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Mirror Neurons and Their Effect on Social-Emotional Learning

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Abstract

Mirror neurons are neurons which fire not only when an individual exhibits a behavior, but also when observing a behavior (Cattaneo & Rizolatti, 2009; Williams et al., 2001). Mirror neurons play a functional role in theory of mind, emotional recognition, empathy, acquisition of language, predicting intention, and imitation (Cattaneo & Rizzolatti, 2009; Acharya & Shukla, 2012; Goleman, 2006). We can use mirror neuron and learning theories to effectively teach social-emotional skills. However, we must give special consideration to students on the autism spectrum, as it has been hypothesized that autism is influenced by neuron system dysfunction (Williams et al., 2001)

Introduction

Neurons are the most basic, and essential units of the nervous system (Simon et al., 2010). They are a fundamental part of the brain, both structurally and functionally. A human brain contains about 100 billion neurons, all connecting to form complex networks, which allow humans to have motor movement and perception, as well as the ability to learn and remember (Simon et al., 2010). Motor, sensory, and interneurons have been studied in depth, but recently, there has been fascination around mirror neurons as we are discovering the significant role they play in learning. Mirror neurons are unique in that they fire not only when an individual does a motor task, but also when an individual observes a task (Cattaneo & Rizolatti, 2009; Williams et al., 2001). Whereas motor and sensory neurons only fire when doing or observing a task, but not both (Kilner & Lemon, 2013). Research suggests the same theories apply for emotions and facial expressions (Wicker et al., 2003; Acharya & Shukla, 2012), which implies an innate understanding of emotion.

Mirror neurons were originally discovered in monkeys over 20 years ago, and similar brain activity has since been observed in humans (Kilner & Lemon, 2013). Mirror neurons are not an independent system, but instead a complex network of connections involving various areas of the brain (Catteneo, 2009). In the human brain, mirror neuron activation has been found in the premotor cortex, supplementary cortex, primary somatosensory cortex, and parietal lobe (Acharya & Shukla, 2012). The location of the activity is significant because it includes parts of the brain involved in motor movement and sensory perception.

Research suggests mirror neurons develop in infants before the age of one year and supports the innate social nature of humans (Acharya & Shukla, 2012). Mirror neurons provide a direct relationship between an individual sending a message and the receiver (Acharya & Shukla, 2012). The mirror neuron system allows humans to understand the actions and emotions of others. Mirror neurons play a functional role in theory of mind, emotional recognition, empathy, acquisition of language, and predicting intention (Cattaneo & Rizzolatti, 2009; Acharya & Shukla, 2012; Goleman, 2006.).

Theory of Mind

Mirror neurons have been linked to a significant development in social cognition, Theory of Mind (ToM) (Gallese & Goldman, 2008). ToM is the understanding that other people have thoughts and feelings, which may differ from your own (Astington & Dack, 2008). Having ToM allows us to recognize and attribute mental states in ourselves and others (Gallese & Goldman, 2008). Typical ToM development in children can involve joint attention, copying others, recognizing emotions, understanding cause and consequences, and engaging in pretend play (Astington & Dack, 2008).

There are two theories which attempt to explain the execution of ToM. The Theory-Theory is based on the idea the individuals naturally attempt to understand and explain their surroundings (Goldman, 2012). Simulation Theory postulates that ToM involves creating an internal simulation, in which we can understand the perspective of someone else (Oberman & Ramachandran, 2007). Mirror neuron activity supports the Simulation Theory. Mirror neurons allow us to understand other people's actions and emotional states by firing when we observe those behaviors (Gallese & Goldman, 1998). This ability to understand others is essential to social cognition; to recognize and understand actions, emotions, and intentions, we must first understand that other people have different perspectives.

Emotion Recognition and Empathy

Mirror neurons have been linked with emotional recognition and empathy. FMRI scans have shown mirror system activation during the observation and imitation of facial expressions of basic emotions (Wicker et al., 2003), suggesting an association between mirror neurons and emotions. According to Enticott and his colleagues (2000), facial emotional processing, or the ability to identify emotion, is significantly correlated with mirror system activation. Mirror neurons provide an internal simulation of an observed facial expression during facial emotional processing (Gallese, 2006; Endicott 2008). Observing an emotional display activates neural connections similar to that of feeling the emotion, therefore assisting in the identification of that emotion (Bastiaansen, 2009; Wicker et al., 2003). This finding provides humans with a centralizing process for understanding others (Wicker et al., 2003).

When two individuals interact, their emotional states influence each other. Witnessing an emotion activates a similar neural response to feeling that emotion, allowing an understanding between individuals (Bastiaansen, 2009). This not only protects humans, by

recognizing emotions such as pain or anger, but it also provides understanding for empathy. Furthermore, in a self-reported study, individuals who reported being more empathetic showed stronger activity in the mirror system (Acharya & Shukla, 2012).

Not only can observing an emotion cause an emotional state in the observer, but it can also affect their motor behavior, as seen in facial mimicry (Bastiaansen, 2009). Facial mimicry is the tendency to imitate facial expressions and serves as a social tool (Rymarczyk et al., 2016). This finding can be a crucial for learning, as it indicates humans have an automatic understanding of emotions and actions in others (Bastiaansen, 2009). Children can learn appropriate emotional recognition and expression by observing others.

Understanding Intention

When observing an individual, we must consider what they are doing and why. Mirror neurons provide a neural mechanism to understand actions, emotions, and intentions (Kilner & Lemon, 2013), which is fundamental to social behavior (Iacoboni et al., 2005). It is essential to understand the actions of others in order for humans to survive (Rizzolatti & Fabbri-Destro, 2009). Mirror neurons help us to understand intention and anticipate the actions of others (Acharya & Shukla, 2012). This was exemplified in Cattaneo's study (2007) where children observed an experimenter who picked up a piece of food and either raised it to his mouth or placed it into a container. An activation of the mouth-opening muscles occurred in the observer when the piece of food was brought to the experimenter's mouth, but not when it was placed in a container. The observers never saw the experimenter eat the food, however, they could predict what the experimenter intended to do. This suggests humans have the automatic ability to understand the actions of others.

If we know a person's intentions, we can usually predict their actions or, if we see an action, we can often reason backwards to what their intentions must have been (Meltzoff et al., 1999). Iacoboni and his colleagues (2005) took fMRI scans of 23 individuals as they observed an action with different intentions. The first situation showed an organized table with plates and cups; the action was to grasp the cup, and the intention was to drink from it. The second situation showed a messy table; Again, the action was to grasp the cup, but the intention was to clean it up. The action was always grasping the cup, but context and intention varied. FMRI scans indicated the activation of the mirror neuron system during observation of action and intention contexts. Moreover, there was significant increase in activation during the intention condition. This suggests the mirror neuron system not only plays a functional role in action recognition, but also in understanding intention (Iacoboni et al., 2005).

Similarly, an emotional reaction to an action can help us understand intention (Meltzoff, 1996). In Meltzoff's 1996 study, children, aged 18-36 months old, observed an adult preform an action which was followed by an emotional reaction. The action preformed was always putting a toy on a shelf which then fell over, but the adult would then act happy/satisfied or unhappy/dissatisfied. Based on the adult's reactions, 36-month old children could understand what the adult intended to do. If the adult reacted in happy manner, the children would perform the same action and let the toy fall over purposely. However, if the adult's reaction was unhappy, the children would successfully put the toy on the shelf, even though this was not what they observed. This indicates humans as young as 36-months old can reason backwards and clarify intended actions based on an emotional reaction.

Imitation and Observational Learning

Mirror neurons provide a neural basis for imitation and observational learning (Myers, 2012). Imitation begins in infancy with children copying what they see, such as reaching for a toy, attempting to walk, or looking in the same direction as others. In Meltzoff's study (1988), infants learned how to use objects through observing and imitating; No reinforcement or shaping was used. In the experiment, 14-month-old infants were shown how to perform particular actions with six different objects but were not allowed to touch the objects and were never told to "copy" or "follow" the demonstrator. After a one-week delay, the infants imitated similar actions with the six objects. This finding indicates the importance of imitation in learning.

While imitation only requires replicating a viewed behavior, behaviors can also be specifically modeled to be learned. Observational learning is simply learning by observing events or individuals and their consequences (Myers, 2012). Bandura's Social Cognitive Theory and the operant learning model are the basis of observational learning (Chance, 2012). The social-cognitive perspective focuses on how behavior is influenced by social interactions and cognitive processes (Meyers, 2012). Bandura (1986) theorized that behavior, cognition, and environmental factors all interact and operate together.

Operant learning involves the association of actions with consequences (Skinner, 1938). If a behavior is followed by a reward, the likelihood of that behavior reoccurring increases, whereas if the behavior is followed by a punishment, the likelihood decreases (Meyers, 2012). Consequences can be given via the environment or by other people, suggesting students can be shaped by reinforcement. Children will often observe, imitate, and then receive reinforcement, strengthening the likelihood of the child doing the task again.

Observational learning evolved to facilitate the distribution of new ideas and methods of problem solving to improve chances of human survival (Chance, 2014; Dandurand et al., 2004). Doreen Thompson and James Russel (2004) conducted an experiment in which children aged 14-26 months solved a problem by watching a model. The children observed a model pushing a mat away which caused a toy to come closer. Children who observed the demonstrations were three times more likely to get the toy, and get it quicker, compared to the children who attempted to figure it out on their own. When one person solves a problem, many others can benefit.

We can also learn how to behave and express emotion through observation and imitation. We learn to respond in a particular manner by observing how others act (Bandura, 1971). Bandura's most famous study (1961) was the Bobo doll experiment. This study showed that children who watched adults behaving aggressively (hitting a Bobo doll) were more likely to behave aggressively themselves. While the Bobo doll experiment replicated negative behavior, it suggests we can teach new behaviors through observational learning (Bandura et al., 1961).

Observational learning can be reinforcing. As previously stated, an observer watching a behavior and its consequences can strengthen the observer's inclination to behave similarly if it has positive consequences (Chance, 2014). If we pair imitation and observational learning with mirror neuron theories, we can more effectively teach social and emotional skills. Furthermore, if we consider Donald Hebbs theory of synaptic plasticity, which proposes that synapses strengthen through repeated simulation (Acharya & Shukla, 2012), just observing others strengthens our own neural connections.

Benefits of Social-Emotional Learning

Emotions can improve or impede children's academics, work ethic, and ultimate school success (Durlak et al., 2011). Unfortunately, many students lack social-emotional abilities, causing them to become less connected to school as they advance from elementary to middle to high school (Payton et al, 2008). Lack of connection to school can negatively affect academic performance and behavior (Blum & Libbey, 2004). We want to prepare our students for their future academically, socially, and emotionally (Payton et al., 2008). Social-Emotional Learning (SEL) provides a variety of benefits for our students. SEL involves self-awareness, stress and anger management, empathy, conflict resolution, and responsible decision-making (Goleman, 2006).

There is a vast amount of research to support SEL programs and their efficacy across diverse groups of individuals. Moreover, most programs fit effortlessly into standard classrooms (Blum & Libbey, 2004). Durlak et al. (2011) conducted a meta-analysis of 213 school-based, universal teacher-led SEL programs. The study involved 270,034 children, ranging from kindergarten to high school students. SEL program participants demonstrated significantly improved social and emotional skills, attitudes, behavior, and academic performance compared to control groups. All programs within the meta-analysis were teacher-led, suggesting SEL can be implemented in any classroom and should be easily accessible. SEL can clearly be taught, modeled, and practiced, and only requires a skilled demonstrator, such as a teacher (Dandurand et al., 2004). Also, the wide subject pool indicates that SEL programs are effective for children of all ages, learning levels, and backgrounds.

Payton and colleagues (2008) also conducted a large-scale review, comparing 314 studies involving 324,303 children in elementary and middle school. They reviewed SEL programs

which were implemented in school and in after-school programs. This study demonstrated that SEL programs are effective for students of all racial and ethnic backgrounds, and in rural, urban, and suburban settings. Furthermore, programs implemented were beneficial to students with and without behavioral and emotional problems. Despite the many differences between the subjects and settings, those who were involved in SEL programs exhibited increased social-emotional skills, attitudes about self and others, connection to school, and academic performance, while conduct problems and emotional distress reduced. SEL programs improved achievement test scores by 11-17 percentile, providing evidence for its educational benefits. Research clearly confirms the multiple advantages for SEL. We should be using this information to help our students.

Social-Emotional Learning in The Classroom

Learning theories and the mirror neuron theory can be combined to effectively teach social-emotional skills. Mirror neurons play a large role in social-emotional processes, and their activation increases neural plasticity (Acharya & Shukla, 2012). Students can effectively learn social-emotional skills through exposure to appropriate behavior and social interactions, paired with the natural firing of mirror neurons, and reinforcement.

An engaging and supportive classroom is the best environment for learning (Goleman, 2006). To create a positive social culture within our schools, we must start with the leaders. The tone of a room is often set by the most powerful person there (Goleman, 2006). In a school setting, this would be the principal or teacher. Leaders have the ability to create a positive environment, conducive with learning (Goleman, 2006). The leaders of our schools influence the teachers who in turn influence the students. All our social and emotional interactions, both positive and negative, affect how and what we learn (Durlak et al., 2011).

The culture of the school, the norms and habits exhibited by teachers and leaders, impact how the students behave (Goleman, 2006). Leaders in education can use their position to adapt their school culture and demonstrate positive learning environments.

Teachers can provide a safe space in which their students feel comfortable and confident. Teachers are not only leaders, but models for their students. Teacher behavior and level of positivity and understanding set the tone for the entire classroom and demonstrates how the students are expected to act (Weissbourd & Jones, n.d.). Positivity and excitement while teaching will set an example for students. Observed emotions can be mirrored (Bastiaansen, 2009), thus the students will feel happier and more confident while learning too. We learn by observing others (Bandura, 1971), meaning teachers can demonstrate appropriate reactions to situations and how to manage emotions. Teachers can model the five core competencies of SEL: self-management, social awareness, relationship skills, and responsible decision-making (Anderson, 2015).

Social-emotional skills can also be taught through discussion. Providing students with an opportunity to share their thoughts and feelings can create a sense of openness and understanding. We can utilize class discussions to demonstrate the differences between everyone, including different points of view, culture, race, and religion, as well as the similarities that bring us all together. Empathy begins with the ability to understand other perspectives (Gallese & Goldman, 2008). Children are born with the capacity for empathy but must practice it like any other skill (Weissbourd & Jones, n.d.). The classroom is a diverse environment which can provide students with opportunities to understand and care for individuals who are different from them.

Self-reflection can also be utilized to improve social-emotional competency. Allow time for students to express and think about their behaviors and emotions. Teachers can prompt

questions such as why a student acted in a certain manner, how it affected the student and others, how it made the student feel, what could they have done differently, etc. Sch probpts can assist in the practice of seelf-management and responsible decision-making which are two key aspects to SEL (Anderson, 2015).

Obtaining social-emotional skills is a gradual process. Appropriate social interactions evolve through elementary, middle, and high school students, whom all have very different levels of social and emotional abilities. The Resource Guide on pages 20-23 provides tools for teachers to assess social-emotional competency in themselves and their students, as well as age-appropriate activities to practice SEL in the classroom.

Autism

We must take into consideration students who are on the autism spectrum. Autism spectrum disorder (ASD) is a complex, neurological disorder characterized by deficits in communication and behavior (Perkins et al., 2010). It has been hypothesized that ASD may be, to some extent, impacted by neuron system dysfunction, which can explain the failure to develop social skills (Williams et al., 2001). In child development, mirror neurons facilitate the early imitation of actions, language, and ToM; Failure to develop an effective mirror neuron system may therefore impair development (Williams et al., 2001). Vivanti and Rogers (2014) suggested there are three main aspects of social learning which may also involve mirror neurons: mapping and understanding of behavior of others, motivation for social interaction, and appropriate use of social learning. All three of these abilities tend to be lacking in individuals with ASD.

Autism is dimensional causing individuals to experience a variety of different symptoms. ASD involves a reduced, or atypical, involvement in social interactions (Vivanti & Rogers

2014). Social learning dysfunction can affect joint attention, affect sharing, goal understanding, language, and pretend play (Vivanti & Rogers, 2014). Baron Cohen et al. (1985) suggested individuals with autism may lack ToM altogether, which can, in part, explain the deficits in social abilities. ASD is also associated with imitation dysfunction and delayed or abnormal language (Oberman et al., 2005). Imitation dysfunction can include repetitive behavior and speech, as well as mimicking without regard to meaning (Williams et al. 2001). Such findings suggest an underlying neural dysfunction.

Furthermore, individuals with autism have shown decreased activation within the mirror neuron system. Dapretto (2005) observed reduced mirror neuron activity when individuals with ASD underwent fMRI scans while imitating and observing emotional expression. Mirror neuron activity was inversely related to symptom severity, suggesting mirror neuron dysfunction may underlie social deficits in ASD.

EEG has also been used to confirm lowered mirror neuron activity in individuals with autism. Mirror neuron activity is thought to be represented by EEG oscillations in the mu frequency (8-13 Hz) within the sensorimotor cortex (Oberman et al., 2005). In typically developing individuals, the mu frequency decreases when performing or observing an action. Oberman and her colleagues (2005) measured mu frequency in ten individuals with ASD as they watched a hand move, a ball bounce, a visual noise, or moved their own hand. Typically developing individuals showed a decrease in mu frequency when moving their own hand and when observing movement, while those with ASD only showed reduced frequency during self-performed actions. These results support the hypothesis that individuals with ASD have mirror neuron system dysfunction. Therefore, the mirror neuron and learning theories previously discussed may not apply to students on the autism spectrum.

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Resource Guide

https://files.eric.ed.gov/fulltext/ED553369.pdf

Self-Assessing Social and Emotional Instruction and Competencies: An SEL assessment tool designed to help educators reflect on their current social-emotional teaching practices and their own competencies.

https://www.air.org/sites/default/files/downloads/report/Social-Emotional-Learning-Afterschool-Toolkit-Sept-2015.pdf

Social and Emotional Learning Practices: An SEL self-reflection tool for after-school staff.

https://dpi.wi.gov/sites/default/files/imce/sspw/pdf/seluserguide.pdf

Social Emotional Learning (User Guide): An SEL tool designed to help educator understand the social-emotional competencies of their students.

http://www.casel.org/wp-content/uploads/2017/08/Sample-Teaching-Activities-to-Support-Core-Competencies-8-20-17.pdf

Sample Teaching Activities to Support Core Competencies of Social and Emotional Learning: Provides examples for what teachers can do in lessons and through ongoing teaching practices to improve SEL.

http://csefel.vanderbilt.edu/modules/module2/script.pdf

Social Emotional Teaching Strategies: Provides teaching techniques to help students develop

friendship skills, enhance emotional literacy, identify feelings in self and others, controlling

anger and impulse and developing problem solving skills.

https://www.oakland.edu/Assets/Oakland/galileo/files-and-documents/Empathy%20in

%20Your%20Classroom%20Teachers%20Guild.pdf

Empathy in Your classroom: Activities designed by teachers to help build empathy and

community in the classroom.

https://www.mass.gov/files/2017-07/social-emotional-standards-prek-k%20%281%29.docx

Social and Emotional Learning, and Approaches to play and learning: Details what SEL

abilities preschool and kindergarten student should have.

https://www.scholastic.com/teachers/sponsored-content/pj-masks/

Social-Emotional Learning for Preschool: Contains lesson plans and student activities with a

superhero theme to help teach SEL skills.

http://www.casel.org/wp-content/uploads/2017/08/SEL-in-Elementary-ELA-8-20-17.pdf

Examples of Social and Emotional Learning in Elementary English Language Arts

Instruction: SEL activities for elementary students, with an emphasis on how to incorporate

into English language arts classes.

http://www.casel.org/wp-content/uploads/2017/08/SEL-in-Elementary-Math-8-20-17.pdf

Examples of Social and Emotional Learning in Elementary Mathematic Instruction: SEL activities for elementary students, with an emphasis on how to incorporate into mathematic classes.

http://www.casel.org/wp-content/uploads/2017/08/SEL-in-Middle-School-Social-Studies-8-20-17.pdf

Examples of Social and Emotional Learning in Middle School Social Studies Instruction: SEL activities for middle school students, with an emphasis on how to incorporate into social studies classes.

https://www.scholastic.com/teachers/articles/teaching-content/grades-6-8-social-emotional-skills/

Grades 6-8: Social-Emotional Skills: Consists of activities and worksheet for SEL in middle school aged students

http://www.youevanston.org/tl_files/youevanston/images/Staff%20Manual/May2013%20updates/Social%20Emotional%20Activities%20Workbook.pdf

Social Emotional Activities Workbook includes interactive group activities and individual reflections to promote self-awareness, self-management, relationship skills, responsible decision-making in middle and high school students.

http://ong.ohio.gov/frg/FRGresources/emotional_intellegence_13-18.pdf

Emotional Intelligence Activities: Provides activities to promote emotional skills in high

school students.

http://www.casel.org/wp-content/uploads/2017/08/SEL-in-High-School-ELA-8-20-17.pdf

Examples of Social and Emotional Learning in High School English Language Arts

Instruction: SEL activities for high school students, with an emphasis on how to incorporate

into English language arts classes.