Mirror Neurons as a Key to Stroke Rehabilitation

Dr Michael Hoffmann

Scientia

MIRROR NEURONS AS A KEY TO STROKE REHABILITATION

Mirror neurons are specialised brain cells that underpin our capacity to learn and understand a myriad of behaviours. **Dr Michael Hoffmann**, from the University of Central Florida and the Roskamp Institute in Florida, has unravelled the profound implications of these brain cells. Beyond their role in cognition, mirror neurons could play a major role in patient rehabilitation, particularly in the context of stroke recovery.

Evolution of the Human Brain, Intelligence, and Learning

Have you ever wondered how our brains evolved to make us the intelligent beings we are today? Many myths and misunderstandings have emerged in the scientific quest to explore the relationship between the brain and intelligence. For example, while it is a common belief that brain size determines intelligence, the reality is a little more complex! Studies show that primates have proportionally similar frontal lobe sizes to humans. This challenges the oversimplified idea that larger brains inherently mean higher intelligence. This nuance becomes evident when observing corvids like ravens, who display remarkable cognitive abilities much larger than expected for the size of their brains. Researchers think that what distinguishes humans is not the sheer size of the brain but the unprecedented evolution of so-called mirror neurons.

Dr Michael Hoffmann uses evolutionary insights to answer important questions about how brains can undergo major reorganisation after traumatic events such as stroke. Dr Hoffmann believes that the ability of mirror neurons to translate visual information into new knowledge is the key to the ability of human brains to learn and, importantly, relearn behaviours.

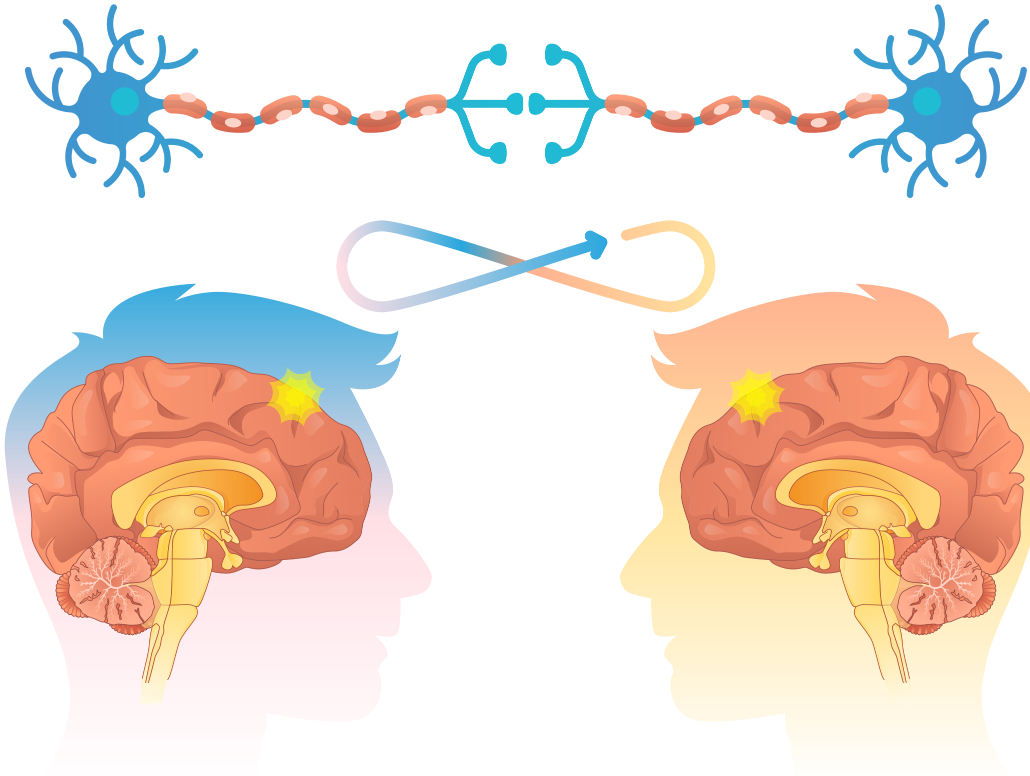
Mirror Neurons: The Brain's Learning Engine

Mirror neurons, often regarded as the brain's learning engine, are specialised brain cells known for their unique firing patterns during both the execution of an action and the observation of that same action done by others.

To illustrate, imagine a hypothetical brain cell named Miriam. Miriam likes coffee. This means that Miriam fires and gets active during specific coffee-related actions, such as grabbing a cup. What sets Miriam apart from other brain cells is her ability to get active not only when we perform an action related to drinking coffee but also when others perform it. If we sit in a coffee shop and reach for a cup of coffee, Miriam, the mirror neuron, fires with activity. But also when she sees a barista pouring a cup of coffee for us. Miriam doesn't distinguish between our actions and the actions of others because her activity is related to the perceptions and shared experiences for a specific action rather than a direct motor action.

We have many mirror neurons in our brains, each specialising in various activities. This forms what is called a Mirror Neuron System (MNS). These neurons, like Miriam, contribute to our ability to learn and understand a wide range of actions and behaviours that extend beyond motor actions.

Among other domains, the MNS is related to our capacity for imitation or language acquisition, which helps us to learn. The MNS operates through distinct networks for familiar and novel imitation. The familiar network relies on recall, requiring individuals to recollect past experiences during imitation. Conversely, the novel network focuses on learning new actions by observing. If we take Miriam as an example, in the familiar network, she would activate every time we mimic actions we have done before, such as reaching for a cup of coffee. In the novel network, she would learn a new action, such as a specific technique to brew and pour coffee by observing a barista.



The Clinical Applications of Mirror Neurons in Action

Dr Hoffmann explores how the MNS impacts cognitive functions in clinical settings, especially in imitation, language, and learning. With a keen focus on stroke, Dr Hoffmann applies this knowledge to unravel the complexities of the Frontal Network Syndrome (FNS). FNS is a set of problems that arise from lesions or dysregulations within the brain's frontal lobe, which plays an important mediating role in many cognitive processes.

In his research, Dr Hoffmann methodologically selected patients who met predefined criteria and were evaluated by board-certified neurologists. The evaluation included comprehensive brain scans from several neuroimaging modalities, providing insights into both structure and function. Cognitive assessments were then conducted. Patients were examined for FNS using a diagnostic tool originally developed in Dr Hoffmann's collaboration with Dr Frederick Schmitt and Dr Ena Bromley, followed by other test versions. If any abnormality was found, more tests were completed using more comprehensive FNS tests. For example, this could include looking specifically at field-dependent behaviour, which is a clinical sign of dysfunction in the frontal part of the brain. It incorporates actions like imitation behaviour, utilisation behaviour, or environmental dependency syndrome – all regulated by the MNS.

Results from Patients Who Experienced Stroke

Dr Hoffmann's study started with 1,436 patients who had experienced stroke. Only a proportion of these patients underwent cognitive testing due to other neurological problems or difficulties in cooperation. This is quite common and likely represents the real-world population of patients after a stroke, especially in the first month. While conducting the assessments, Dr Hoffmann noticed that one specific type of field-dependent behaviour was very common in patients after stroke – imitation.

Imitation seems to be the most consistent field-dependent behaviour in stroke survivors. However, the study pointed to some interesting behaviours that differed from one patient to another. A captivating case study later published by Dr Hoffman adds further depth to our understanding of FNS. Here, a 59-year-old stroke patient reported remarkable visual phenomena that had not been commonly reported as a form of FNS.

Dr Hoffmann thinks this visual problem represents an unusual form of environmental dependency syndrome – one of the common field-dependent behaviours of FNS that relate to network dysregulations between the frontal and parietal brain regions. The case study sheds light on the diverse manifestation of FNS in stroke survivors. It also highlights the importance of understanding these behaviours in the context of frontal lobe pathology and their impact on patients' everyday lives.

What Does It Mean for Patients?

Dr Hoffmann's work has wide-reaching implications. While pinpointing imitation as the main FNS behaviour is a remarkable discovery, it also underscores its significance as a diagnostic marker for FNS. Additionally, the findings showcase the therapeutic potential of MNS in motor rehabilitation, where action observation activates the same frontal networks as physically performing the action. This can complement traditional physical therapy and enhance rehabilitation outcomes. Dr Hoffmann is committed to continuing his endeavours of exploring potential MNS interventions, encompassing actions of observation, motor imagery, and imitation.

Meet the Researcher

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Dr Michael Hoffmann undertook medical training at the University of Witwatersrand in South Africa and obtained senior doctorate degrees in clinical cerebrovascular medicine (MD) and behavioural medicine (PhD) from the University of Kwa-Zulu (also in South Africa). He completed a fellowship in stroke medicine at Columbia University, New York and was the founding director of four stroke centres in the USA, including the Primary Stroke Center (2002) and the Comprehensive Stroke Center, Tampa General Hospital/University of South Florida (2004). He was also the founding director of the Primary Stroke Center at the James A Haley VA Hospital, Tampa, Florida (2013) and Orlando VA Medical Center (2017). Currently a Professor of Neurology at the University of Central Florida, his prior academic positions at the University of South Florida have included Associate Dean of Academic Assessment, Interim Chair of Neurology, and Vice Chair of Neurology. During his illustrious academic and clinical career, he has produced over 230 peer-reviewed publications and authored several books about cognition, behaviour, and related clinical applications. In 2021, he established Brain Beat Neurology Practice, a part-time private practice dedicated to cognitive and behavioural neurology, traumatic brain injury, and war-related illnesses.

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FUNDING

Medical Research Council of South Africa
College of Medicine of South Africa
National Institutes of Health
University of South Florida

FURTHER READING:

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