Mirror Neurons:
Recongnition, Interaction, Understanding

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Recognition of how another person is feeling is the fundamental basis upon which interactions between humans take place. In order to neurologically define and pinpoint the idea of human understanding, scientists have been looking into research on mirror neurons. Mirror neurons, or neurons that fire in the same way regardless of whether the person is performing or watching an action being performed have been called the Rosetta stone for understanding human empathy, and other social behaviors; a lapse in mirror neuron function has also been suggested as the reason for many neurological ailments such as Autism. Surprisingly and frighteningly enough, mirror neurons were an accidental discovery made quite recently- in the early 1990's.

Discovery

Mirror neurons were first observed by Italian Neuroscientist Giacomo Rizzolatti, MD of the University of Parma, and several of his colleagues in 1992. (Rizzolatti & Craighero, The Mirror-Neuron System, 2004) They had been using electrodes connected directly to neurons in the brains of macaque monkeys to study the firing of neurons when a monkey performed various actions

> *"The same neurons were firing regardless of whether or not the monkey was doing or watching the action."*

using different objects. One day they accidentally left the machines connected to the monkeys during their lunch break- and when one of the researchers picked up his lunch, they saw that the machines were making the same noise as when a monkey would pick up its own food. When they compared the neurons that fired when the monkey went to pick up its own food to the neurons that fired when the monkey watched the researcher pick up his food, they found no difference at all. Essentially, the

Figure 1. Psychological consequence of seeing and performing an action from a monkey's point of view.

same neurons were firing regardless of whether or not the monkey was doing or watching the action! (Brain Briefings: Mirror Neurons, 2008) To confirm their discovery of what they aptly called "mirror neurons," the Rizzolatti and his team ran multiple similar tests using other monkeys, and other types of actions. What they found was that the same neurons fire when a monkey is doing an action as when the monkey is watching that same action being done. This discovery was significant because it essentially meant that the brains of these monkeys were undergoing the same processes, and in effect understanding in the same way- regardless of whether the action was their own. They were, in other words, understanding what their partner was doing in the same way

as if they themselves had done it. They were having the same neural effect.

Rizzolati and team's next step was to look for these same neurons in humans. They could not do this directly, because it would require connecting electrodes directly to the human brain. However, instead they were able to record motor-evoked potentials, or the signal that a muscle is ready to perform an action, in both observers and performers. These motor-evoked potentials were visible regardless of whether the person was an observer or performer, thereby bolstering the hypothesis that mirror neurons exist in humans as well. However, since they hadn't seen the neurons themselves fire, no one could be sure. Researchers have yet to be able to determine whether or not the individual neurons that fire in humans are identical regardless of who is doing the action. The closest they have been able to get is to look at neuron groups (or "chunks" of the brain at a time) using fMRI (funtional magnetic resonance imaging) to determine that neurons in the same "chunks" or areas fire regardless of whether an action is performed or observed. However,

Figure 2. Illustrated cross-section of the human brain.

since it hasn't been possible to look at neurons individually, they have not been able to tell whether the same "mirror neuron" concept is at play. As a matter of fact, this failure to look at individual neurons in the human brain is one of the biggest criticisms of the mirror neuron hypothesis.

Not Just Motion

While "mirror neurons" were originally found in the pre-motor and motor cortex part of the brain, many researchers have found mirror neuron properties in neurons that control for functions other than motor function. One example of this can be seen in the research done by Christian Keysers, PhD and his associates who have discovered that this "mirror neuron" firing pattern applies to feelings and perceptions. In one study, Keysers and his team tested the neural signals of men who were subjected to the smell of rotten butter, and compared them to neural signals from another group of men who simply watched as other men encountered such smells. In both groups of men, the olfactory area of of the brain lit up therby signifying that the concept of mirror neurons is not limited to actions but can be extrapolated to emotions and perceptions as well. Since then, many such experiements have been organized, testing different senses and emotions such as disgust. The general consensus of these experiments is that mirror neurons are very versatile and that they do fire for many different emotions and perceptions. (Lehrer, 2008) Thus far, mirror neurons properties seem to exist in the postcentral gyrus (which primarily deals with the senses) and the parietal lobe (which has been associated with planning).

Implications

Thus, while there are some controversial counterarguments for the idea of mirror neurons- such as the the fact that we do not know for sure that they exist in humans- the implications of their existance in monkeys are interesting to look at. These implications manage to span a number of aspects of human cognition and behavior including, but not limited to language, disease, social interactions, and the future of artificial intelligence.

Empathy

There is an entire school of thought that is currently researching the idea that mirror neurons are the basis upon which humans interact. Mirror neurons are suspected to be strongly connected to the science behind human empathy, and to how humans understand eachother's intentions. We can say intentions because it has been found that "mirror neurons" are specific to what the intention of the performer was. For example, if a man picks up a cup of water because he is thirsty, a certain set of neurons fires. When someone watches him pick up the cup because he is thirsty, the same set of neurons fire. However, if he is picking up the cup to clear the table, a new set of "mirror neurons" fire, and when someone watches him pick up the cup to clear the table, the same new set of neurons fire. Thus, we can see that instead of simply obeserving actions or feelings, these neurons are going one step further and understanding the reasons for these feelings and actions. In other words, the mirror neurons are not simply immitating visual cues. They're understanding the cues for the visual cues. (Brain Briefings: Mirror Neurons, 2008)

Research in this area could potentially lead to a better understanding of emotions and could be used to create

Figure 3. V.S Ramachandran is a neurologist at UCSD studying the connections between autism and mirror neurons.

new pharmaceutical drugs that enhance or shut down feelings of empathy. Research in this area could open a number of doors for people with psychological problems including vetrans, criminals, et cetera.

Language

Since mirror neurons are based on imitation, and understanding, it makes sense to hypothesize that perhaps the way that many children learn languages has to do with mirror neurons. As a matter of fact,"...Rizzolatti & Arbib (1998) proposed that the mirrorneuron system represents the neurophysiological mechanism from which language evolved." One could hypothesize that children learn languages simply by watching people speak, and unconciously training their mirror neurons to fire in the same ways, based on the same external cues (ie. certain words). As a matter of fact, there are currently researchers trying to determine whether or not this is the model of learning that children use. Researchers that don't agree with this theory take mirror neurons one step backwards and ask the following question: If mirror neurons learn language by imitating, how did the mirror neurons learn to imitate in the first place? They believe that there must be more to language than mirror neurons.

If investiagtors are able to answer these questions, advancements in language learning for certain groups (i.e autistic children) could be possible.

Gender Differences

Mirror neurons could also potentially neurologically define common gender differences between men and women. It is well publicized that women seem to be biologically wired to produce feelings of empathy better than men. Research in this area would increase our understanding of humanity, and could be used in other fields such as artificial intelligence and business.

Disease

Current research on mirror neurons being done by V.S Ramachandran, Marco Iacoboni and a number of other researchers could also possibly answer questions about autism and other cognitive disorders. (Lehrer, 2008) (Rizzolatti & Fabbri-Destro, Mirror Neurons: from discovery to autism, 2010) (Cort, 2005)For example, data indicate that children with autistic spectrum disorder or ASD react to the actions done by others in a manner different from that of TD or typically developing children. The simplest way to account for these differences is to postulate (see also above) that children with ASD have an impairment of the mirror neuron mechanism. Data from various imaging experiement support this hypothesis- also known as the "broken mirror" hypothesis (Ramachandran and Oberman 2006)" However, other researchers have found different results. As with all new discoveries, the potential of this subfield of neurological sciences is overwhelming. Whether or not it will live up to expectations is yet to be determined.

> *"The mirror-neuron system represents the neurophysiological mechanism from which language evolved."*

Conclusion

While the list of implications of research on mirror neurons seems to be small, the significance of understanding these few topics is unfathomable. We could potentially answer the questions, "Are humans human because they have a far more developed mirror neuron system and can comprehend empathy?" and "Where does the knowledge with which we have developed such a complex language system come from?" These amongst many other questions can potentially be answered via the mirror neuron mechanism- and to think it was an accidental discovery.

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