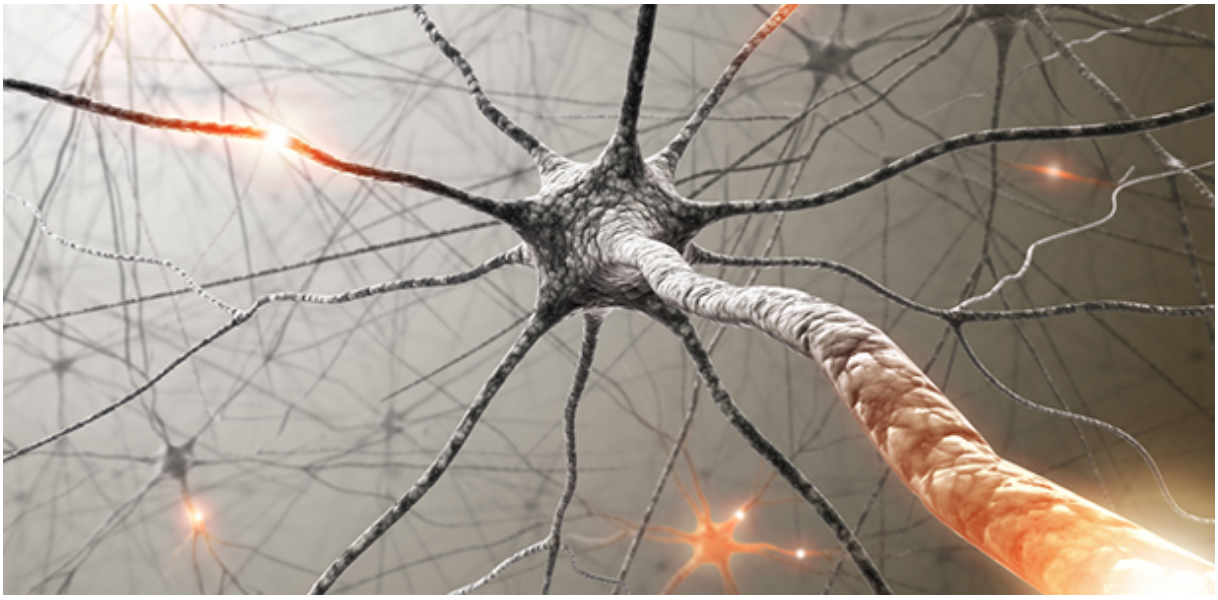
The Neural Rhythms That Move Your Body

By Leslie Carr

A new study finds that motor neurons encode the world differently from other types of brain cells.



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How do neurons firing in the brain produce movement in the body? For years, scientists trying to establish a one-to-one relationship between a neuron's behavior and factors such as muscle activity or speed of movement, have come up empty. The sorts of discoveries that have illuminated the neural circuitry behind vision have eluded scientists studying how we move, largely because of the unpredictability of the neurons that control movement.

But a game-changing new conceptualization of how brain activity translates into motion by a team of

electrical engineers and neuroscientists may finally offer an explanation of activity in the motor cortex that has long bewildered scientists.

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The researchers, working at Stanford University, found that when directing arm movement, the motor cortex does not encode neurons based on spatial information such as direction, distance and speed the way visual neurons do for color, intensity and pattern. "Visual neurons encode things in the world. They are a map, a representation," said Mark Churchland, now a professor at Columbia and first author of the paper, in a press release. As closely as they looked at the behavior of motor neurons connected to arm movement, no rules for firing similar to those of visual processing emerged.

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That's because it appears the motor cortex uses rhythm to generate patterns that provide different types of information to neurons instead. Using an automotive analogy, researchers described the motor cortex as operating like an engine, not a steering wheel. Instead of producing movement directly, the motor cortex is comprised of parts that cooperate in an organized way to produce different actions. Researcher John Cunningham of Cambridge University now a professor at Washington University in Saint Louis, put it this way, "If you saw a piston or a spark plug by itself, would you be able to explain how it makes a car move? Motor-cortex neurons are like that, too, understandable only in the context of the whole."

When they monitored the electrical activity of motor-cortex neurons, researchers found that they typically oscillate briefly, not independently as single neurons, but as an entire neural population in one beautifully coordinated way. "Each neuron behaves like a player in a band," said Churchland. "When the rhythms of all the players are summed over the whole band, a cascade of fluid and accurate motion results." The electrical signal for a movement is the sum of the rhythms of all the motor neurons firing at a given moment.

Rhythmic neural activity has been known for a while. It is present in the swimming motion of leeches and the gait of a walking monkey, for instance.

The engineers studied the brain activity of monkeys reaching to touch a target. The pattern of shoulder-muscle behavior could always be described by the sum of two underlying rhythms. "Say you're throwing a ball. Beneath it all is a pattern. Maybe your shoulder muscle contracts, relaxes slightly, contracts again, and then relaxes completely, all in short order," explained Churchland. "That activity may not be exactly rhythmic, but it can be created by adding together two or three other

rhythms. Our data argue that this may be how the brain solves the problem of creating the pattern of movement."

More research is needed to put this new theory to the test, but according to Cunningham, it explains many of the most baffling aspects of motor cortex neurons.

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