If you yawn, I yawn too: New mechanisms behind imitative behavior revealed

August 7 2024

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An international team of researchers, led by scientists from the University of Bologna has investigated the neural mechanisms underlying imitative behavior: a phenomenon that facilitates interaction

and social cohesion and allows people to engage spontaneously with others.

The study—published in *Proceedings of the National Academy of Sciences (PNAS)*—has uncovered new insights into how the brain regulates this behavior, opening up new perspectives for clinical and therapeutic applications.

"Our findings open up new avenues for understanding how brain plasticity can be manipulated to increase or decrease imitative behavior and make people less sensitive to interference during task performance," explains Alessio Avenanti, professor at the "Renzo Canestrari" Department of Psychology at the University of Bologna, who coordinated the study.

"This could lead to therapeutic applications to improve cognitive performance in patients with neurological impairments and social dysfunction disorders."

What is automatic imitation?

Imitative behavior underlies many complex social interactions and can influence interpersonal relationships as well as group dynamics. Moreover, automatic imitation can have negative consequences and often needs to be controlled: to save a penalty kick, for example, a goalkeeper has to inhibit the imitation of the forward's movements.

"Automatic imitation is a pervasive behavior in everyday life: think of when we see someone yawn and immediately feel the urge to do the same, or when we notice that our speech or facial expressions adapt to those of a friend we are talking to," confirms Turrini, a research fellow at the Department of Psychology "Renzo Canestrari' at the University of Bologna and first author of the study.

"Understanding the mechanisms behind this phenomenon can therefore provide new perspectives on social behavior, which is the context in which most of our daily lives unfold."

An advanced brain stimulation technique

It is known that the motor system is constantly involved in the automatic imitation of actions, facial expressions and speech, but the precise, and potentially distinct roles of different cortico-cortical circuits within the motor system remain to be clarified.

To shed light on this, the researchers used an advanced non-invasive brain stimulation technique called 'cortico-cortical paired associative stimulation' (ccPAS), which Prof. Avenanti's research group helped to develop.

"Thanks to this stimulation technique, it was possible to target the plasticity mechanisms of the brain connectome, the comprehensive map of neural connections in the brain," explains Prof. Avenanti.

"By temporarily enhancing or hindering communication between different areas of the motor system, it was possible to pinpoint the causal role of the different circuits in facilitating or inhibiting the phenomenon of automatic imitation."

The experiment

The study involved 80 healthy participants divided into four groups, each of which was subjected to a different ccPAS protocol. Each participant performed two behavioral tasks, before and after ccPAS treatment: a voluntary imitation task and an automatic imitation task. The aim was to test whether manipulating connectivity between frontal

areas—specifically the ventral premotor area (PMv), supplementary motor area (SMA) and primary motor cortex (M1)—influences automatic and voluntary imitation.

The results showed that different circuits of the motor system serve distinct and dissociable social functions, and that the direction of stimulation and the target area differently affect the neural circuits involved in imitation.

"We have seen that enhancing the connectivity between the ventral premotor area (PMv) and the primary motor cortex (M1) increases the tendency to automatically imitate the behavior of others, while weakening it has the opposite effect," says Sonia Turrini.

"On the contrary, the supplementary motor cortex (SMA) seems to have a cognitive control role on the motor system: enhancing its connectivity with the primary motor cortex (M1) actually induces a greater ability to avoid imitation when it is inappropriate to the context."

In addition to Avenanti and Turrini, other contributors included Francesca Fiori, Naomi Bevacqua, Chiara Saracini, Boris Lucero and Matteo Candidi.

More information: Sonia Turrini et al, Spike-timing-dependent plasticity induction reveals dissociable supplementary– and premotor–motor pathways to automatic imitation, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2404925121

Provided by University of Bologna

August 7) retrieved 7 August 2024 from https://medicalxpress.com/news/2024-08-mechanisms-imitative-behavior-revealed.html