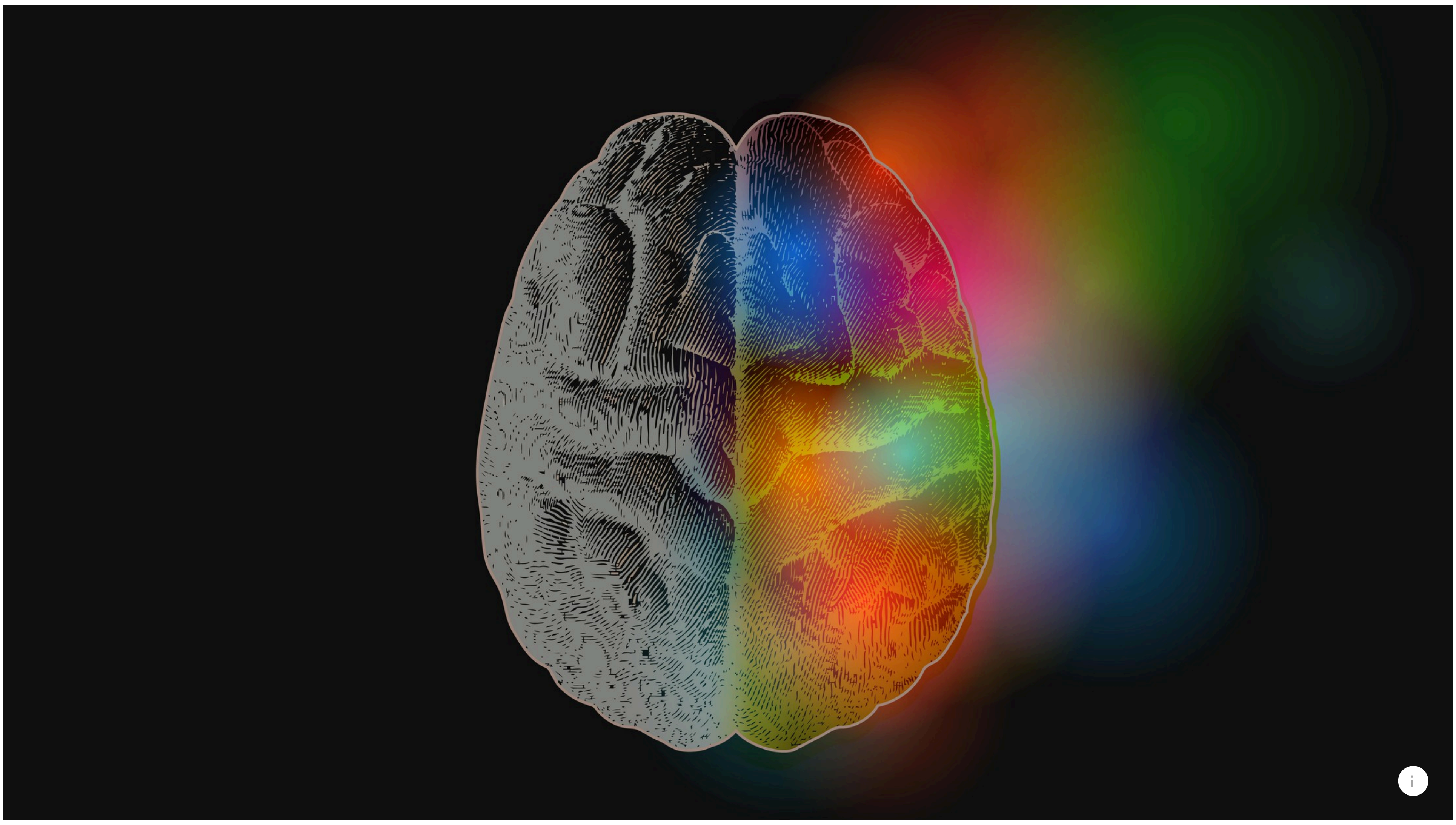
Brain stimulation effectiveness tied to learning ability, not age



A study from EPFL reveals that the effectiveness of brain stimulation on motor skills is determined by an individual's learning ability rather than age, highlighting the need for a more personalized approach to neurorehabilitation.

As we age, our cognitive and motor functions deteriorate, which in turn affects our independence and overall quality of life. Research efforts to ameliorate or even completely abolish this have given rise to technologies that show a lot of promise.

Among these is non-invasive brain stimulation: a term encompassing a set of techniques that can affect brain functions externally and noninvasively, without the need for surgery or implants. One such promising technique, in particular, is anodal transcranial direct current stimulation (atDCS), which uses a constant, low electrical current delivered via electrodes on the scalp to modulate neuronal activity.

However, studies exploring atDCS have produced inconsistent results, which has prompted researchers to explore why some people benefit from atDCS while others don't. The problem seems to lie in our understanding of factors that may influence responsiveness to brain stimulation, leading to responders and non-responders; among these, age has been suggested as one important factor.

Some studies suggest further factors such as baseline behavioral abilities and previous training might be important considerations, but an interplay of these factors with behavior has not been determined in detail, pointing to the need of refined predictive models of the effects of atDCS.

Now, scientists led by Friedhelm Hummel at EPFL have identified an important factor affecting an individual's responsiveness to atDCS. The team looked at how native learning abilities determine the effect of brain stimulation applied while learning a motor task. Their findings suggests that individuals with less efficient learning mechanisms benefit more from stimulation, while those with optimal learning strategies might experience negative effects.

The researchers recruited 40 participants: 20 middle-aged adults (50-65 years old) and 20 older adults (over 65). Each group was further divided into those receiving active atDCS and those receiving placebo stimulation.

Over ten days, participants practiced a finger-tapping task designed to study motor sequence learning at home while receiving atDCS. The task involved replicating a numerical sequence using a keypad, trying to be as fast and as accurate as possible.

The team then used a machine-learning model trained on a public dataset to classify participants as either "optimal" or "suboptimal" learners, based on their initial performance. This model aimed to predict who would benefit from atDCS, based on their ability to integrate information about the task efficiently early during training

The study found that suboptimal learners, who were seemingly less efficient at internalizing the task at the early stages of learning, experienced an accelerated accuracy improvement while performing the task when receiving atDCS. This effect was not limited to people of a certain age (e.g., older adults), with suboptimal learners being found among younger individuals as well.

In contrast, participants with optimal learning strategies, regardless of age, even showed a negative trend in performance when receiving atDCS. This difference suggests that brain stimulation is more beneficial for individuals who initially struggle with motor tasks. As such, atDCS seems to possess a restorative rather than an enhancing quality, with important implications for rehabilitation.

"By leveraging different methods in Machine learning, we were able to untangle the influence of different factors on the individual effects of brain stimulation," says Pablo Maceira, the study's first author. "This will pave the way to maximize the effects of brain stimulation in individual subjects and patients."

The study implies that, in the long run, personalized brain stimulation protocols will be developed to maximize benefits based on an individual's specific needs, rather than a common trait such as age. This approach could lead to more effective brain stimulation-based interventions, targeting specific mechanisms supporting learning, especially in the view of neurorehabilitation, for which the main basis is the re-learning of lost skills due to a brain lesion (e.g., after a stroke or a traumatic brain injury).

"In the future, clinicians could apply a more advanced version of our algorithm to determine whether a patient will benefit from a brain stimulation-based therapy, to enhance the effects of neurorehabilitation and personalize treatment," says Hummel.

Other contributors

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