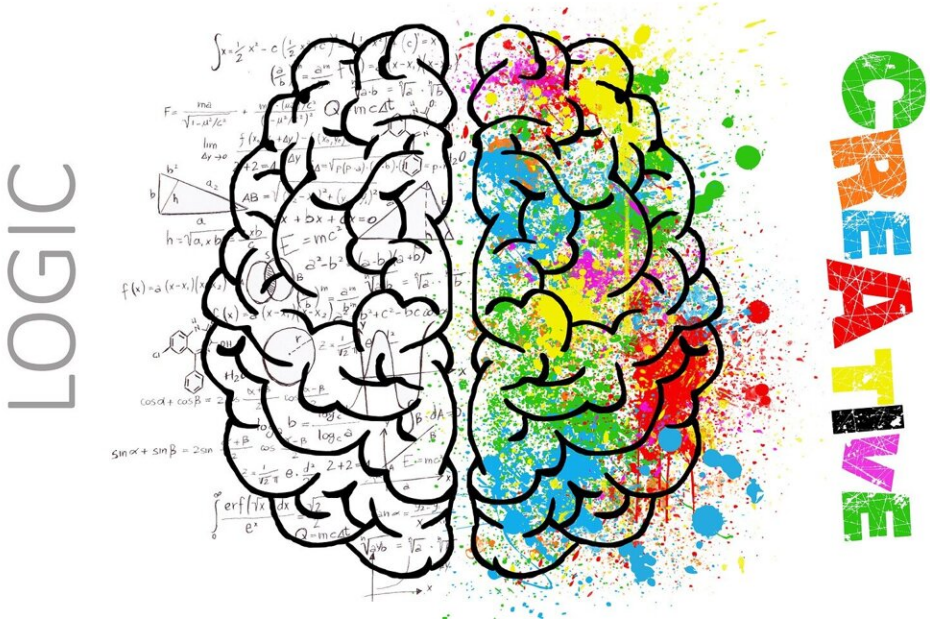

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The human brain prepares skilled movements such as playing the piano, competing in athletics, or dancing by "zipping and unzipping" information about the timing and order of movements ahead of the action being performed, a new study reveals.

Experts discovered that the order and timing of movements in complex sequences are separated by the brain, before being zipped and

transferred into specific movement commands, or "muscle memory," as the person begins the action.

They found that high-level sequencing of movement (such as order and timing) can be stored across several motor areas of the brain, often across several days of training and memorizing action sequences, before being activated following a particular trigger such as a musical cue or a starting gun.

Publishing their findings today in *Journal of Neuroscience*, researchers from the University of Birmingham and Bangor University believe the discovery may help to improve motor rehabilitation for stroke victims.

Principal investigator Dr. Katja Kornysheva, from the Center for Human Brain Health at the University of Birmingham, commented, "From handwriting to playing a musical instrument, performing sequences of movements from memory is a hallmark of skilled human behavior.

"What is surprising is that the brain separates these skills into their constituent features rather than encoding them as an integrated muscle memory, even after extensive training. There is a shift in information states within the brain when performing such tasks.

"Information is retrieved from memory unzipped when we prepare it for execution, before being zipped together to start the task. Perhaps this unzipping mechanism helps us to stay flexible for adjustments, even in the final hundreds of milliseconds before we start the movement, e.g., if we need to change the speed or timing of an upcoming action."

A series of almost 1,000 trials saw right-handed participants—excluding professional musicians—learn and memorize four keyboard sequences that they prepared and subsequently produced after a visual cue. After training, participants produced the keyboard sequences in an MRI

scanner which measured activity patterns across the brain during the task. The go cue didn't appear on some trials which allowed the researchers to separate preparation from the movement itself.

First author Rhys Yewbrey, from Bangor University, commented, "We also found several brain regions which control timing during movement production, but none seemed to control order without integrating it with timing.

"There was a matching effect in our participants' behavior—they were faster in acquiring a sequence with a new order of finger presses when they were familiar with the timing yet struggled to learn a sequence when they had to pair a previously trained order with a new timing. Perhaps timing control staying active during production allows for flexibility even after the movement has started."

Researchers believe that the brain separates sequence order and timing as "what" elements representing higher-level control, which are combined to define "how" exactly the task should be performed.

These new results help us to better understand how skilled actions are stored and controlled in the brain for everyday skills such as typing, tying shoelaces and playing a musical instrument, and what makes them flexible and resilient to changes in the environment or in neurological disorders.

More information: Cortical patterns shift from sequence feature separation during planning to integration during motor execution, *Journal of Neuroscience* (2023).

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