Introduction to Brain & Behaviour
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Lecture 37
Theory of Mind: Understanding Other's Mental States

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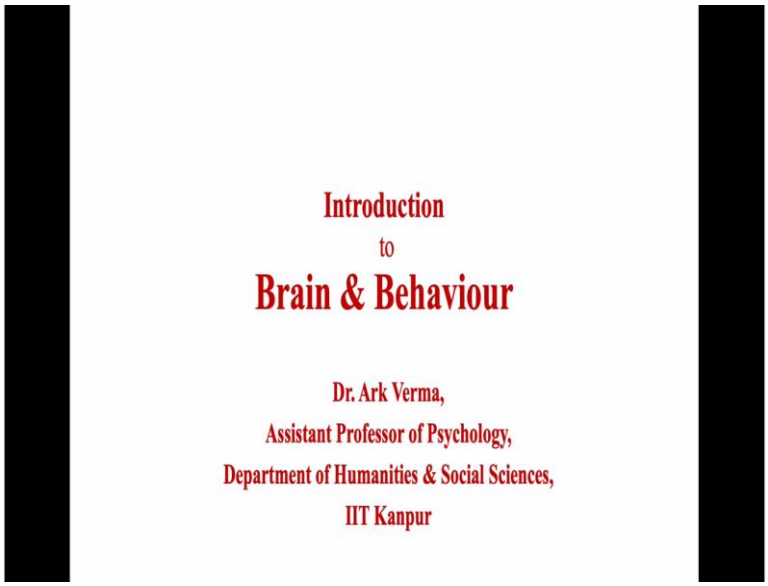

Hello and welcome to the course, introduction to brain and behaviour. I am Dr. Ark Verma from IIT Kanpur. This is week 8 of the course and in this lecture we will talk about theory of mind which is a bit about understanding others mental states.

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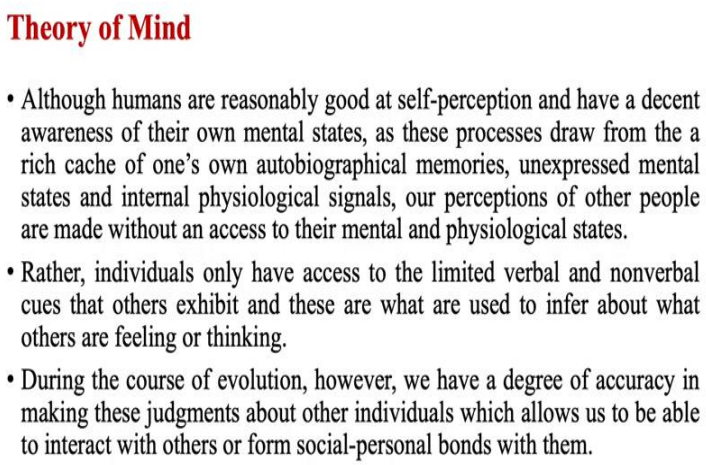

Now, although humans are reasonably good at self-perception and have a decent awareness of their own mental states, as these processes draw from a rich cache of one's own autobiographical memories, unexpressed mental states and internal physiological signals.

Our perceptions of other people are made without an access to their mental and physiological states. Rather, individuals only have access to the limited verbal and nonverbal cues that others exhibit and these are what are used to infer about what others are feeling or thinking. During the course of evolution however, we have acquired a degree of accuracy in making these judgments about other individuals which allows us to be able to interact with others or form social-personal bonds with them.

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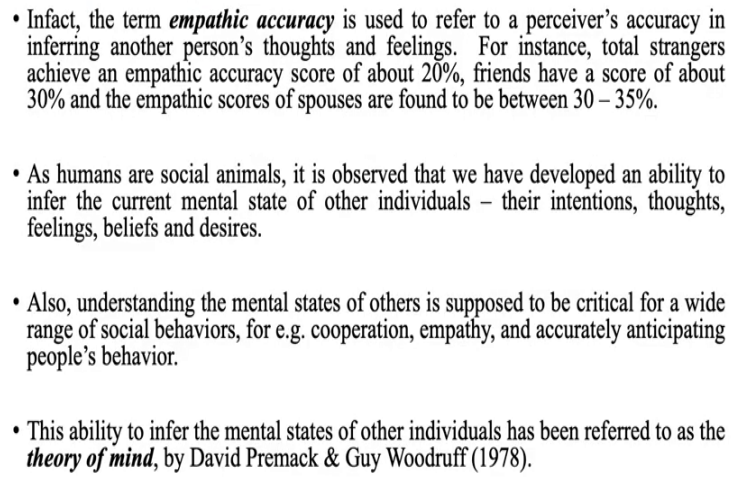

In fact, the term empathic accuracy is used to refer to a perceiver's accuracy in inferring another person's thoughts and feelings. For instance, total strangers achieve an empathic accuracy score of about 20 percent friends have a score of about 30 percent and the empathic scores of spouses are found to be between 30 to 35 percent. As humans are social animals, it is observed that we have developed an ability to infer the current mental state of other individuals - their intentions, thoughts, feelings, beliefs and desires.

Also, understanding the mental states of others is supposed to be critical for a wide range of other social behaviours, for example cooperation, empathy and accurately anticipating others behaviour. This ability to infer the mental states of other individuals has been referred to as the theory of mind, by David Premack & Guy Woodruff.

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Developmental milestones in Theory of Mind

- Loads of research has gone into investigating the development of the ability of the ***theory of mind***.
- Infants have been observed to prefer looking at a human face rather than other objects.
- Moreover, research using ERP has shown that even 4-month old infants exhibit early evoked gamma activity at occipital channels and a late gamma burst over right prefrontal cortex channels in response to direct eye – contact.
- These findings suggest that infants are very quick at processing information about faces and use neural structures similar to those found in adults (Grossman et al., 2007).

Now, let us talk about how the theory of mind develops gradually. Loads of research has gone into investigating the development of the ability of the theory of mind. For example, infants have been observed to prefer looking at a human face rather than other objects. Moreover, research ERP has shown that even four months old infants can exhibit early evoked gamma activity at occipital channels and a late gamma burst over right prefrontal cortex in response to direct eye contact. These findings suggest that infants are very quick at processing information about faces and use neural structures similar to those found in adults.

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- Even adults focus mostly on the social aspects of our environment. Indeed, numerous studies have shown that adults spend on an average 80% of their total waking time in the company of other individuals, and upto 80-90% of conversations area spent talking about ourselves and other people.
- A lot of behavioral studies have investigated the development of the theory of mind in children. One of the major tasks being the Sally Anne false-belief Task.
- Of what is known from developmental research into infant's ability of theory of mind, the following facts are known:

Even adults mostly focus on the social aspects of the environment. Indeed, numerous studies have shown that adults spend on an average of about 80 percent of their total waking time in

the company of other individuals, and upto 80 to 90 of conversations are spent talking about ourselves and other people. A lot of behavioural studies have investigated the development of the theory of mind in children. One of the major tasks being the Sally Anne false-belief task.

Of what is known from the developmental research into infant's ability of theory of mind, the following facts are there to see.

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- At around 12 months babies know can understand the goals and intentions of adults around them.
- At around 15 months, infants can show "surprise" when an adult looks for a toy in a container for a toy that had been placed there in their absence, suggesting that they understand that the person was unaware that the toy had been placed there.
- At 17 months, infants can understand when other individuals have a fals— belief.
- At about 3-4 years, children can recognize that their physical vantage point gives them an individual perspective that is different from that of other people.
- By about 5-6 years of age, children can appreciate that their mental states are different from other people's mental states; and they can appreciate that different people can have different mental states.

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At around 17 months, infants can understand when other individuals have a false-belief. At about 3 to 4 years, children can recognize that their physical vantage point gives them an individual perspective that is different from that of the other people. By about 5 to 6 years of age, children can appreciate that their mental states are different from other people's mental states; and they can appreciate that different people can have different mental states.

Say, for example I am feeling sad and the other person is feeling happy. Infants, the young children can actually have a sense of this background at 5 to 6 years of age.

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- By around 6-7 years, children can appreciate when the literal meanings of words communicate only a part of the speaker's intention or that the actual intention may be quite different.
- By about 9-11 years of age, children are able to simultaneously represent more than one person's mental state and to discern when one person hurts another person's feelings.
- However, some of these observations were challenged by Hungarian psychologists Agnes Kovacs, Erno Teglas and Ansgar Endress (2010) who proposed that the theory of mind is innate and automatic.
- As per their proposal, computing the mental states of others may be a spontaneous process, and just the presence of other individuals may be sufficient for automatic computation of their mental states and beliefs, even when performing a task in which their beliefs are irrelevant.

By around 6 to 7 years, children can appreciate when the literal meanings of words communicate only a part of the speakers intention or that the actual intention may be quite different. So the idea is, say for example, sometimes adults do that they try and tell children, suppose the child is repeatedly asking for being having ice-cream, but the weather is not nice, etc.

So, the parents are saying that I will get you the ice-cream once you do this job. So, what happens is the children who start understanding that okay, even though the person is saying this he may or may not actually do it because, the actual intention may or may not match whatever the words are been spoken. Similarly, around 9 to 11 years of age, children are able to simultaneously represent more than one person's mental stage and to discern when one person hurts another person's feelings.

Say, for example, if an infant is observing an interaction, let us say if a challenge is observing an interaction between the father and the mother or two other friends. One of the person has said something that probably would have hurt the other person. By around 9 to 11 years of age children start getting the sense, they start being able to represent not even their own mental state but that of others and also, not just a single but more than one person's mental state.

However, some of these observations were challenged by Hungarian psychologists Agnes Kovacs, Emo Teglas and Ansgar Endress who proposed that the theory of mind is innate and automatic. As per their proposal, computing the mental states of others may be a spontaneous process, and just the presence of other individuals may be sufficient for automatic

computation of their mental states and beliefs, even when performing a task in which their beliefs are irrelevant.

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- Kovacs and colleagues designed a study to test the hypothesis. Adult participants in their study were shown several animated movie scenarios that started with an agent placing a ball on a table in front of an opaque screen. The ball then rolled behind the screen.
- Moving further, four scenarios were possible:
  - The ball stays behind the screen while the agent is watching, and after the agent leaves, the balls stays put.
  - The ball rolls out from behind the screen while the agent is watching, and after the agent leaves, the ball stays put.
  - The ball stays behind the screen while the agent is watching, but after the agent leaves, the ball rolls away.
  - The ball rolls out from behind the screen while the agent is watching, but after the agent leaves, the balls returns to its position behind the screen.

So, Kovacs and colleagues designed a study to test the hypothesis. Adult participants in their own study, adult participants in their study were shown several animated movie scenarios that started with an agent placing a ball on a table in front of an opaque screen. The ball then gradually rolls behind the screen. Now, four things can happen, the ball stays behind the screen while the agent is watching, and after the agent leaves, the balls stays put.

So, when the agent comes back he can pick up the call from behind the screen. The other thing is the ball rolls out from behind the screen and while the agent is watching, and after the agent leaves, the ball does not move, it stays out (())(7:59) come in front of the screen and now he can come and pick this up. The third thing is that the ball stays behind the screen while the agent is watching, but as soon as the agent leaves, the ball rolls away.

So, now the agent does not know where the ball is and similarly the ball could roll out from behind the screen while the agent is watching, but after the agent leaves, it could go back to its own place. Now, again when the agent comes back he will not know where exactly to look for the ball.

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- As can be seen, in the first two instances, when the agent returns, he will have a true belief about the location of the ball, whereas in the bottom two instances the agent will have a false belief.
- On the other hand, the participants would know the location of the ball in all four scenarios.
- At the end of the movie, the screen was lowered, and either the ball was there or it was not. The participants task, was to press a button as soon as they detected the ball.
- Their reaction times in pressing the button was measured. Here, the agents' belief was irrelevant to the task.
- The researchers predicted that reaction times of participants would be faster when participants and agents, both, thought that the ball was behind the screen (and it was) compared to a condition when neither the participant nor the agent thought the ball was there (but it was). The baseline sceanrio was expected to have the lowest RT.

So, as can be seen in the first two instances, when the agent returns, he will know exactly where the balls is, he will have a true belief about the location of the ball, whereas in the bottom two instances the agent will have a false belief.

They will have expected something else but the ball has changed its location. So on the other hand, the participants will know the location of the ball in all the four scenarios. Now, what happens is that at the end of the movie, the screen was lowered, and either the ball was there or it was not. The participants task, was to press a button as soon as they would detected the ball. As soon as they sort of know that here is the ball.

Now, their reaction times in pressing the button was also measured, here whatever the agent believes is irrelevant to the task. You remember the person, actually knows whatever (())(9:20). The researchers predicted that reaction times of participants would be faster when participants and agents, both, thought that the ball was behind the screen and it actually was compared to a condition where neither the participant nor the agent thought the ball was there, but then it is found. The baseline scenario was expected to have the lowest reaction times.

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- Indeed, when the participants and the agents thought that the ball was there and it was, their RT was fastest, as compared to the baseline condition. It was also when only the participant believed it was there.
- In a condition when the participant did not believe that the ball was there but the agent did, their RTs was faster than the baseline condition.
- Such a pattern of results, suggests that the agents' belief influenced the participants RT as much as his very own belief did, even though it was not the same as the participant's belief.
- It seems therefore that adults can indeed track other adult's belief automatically.
- In a related finding, according to which even 7-month old infants were able to give a similar pattern of results, suggests that theory of mind might be innate and that the mere presence of another individuals automatically triggers computations of other individual's beliefs.

Actually this happens so, indeed when the participants and the agents thought that the ball was there and it was and it sort of plays out with their expectations. Their reaction times was fastest, as compared to the baseline condition. It was also when only the participant believed it was there when the participant just went by their selfly. Now, in a condition when the participant did not believe that the ball was there but the agent did, their reaction times was faster than the baseline condition.

But, obviously slower than, when both different thoughts were same. Now, this pattern of results, suggests that the agents belief influenced the participants in as much as his very own belief did, even though it was not really the same as the participant's belief. So, it seems that there is some sort of interaction between the eight participants believe here and the agents. It seems that, therefore that adults can indeed track other adult's belief automatically.

Because, see they are not meant to interact with their belief system, but the thing is that in some sense their belief systems are interacting. The participant is detecting the agents belief system. In a related finding, according to which even seven month old infants were able to give a similar pattern of results, you could say that or it suggests that the theory of mind might be innate and that the mere presence of another individuals automatically triggers computations of other individual's beliefs. So, this is sort of in line with what Agnes Kovacs and other people were saying.

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Mechanisms for Inferring Other People's Thoughts

- Neuroscientists have long been interested in discovering how the brain supports our ability to make inferences about what other individuals thought processes are and how do individuals read other individuals nonverbal cues.
- Now, to be able to infer the thoughts of others the perceiver must translate observable behavior into an inference about what is unobservable – his psychological state.
- One of theories about the same, known as the ***simulation theory*** or ***experience sharing system theory*** (Zaki & Oschner, 2011) suggests that individuals observe others behavior, imitate it and have a physiological response that is felt and allows the inference that others might be feeling the same way.
- This process may happen unconsciously, involving a mirroring system similar to that of mirror neuron systems involved with goal directed actions and action understanding.

Now, let us talk about the mechanisms for inferring other people's thoughts. Neuroscientists have long been interested in discovering how the brain supports our ability to make inferences about what other individuals thought processes are and what their mental states are. How do you also, say for example use the other individuals nonverbal cues to infer what they are feeling.

If somebody is very (())((11:42) the moving their hands here and there they are sort of facing around in and out of the room. You would automatically sort of get a sense of that the person is nervous or is anxious about something. So, how is the brain able to do that, how does the brain sort of carry us. Now, to be able to infer the thoughts of others the perceiver must translate observable behaviour, whatever their observable behaviour is, into an inference about what is unobservable that is the person's psychological state.

If I am making faces, if I am facing angryly and here and there. If am huffing and puffing you would basically be able to know after sometime that I am angry or let us say, anxious. So, this is basically what the individuals need to know, if they want to estimate the other person, whatever the internal mental state etc. Now, one of the theories about this happens is called as simulation theory or experience sharing system theory.

It suggests that individuals observe others behaviour, they imitate it and have a physiological response that is felt and this physiological response basically allows the inference of what the other person might be feeling. It is almost like, if I were in your place I would feel this and therefore I assume that you are feeling it. It is a bit like that, now this process may happen

almost unconsciously, involving a mirroring system that is similar to that of the mirror neuron systems involved with goal directed actions understanding of actions.

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- Alternatively, sometimes individuals can infer other's feelings by consciously "stepping into someone else's shoes". We are able to perform this task even at times when the target individual is not present with us or when they are happy outside and hurting inside, or when they are acting one way but intending another way.
- This suggest that these inferences involve a bit more than behavioral observation and imitation.
- ***Theory theory*** or ***the mental state attribution system*** theory suggests that individuals may build a theory about the mental states of others from the knowledge that has been accumulated about them. This knowledge may include memories of others, their situations, their family, their culture and so forth.
- It seems although that both behavior reading and mind reading may play a part.

Alternatively, another theory basically is there. So, alternatively individuals can infer others feelings by consciously stepping into someone else's shoes. Imagine that if I were you, I will do this. We were able to perform this task even at times when the target individual is not present. People are able to perform this task even when the target individual is not present. Sometimes, you think that if do this my father will think like this. If I do that, my mother will think like this.

Even, the father or mother are not exactly standing in front of you. You have this tendency of being able to estimate what they will feel. This suggest that these inferences involve a bit more than behavioural observation and imitation. It is not like you are always to be able to understand what the other person will feel, it is not that they should always be present in front of you. Now, the mental state attribution system theory suggests that individuals may actually build a theory about the mental states of others from the knowledge that has been accumulated about them.

What do you know about the person? Suppose, my friends know that I am a very patient person that I am person who does not lose my calm so easily, etc. Then, once you pitch a question to them, this situation has happened and how will Dr. Ark feel? So, they will be able to know on the basis of whatever they know about me, they will estimate that what could be my possible feeling or about my possible reaction.

So, this knowledge basically would include memories of others whatever I have being with them , whatever interaction we had, the memories of those interactions, their situations, their family, their culture and so on and so forth. So, there is a lot of knowledge about the others that we accumulate and on the basis of this knowledge we sort of commit a estimate of what the lightly feeling or what the lightly reaction will be like.

So, it seems that although that both behaviour reading and mind reading may somehow play a part in this ability of understanding others feelings.

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Simulation Theory

- It is possible that a common brain region is recruited for both self – perceptions and estimating other's mental states. For e.g. people may make inferences about other persons based on their own self – representations.
- Simulation theory puts forth the idea that certain aspects of inferring the thoughts of other people, especially in the domain of motor actions and emotions rely upon our ability to put ourselves in the shoes of another person, basically by using our own mind to simulate what other person's might be thinking (Harris, 1992).
- One might ask as to how do these simulations reflect in barin activity?

Now, just look at this in a little more detail, let us talk about simulation theory. Now, it is possible that a common brain region is recruited for both self-perceptions and estimating other people's mental states. For example, people may make inferences about other persons based on their own self-representations.

Simulation theory puts forth the idea that certain aspects of inferring the thoughts of other people, especially in the domain of motor actions and emotions can be relied upon our ability to put ourselves in the shoes of another person. That simulation sort of a thing, basically by using our own mind to simulate what other person's might be thinking. Now, one might ask as to how these simulations reflect in brain activity.

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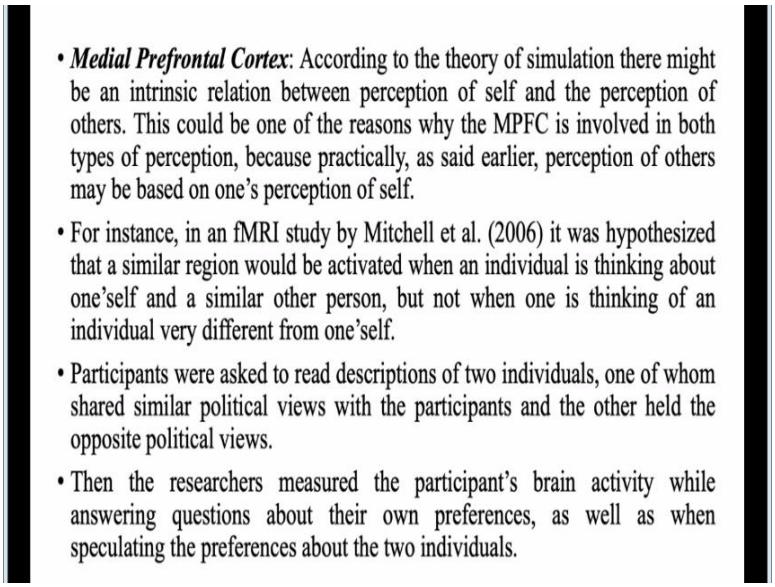

Let us look at some of the structures that might be helping these simulations. Now, medial prefrontal cortex, according to the theory of simulation there might be an intrinsic relation between perception of self and the perception of others. This could be one of the reasons why the medial prefrontal cortex is involved in both types of perception, perception of ourselves and perception of the individuals different from others, because practically perception of others may be based in som sense on better perception of ourselfs.

Our own simulations and how we will feel in a given scenario. For instance, they perform several studies. For instance, in an fMRI carried out by Jason Mitchell and colleagues in 2006 they hypothesized that a similar region would be activated when an individual is thinking about one's own self and a similar other person, but not when one is thinking of an individual very different from one self. So, for example, we know that friend x is very similar to friend y, although he is a friend and there is mutual friendship.

But, friend y is very different from how we are. So, we can say that in a doing situation friend x will act we will and friend y will act slightly differently. So, in their study, participants were asked to read descriptions of two individuals, one of whom shared similar political views with the participants and the other held the opposite political views. Suppose, in party A and I am also a supporter of part A and the other person is a supporter of party B, which I am leaving the supporter.

So, this is basically the setting. Now, then the researchers measured the participant's brain activity while answering questions about their own preferences, as well as when speculating

the preferences about the two individuals. Say, for example how will you feel? How will person A feel? How will person B feel?

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- ***Medial Prefrontal Cortex***: According to the theory of simulation there might be an intrinsic relation between perception of self and the perception of others. This could be one of the reasons why the MPFC is involved in both types of perception, because practically, as said earlier, perception of others may be based on one's perception of self.
- For instance, in an fMRI study by Mitchell et al. (2006) it was hypothesized that a similar region would be activated when an individual is thinking about one'self and a similar other person, but not when one is thinking of an individual very different from one'self.
- Participants were asked to read descriptions of two individuals, one of whom shared similar political views with the participants and the other held the opposite political views.
- Then the researchers measured the participant's brain activity while answering questions about their own preferences, as well as when speculating the preferences about the two individuals.

It was found that a ventral region of the medial prefrontal cortex was highly activated for self-perceptions and the perception of the other similar person, whereas a different dorsal region of the medial prefrontal cortex was activated when talking about the preferences of the dissimilar person.

These activation patterns can be taken up as evidence for the fact that participants may have reasoned that their own preferences would also be able to predict the preferences of the similar individual. However, other studies have shown that there might be a variable pattern of MPFC activation between the ventral and dorsal regions, suggesting that the activation patterns do not merely depend upon similarity per se, but also on the level of relatedness between the two people based on familiarity.

For example, I will basically be able to predict, let us say how my father, mother or brother will act. As supposed to as a friend will act, as supposed to as a stranger will act. So, lot of these factors in these familiarity, closeness, emotional importance, warmth, competence, and knowledge about the other individual also clear path.

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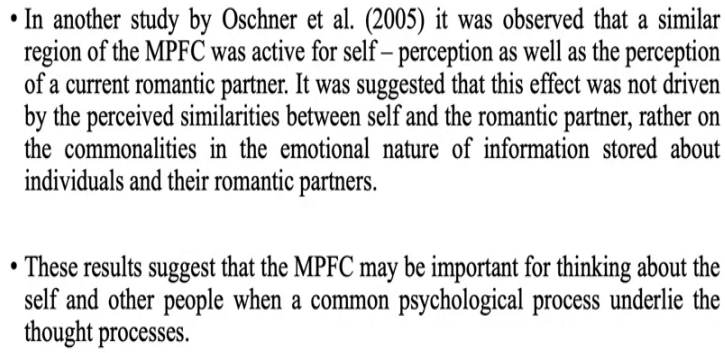

Now, in another study by Oschner and colleagues in 2005 it was observed that a similar region of the medial prefrontal cortex was active for self-perception as well as the perception of a current romantic partner.

It was suggested that this effect was not driven by the perceived similarities between self and the romantic partner, rather on the commonalities in the emotional nature of information stored about the individuals and their romantic partners. So, these results also sort of suggest that the medial prefrontal cortex may be important for thinking about the self and other people when a common psychological process underlies the thought processes. I also like this, he or she also likes this and that is how I am basically able to predict not only mine but the other person's emotional states.

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Empathy

- Being able to understand the mental states of others also involves understanding their emotions. Empathy i.e. our capability of understanding and responding to the unique experiences of another person, epitomizes the strong relation between self – perception and the perception of others.
- To be able to respond appropriately to others emotional needs, individuals need the ability to be accurately detect the emotional information transmitted by another person.
- Although the details about the process of empathy are not clear, there is agreement on the fact that the first step in this direction is to be able to take another person's perspective, i.e. we must be able to momentarily in ourselves be able to create the other person's internal state in our effort to understand it.

Now, let us talk a little but about empathy, being able to understand the mental states of others also involves understanding their emotions. Empathy refers to our capability of understanding and responding to the unique experiences of another person and this sort of epitomizes the strong relationship between self-perception and others perception. To be able to respond appropriately to others emotional needs, individuals need the ability to be accurately detecting the emotional information transmitted by another person.

Suppose there is a person and you are great friends with this person. If you are not able to understand what that person is feeling at any given point in time, you will not be able to form a lasting relationship. To be able to do that, you have to able to detect accurately the emotional information that the person is transmitting. You know, the person is feeling sad and it's there on their face. It is there in their mannerism etc. The person is angry, anxious, very happy, all of that.

Basically, people are almost transmitting emotional information about themselves all the time. One has to be perspective and be able to accurately detect that emotional information. Now, although the details about the process of about empathy are not really clear. There is agreement on the fact that the first step in this direction is to be able to be able to take another person's perspective. Literally speaking, to be able to step in other person's shoes So, we must be able to, sort of momentarily in ourselves be able to create the other person's internal state in our effort to understand it. How would x feel, if I stole his pen or something like that.

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- The perception – action model of empathy assumes that being able to perceive another person's state of mind automatically activates the same mental state in the observer, triggering somatic and and autonomic responses.
- This observation is consistent with the idea that we can understand someone's mental state by sharing it.
- It has been proposed that mirror neurons may be a critical physiological mechanism that allows us to have the same representation of another's internal state within our own bodies - a mechanism often referred to as embodied simulation.
- Indeed, some evidence was found for the connection between the mirror neuron system and the emotion processing system in the primate brain. More specifically, the mirror neuron system was found to be anatomically connected to the limbic system by the insula, suggesting that a large scale network might underlie our ability to empathize with others.

Now, the perception action model of empathy assumes that being able to perceive another person's state of mind automatically activates the same mental state in the observer, triggering somatic and autonomic responses. So, you can almost simulate that and feel that physiological as well. This observation is consistent with the idea that we can understand someone's mental state by sharing it. By having the same kind of process going through us.

It has been proposed that mirror neurons may be a critical physiological mechanism that allows us to have the same representation of another's internal state within our own bodies. The a mechanism often referred to as embodied simulation. Now, indeed, some evidence has actually been found for the connection between the minor neuron system and the emotion processing system in the primate brain. More specifically, the mirror neuron system was found to be anatomically connected to the limbic system by the insula, suggesting that a large scale network might underline our ability to empathize with others.

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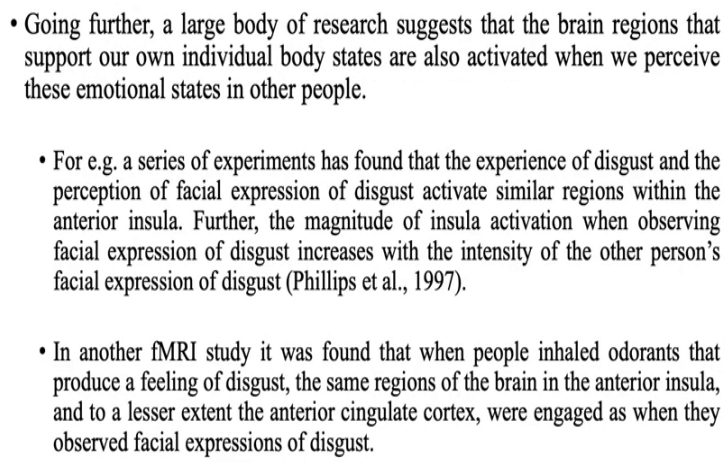

Going further, a 1arge body of research suggests that the brain regions that support our own individual body states are also activated when we perceive these emotional states for other people. So, for example in a series of experiments it has found that the experience of disgust and the perception of facial expression of disgust activate similar regions within the anterior insula. Now further, the magnitude of insula activation when observing facial expression of disgust increases with the intensity of the other person's facial expression of disgust.

So, for example if you are observing this and the other person is feeling disgust, you will sort of always mimic that in your brain itself. In another fMRI study it was found that when people inhaled odorants that produce a feeling of disgust, maybe you know sulphur dioxide (())(23:41). The same regions of the brain in the anterior insula, and to a lesser extent the anterior cingulate cortex, were engaged as when they observed facial expressions of disgust. So, basically if you are observing somebody feeling disgust versus yourself getting disgust. The regions that are activated or engaged are the same.

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- A single patient case study of insula damage also provides additional support for mirror neurons in the insula whereby a patient with insula damage lost the ability to recognize disgust ; suggesting that the insula is an important region to experience disgust as well as for perceiving it in others.
- Further, in a pain study by Taniya Singer and colleagues, FMRI investigation showed that the insula and the anterior cingulate cortex are activated when individual experience pain in themselves as well as when they are perceiving physical pain in others.
- When the researchers examined the brain activity of participants when they received painful stimulation through an electrode on their hand or saw the painful stimulation delivered through an electrode to a romantic partner's hand.
- It was found that both the experience of pain and the perceptions of a loved one's pain activated the anterior insula, adjacent frontal operculum, and anterior cingulate.

Now, a single patient case study of insula damage also provides additional support for mirror neurons in the insula whereby a patient with insula damage lost the ability to recognize disgust suggesting that the insula is an important region to experience disgust as well as for perceiving disgust in others. In another study by Taniya Singer and colleagues, fMRI investigation showed that the insula and the anterior cingulate cortex are activated when individual experience pain in themselves as well as when they are perceiving physical pain in others.

If you stub your toe or if you pinch yourself, you are feeling that pain. The same regions will get activated in the insula and anterior cingulate cortex as if when you see somebody else stub their toe or pinch themselves. When the researchers examined the brain activity of participants when they received painful stimulation through an electrode on their hand or saw the painful stimulation being delivered through an electrode to their romantic partners, it was found that both the experience of pain and the perceptions of a loved one's pain activated the same region. That is the anterior insula, adjacent frontal operculum, and the anterior cingulate.

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- Moreover, participants who obtained higher scores on a questionnaire that measured their degree of empathy showed the greatest activation in the insula and anterior cingulate when perceiving pain in their romantic partners.
- The somatosensory cortex also seems to have a mirroring system, which is engaged when experiencing and observing painful touch or non painful touch.
- In accordance with these studies, another study was conducted with lesion patients, having damage to their somatosensory cortices. These patients were found to be significantly impaired in the capacity to identify another person's emotional state when compared to patients who had damage to other brain regions.

Further, participants who obtained higher scores on a questionnaire that measured their degree of empathy showed the highest degree of activation in the insula and anterior cingulate when perceiving pain in their romantic partners. So, if let us say you know that your degree of empathy was high as judged by in the questionnaire. It is also that brain activation will be high in a similar manner.

So, it basically is that if you feel empathy, the brain regions will also show that and as well as your answers in self. Now, The somatosensory cortex also seems to have a mirroring system, which is engaged when experiencing and observing painful touch or non-painful touch. So, according to these studies, another study was conducted with lesion patients, having damage to their somatosensory cortices.

These patients were found to be significantly impaired in the capacity to identify another person's emotional state when compared to patients who had damage to other brain regions.

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- All in all, these studies suggest that same regions of the brain may become engaged when individuals experience an internal state and when they observe someone else experience the same internal state.
- The idea of shared experiences between individuals poses an interesting question of "who was feeling what?"
- Murray et al. (2012) performed a meta-analysis of 23 fMRI and 2 PET studies comparing self – relevant processes with processing of close others and of public figures.
- The objective of the meta-analysis was to be able to identify self-specific activations as well as activations that allow the differentiation between evaluation of close others and evaluation of people who we have no connections with.
- Murray and colleagues found that the anterior insula is activated when appraising and processing information about the self as well as close others; but not when appraising and processing information about public figures.

So, all in all these studies suggest that same regions of the brain may become engaged when individuals experience an internal state and when they observe someone else experience the same internal state.

So, this is sort of along the idea of shared experiences between individuals poses an interesting question of like, how do you then determine you is feeling what, whether you are feeling the pain or the other person is feeling the pain. Now, Murray and colleagues in 2012 performed a meta-analysis of twenty-three fMRI and two PET studies comparing self - relevant processes with processing of close others and of public figures.

So, the objective of the meta-analysis was to be able to identify self-specific activations as well as activations that allow the differentiation between evaluation of close others and evaluation of people who we have no connections with. Murray and colleagues found through the meta-analysis that the anterior insula is activated when appraising and processing information about the self as well as close other such as mother, father, brother sister and spouse, etc.

But not when appraising and processing information about let us public figures who you have no connection. It could be some Bollywood actor or somebody.

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- Based on the same, the researchers suggested that when we appraise ourselves and close others, we share a conscious mental representation that is internal, visceral, and actually felt physiologically. This representation has been referred to as ***embodied awareness*** and is known to affect each person's emotional perspective.
- Such a result suggest that we garner knowledge of close others based on our embodied experience of those people.
- Self – specific processing was found to activate regions of the vACC and dACC, areas that were not activated when appraising close others and public figures.
- The dACC has been implicated as an effortful, goal-directed mechanism for allocating and regulating attention, also responding ro self – related stimuli and engaged in self – reflection and action monitoring.
- Further, it has been suggested that dACC and vACC specialize in self – specific processing by selecting representations and mental attributes that fit an individual's own personality.
- Also, researchers found differential activations within the MPFC for self, close other, and public other. Activations for the self was found clustered primarily in the righ VMPFC; for close other activations were clustered mainly in the left VMPFC, along with some shared activation engaging the VMPFC depending upon the level of relatedness.
- Activations for the public other was significantly dissociated from these two regions, and showed greater dorsal MPFC activation in the left superior frontal gyrus.
- Hence, it became established that different regions of the brain index, "who is feeling what."

Now based on the researchers... Further, it has been suggested that dACC and vACC specialize in self-specific processing by selecting representations and mental attributes that fit an individual's own personality. They have sense of your own personality and you basically you select those things.

So, researchers found differential activations within the MPFC for self, close other, a public figure. Activations for the self was found clustered primarily in the right VMPFC; for close other activations were clustered mainly in the left VMPFC, along with some shared activation engaging the VMPFC depending upon the level of relatedness. It is very close friends, slightly different distance and so on. Activations for the public other was significantly

dissociated from these two regions, and showed greater dorsal MPFC activation in the left superior frontal gyrus.

So, it became established that different regions of the brain are capable of index, who feels what and so we have a sense that these are our feelings, there are the feelings of close other. These are the feelings of that friend, these are the feelings that the other individual would feel.

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Modulation of the empathic response

- While it is indeed important to experience empathy for others, it might unproductive if an individual gets overly affected by the experiences of others, for instance a doctor may not be able to perform a surgery if he were to over empathize with a patient.
- Jean Decety and colleagues (Decety, 2011) have put forward a model which includes stimulus-driven processing of affective sharing along with goal directed processing.
- As per this model, the perceiver's motivation, intentions and self – regulation influence the extent of an empathic experience, as well as the likelihood of behavior that would help others.

Let us talk a little bit about the ability of modulation of the empathic response. Now, while it is indeed important to experience empathy for others, it might be unproductive if an individual gets overly affected by the experiences of others, for instance let us say if a doctor is too empathic, they might not be able to perform as surgery or simply give an injection to the patients who feel pain.

Jean Decety and colleagues have put forward a model which includes stimulus-driven processing of affective sharing along with goal directed processing. As per this model, the perceiver's motivation, intentions and self-regulation influence the extent of an empathic experience, as well as the likelihood of behaviour that would help others. Unless, you are able to understand what the other person is feeling very closely. You are not going to be able to, let us say find in yourself to be helping to others. People not really understand about what pain somebody is going through.

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- In an experiment, Decety and colleagues hypothesized that regions of the brain typically associated with eperceptions of physical pain would not be activated in acupuncturists whose jobs requires them to detach themselves from the painful aspect of administering acupuncture and instead focus on the long – term benefits to the patient.
- To test the same, researchers observed the brain activity of professional acupuncturists vs. lay people when they watched the video clips depicting body parts receiving nonpainful stimulation vs. painful stimulation.
- As in previous research, regions associated with the experience of pain, including the insula, anterior cingulate and somatosensory cortex were found to be activated in nonexperts. On the other hand, in acupuncturists these regions were not significantly activated, rather regions associated with mental state attribution about others such as the MPFC and the TPJ were found to be activated. Also, regions involved in executive functions, self – regulation (DLPFC, MPFC) and executive attention (precentral, superior parietal and TPJ) were found activated.

Now, in an experiment, Decety and colleagues hypothesized that regions of the brain typically associated with perceptions of physical pain would not be activated in acupuncturists whose jobs requires than to detach themselves from the pain. See, acupuncture is Chinese ancient medical technique where the idea is that they have these pains. They actually puncture your body, there is this entire acupuncture map, and there these very specific spots in the map where the pin has to be inserted.

The ideas is already that its pains in immediate current situation. These practitioners believe that it has long term benefits. So, somebody who's job is to give acupuncture should be able to detach themselves completely. For what the immediate thing is that, obviously the patients will say that this is paining and that is paining. But, just these people will sort of focus in the long term gain and not really feeling bad about this.

So, to test this hypothesis, researchers observed the brain activity of professional acupuncturists versus the lay people when they watched video clips depicting body parts, receiving painful stimulation versus non painful stimulation. As in previous research, regions associated with the experience of pain, including the insula and anterior cingulate cortex and somatosensory cortex were found to be activated in non experts.

So, these people are actually emphasizing with the person in the video, they are actually being able to feel the pain because those individuals are receiving painful stimulation.

On the other hand, in acupuncturists these regions were not significantly activated, rather regions associated with mental state attribution about others, what this person must be

feeling, etc. Such as the MPFC and the TPJ were found to be activated. Also, regions involved in executive functions, self-regulation DLPFC, MPFC and executive attention like precentral, superior parietal and TPJ were found to be active. So, you can see that the acupuncture is much less over well by a video clip of another guy receiving these painful stimulations.

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- These findings suggest that the activation of the mirror neuron system can be modulated by a goal directed process that enhances flexible responses.
- Researchers have also been interested in studying whether fairness in social relations influences empathy.
  - In a study by Singer et al. (2006) male and female participants were asked to play a card game (involving cash) with two confederates, one who cheated and the other who did not.
  - fMRI was used to measure the participant's brain activity while they watched the confederates experiencing pain.
  - Although both genders had activation in the empathy associated regions while watching the fair confederate receive pain, the empathy induced activation in males were reduced significantly when they saw the cheating confederate receive pain.
  - These observed reduction were accompanied by increased activation in the ventral striatum and nucleus accumbens, which are reward associated areas, suggesting that the males actually enjoyed seeing the cheater in pain.

So, these findings suggest that the activation of the mirror neuron system can be modulated by a goal directed process that enhances flexible responses. Researchers have also been interested in studying whether fairness in social relations influences empathy. Whether you are a fair person or you are a cheater. In a study with Singer and colleagues in 2006, male and female participants were asked to play a card game involving some money with two confederates, one of the confederates were asked to cheat. The other confederate was asked to be honest.

Now, fMRI was used to measure the participant's brain activity while they watched the confederates experiencing painful stimulation. Now, although both genders had activation in the empathy associated regions while watching the fair confederate receive pain, the empathy induced activation in males were reduced significantly when they saw the cheating confederate receiving pain. So, these observed reduction were accompanied by increased activation in the ventral striatum and nucleus accumbens, which are actually reward associated areas.

Suggesting, that not only these people are feeling less pain, not only these males are feeling less pain, less empathy for the individual who cheated in the game. They are in fact enjoying seeing the person who cheated in pain.

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- These findings suggest that individuals value the gain positively if someone has gained fairly, but not if it was gained unfairly. Individuals like cooperating with fair opponents but they like punishing unfair ones.
- Cikara et al. (2011) wanted to investigate whether the modulation of empthay also occurred at the group level.
  - In her study, she recruited fans of rival baseball teams: Boston Red Sox and the New York Yankees. fMRI was used o measure participant's brain activations while they viewed simulated figures representing the two teams making baseball plays.
  - In some plays the favored player was successful, while in some others the rival players succeeded. Participants also saw some control scenarios wherein a player from a neutral team made plays against another neutral team.
  - After each play, participants were asked to rate their feelings of anger, pain or pleasure which they had experienced while watching that play. After a gap of 2 weeks, they were also made to fill out a questionnaire that asked them to rate the likelihood that they would heckle, insult, throw food, threaten, shove, or hit a rival fan or hit a fan of the neutral team.

Now, these finding suggest that individuals value the gain positively if someone has gained it fairly, but not if it was gained unfairly. Individuals like cooperating with fair opponents but they 1ike punishing unfair ones. So, this is something very interesting to note.

Now, Cikara and colleagues in 2011 wanted to investigate whether the modulation of empathy could also occur not only just at the individual level but at the group level. So, in her study, she recruited fans of rival baseball teams, so Boston Red Sox and the New York Yankees, these are two baseball teams, let us take an example you can imagine and there are two teams. Let us say, in Indian Premier League if you are a supporter of Chennai Super Kings or Mumbai Indians.

So, fans of rival cricket IPL teams etc, let us say they were taken. Now, fMRI was used to measure participant's brain activations while they viewed simulated figures representing the two teams. Let us say, video game sort of making base ball players.

Let us say, playing cricket and now in some place the favoured player was successful while in some other the rival players succeeded. So, in one case your team, the on you support is winning and while the other team, in some other cases the rival team is winning. Participants also saw some control scenarios wherein a player from a neutral team made plays against

another neutral team. So, there was a neutral match also going on. Say, for example, Rajasthan Royals and the Sunrisers Hyderabad, something like that is also going on.

So, there you are not really going to be so worked up emotionally. So, after each play, participants were asked to rate their feelings of anger, pain or pleasure when they were watching the game. After a gap of two weeks, they were also made to till out a questionnaire that asked them to rate the likelihood that they would heckle, insult, throw food, threaten, shove or hit a rival fan or hit a fan of the neutral team. So, just like how strongly do you feel, whether you go or the physical steps or not.

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- While viewing subjectively positive plays, i.e. in which the rival team failed, there was an increased response in the ventral striatum, whereas failure of the favored team and success of the rival team activated the ACC and insula.
- The ventral striatum reward effect was found to be correlated with the self-report likelihood of aggression against the fan of the rival team.
- So the response to a rival group's misfortune is neural activation associated with pleasure and which is found to be correlated with endorsing harm against those groups.

Now, while viewing subjectively positive plays, that is in which the rival team failed, there was an increased response in the ventral striatum, basically saying that you enjoy the loss of the rival team. Whereas failure of the favoured team and success of the rival team activated the ACC and insula. So, you are actually feeling pain at that time, so that is basically what and it says the modulation is happening at the group level. The ventral striatum reward effect was found to be correlated with the self-report likelihood of aggression against the fan of the rival team.

So, the individuals who are more inclined to hate the rival team with resort to aggression with them actually show more enjoyment or ventral striatum activity. So, finally the response to a rival group's misfortune is neural activation associated with pleasure and which is found to be correlated with endorsing harm against those groups.

So, this is an interesting aspect of how individuals carry themselves around in social relationships. Whether they, even, at a group level, like some group, do not like some group, whether they enjoy the other group suffering or they would actually feel pain.

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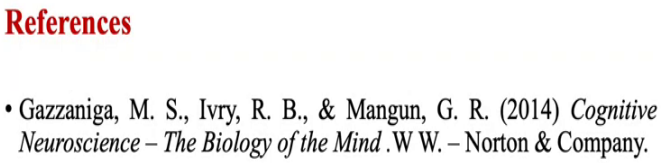

The other group is also in a difficult situation. I think we will stop here, we will continue the same talk on social cognition in the next lecture, thank you.