Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva / Italian Journal of Health Education, Sports and Inclusive Didactics - Anno 5 n. 2 - ISSN 2532-3296 ISBN 978-88-6022-411-8 - aprile - giugno 2021 - CC BY-NC-ND 3.0 IT - https://doi.org/10.32043/gsd.v5i2.379

I NEURONI SPECCHIO: L'IMITAZIONE UTILIZZATA COME STRUMENTO EDUCATIVO

MIRROR NEURONS: IMITATION USED AS AN EDUCATIONAL TOOL

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Abstract

Mirror neurons are currently a subject much treated by motor science due to their implications in sports disciplines and relative repercussions on teaching. The interest of Motor Sciences for this topic is obviously dictated by the fact that one of the main forms of learning is precisely that by imitation. Our motor system is no longer to be considered a mere passive executor of the impulses coming from the sense organs, but rather a system used to understand the acts of others, including the possibility of codifying the type, methods, times of realization and also the execution of an action. Mirror neurons therefore allow us to understand the intentional dynamics of the gesture, anticipating the outcome to which the initial movements of the observed subject correspond. Crucial to the recognition of intention is the context in which the action takes place. With regard to the aspect of learning through imitation, the student therefore has the possibility of easily imitating the gesture when it is part of his motor heritage. It is therefore legitimate to think that the technical proposals by the instructors must be made taking this fact into consideration.

I neuroni specchio sono attualmente un argomento molto trattato dalle Scienze motorie per la loro implicazioni nelle discipline sportive e relativa ricaduta sulla didattica. L'interesse delle Scienze Motorie per questo argomento è ovviamente dettato dal fatto che una delle principali forme di apprendimento è appunto quella per imitazione. Il nostro sistema motorio non è più da considerarsi un mero esecutore passivo degli impulsi provenienti dagli organi di senso, quanto semmai un sistema adibito alla comprensione degli atti altrui, includendo la possibilità di codificare tipo, modi, tempi di realizzazione e anche l'esecuzione di un'azione. I neuroni specchio consentono quindi di capire la dinamica intenzionale del gesto, anticipando l'esito cui corrispondono i movimenti iniziali del soggetto osservato. Fondamentale per il riconoscimento dell'intenzione è il contesto in cui l'azione avviene. Per quanto riguarda l'aspetto dell'apprendimento attraverso l' imitazione, l'allievo ha dunque la possibilità di imitare agevolmente il gesto nel momento in cui esso fa parte del suo patrimonio motorio. E' dunque lecito pensare che le proposte tecniche di noi Istruttori debbano avvenire tenendo in considerazione questo fatto.

Keywords

Mirror Neurons, Neuroscience, Posture, Learning.
Neuroni Specchio, Neuroscienze, Postura, Apprendimento.

Introduction

Understanding the neurophysiological basis of action, language and neuropsychological skills is due to the discovery of Mirror Neurons. These constitute a neural system from which the integration of sensory and motor information is obtained. In addition, they develop processes initially attributed to the cognitive system, such as the perception and recognition of actions performed by others, imitation and communication. These processes, thanks to the Mirror Neurons, recognize the primary neural basis in the motor system. Mirror neurons were initially discovered in the macaque's ventral premotor cortex. They are nerve cells that are activated both when the monkey performs a specific motor act, for example grasping a piece of food, and when it observes another individual performing an identical or similar motor act (Rizzolatti & Craighero, 2004). These neurons have been defined as Mirror Neurons, because the observed action seems to be reflected, as in a mirror, in the neuronal structure responsible for the motor representation of the same action by the observer (Buccino, Solodkin & Small, 2006). Being motor neurons, mirror neurons are activated exclusively in association with a motor act (e.g. grasping), as do other neurons of the premotor cortex. Other studies (Kohler et al, 2002) have identified the activity of these mirror neurons also within an audio-motor system. There are therefore two properties of which Mirror Neurons are characterized: the first is the reaction to sight, or to sound, of meaningful actions; the second is represented by their activation during the execution of the same actions.

Mirror neurons have been observed in a primate brain area corresponding to Broca's area in humans (Kohler et al, 2002). The development of the human brain region dedicated to linguistic production is located within the long evolutionary process of the frontal cortex that began in non-human primates (Petrides et al, 2012). Some research carried out thanks to Positron Emission Tomography (PET) on humans during the act of grasping an object has shown that the brain areas activated were those of the superior temporal sulcus and the posterior part of the lower frontal gyrus of the left hemisphere: the latter constitutes the Broca area (area 44) (Gallese et al, 1996). In humans, the mirror system (Buccino et al, 2001) is organized in a somatotopic way: the observation of actions performed by others with the hand, mouth or foot activates distinct regions of the fronto-parietal motor system, which are activated in the 'perform the same action. Mirror neurons also respond to only mimic motor acts, they are able to select both a specific type of act and the sequence of movements that compose it. The actions are therefore codified at the cerebral level also in terms of "aims" and not only on the basis of the movements that compose them or the type of effect with which they are performed. Our brain therefore recognizes the "intentions". It follows that the concept of specificity, in sports, cannot refer only to the form of the movement but also, and above all, to its purpose. (Doidge, 2007). It is therefore essential to know the mechanisms of the functioning and capabilities of mirror neurons in order to use them as a motor learning technique by carrying out targeted and effective teaching (Lucariello, Donini & Tafuri, 2019).

1. Imitation and learning

At the base of the imitation there is a sequence formed by the ventral premotor cortex and the posterior parietal cortex, together with the visual inputs coming from the posterior part of the superior temporal sulcus, whether it is simple movements or for complex and organized motor patterns typical of the forms. of human imitation (Iacoboni et al, 1999). Motor imitation is a cognitive function that involves observation, motor imagination and the execution of action (Buccino, Solodkin & Small, 2006). The neural basis and functional mechanisms of this faculty are poorly understood. Since their discovery, researchers have wondered if Mirror Neurons could be the basis of imitation (Rizzolatti & Sinigaglia, 2006). According to experimental psychologists, imitation would be the ability of an individual to replicate an act after having seen it done by others, because it already belongs to her motor heritage; according to ethologists, on the other hand, imitation presupposes that through observation, an individual learns a new pattern of action and is able to reproduce it in detail (Rizzolatti & Sinigaglia, 2006). According

to the first theory, imitation is based on a mechanism that directly associates the observed action to the internal motor representation of that action ("direct matching hypothesis"). Iacoboni and colleagues (Iacoboni et al, 1999), confirmed that the Mirror Neuron System is involved in the imitation of acts already present in the observer's motor vocabulary, suggesting an immediate motor translation of the action itself. The activation of the right anterior parietal area during the observation of the action would indicate the formation of a kinesthetic copy of the movement to be imitated, so that it can be memorized and repeated. The lower left frontal area would be activated, however, following the observation of the actions, but with the aim of understanding their meaning. It can be concluded that the lower left frontal area (where Broca's area is located) encodes the purpose of the movement without defining the precise details of the motor sequence; while the activation of the right anterior parietal area reflects the coding of precise kinesthetic aspects of the action to be imitated. Learning via imitation would result from the integration of two distinct processes: the first should allow the observer to segment the action to be imitated into the individual elements that compose it, or to convert the continuous flow of movements seen into a series of acts belonging to its motor heritage; the second should allow the motor acts thus codified in the most suitable sequence so that the action performed reflects that of the demonstrator (Byrne & Russon, 1998; Byrne, 2002; Byrne, 2003). The Mirror Neuron System discharges in response to the individual elementary motor acts that make up the observed action; it is assumed that through this mechanism the action seen is divided into its elementary components and coded from the motor point of view. When the action to be imitated corresponds to the single elementary act already present in the mirror neuron system, this act can be immediately sent to the brain structures responsible for movement and replicated. No learning of any kind occurs in this type of imitation (Iacoboni et al, 1999). When imitation requires the learning of a new motor pattern, an additional mechanism is required. It is assumed that this type of learning mechanism consists in the recombination of the observed motor acts in a new motor pattern. The "true" imitation, therefore, would consist of two well-defined steps: the encoding of the individual elementary motor acts of each complex action, by the Mirror Neuron System, and the recombination of these encoded acts into a new motor pattern so as to be able to replicate the observed action.

Buccino and colleagues (Buccino et al, 2004), dealt with defining the neural substrates at the basis of learning by imitation and responsible for the recombination of elementary motor acts in a new motor pattern. They demonstrated the involvement of the left dorsolateral prefrontal cortex (Brodmann area 46) mainly during motor preparation for imitation execution. By this area, individual motor elements, already present in the Mirror Neuron System, are selected and combined into a new motor pattern.

The Mirror Neuron System is therefore involved during the early stages of learning by imitation. When imitative behavior is required, the new actions to be observed are broken down into familiar micro sequences through the motor resonance of the Mirror Neuron System (Buccino et al, 2004). Combinations of such micro-sequences into new configured actions proceed under the supervisory control of the left dorsolateral prefrontal cortex. As we have seen, the subject who imitates a gesture can do it more easily if it is already part of his motor heritage. Therefore educators, coaches or instructors must know the importance of learning through imitation. In order to achieve rapid and effective learning, learners must have already known or experienced movement patterns. In fact, the more motor experiences have been made, the more teachings can be linked to these, even specific to various disciplines. The ease of imitation becomes greater if the student recognizes its meaning through a reflection that occurs within it. The more what is observed is partly known, the greater will be the performance of the athletic gesture. It is therefore important, from an early age, to include exercises not always inherent to the specific activity in the training schemes, to provide students with the basic motor schemes on which to later build the specific techniques of the discipline.

Since learning by imitation consists in repeating what is observed in ourselves, and that this can happen if there is a shared motor heritage, it is clear that what is taught is never completely

new. In school age, as movement educators, one can come across pupils who understand and replicate actions with marked immediacy; they are subjects who learn "by insight", a characteristic that implies uncommon psycho-physical qualities and mechanisms, linked to a specific genetic patrimony of that person. That said, it is important to consider that it is not always appropriate and effective to ask a student to imitate a technique: he may not be able to reproduce it, neither from the motor point of view nor from the attention one, especially if that technique does not reflect his motor heritage.

2. Stages of imitation

Mirror neurons, as already mentioned, give us the possibility of encoding intentions, and also the result of an action, since, more than mere gestures detached from a specific context, mirror neurons encode actions. Therefore the demonstration of a technique to be imitated must be divided into several phases in order to create the best didactic communication strategy for an easy and effective learning of our students.

1) Mirror neurons have the ability to distinguish the type of action observed in reference to the purpose, that is to encode the "intentions". Therefore, showing the action in its entirety without fragmenting it into sub-movements should help to understand the intention of the person showing the action and also to predict the final result. To further understand the intentions of the performer one can show the action in a broader general context. For example, it is possible to use a "postural training" context by asking only to observe, without imitating, to allow the student to first create the image of the movement and then understand the meaning, the end, the purpose. The technique will be performed standing still, highlighting a few salient inputs and focusing the students' attention on them. Charles Edward Beevor (1854-1908) English neurologist and anatomist, in addition to various discoveries, coined the so-called "Beevor's Axiom" according to which the brain does not know the single muscle and its action, but the movement in general (Beevor, 1903) . This does not mean that the more detailed exercises should not be performed, but only proposed later, clarifying the meaning and purpose, to allow the student to reconnect the exercise to the complete technique.

2) To induce a right perception in the student, the technique must be shown at the right speed. If it were done too quickly the student could not record the image correctly, instead a too slow execution could distort the demonstration with respect to the real image that is intended to be given.

3) The technique must be performed in the perspective from which the student will then have to repeat it. If the teacher places himself in front of the students, they will repeat it on the opposite side, that is, in a mirror image. It is therefore advisable to place oneself from the same angle as the pupil, or to have the pupils positioned in the right way. One study showed that the first-person perspective is the one that determines the best performance, thus confirming the importance of perspective in motor learning (Jakson, Meltzoff & Decety, 2006).

4) Numerous evidences show that if it is made clear to the students that the observed technique will also be reproduced, the attention will increase more than what can be activated during the simple observation of an act, without having to worry about having to repeat it. Therefore by directing the concentration on the essential points of understanding the action, the mirror system is more activated. At the same time, high-level cognitive processes are also activated which lead to a more stable memorization of the action itself. The objective of the action must be clearly stated in order to achieve significant motor action.

5) The educator must be aware of what happens when a new gesture is taught to a student, who is not yet part of his motor repertoire, and of what to do to improve learning. The mirror system is activated even in the presence of movements foreign to our motor heritage, creating, at the neurological level, a first image of the movement. This involves an activation of cognitive and attentive processes that the student must be able to put into practice. The possibility or availability that can make that gesture depends in part on the will or not to do it, but above all on the degree of neurophysiological maturity that is available at that time.

In practice, mirror neurons in the observation of a motor act not present in our repertoire, are activated first by breaking into several fragments of the observed act, then recomposing it in the appropriate temporal sequence. Each fragment corresponds to a movement already stored, and through the collaboration of other frontal areas, all the pieces are reassembled to allow the reproduction of the gesture and a new motor pattern. The teacher must know how to direct the attention of the students and support their motivation. In case of motor, attentive, cognitive limits of the students, it must understand whether to continue or change tactics of training, waiting for more favorable moments or acting in other ways.

6) If one observes an individual learning a new gesture, it is natural to note that the goal set is not reached in the first attempts, where the executions are coarse or wrong. All this is explained on the basis of the principle that the individual does not yet have a scheme that allows him to properly use the necessary motor program. The mirror neurons are used to imitate a gesture through the creation of an image, a neurological trace in our brain, then the movement will then be perfected through repetitions, that is with the learning by trial and error.

The student will have to perform "conscious repetitions" to be able to appreciate the corrections of the teacher or to self-correct and thus avoid mistakes or engine defects difficult to correct.

Learning is therefore not only attributable to the mirror system, but also to the work of trial and error, which helps to move from raw coordination to fine coordination.

However, it is equally clear that both imitation and error learning have proven efficacy if students are neurophysiologically mature for this type of methods. An important role is played by two functions belonging to the area 46 of Brodmann: 1) the recombination of the single motor actions and the definition of a new pattern of action, as much as possible corresponding to that explained with examples from the demonstrator; 2) the supervisor of the mirror system, that is the ability to inhibit or facilitate the activation of such a system.

Area 46 of Brodmann is therefore a kind of executive body of the mirror system, which therefore decides when it should enter into action or not.

7) The educator does not merely observe the gesture of a pupil, but repeats it internally. When you analyze a gesture with careful competence, this activates in our motor system the program of the movement examined. Thanks to the action of mirror neurons, the observed movement is recreated internally automatically. So the teacher, observing the movement of one of his students, thanks to the mirror system is able to process the entire gesture by comparing it with his own (that is reliving it inside) and from this notice the errors or imperfections, that is, all those aspects that differ from one's own execution, which is supposed to be the correct one. Finally, it is important that the educator knows that movement well in order to make the right corrections to the act of the student.

8) In imitating the gesture the visual aspect generally predominates, but it must be considered that this must be accompanied by verbal instructions consistent with what is shown. If this does not happen, the students will repeat the observed movement and not what they will hear, causing a probable error in the execution. The verbal indications must be few and concentrated on aspects of the technique, without insisting on the details that will be proposed and refined later. The ability to share, a movement or a word, or a noise, continues to be the basis of the mirror system operation. If what the instructor says, that is, his language, approaches that of his students, they will be able to understand its contents, that is, to share its meaning, its meaning. For example, to get the attention of children it is enough to explain referring to games, animals, environments close to them, familiar, known, rather than express themselves with a technical language, descriptive of the movement. Even our verbal commands can be filled with contents close to them, in which they can mirror, find, with which there is a correspondence. Even noises and sounds can easily activate the mirror system: from studies done in basketball, for example, there is a recognition of what is happening based on the perception of the sound of the ball, how it bounces, the sound in the way you grab it etc. It is also important to keep in mind that the level of understanding of a child is different from that of an adult: the adult can rely on an abstract

thought, able to perform complex operations, to abstract concepts and apply them, the child is based on a less complex thought, not being yet able to reason on data presented in purely verbal form. Therefore, the educator will have to distinguish between adult students (from adolescence onwards) and children, adapting their language and verbal explanations to them.

9) The space that surrounds us, both the closest, peripersonal, and the farthest one, that is to say, to reach, takes on different meanings depending on the actions you intend to do or think about these spaces. These different perceptions of near and far can vary according to the possibilities of action that the individual possesses within this space, thus reshaping the concept of near and far, depending on the interaction with the space and / or with the objects contained therein. The possibility of interacting with objects changes the perception of peripersonal and extrapersonal space, a distant balloon, one approaching, one very close, one launched slowly, one launched quickly ... Because space is here too, a space of meaning, it is a space that evokes potential actions, it is therefore an interpreted space, according to the motor skills and according to the discipline of reference, or more simply according to the life experience.

10) Between the teaching methods and the possibility of receiving them from the students, we distinguish the inductive method and the deductive method. In inductive methods knowledge starts from the subject, while in deductive methods it starts from the object. In deductive methods the teacher is at the center, dictates what to do and how to do it, through examples, demonstrations to imitate. In inductive methods a freer learning process is supported, where the performance of the task is conditioned by the subjectivity of the student, where the teacher certainly gives 'deliveries, but also leaves the freedom to perform them in their own way. The learning by imitation obviously re-enters in the deductive methods, in how much the movement is replicated, imitated beginning from that shown from the teacher, therefore from the technique. While in inductive methods the process is inverse, one arrives at the technique through a process of experimentation by the student. It's the process, in this case, that interests us and that needs to be supported, even by changing deliveries from time to time.

3. Neuroni a specchio, empatia e apprendimento

According to some scientists the discovery of Mirror Neurons could explain the phenomenon of empathy, because the neuronal structures involved in the sensations and emotions seem to be the same that activate when we attribute to someone else those "same" feelings and emotions, allowing us to grasp the experience of others. According to some studies, (Welsh, 2005) at the base of empathy there would be a neurological process called "incarnate simulation", that is a mechanism of motor nature, very ancient from the point of view of human evolution, characterized by a series of neurons that would act immediately before properly cognitive processing. This mechanism establishes a direct link between the agent and the observer, as both the agent and the observer act in an "anonymous" and neutral manner. The emotion of the other is constituted by the observer and understood thanks to a simulation mechanism that produces in the observer a body state shared with the act of that expression. It is precisely the sharing of the same body state between observer and observed to allow this direct form of understanding that we could define "empathy". By now numerous studies attest to the role of mirror neurons in the recognition of emotions, in which the association between perception and action is even closer in order to regulate the strategies of adaptation to environmental events. These circuits download only if it is an agent subject, "regardless" of whether that subject is the one who observes the scene or the one who is observed (Welsh, Migone & Eagle 2006). A same neural circuit, which partly coincides with the ventral premotor cortex and includes the amygdala and the insula, in particular its anterior region, is activated both during observation and imitation of facial expression of basic emotions, fear, anger, happiness, disgust, surprise, sadness. Perception and active production of expressive manifestations would therefore have a common basis. In psychology, empathy is the ability to pose immediately in the mood or situation of another person, with no or little emotional involvement. In the human sciences, therefore, empathy designates an attitude towards others

characterized by a commitment to understanding the other, excluding any personal affective attitude (sympathy, antipathy) and any moral judgment. The recent studies on mirror neurons discovered by Giacomo Rizzolatti, confirm that empathy is not born from an intellectual effort, but is part of the genetic makeup of the species. An educator, whatever subject he teaches, will in no way fail to also give information about himself, what he feels, what he is. Paul Watzlawick, an authority in the treatment of human communication, tells us that "it is impossible not to communicate"explaining that communication always has two aspects, that of news, and that of relationship. Although the teaching task requires that any subject be explained, this will never be the only one. The human factors that we have mentioned above, make a teacher be perceived as sympathetic, obnoxious, affable, authoritarian, despot, available, etc. ; the teacher will therefore be recognized and connoted also, or perhaps above all, for his human characteristics, as well as for his competence or not in the subject he teaches. So the educator can leverage the empathic abilities of the students, and their own, to facilitate them in their task of learning. Another side of empathy is that for which students very often will be led to imitate the educator also in his beliefs, in values, in what they really are and manifest. A person who becomes part of a group needs to be accepted, and in order to be accepted, must share its core values. This behavior is born from a biological factor: we start with the family, to make our educational model of the family certainly not for a reasoned and considered choice, but for the biological need to be part of our family system, Because that family spawned us, raised us, nurtured us, cared for us, so deep down it is as if the family system were indisputable. It's the survival instinct that leads us to adapt, the one that from the very beginnings of humanity has led us to form into social groups so that we can better face the dangers of the world, because mankind, If it were made up of individuals and not groups, it certainly would not have survived. Moreover, we are born in a first natural social group, which is precisely that of the family, so we are biologically predisposed to be with others, and to do this we obviously renounce a part, some part of our individuality. The main problem is that when learning is no longer about survival per se, when teaching also takes on certain educational precepts, the question arises of personal influence on individuals and groups, keeping in mind, that the educator becomes a leader. The winning weapon that can outline the success of an educator lies in the ability to choose. Whether it is a question of choosing a teaching method, a style of power management, an attitude to be used on the most disparate occasions, this ability to choose is not only part of the competence of a teacher as the bearer of a subject, but also and above all in his being an educating person, who as such will have a great influence on his students and generations to come.

Conclusions

This work has shown that when it comes to learning by imitation, since imitation is not immediate or at least relatively easy (as in the case of imitation of partly known movements, that is, which belong at least partly to the student's driving programs), important attentive and cognitive processes take place, on which the students must be able to leverage. Furthermore, imitating is not enough, since imitation must then follow the exercise, learning by trial and error, which also presupposes a maturity on the part of the student, who must from time to time "control" the movement and do not repeat it automatically. Finally, all this is not always available to students, not so much because they are malicious, rude or distracted, but because they have not yet matured those neurophysiological, attentive and cognitive processes that underlie this type of learning. Therefore, for a teacher, it would seem appropriate and effective to be able to leverage inductive methods, which start from the student's reality and conform to it, through targeted exercises that are suited to their level, to their real abilities. Not because, of course, deductive methods are wrong, but because sometimes they seem not to be effective, they don't seem to be the best way to arrive at a result.

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