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MIRROR NEURONS FOR EDUCATION

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Abstract

This paper deals with the discovery of mirror neurons, their most important features and the way they influence our social lives. It focuses on their impact on children and their behavior at school. This paper aims at teachers and students in the teachers' program who hope to better understand their pupils by gaining some insight into the way mirror neurons work.

In the early 1990s, mirror neurons were discovered by a group of scientists from the University of Parma in Italy, led by Giacomo Rizzolatti. Mirror neurons' defining functional characteristic is that they are activated when a motor act is performed and also when it is witnessed. Mirror neurons enable us to understand, interpret and imitate observed actions and to predict their results. They inform us about other people's mental and physical condition and can change our own by mirroring our counterpart's [1].

From birth, mirror neurons enable children to communicate with their environment by imitating actions they witness. Although this is not an essential part of communication anymore when speech is acquired, mirror neurons allow us to keep imitating facial expressions, sentiments and postures subconsciously throughout life, thus facilitating interpersonal relationships [1]. Nevertheless, mirror neurons have so far received little attention in educational theory. As teaching always involves interpersonal dealings, however, they play an important role in relations between teachers and students and among students. This paper is supposed to raise awareness to the way mirror neurons work and their range of influence; thus contributing to an improvement of children's learning environment and interpersonal communication at school.

Keywords: mirror neurons, education theory, action understanding, intention understanding, learning by imitation, interpersonal relationships, brain-based teaching.

1 INTRODUCTION

When paying attention to our surroundings, we can frequently observe different kinds of imitational behavior and resonance phenomena, such as two people yawning or changing their posture at the same time or children learning a new skill by watching their parents. The key to understanding this "mirroring" of other humans' actions and behavior was found when mirror neurons, neurons firing both when an action is executed and when it is observed, were discovered by a group of scientists led by Giacomo Rizzolatti from the University of Parma in Italy. This paper's aim is to give an overview of the way mirror neurons work and their sphere of influence, focusing on their impact on students' imitational learning and interpersonal dealings at school. Thereby, mirror neurons' influence on students' performances and their relationships to teachers and peers are discussed.

This paper's first part addresses mirror neurons' discovery in monkeys and humans, circumstances under which they are activated, and their still controversial contribution to speech development in humans. Secondly, several aspects of mirror neurons' impact on social interaction are presented. They are believed to render action understanding and imitation, understanding of intentions and mirroring of other people's body language possible. Following this, mirror neurons' influence on students' learning performances and relationships with their teachers and peers are discussed. As a last point, still controversial theories concerning mirror neurons' influence on self-consciousness, the way mirror neurons are affected by negative emotions and the role mirror neurons play in mobbing are addressed.

2 MIRROR NEURONS

In the early 1990s, Rizzolatti *et al.* noticed that specific neurons in a macaque monkey's area 5 of the premotor cortex reacted when it reached for a nut and when it saw other scientists and animals reach for it [2]. Later on, some of the same neurons were found to react to the sound of paper being torn too,

as the monkey associated it with food being unwrapped [3]. They also fired when the aim of the reaching-action was hidden from the monkey's view and could only be inferred [4] and – occasionally – before the action was finished [5]. They were not activated, however, when scientists only pretended to reach for an imaginary object and when the monkey was observing an object without another animal or person interacting with it [6].

Because they fired when a movement was executed and observed, Rizzolatti and his team named these neurons “mirror neurons” and reasoned that they react to and maybe even create a motor representation of an action in our brains. Mirror neurons are also believed to have auditory access to this representation as they can be activated by sound perception. Firing when the aim of a reaching-action was out of the monkey's view, they might even be able to generalize actions already having a motor representation in the brain [4] and to develop predicting qualities, as they, by firing before an action was finished, must have anticipated its aim [5]. Mirror neurons' indifference to scenes without an object or agent suggests that these two elements are crucial to their stimulation.

In 2010, Mukamel *et al.* provided the first secure evidence of the existence of a mirror neuron system in humans [7]. Although, for a number of ethic and medical reasons, the way this system functions and develops is still largely uninvestigated, scientists expect human mirror neurons to be similar to the ones observed in apes [5]. They suggest that mirror neurons either exist because they are an adaptation for action understanding or because they are a product of associative learning, developing when an action is observed and executed [8]. Beforehand associated with the ventral premotor cortex and the inferior parietal lobule only, Mukamel *et al.*'s electrophysiological studies proposed that mirror neurons exist in a number of regions of the human brain [7].

Today's state of research suggests that mirror neurons have influenced the development of speech in humans and are the mechanism behind action and intention understanding and action imitation. They are also believed to have a major influence on our social lives, as they seem capable of making us unconsciously mirror other peoples' body language, facial expressions and emotions [9].

2.1 Mirror neurons and language

As early as 1998, Rizzolatti and his colleagues suggested that mirror neurons constitute the basis for speech development in humans [10]. This hypothesis bases on the assumption that mirror neurons are an innate adaptation for action understanding. As such, their existence suggests a pre-existing brain structure which could have contributed to lateral speech circuit's evolvement. Neurons similar to the ones involved in the performance and observation of an action might thus also be involved in the perception and performance of a sound [11] and the link between actor and observer could easily be a link between the sender and receiver of a message too [10]. However, as little evidence for this assumption has been presented so far, Rizzolatti *et al.*'s hypothesis is still very controversial.

3 MIRROR NEURONS AND SOCIAL INTERACTION

Mirror neurons are believed to play a crucial role in interpersonal relationships and social interaction. In 2004, Rizzolatti *et al.* presented two hypotheses on the functional role of mirror neurons and suggested that they constitute a basis for action and intention understanding and action imitation [9]. More recent findings also show that this special class of neurons prompts people to consciously and unconsciously mirror their fellow human beings' body language, facial expressions and emotions [12].

3.1 Action and intention understanding

Action understanding, “the capacity to achieve the internal description of an action and to use it to organize appropriate future behavior”, is the first of mirror neurons' initial functions [6]. As it is considered to be one of social behavior's building blocks, a lack of mirror neurons is often associated with socially isolating diseases such as autism [3]. Action understanding is also essential to the survival and development of primates. If danger approaches and others turn to flee, understanding their behavior might be lifesaving. Similarly, understanding how others' crack a nut or use a tool enables us to imitate and learn useful skills.

Our ability to understand actions implies that mirror neurons are able to transform visual information of an observed action into knowledge allowing us to imitate it [9]. This happens whenever we are surrounded by other people. Watching them, mirror neurons are activated both when they accomplish tasks we have and have not been confronted with before. In the first case, they draw a motoric pattern

in our brains which allows us to imitate an observed movement in future instances. In the second case, this pattern is activated and enables us to understand what we are observing [12]. If we are more familiar with an action, we might even be able to foresee its aim as soon as the assigned motoric pattern is activated in our brains [5]. This understanding of our fellow human beings' behavior and intentions is important for social organization and facilitates human interaction. When approaching someone in a narrow street, for instance, we know whether they will move to the right or to the left to avoid walking into us before they have finished sidestepping. In consequence, we will turn to the other side. Occasionally, however, our mirror neurons misinterpret situations and the wrong motoric pattern is activated. In this case we will walk into the other person nevertheless.

3.2 Action imitation

In humans, a common consequence of action understanding is action imitation, as we – unlike most species – are able to learn by imitation [9]. As a result, we can acquire knowledge and abilities which, among others, allow us to fit into our society by assimilating to social movement. Mirror neurons thus contribute to learning what is appropriate in social interactions and to the transfer of mannerisms and allow children to follow behavioral rules which were never explicitly explained to them [13]. Action imitation might also lead to a shared scope of attention, also referred to as “joint attention”, which emerges when a number of people follow and pay attention to others' looks, which usually mark interest. This joint attention often creates a sense of belonging in humans [12].

Two forms of imitation learning prompted by mirror neurons can be distinguished: Firstly, they enable us to incorporate new patterns to accomplish tasks we have never been confronted with before. Secondly, in substitution, a motoric pattern we have formed a habit of can be substituted by a different – usually enhanced – pattern observed in someone else's behavior [9]. Mirror neurons thus, for instance, allow children to learn how to ride a bike by watching their parents and – at a later stage – to ride it without stabilizers.

3.3 Mirroring facial expressions and feelings

Recent studies showed that mirror neurons do not only fire when an action is consciously observed and performed, but also when we unconsciously notice other people's behavior and – consciously and unconsciously – are aware of their feelings and emotions. Mirror neurons, for instance, were recorded to show the same reaction when testees felt physical sensations, such as the pain experienced when cutting a finger, and when they watched others hurt themselves in a similar way. They also seem able to transfer emotions such as happiness, fear and disgust. Thereby, mirror neurons can change our constitution [12]. Additionally, they also influence our facial expressions and body language. Without thinking about it, we return an approaching person's smile, cross our legs when our counterpart crosses them, and laugh or yawn when we see someone else doing it [11]. We are not subjected to mirror neurons' influence, however, as we are able to inhibit reflexes triggered by their activation. Laughing and yawning, for instance, usually are not mirrored when we are unhappy and not tired. Imitation and resonance phenomena like these, which have been known and examined for a long time, finally seem explicable through mirror neurons.

Evidence is provided by scientists such as Ulf Dimberg from the University of Uppsala in Sweden and his colleagues. Showing their testees pictures of emotional human faces for five-hundred milliseconds each, they asked them to keep a straight face themselves. Nevertheless, cables registering every movement of their facial muscles showed that they failed not to smile or frown in response to the models' facial expressions. In most cases, Dimberg *et al.*'s testees did not even notice that they were reacting to the pictures [14]. Another study, conducted by Bruno Wicker *et al.*, concentrated on the transmission of emotions and showed that the observation of disgust activates neurons also activated when actually feeling disgusted [15].

4 MIRROR NEURONS FOR EDUCATION

As a basis for understanding actions and intentions as well as imitating actions, mirror neurons enable humans to learn by imitation. Because they also allow us to mirror body language, facial expressions and emotions, mirror neurons play a crucial role in our everyday and social life. At school, they are thus essential to children's development and their interpersonal relationships and contribute to a positive or negative learning environment. Still controversial theories about the development of student's self-consciousness, mirror neurons and the way they are influenced by stress and fear and mirror neurons' role in mobbing also address promotions and hindrances to children's wellbeing.

4.1 Imitation learning

When an observed action triggers our interest, we are motivated and plan or are told to imitate it, an intensified reaction of mirror neurons occurs, enhancing our ability to acquire new knowledge and skills [16]. Activated mirror neurons thus positively influence students' learning performances. This implies that a communication of knowledge fit to activate mirror neurons, i.e. a communication of knowledge which allows a form of imitation, should be targeted by teachers. Crafting a volcano with students to explain its structure, for instance, will activate their mirror neurons and help them understand more effectively than having them copy it from a book. Additionally, new learning contents should be presented in an interesting way to trigger an above-average reaction of mirror neurons. Students should also be motivated and allowed to apply newly communicated knowledge. A theoretical input, for instance in Chemistry, should therefore be followed by an experiment emphasizing the input's contents. Brain-based teaching methods meet all of these requirements and are an ideal way of ensuring mirror neuron's activation while teaching new learning contents.

4.2 Interpersonal relationships

Mirror neurons are able to influence interpersonal relationships in positive and negative ways by making humans – consciously and unconsciously – imitate others' body language, facial expressions and emotions. A returned smile, for instance, might encourage a person. A returned frown, however, can worsen an already difficult situation.

Relationships with their teachers and peers are an important part of every student's life. Ideally, these contacts are friendly and appreciative and contribute to a positive learning environment. Usually, student-teacher relationships are dominated by teachers and can therefore be shaped by them [16]. Being aware of the way mirror neurons work, teachers might thus be able to actively use them to create a positive atmosphere in class; for example by trying to mirror positive gestures, such as smiles and a relaxed posture, and avoiding negative ones, such as frowns and crossed or akimbo arms.

As emotions too can be conveyed from one person to another, a teacher's motivated, self-conscious and interested appearance can carry students along. Usually, however, a class consists of fifteen to thirty students, facing a single instructor. Through this distribution, it seems more likely that their emotions, which are often less motivated and interested, will be mirrored. In this case, being aware of the way mirror neurons work might help teachers block the transmission of such negative emotions. If teachers try to motivate their students through a positive appearance nevertheless, it might be helpful to start with concentrating on a small number of pupils, hoping that through joint attention their interest will be mirrored by others.

4.3 Student's self-consciousness, fear and stress, mobbing

A number of still controversial theories concerning the development of students' self-consciousness, the impact of fear and stress on mirror neurons and the role mirror neurons play in mobbing might also influence students' academic performances and social contacts at school.

In the past, a number of theories concerning the way student's self-consciousness, the "consciousness of one's own mental states, such as perceptions, attitudes, opinions, intentions to act, and so forth" [17] evolves have been presented. A recent hypothesis claims that mirror neurons strongly influence children's self-consciousness because they imitate and adopt good and bad habits observed in other people [1]. In this instance, teachers' influence as role models on their students might be more powerful than it is treated as at this juncture.

Recent studies also suggest that mirror neurons' activation is strongly connected to our emotional state. Fear, tension, stress and other negative feelings are believed to inhibit mirror neurons and thereby obstruct the learning by imitation process [12]. According to these discoveries, the creation of a relaxed learning environment in schools seems more important than ever.

Mirror neurons might even play a critical role in mobbing: Because they are essential to our social lives and fire whenever we are surrounded by other people, we are used to being mirrored by others and to mirroring them. In certain forms of mobbing, most common among teenagers, this habit is purposely disturbed. The excluded person is neither looked at nor reacted to and their body language and facial expressions are not mirrored anymore. Being socially isolated like this can be a traumatic experience leading to physical and mental illness [12]. Being aware of the way mirror neurons work might help teachers recognize this particular form of mobbing and intervene at an early stage.

5 CONCLUSION

In the early 1990s, mirror neurons were discovered by Giacomo Rizzolatti *et al.* in a monkey's premotor cortex. In 2010, evidence for their existence in the human brain was produced by Mukamel *et al.* Today, mirror neurons are considered to constitute the basis for action and intention understanding and action imitation. Debatably, they have also contributed to the development of speech in humans.

Even though the mirror neuron system in humans is still largely uninvestigated and future studies will have to further examine the reach of mirror neuron's sphere of influence, the crucial role these neurons play in our lives is beyond debate. Today already, we know that they enable people to understand observed actions and imitate them, thereby allowing them to learn by imitation, gain new knowledge and master new skills. Mirror neurons also seem able to predict intentions, facilitating everyday life within society, and contribute to interpersonal relationships and contact by transmitting emotions and making humans copy their fellow beings' body language and facial expressions.

Future studies of mirror neurons will certainly provide new insights allowing us to create a more positive learning environment for children at school and answer still controversial questions concerning mirror neurons' role in the formation of self-conception and mobbing and the impact negative emotions have on them. Nevertheless, improvements can already be achieved today. By applying brain-based teaching methods supposed to activate mirror neurons, for instance, students' learning performances can be enhanced. Similarly, raising teachers' awareness of mirror neurons' influence on interpersonal relations and the way they might shape them could also facilitate in-class communication and improve student-teacher relationships.

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