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# MIRROR NEURONS AND SUBCONSCIOUS SIMULATION IN THE HUMAN BRAIN

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**ABSTRACT**
Mirror neurons are special type of nerve cells in the brain that are seen to simulate observed behaviour. Research on mirror neurons in humans is still in a nascent stage, but shows promise as scientists are unraveling newer functions of these specialized cells. The present study aims to evaluate the hypothesized role of mirror neurons in subconscious imitation of observed behaviour. A group of 30 participants were monitored for their respiratory rate as they observed video clippings of the behaviour of models on the screen. It was seen that the respiration rate of the observers shifts towards that of the models, although the participants do not report this consciously. The results show that behaviour is subconsciously imitated, a finding that is consistent with earlier studies implicating mirror neurons. The present study discusses various functions and applications of mirror neurons in behavioural sciences.

**KEY WORDS:** imitation learning, Mirror neurons, mind reading, observed behavior

## INTRODUCTION

Imitational or observational learning was a very important strategy adopted by humans during evolution in order to learn new responses and modify behaviour that was strategically important for adaptation. Observational learning allowed exchange of thought and action that facilitated rapid progress as the output of one person's action became the 'starting point' for another. Until recently, psychologists attributed imitation to deliberate and overt attempts on part of the observer to observe and replicate the behaviour of a model. For example, such behaviour is most commonly seen in children imitating their parents and teachers. It is also common to see upcoming artists and sportspersons imitate their idols. Explorations in the field of neuropsychology are now unraveling the underlying neural mechanisms in imitation that show that it is not always that imitation is done consciously and with intent; rather we observe and subconsciously simulate actions of other people without making conscious efforts.

Towards the turn of the twentieth century, psychologists began to recognize the role of neuro-cognitive processes in observational learning. The neurological base of observational learning was accidentally discovered by Vittorio Gallese, Giaccamo Rizzollati and their colleagues while experimenting on monkeys in their laboratory in the University of Parma in Italy in 1992 (di Pellegrino *et al.,* 1992). The scientists had implanted electrodes in the premotor cortex of macaque monkeys, an area in their brain considered analogous to Broca's area in the human brain. The scientists discovered that when the monkeys performed a particular act, like lifting a bowl, a particular group of motor neurons in the premotor cortex region of the brain fired. But what they found surprising was that when the monkeys observed another monkey perform the same act, the very same group of neurons fired again, suggesting as though the act was being performed by the observing monkeys. The researchers named this group of neurons as *Mirror Neurons* (Gallese *et al.,* 1996).

Vilanayur Ramachandran has described the finding of the mirror neurons as one of the biggest discoveries in science in the last century. Ramachandran believes that mirror neurons have played a major role in the development of culture and language in human evolution, what he terms as the 'second big bang' of human evolution (Ramachandran, 2000). Mirror neurons are believed to simulate the actions of other people, thereby making understanding possible. Humans are very adept at 'understanding' the complex motives and emotions of other people. Psychologists and neurologists have come to agree that the underlying base could be mirror neurons (Gallese *et al.,* 2004; Iacoboni *et al.,* 1999; Jellema *et al.,* 2000; Rizzolatti *et al.,* 1996). We subconsciously interpret the actions, facial expressions, gestures and body movements of other people by simulating the same in our brains. This simulation is done by the mirror neurons, thus giving our brains a precise input of what the other person is 'thinking'. This is what is commonly referred to as 'mind reading' (Gallese and Goldman, 1998).

If mirror neurons are to simulate the actions of another person, these would not necessarily be reflected in observed behaviour. Otherwise the whole world would be doing the same action. This is because the simulations are not directly carried to the motor cortex for action (Keysers *et al.,* 2004; Kohler *et al.,* 2002). However, there could be certain actions or changes that could occur at the subconscious level which could still be observed and measured. The present study aims to investigate the effects of subconscious imitation that may occur in an individual by observing the behaviour of another person. Certain physiological parameters of the subjects in the study were monitored for this purpose as the subjects observed the respiration patterns of another person. The following hypothesis was tested: There is a change in the respiration rate of the observer in the direction of the observed behaviour of the model.

## MATERIALS AND METHODS

A laptop, 3 video clips, multi-para monitor, stethoscope, EEG apparatus.

The research was conducted in two sessions. Thirty subjects (observers) were randomly divided into two groups, and each group was shown two video clippings for 1 minute duration each. All the subjects were monitored by a physician for their respiration rate as they watched the video clips. In order to deviate their attention away from their respiration monitoring, as the physician opined that this could affect the respiration rate, the subjects were told that multiple physiological parameters would be observed that included blood pressure, oxygen saturation level, heart beats, EEG etc on a multi-para device. The subjects were strapped with the requisite electrodes on the body for this purpose, which however was a dummy exercise.

**Subjects:** 30 undergraduate male students aged between 18 and 20 years voluntarily participated in the study.

**Experimental Procedure**

The 30 students were randomly divided into two groups of 15 students each by the lottery method. Each participant in both the groups was shown 2 video clips separated by 15 second duration. The first clip was common to both the groups which showed a young man sitting in a chair and talking normally about the importance of academics in front of the camera. However, the second clip was different for the two groups. Participants in the first group, termed the control group, were shown a similar clipping of another young man who talked about the importance of sports in life. Participants in the second group, termed the experimental group, were shown a clipping of a boy completely submerged in water and holding his breath as his expressions showed that he struggled to hold his breath. Each subject was monitored for his rate of respiration as he watched the video clips. Participants in both groups were told to observe the emotions and gestures of the models in the clip closely as a few questions would be asked later. This ensured that the subjects watched the video clips intently.

## RESULTS

The respiratory rates of the participants in both the groups under the two conditions are presented in the observation table. The values represent the number of breaths per minute when the participants were under observation.

Independent‘t’ tests are computed for both the conditions in the study for the two groups. The first‘t’ test is computed for comparing the respiratory rates of the participants in the two groups for the baseline values, i.e. when participants in both the groups watched the first video clip. It is seen that there is no significant difference in the respiratory rates of the participants from the control ($M=15.67$, $SD=1.23$) and experimental ($M=15.40$, $SD=1.06$) groups, $t(28)= 0.64$, $p>.05$. However, the independent‘t’ test for the second condition is found to be significant, $t(28)= 7.74$, $p<.01$, with the respiratory rate of participants from the experimental group ($M=12.07$, $SD=1.33$) dropping significantly lower than that of the control group ($M=15.27$, $SD=0.88$).

## DISCUSSION

How many times have we found ourselves yawning on seeing another person yawn? Or see another person in the room yawn as we let out a yawn? Some scientists attribute this to a lack of oxygen intake, but the fact remains that the behaviour of the observer is ‘stimulated’ by observing another person’s behaviour. Many such behaviours are stimulated on observing other people perform an act, but go largely unnoticed. The present study aimed to study one such behaviour under controlled conditions. The participants in the study were instructed to observe closely the expressions of the person in the video clip. They were not instructed to imitate the models, nor did they report any change in their own conscious behaviour when asked about it after the experiment. However, a change in their physiological behaviour is clearly evident as the respiration rate of observers in the experimental group is found to be significantly lower than that of the control group. The difference can be attributed to the differential behaviour of the models in the video clip, as the control group saw a person breathing normally, but the experimental group observed a person holding his breath for a minute, i.e. virtually not breathing at all.

The agitation on the face of the subject as he experienced asphyxiation while his holding his nose tightly in his fingers and keeping his lips sealed were keenly observed by the participants. Their facial expressions and gestures like foot-tapping, biting nails, and clinching fists showed that most participants were experiencing some of the pain of the model. It is in light of all these observations that one can conclude the dropping of the respiration rate of the participants in the experimental group to be subconscious imitation of the observed behaviour.

**Table 1:** Respiratory rate of participants in the two groups under both the conditions

| Sr. No. | Control group | | Experimental group | |
|---|---|---|---|---|
| | Condition I | Condition II | Condition I | Condition II |
| 1 | 14 | 15 | 16 | 14 |
| 2 | 15 | 14 | 15 | 12 |
| 3 | 18 | 17 | 15 | 13 |
| 4 | 15 | 15 | 17 | 13 |
| 5 | 16 | 15 | 14 | 12 |
| 6 | 14 | 16 | 15 | 12 |
| 7 | 17 | 16 | 16 | 10 |
| 8 | 17 | 16 | 13 | 13 |
| 9 | 15 | 16 | 15 | 10 |
| 10 | 16 | 15 | 16 | 12 |
| 11 | 17 | 15 | 17 | 11 |
| 12 | 16 | 15 | 15 | 10 |
| 13 | 14 | 14 | 16 | 13 |
| 14 | 16 | 14 | 15 | 12 |
| 15 | 15 | 16 | 16 | 14 |
| Mean | 15.67 | 15.27 | 15.40 | 12.07 |
| SD | 1.23 | 0.88 | 1.06 | 1.33 |

**Table 2:** Independent't' test between the two groups for the two experimental conditions

| Condition | t | df | Sig. |
|---|---|---|---|
| Condition I | 0.64 | 28 | 0.53 |
| Condition II | 7.74 | 28 | 0.001* |

(*p<0.01)

Humans have the ability to empathise with other people, as is seen when they share the grief, sorrow or joy of others. Humans are also seen to display the same set of emotions of models in cinema or theater when people in the audience are seen to weep on seeing an actor do that. Till recently, psychologists explained such behaviours with the help of cognitive theories of emotions that looked at cues in the immediate environment for interpretation of physiological changes (e.g. Schachter and Singer, 1962; Bewrkowitz, 1964; Roseman, 1984).

The cognitive theories propose that the physiological changes remain unexplained to the observer and in the effort to interpret these changes, the observer looks for environmental cues. Similarly, imitational learning is also traditionally explained within the precincts of strengthening of established neural networks in the process of memorization (Hebb, 1949). In recent years, scientists have used artificial neural network models like the cognitron to study the neural bases of learning (Fukushima, 1975; Egmont-Petersen, de Ridder, and Handels, 2002). But the discovery of mirror neurons has led to newer possibilities and interpretations of psychological phenomenon, including observational learning.

Following Gallese and Rizzollati's discovery of the mirror neural system, researchers have confirmed the existence of mirror properties in primates and further that the mirror neuron system also responds to the sound of actions (Kohler *et al.,* 2002). For example, if a monkey saw another monkey crack a nut, the mirror neuron system in the observant monkey fired on hearing the sound of a nut cracking. Using fMRI (functional magnetic resonance imaging), researchers have now found evidence of the mirror neuron system in the human brain in the inferior frontal and inferior parietal regions of the brain along with the somatosensory cortex that allows an observer to feel what it would feel like if one is performing the observed action (Gazzola and Keysers, 2009; Keysers, Kaas, and Gazzola, 2010).

The major hurdle in mapping the mirror neuron system in humans is that it is not possible to employ intrusive methods to study the human brain for research purposes. However, researchers utilize an opportunity with consent from a patient if he or she is to undergo a brain surgery for other medical reasons. Some researchers at the Ronald Reagan Medical Center in the US availed of such an opportunity when they got consent from some patients who were being treated for epilepsy (Keysers et al, 2010). Electrodes had been implanted in the patient's brains to identify the neurological base of seizures, which the researchers used for their study. The patients were shown facial expressions, actions and words on a laptop screen and were asked to observe and perform certain actions. In one experimental situation, the patients were also asked to perform an action conveyed by a word on the screen (for example 'CLAP'). The patients were then asked to only observe the word but not to perform the action. Mukamel and colleagues (Mukamel, Ekstrom, Kaplan, Iacoboni, and Fried, 2010) found that a group of neurons fired in both the situations – when the patient performed an action and when he only observed the word. This has established the existence of the mirror neuron system in the human brain, but the scope of the study was limited to only those brain areas (supplementary motor area and medial temporal cortex) which were clinically observed for the epileptic patients. Researchers believe that the mirror neurons are spread across many areas in the human brain, and that further studies will help unravel the system (Heyes, 2010).

It is now beyond doubt that the mirror neuron system in the brain helps replicate or imitate the actions of the observer at the neural level. Psychologists and other behavioural scientists now foresee the application of this system in a wide array of behaviours. Some are of the view that this innate ability to imitate, or simulate, other peoples' behaviour has been highly advantageous to the human race in the process of evolution (Iacoboni *et al.,* 2004). Ramachandran (2002) believes that the neural ability to imitate, rather than genetic mutation, led to the sudden spurt in human development as humans were able to understand and replicate thought and actions. Some scientists have posited that imitation of observed behaviour has led to the establishment of culture, formation of language and the propagation of knowledge (Hubbard and Ramachandran, 2005; Goldman, 2005). It has also helped us empathise with others and has hence facilitated social bonding (Rizzolatti *et al.*, 2001). It is as though we are able to 'feel' the pain and suffering of others, which leads to empathy. Pure cognitive processing minus the feeling would not have elicited the subjective emotional responses that the human race is capable of (Oberman *et al.,* 2007).

Rizzoletti and Arbib (1998) explain that the advantage of the mirror neuron system is that internal simulation of the behaviour of the person in front of you also gets you prepared for reactions if necessary. It is not just the intelligent processing of words of threat for instance that swings a person into action. A slight facial twitch of the boss many a times sends a chill down the spine of the employee, telling him not to argue any further and duck for cover. A stranger is often found repulsive by a lady, though she may not be able to explain in words why she feels so. We experience many such moments in life when we think we 'read' the mind of the person in front and anticipate his/her behaviour. This is largely because of the simulation of the other person's behaviour by the mirror neurons, giving us precise inputs of what the other person may be thinking or experiencing.

## CONCLUSION

Participants in the study were found to subconsciously imitate the observed behaviour of the model, as is evident from a significant drop in the respiration rate of those participants who observed such triggering behaviour. The results are consistent with findings in studies on mirror neurons and their subconscious effect on behaviour.

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