Introduction to Brain & Behaviour
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Lecture 39
Autism and Mental State Attribution

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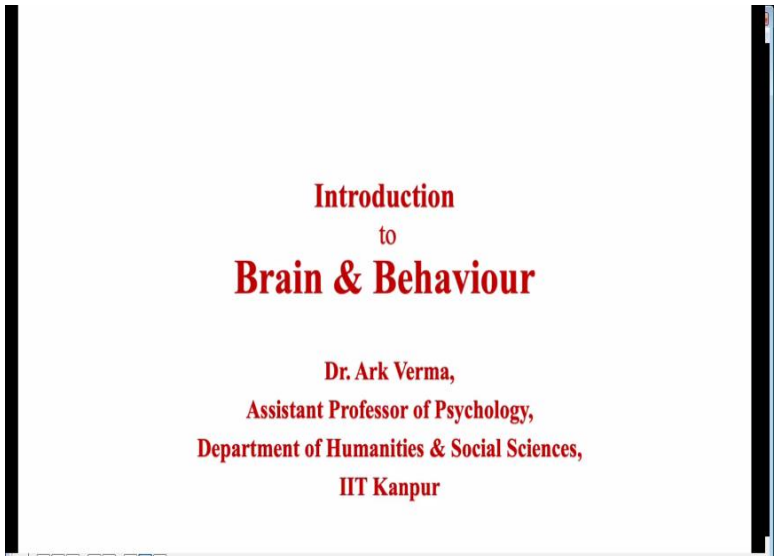

Let us talk about autism and menal state attribition.

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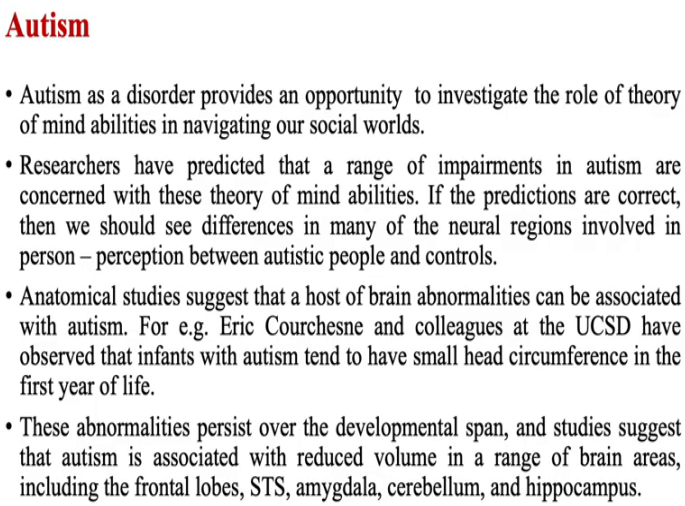

Now, autism as a disorder provides an opportunity to investigate the role of theory of mind abilities in navigating our social environments. Researchers have predicted that a range of impairments in autism are concerned with these theory of mind abilities. If the predictions were to be correct, then we should see differences in many of the neural regions involved in person-perception between autistic people and controls.

Anatomical studies suggest that a host of brain abnormalities can be associated with autism. For example, Eric Courchesne and colleagues at the UCSD have observed that infants with autism tend to have small head circumference in the first year of life. These abnormalities persist over the developmental life span, and studies suggest that autism is associated with reduced volume in a range of brain areas.

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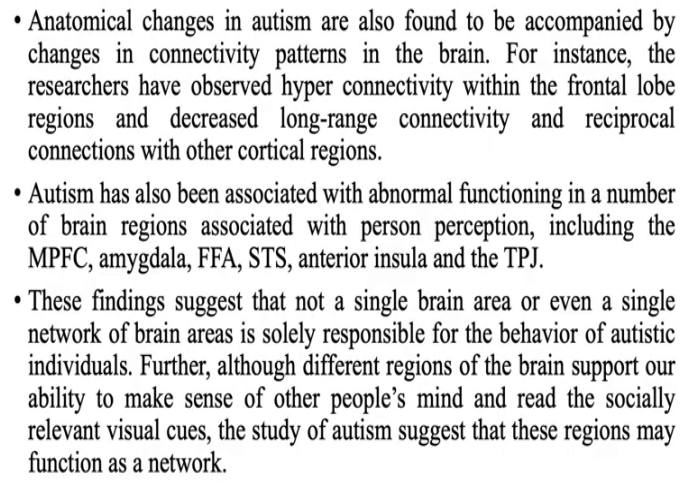

For example, the frontal lobes, STS, amygdala, cerebellum and the hippocampus. Now, anatomical changes in autism are also found to be accompanied by changes in connectivity patterns in the brain. For instance, the researchers have observed hyper connectivity within frontal lobe regions and decreased long-range connectivity and reciprocal connections with other cortical regions. Autism has also been associated with abnormal functioning in a number of brain regions associated with person perception, including the MPFC, amygdala, FFA, STS, anterior insula and the TPJ.

These findings suggest that not a single brain area or even a single network is completely responsible for the behaviour of autistic individuals. Finally, although different regions of the brain support our ability to make sense of other people's mind and read the socially relevant visual cues.

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- Autistic individuals find it extremely hard to perform the False-Belief Tasks, and even when autistic children are well past the age when normal children can do the task easily, they perform the task as if all the characters in the task have access to all the information in the story.
- Lombardo et al. (2011) was investigating the neural systems that are specifically responsible for impairments in representing mental state information in autistic individuals. They examined whether deficits for autistic individuals are observed in processing information about both the self and the other, and also if the abnormal functioning of the neural systems relates to variation in impairment.
- So, they came up with mentalizing task – that would elicit robust activation in all the regions within the standard circuit known to be engaged in normal individuals while thinking about both self and others: the MPFC, the PCC, and the bilateral TPJ.

The study of autism suggest that these regions might be working as a single network. Now, autistic individuals find it extremely hard to perform the false-belief tasks, and even when autistic children are well past the age when normal children can do the task, easily they perform the task as if all the characters in the task have access to all the information in the story.

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And also, if the abnormal functioning of the neural systems relates to variation in impairment. So, they came up with mentalizing task, that would elicit robust activation in all the regions within the standards circuit known to be engaged in normal individuals while thinking about both self and others.

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- They found that the rTPJ functioned abnormally in autistic individuals, in that it is less responsive and nonspecific in its activations, implying that it could not distinguish between thoughts about self and others and physical judgments.
- The lack of specificity was found to be correlated with the degree of social impairment, or in other words the less selective was the rTPJ response the more impaired the individual was in representing the mental state of others.
- Another important characteristic of autistic individuals is that they don't pay attention to eye-gaze as much as normal individuals do. Moreover there are also suggestion that autistic individuals avoid eye contact with others because they find it unpleasant.

These regions were the MPFC, the PCC, and the bilateral TPJ. The research has found that the rTPJ functioned abnormally in autistic individuals. In that it was less responsive and slightly nonspecific in its activations, implying that it could not distinguish between thoughts about self and others and physical judgements. The lack of specificity was found to be correlated with the degree of social impairment or in other words the less selective the rTPJ was, the more impaired the individual was in representing the mental state of others.

Another important characteristic of autistic individuals is that they do not pay attention to eye-gaze as much as normal individuals do.

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- A recent study combined EEG with skin conductance responses o explore whether frontal EEG asymmetry, as an index of approach-avoidance brain activity could resolve whether another person's eye gaze is arousing or aversive to autistic individuals.
- It was found that a direct gaze with either normally open eyes or wide-open eyes evoke neither avoidance related brain responses nor approach related brain responses in children with the autism spectrum disorder.
- Although they observed that autonomic arousal for faces increased as a function of the amount of sclera (white portion of the eye) visible in the direct gaze.
- This differed from the response of normally developing children for whom the normally open eyes evoked an approach response and wide eyes led to an avoidance respone, although the intensity of arousal was constant.

Moreover there are also suggestion that autistic individuals might avoid eye contact with others because they find it unpleasant. A recent study combined EEG with skin conductance responses to explore whether frontal EEG asymmetry, as an index of approach avoidance brain activity could resolve whether another person's eye gaze is arousing or aversive to autistic individuals.

It was found that a direct gaze with either normally open eyes or wide open eyes evokes neither approach nor a avoidance related responses in children with the autism spectrum disorder. Although they observed that autonomic arousal for faces increased as a function of the amount of sclera visible in the direct gaze. So, it seems that these children were basically, they did no really show any kind of avoidance response or approach response towards the eye gaze.

They are not really interacting with it at all. This differes from the response of normally developing children for whom the eyes open evoked an approach response as well as the eyes wide open leads to an avoidance response because, you know that eyes wide open is a bit of a expression of let us say, fear or something like that.

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- These findings do not support the suggestion that direct gaze is an aversive stimulus for children with autism. N fact, they support an alternate hypothesis proposed by Ami Klin and colleagues at Yale University (2002), according to which individuals with autism may just fail to recognize the importance of eye gaze as a cue to understanding their social worlds.

- In their study, while participants were watching the movie *Who's Afraid of Virginia Woolf?,* normal individuals spent much of their viewing time paying attention to the characters faces and eys to gain an understanding of their intentions and feelings, but autistic individuals mostly fixated on mouths, bodies and objects.

Therefore, it will not really invite people to make eye contact which is something like that. These findings do not support the suggestion that direct gaze is an aversive stimulus for children with autism. In fact, they support an alternative hypothesis which was earlier proposed by Ami Kiln and her colleagues at Yale University. According to which individuals

with autism may just fail to recognize the importance of eye gaze as a cue to understanding their social worlds.

In their study, while participants were watching the movie Who's Afraid of Virginia Wolf. It was discovered that normal individuals spent much of their viewing time paying attention to the characters faces and eyes to gain an understanding of their intentions and feelings.

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- More support from this hypothesis comes from a range of studies showing that autistic individuals exhibit significantly less activation in the STS when performing theory-of-mind tasks. Moreover, in the checkerboard task described earlier, tehse individuals showed increased STS activation to any shift in gaze rather than specifically in response to gaze shift to unexpected locations.
- A failure to pay attention to eye gaze in autistic individuals may also be accounted for by the smaller size of their amygdala, which is a characteristic of autism. The size of the amygdala is reported to be correlated with the amount of attention an individual pays to the eyes of another person.
- Combined together, these studies indicate that neural regions associated with person-perception do not function in the same way in autistic individuals as they do for normal people.

Whereas autistic individuals mostly fixated on mouths, bodies and the other objects. More support from this hypothesis comes from a range of studies showing that autistic individuals exhibit significantly less activation in the STS when performing theory-of-mind tasks.

Moreover, in the checkerboard task described earlier, these individuals showed increased STS activation to any shift in gaze rather than specifically in response to gaze shift to unexpected locations. Now, a failure to play attention to eye gaze in autistic individuals may also be accounted for by the smaller size of their amygdala, which is a characteristic of autism. So, in the previous chapter, I believe we have talked about the amygdala size is correlated with amount of attention people pay to eyes.

Because, autistic individuals have smaller amygdala, it might correlate or it might explain why the individuals with autism are able to play less attention to eyes of others. Now, if you combine all these studies together it would indicate that neural regions associate with person-perception do not function in the same way in autistic individuals as they do for normal people.

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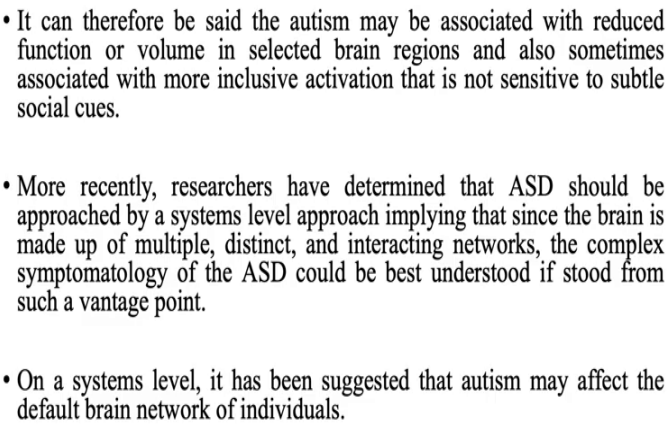

It can therefore be said that autism may be associated with reduced function or volume in selected brain regions and also sometimes associated with more inclusive activation that is not sensitive to subtle social cues. Now, more recently researchers have determined that ASD should be approached by a systems level approach implying that since the brain is made up of multiple, distinct, and interacting networks.

The complex symptomatology of the ASD could be best understood if approached from such a vantage point. So, the idea is because the brain has so many different distinct networks and the symptoms of autism spectrum disorder is kind of vary across the board. It seems that, in order to best understand the autism spectrum disorder it might be that we understand each of the system from a specific networks point of view.

Basically, therefore we will be able to understand how different networks within the brain are all affected in different ways by the autism spectrum disorder.

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- As, we have seen that the MPFC is a part of the brain network that has a higher rate of metabolism at rest, and that this activity may reflect self – referential and social processing, the relation between autism and atypicality of MPFC functioning may also extend to this region's baseline mode of activity.
- It has been observed that when healthy individuals engage in thinking that diverts their attention away from self-referential processing, they experience deactivation in the MPFC. However, autistic individuals do not experience significantly less activity in their MPFC when performing non-self-referential tasks.
- One would wonder whether this could happen if the default network was always on/off with these autistic individuals.

So, on a systems level, it has been suggested that autism may affect he default brain network of individuals. So, as we have seen earlier in the chapter that the MPFC is a part of the brain network that has a higher rate of metabolism at rest, and this activity may reflect self-referential and social processing.

The relationship between autism and atypicality of MPFC functioning may also be extended to this region's baseline mode of activity. It has been therefore, observed that when healthy individuals engage in thinking that diverts their attention away from self-referential processing, they experience deactivation in the MPFC. However, autistic individuals do not experience this deactivation.

Basically, autistic individuals do not experiences significantly less activity in their MPFC when they are performing non-self-referential tasks. So, this deactivation is not really experienced by the autistic individuals.

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- Data from the study points out in the always off direction. More specifically, researchers point out that PET studies are consistent with the always off conclusion.
- Indeed, participants with ASD report very different types of thoughts when their mind is at rest: for instance 2 out of 3 patients reported seeing ony images but no internal speech, feelings of bodily sensations. The 3rd patients appeared to have no inner thoughts at all, and would only describe his current actions.
- Kennedy et al. (2006) estimated that an absence of this resting state activity in ASD individuals may be directly linked to their differences in internal thought.

So, the question could be asked that whether this MPFC or whether the default mode brain network is always on or is it always off in this order. Now, data from this study basically points out in the always off direction. More specifically, researchers point out that PET studies are consistent with the always off conclusion. Indeed, participants with ASD report very different types of thoughts when their mind is at rest; for instance two out of three patients reported in this study.

Just reported seeing only images but no internal speech and feelings of bodily sensations. The third patients appeared to have no inner thoughts at all, and would only describe his current actions.

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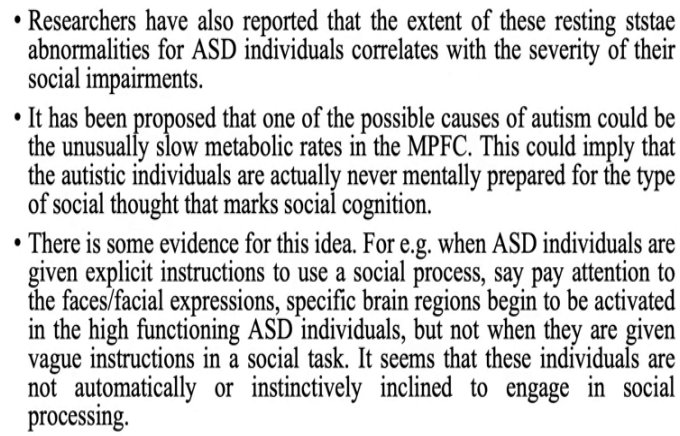

Kennedy and colleagues in 2006, estimated that an absence of this resting state activity in autistic individuals may be directly linked to their differences in internal thought. Researchers have also reported that the extent of these resting state abnormalities for autistic individuals correlates with the severity of their social impairments.

So, here you can see that the default mode network, basically it is not probably not active at all in autistic individuals, which you can see that can explain the deficits in personal and social processing. It could kind of be used to explain their other social impairments as well. It has been proposed that one of the possible causes of autism could be that they have unusually slow metabolic rates in the MPFC.

This could imply that the autistic individuals are actually never mentally prepared for the type of social thought that marks social cognition. There is some evidence tor this idea, for example when autistic individuals are given explicit instructions to use a social process, say pay attention to the faces or facial expressions, specific brain regions then begin to be activated in the high functioning ASD individuals, but not when they are given ambiguous instructions or vague instructions.

It seems that these individuals are not automatically or instinctively to engage in social processing which probably explains the inactivity in the social processing or personal processing areas.

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- Mitchell (2011) puts forward the idea that if the autistic individuals are not constantly engaged in intensive social processing like many normal individuals, they should be freer to attend to objects and nonsocial aspects of their environments.
- Indeed, many ASD individuals are unusually adept in visuospatial and other kinds of nonsocial domains for e.g. musical or drawing talent, puzzle solving aptitude, or solving difficult mathematical calculations.
- Most ASD individuals typically have at least one enhanced nonsocial ability, which seems to arise from resources that are unburdened by the complexities of social processing.

Now, Mitchell puts forwards this idea that if the autistic individuals are not constantly engaged in intensive social processing like many normal individuals, they should be freer to attend to objects and non-social aspects of their environments.

Indeed, many ASD individuals are unusually adept in visuospatial and other kinds of non-social domains, for example, musical or drawing talent, puzzle solving aptitude, or solving complex mathematical problems.

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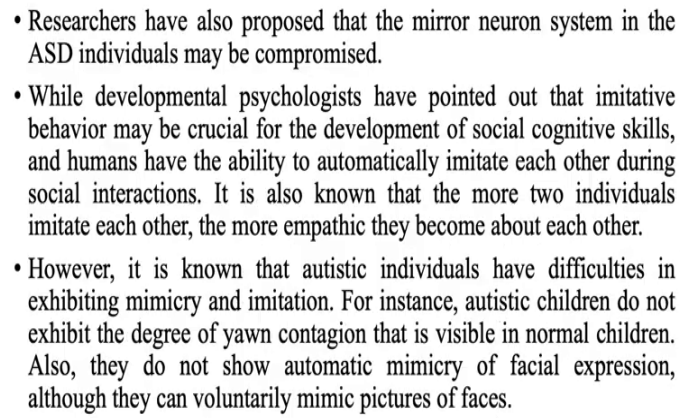

Most ASD individuals typically have at least one enhanced non-social ability, which seems to arise from resources that are unburdened by the complexities of social processing. Moving further, researchers have also proposed that the mirror neuron system in the ASD individuals may be compromised. Now, while developmental psychologists have pointed out that imitative behaviour may be crucial for the development of social cognitive skills, and humans have the ability to automatically imitate each during social interactions. It should also be known that he more two individuals imitate each other, the more empathic they become about each other.

However, it is known that autistic individuals have difficulties in exhibiting mimicry and imitation. For instance, autistic children do not exhibit the degree of yawn contagion that is visible in normal children. Yawn contagion is basically when you are yawning and you look at a person, the person also starts yawning. This is what is called the yawn contagion. Now, this yawn contagion is not really shown or observed so much in the autistic children as it is observed in the normal children.

So, it seems that the mirror neuron network that sort of is behind this yawn contagion basically, it makes you mimic the other person's action is not functioning completely normally in autistic individuals. Also, autistic individuals do not show automatic mimicry of facial expressions although they can voluntarily mimic pictures of faces. So, one of the things is that the autistic you know, typically normal individuals when you are talking with each other or they are engaged in a social interaction.

You know, talking you out something, which is emotional or something. It happens that people start imitating each other's facial expressions, they get in the same mode to kind of follow the flow of the conversation. Sometimes, if somebody is talking to you very angrily, you will not even realize how and when your facial expressions also change into that of anger and your voice also raise up and so on.

Similarly, if some person is talking kindly to you even if you are slightly angry or upset your voice will become kinder. Your expressions will change to more calmer expressions.

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- It has also been suggested that children with ASD are sometimes deficient in understanding the goal of observed motor actions, something that the mirror neurons are responsible for.
- Luigi Cattaneo has suggested that the primary deficit in the mirror neuron systems of autistic children would be the inability in linking initial motor actions into action chains with specific goals and intentions.
- More specifically, they would find it difficult to respond to the initial motor action (such as reaching for food) by firing a specific action chain (reach, grasp, place in mouth) based on the initial motor movement. Typically, an observer of the action would have an internal copy of the action before it occurs, allowing him/her to gain an understanding of people's intentions on that basis.

So, this is something that is very very important aspect of social communication, that automatically is done with individuals. But, it seems that with autistic individuals this aspect is not normally functioning. Now, it has also been suggested that children with ASD are sometimes deficient in understanding the goal of observed motor actions, something that the mirror neurons are responsible for.

Luigi Cattaneo has suggested that the primary deficit in the mirror neuron systems of autistic children would be the inability in linking initial motor actions into action chains with specific goals and intentions. More specifically, they would find it difficult to respond to the initial motor action by firing a specific action chain based on the initial motor movement. Say, for example, if I am picking a pen to write or if I am picking up a pen. You know exactly what the next action will be and you know that I am going to write something. Say, for example, if I am picking pastry from a plate in front of me.

You know, that the next action is going to be that, I am going to bring it near my mouth and I am going to bite it and eat it. Now, these are short action chains, as soon as the first action is taken people can automatically predict what is going to happen in the next two or three actions. This sort of form of action chain for which the goal and everything is known. Typically, normal individuals will be able to do so, but it seems that the autistic children are not able to do this seamlessly.

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- Cattaneo suggests that something may be amiss in the ASD children's motor system in this regard. To test the hypothesis, in his experiment, children with ASD and typically developing children were made to either reach, grasp a piece of food and eat it or to reach, grasp a piece of paper, and place it in a container.
- In another condition, they observed an experimenter performing these actions, in three parts: reaching, grasping and bringing the object to the mouth or the container.
- It was supposed that if an action chain were activated by the initial reaching movement, then the mouth muscle would be activated as soon as a person started for food; but if not, then the muscle would be activated only as the food reached the mouth.

Another interesting aspect of these action chains is that action chains also helps you to predict the observed person's intentions. So, that is also something very very important which it seems does not really wok nicely with the autistic individuals. So, Cattaneo suggests that something may be amiss in the ASD children's motor system in this regard. So, to test this hypothesis in this experiment, children with ASD and typically developing children were made to either reach, grasp a piece of food and eat it or to reach, grasp a piece of paper, and place it in a container.

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- In normally developing children, mylohyoid (MH) activation was present early in the reaching and grasping phases of the grasping for eating action chain and when observing a grasping for eating action.
- This early activation of the muscle in the final stage of the action indicates that understanding of the final goal of the action takes place early on.
- However, for children with ASD, the MH was activated only during the last movement phase of the bringing to the mouth action and no MH activation was found during the observation of the action.
- These findings suggest that individual motor acts are not integrated into an action chain in children with ASD, resulting in their lacking full comprehension of the intention of others.

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However, for children with ASD, the MH activattion was observed only during the last moment phase of the brining to the mouth action and no MH activation was found during the observation of he grasp for eat activation.

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- Intentions an be understood as consisting of two parts: what a person is doing and why is he doing it.
- Researchers suggest that the *what* of a motor act can be understood in two ways: one through a direct matching mechanism by the help of mirror neurons and another by using the semantic cues of the object itself.
- So, just knowing what an object is can cue a person to what motor action will follow. Implying that even if a person's mirror neuron system is impaired, a person could still predict what the goal of a motor act would be through the external; cues.

So, these findings suggest that individual motor acts are not integrated into an action chain in children with ASD, resulting in their lacking full comprehension of the intenion of others. So, they cannot really make out what the other person is going to do, so they wait and in that sense that sort of hampers their communication. So, intentions can be also understood as consisting of two parts: containing of what a person is doing and why is he doing it.

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- About the *why* of the motor act especially when it is not related to an object?
  - For e.g. when the parents of the autistic children extend their arms, the child fails to extend his/her arm in return and cannon understand why the parents made that specific gesture in the first place.
- To understand this kind of behavior, Sonia Boria et al. 92009) investigated whether autistic children nderstood both the what and the why of an action.
- The experiment consisted of two parts again: in the first part, children with ASD and typically developing children were presented with pictures showing hand interactions.
- In half of the why trials the children observed, the hand grip shown was congruent with the function of the object; in the other half, the grip corresponded to the position typicaly used to move that object.

Researchers suggest that the what of a motor act can be understood in two ways; one through a direct matching mechanism by the help of mirror neurons and another by using the semantic cues of the object itself.

So, just knowing what an object is can cue a person to what motor action will follow. If I am picking up a pen, you know that I am going to write. If I am picking up a scissor, you know that I am going to cut. This implies that even if a person's mirror neuron system is not activated, just on the basis s knowledge you can basically predict what is going to be the next action.

Now, about the why of the motor act especially when it is not related to an object? For example, when the parents of the autistic children extend their arms, the child fails to extend his or her arm in return because they cannot understand why the parents have made that specific gesture in the first place. To understand this kind of behaviour, Sonia Boria and colleagues in 2009, investigated whether autistic children understood both the what and the why of an action.

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- Then the children were asked what the individual was doing and why she was doing it.
- Both sets of children could accurately report the what, or goal, of the motor acts.
- The children with ASD, made several errors in the why is she grabbing the object task, and all of the errors occurred in the "why-place" trials.
- In the second experiment, the children saw the pictures of a hand grip that was compatible with the object's use. The object was placed in context suggesting that it was going to be used (congruent with the grasp) or that it was about to be placed into a container (incongruent with the grasp).
- Here both sets of children performed equally, correctly reporting the agent's intention.

The experiment consisted of two parts again; in the first part, children with ASD and typically developing children were presented with pictures showing hand interactions with certain objects. Now, in half of the why trials the children observed, the hand grip show was congruent with the function of the object. Suppose, say for example there is a pen, the grasp will be of holding the pen and writing.

In the other half, the grip corresponded to the position typically used to move that object. Say, for example, it will be a pushing sort of an action. Then the children were asked what the individual was doing and why she was doing it. Both sets of children, normal and autistic could accurately report what or the goal of the motor acts.

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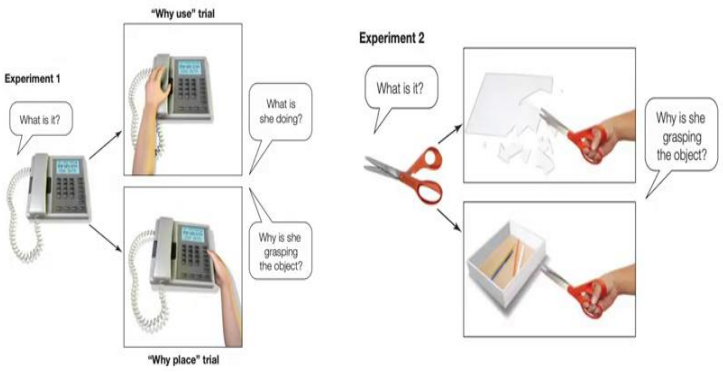

Experiments from Boria (2009). Image Source: Gazzaniga, Ivry & Mangun (2014) Cognitive Neuroscience-The Biology of the Mind. pp 591. W W Norton & Company.

So, the children with ASD, made several errors in the why is she grabbing the object task.

All of the errors occurred in the why-place trials. There is why, this thing being pushed to that place. In the second experiment, the children saw the pictures of a hand grip that was compatible with the object's use. The object was placed in context suggesting that is was going to be used or that it was about to be placed into a container.

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- These researchers concluded that understanding the intentions of other can occur in two ways: by relying on motor information derived from the hand-object interaction, and by using semantic information derived from the object's standard use or the context in which it is being used.
- Children with ASD show no deficit in the second type of understanding, but they have difficulties in understanding the intention of others when they have to rely exclusively on motor cues.
- In other words, they understand the intentions from external cues, not internal ones, and hence, providing additional support for the notion that autism involves a deficit in the mechanics of the mirror neuron system.
- This evidence suggests that the mirror neuron system is highly interconnected and that the imitation deficits and some of the other cognitive deficits in autism may be a result of underconnectivity in the mirror neuron system and the involvement of the alternative communication pathways.

Here, both sets of children performed equally, correctly reporting the agent's intention. You can here have a look at the set of experiment. You can see, this is the what condition, what is it? It is a phone. Why is this person holding it is going to use it. Why is the person holding it

like this, she is going to place it somewhere. So, in the second experiment what is it? Why is she grasping the object? She is going to cut it, whys is she grasping the object here, you don't know and here it is A typical.

Now, these researchers concluded that understanding the intentions of other can occur in two ways; by relying on motor information derived from the hand object interaction, and second by using semantic information, by using semantic information derived from the object's standard use or the context in which it is being used. Children with ASD show not deficit in the second type of understanding, but they have difficulties in understanding the intentions of others when they have to rely exclusively on motor cues.

So, the semantic knowledge part is alright, but the motor cue part is not really functioning nicely.

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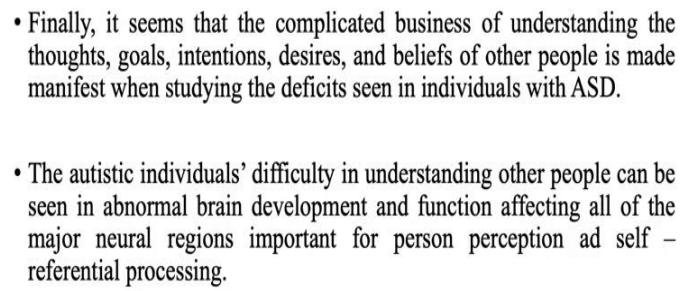

So, in other words they understand the intentions from external cues, not internal ones, and hence, providing additional support for the notion that autism involves a deficit in the mechanics to the mirror neuron system. This evidence totally suggests that the mirror neuron system is highly interconnected system.

That the imitation deficits and some of the other cognitive deficits that are observed in autism, may be a result of underconnectivity in the mirror neuron system and the involvement of the alternative communication pathways. Finally, it seems that the complicated business of

understanding the thoughts, goals, intentions, desires and beliefs of other people is made manifest when studying the deficits of children observed with ASD.

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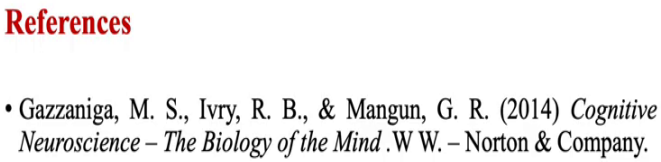

Finally, the autistic individuals difficulty in understanding other people can be seen in abnormal brain development and function affecting all of the major neural regions important for person perception and self-referential processing. So, I think this is all I wanted to talk about autism. We will meet for the last lecture, we will meet for the last part of the chapter in the next lecture, thank you.