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The Mystery of the Mirror Neuron System

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Abstract:

Objective: *To highlight the link of mirror neurons with body movements*

Method: *A literature search was conducted in PubMed and various other data bases to collect some studies about the association of mirror neurons with body movement.*

Result: *Studies do exist that support the notion that there are some sets of neurons in the human and animal brain that are activated when humans or animals perform certain actions. The same neurons are activated when they observe another person or animal performing some movement like walking and hand related movement.*

Conclusion: *The area of the human and animal brain that is activated when we perform an action and when we see someone else performing the same action, is believed to have a special kind of neurons known as "mirror neurons". The evidence proving the existing of these new neurons is still not sufficient, as these neurons were discovered just couple of decades ago. We believe future studies will be useful to provide more information about the subject.*

Keywords: *Mirror Neurons, Mirror Neurons legs, mirror neurons limbs, mirror neurons hands, mirror neurons grip, mirror neurons movement, mirror neurons motion.*

1. BACKGROUND

According the world renowned mirror neurons expert Dr. VS Ramachandran, "I predict that mirror neurons will do for psychology what DNA did for biology" (1). Sounds strange, but if we study mirror neurons in depth we will find out that this new discovery of mirror neurons has a potential to unearth so many mysteries, like why we yawn, when we see the other person yawning, and why we smile when we see other person smiling, or why we feel sad when seeing a sad person (2).

Mirror neurons are a distinct group of neurons that fire both when an individual executes a motor act and when he/she observes another individual performing the same or a similar motor act (3-4). Thus the neuron "mirrors" the behavior of the other. Mirror neurons were first discovered over 20 years ago in monkey's brain, in the inferior frontal gyrus (area F5) and inferior parietal gyrus. As of now, these neurons havebeen found in the premotor cortex, the supplementary motor area, the inferior parietal cortex, and the primary somatosensory cortex (5).

Many new readers who read about mirror neurons have a tendency to believe that mirror neurons are only related to facial expressions or emotions. However, recent research and observations have broadened our understanding about these unique neurons. Today we do know that these neurons are associated with many bodily functions.

Not much was known about the association of mirror neurons with body movements and function until the extensive fMRI studies made it possible to dig deeper into the human and animal brain and extract the answers to this unsolved mystery. In this article, we are not hypothesizing any question, but we are only bringing together some recent pieces of evidence regarding the association of mirror neurons with various other body functions especially movement.

2. DISCUSSION

During our various activities of daily living, we communicate, socialize and connect with other people and we somehow recognize the state of mind they are in and what they will do or how they will likely act. Different motor simulation theories of perception state that effective perceptual processing of

others' actions can be attained not solely by visual analysis of the movements but also by a process of motor simulation. To disprove this notion, Vannuscorps et al conducted eight experiments and found that individuals born with absent or severely shortened upper limbs (upper limb dysplasia), could understand, anticipate and recall upper limb movements, which they cannot mimic, as efficiently as typically developed participants [6].

The function of mirror neurons has been, in someway, elucidated by the method coaches use to train athletes. They apply a technique called "action demonstration" to make athletes acquire new motor tasks[7,8]. To achieve this, the learners are presented with a model that demonstrates how to perform the action they want to learn[9,10]. The learners then need to transform the observed visual information into motor commands that allow them to execute the action correctly (visio-motor transformation)[11,12]. In these trainings two apprentices work together. Alternating the physical practice with one another, the second player observes and executes what the first player does. Then the first player observes the second player and executes the same thing [13]. The observation of his/her partner and the subsequent execution of the task would be the factors that increase performance efficiency.

A study by Salvia et al proposed that observing others' actions augments muscle-specific cortico-spinal excitability, indicating presumed mirror neurons activity. They also suggested that the exposure to emotional stimuli modify cortico-spinal excitability. The interaction of these two phenomena when they are combined was further explored. A single-pulse transcranial magnetic stimulation (TMS) was delivered over the hand area of the left primary motor cortex of 27 healthy adults and adolescents and their right first dorsal interossus (FDI) muscle activity (i.e., motor evoked potential - MEP) was recorded, while they watched either videos of neutral or angry hand actions and facial expressions, or neutral objects as a control condition. They were able to recreate the motor resonance and the emotion effects. It was found that hand-actions and emotional stimuli triggered greater cortico-spinal excitability than the faces/control condition and neutral videos, respectively. Furthermore, the impact of emotion was present for faces but not for hand actions, which indicated that the motor resonance and the emotion effects might not be additive [14].

Furthermore, Maeda et al emphasized the important role of parieto-frontal pathwaysin visually guided motor control. They documented 235 neurons related to hand manipulation exercises. Of these, fifty-four showed the same response to both the video clips of the monkey's own hand movement as well as to the visual feedback during that action or clips of the experimenter's hand movementin a lateral view. Twenty-five out of the 54were labeled "hand-type" as they only responded to video clips of the monkey's own hand, without an image of the target object. Thirty-three of 54 neurons that were defined as mirror neurons showed visual responses to the experimenter's action and motor responses.The study concluded that activity of hand manipulation-related and mirror neurons in anterior intraparietal/Parieto-frontal gyrus (PFG) plays a fundamental role in monitoring one's own body state based on visual feedback [15].

The effect of mirror neurons on empathy has been shown in different studies. The same neural circuits that fire when a person is happy are also activated when we see someone is feeling happy [16]. Another way of exploring the role of mirror neurons in empathy is through pain and disgust [17]. It was found that applying painful stimuli to subject's hands activated neurons in the anterior cingulate cortex. Similarly, the same neurons discharged when watching painful stimuli being applied to someone else's hands. The neurons in the anterior cingulate gyrus also fired when noticing people who would be painfully stimulated at a later time. Hence, the area of the brain accounted for reacting to pain are activated not only while experiencing pain but also watching someone else experiencing pain as well as noticing someone else who would encounter pain at a later time[18]. Similarly, neurons in the Insula, which fire when the person experiences disgust, also become activated when he/she observes faces showing disgust. This shows that when a person is incapable of experiencing emotion, this person will likely have impaired understanding of the same emotions in others. A case report written on a patient with brain injury entailed that damage to the area of the brain responsible for experiencing disgust led to difficulty detecting disgust in others[17].

Another concept coined about mirror neurons' function is Mirror-touch synesthesia. This is a condition where seeing other individuals experiencingsomatosensory sensation causes the same sensation in the observer [19]. The most supported theory behind this phenomenon is that in normal people the somatosensory mirror system, which moderateobserved and felt touch, has activations that

are below a certain threshold. When the activations are below this threshold, a person can sense and appreciate the observed touch. In motor neuron synesthesia the mental imitation is so strong that it crosses a threshold into near-tactile sensation, which is sometimes indistinguishable from the synesthete's own [20]. This condition has been seen in patients who have suffered stroke with loss of sensation and amputees where visual stimuli elicited a tactile sensation [21].

3. CONCLUSION

The mirror neuron system (MNS) is linked with many functions including the body movements such as limb movements such as walking, hand movement like gripping and grasping etc. Action observation is also found associated with mirror neurons. It is also found thatobserving others' actions augments muscle-specific cortico-spinal excitability, indicating presumed mirror neurons activity. Empathy and mirror-touch synesthesia has also been studied in relation to mirror neurons.

There so much more to mirror neurons. This article is just a mini review to highlight some facts about the mirror neurons, to help new scientists and clinicians learn some basics about mirror neuron system. Although it has been more than two decades since the mirror neurons were first discovered, the data present is still not sufficient and future research studies will help us learn more about these mysterious kinds of neirons.

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