Introduction to Brain & Behaviour
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Lecture 36
Neuroscience of Social Cognition

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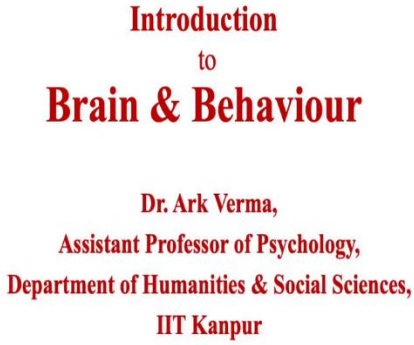

Hello and welcome to the course, introduction to brain and behaviour. I am Dr. Ark Verma from Indian Institute of Technology, Kanpur. This is week 8 of the course and we are going to talk about the neuroscience of social cognition.

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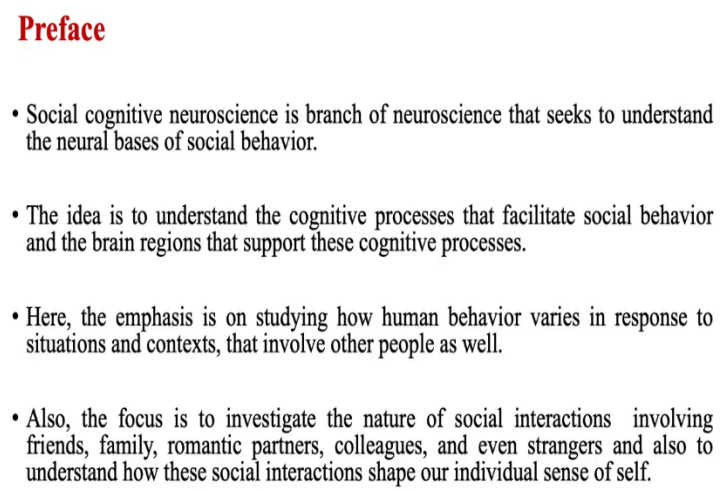

Now, social cognitive neuroscience is a branch of neuroscience that seeks to understand the neural causes of social behavior. The idea is to understand that cognitive processes that facilitate social behavior and the brain regions that support these cognitive processes.

Here, the emphasis is on studying how human behavior varies in response to situations and contexts, that involve other people as well. Also, the focus is to investigate the nature of social interactions involving freinds, family, romantic partners, colleagues, and even strangers and also to understand how these social interactions shape our individual sense of self.

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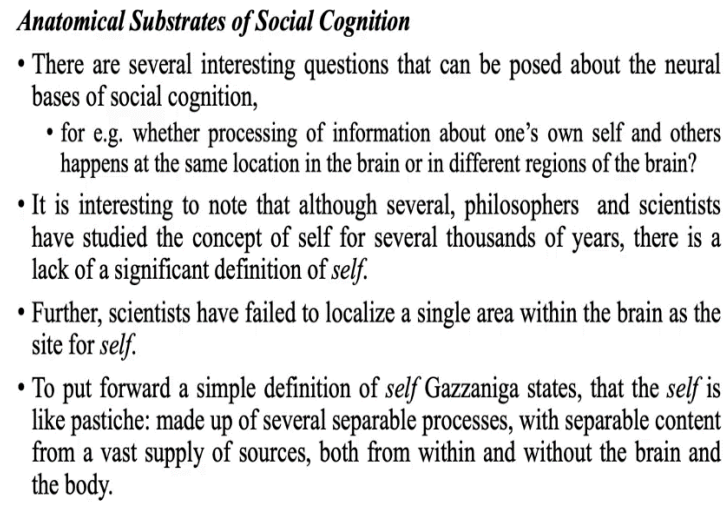

Let us talk about anatomical substrates of social cognition. There are several interesting questions that can be posed about the neural bases of social cognition. For example, whether the processing of information about one's own self and others happens at the same location in the brain or in different regions of the brain. It is interesting to note that although several philosophers and scientists have studied the concept of self for several thousands of years, there is still a lack of a significant definition of self.

Further, scientists have failed to localize a single area within the brain as the site for self. To put forward a simple definition of self gazzaniga states, that the self is like pastiche it is made up of several separable processes, with separable contents from a vast supply of sources, both from within and without the brain and the body.

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- The prefrontal cortex (PFC) has been implicated as an important region for self –related processing.
- The lateral aspect of the PFC has two parts, i.e. the Dorsolateral Prefrontal Cortex (DLPFC) and the Ventrolateral Prefrontal Cortex (VLPFC). The medial regions include the Orbitofrontal Cortex (OFC) and the Ventromedial Prefrontal Cortex (VMPFC).
- The regions of the PFC that have implicated in self-referential processing are the DLPFC and the VMPFC, the posterior cingulate cortex (PCC) and the medial and lateral parietal cortex.
- An important aspect of the sense of self is the subjective feelings that we have about ourselves, the regions of the brain that contribute to the subjective feelings and our sense of self are the orbitofrontal cortex, anterior cingulate cortex, and the insula, as well as parts of the autonomic nervous system, hypothalamic-pituitary-adrenal axis (HPA) and endocrine systems that regulate bodily states, emotions and reactivity.

For example, the prefrontal cortex has been implicated as a region for self related processing.The lateral aspect of the prefrontal cortex has two parts ones is the dorsolateral prefrontal cortex and the ventrolateral prefrontal cortex. The medial regions include the orbitofrontal cortex and the ventromedial prefrontal cortex. The regions of the of the prefrontal cortex that have implicated in selfreferential processing are the DLPFC which is the dorsolateral prefrontlal cortex and the ventromedial prefrontlal cortex and the posterior cingulate cortex also the medial and the lateral parietal cortex.

An important aspect of the sense of self in the subjective feelings that we have about ourselves, the regions of the brain that contribute to the subjective feelings and our sense of self are the orbitofrontal cortex, the anterior cingulate cortex, and the insula, as well as parts

of the autonomic nervous system, hypothalamic pituitary adrenal axis and the endocrine systems that regulates bodily states, emotions and reactivity.

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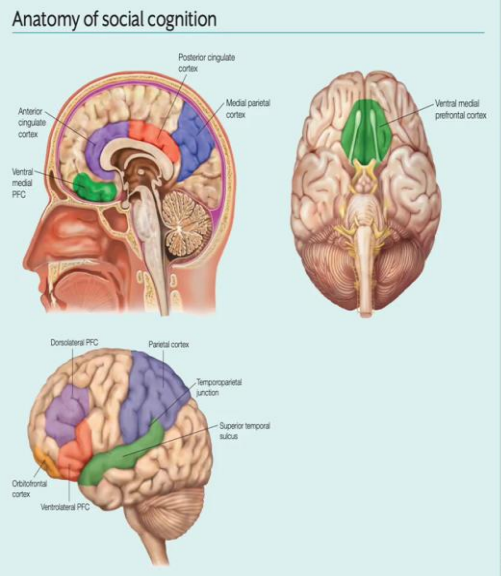

Image Source: Gazzaniga, Ivry & Mangun (2014). Cognitive Neuroscience – The Biology of the Mind. Pp 562. W W Norton & Company.

In this figure, you can see the different regions that have been implicated in self and other processing. You can see the anterior cingulate cortex, the ventral medial prefrontal cortex, the posterior cingulate cortex, the medial pareital cortex, the ventromedial prefrontal cortex. The dorsolateral prefrontal cortex, orbitofrontlal cortex, ventrolateral prefrontal cortex, parietal cortex, temporoparietal junction, and the superior temporal sulcus.

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- Further, as memory is also an important aspect of self – referential processing, the temporal lobe is also important for the sense of self.

- Also, there are brain regions and networks that facilitate our ability to understand others, which include the amygdala, and its interconnections with superior temporal sulcus (STS), the medial prefrontal cortex and OFC, ACC and the fusiform face area, regions associated with mirror neuron systems, the temporal poles, temporoparietal junction (TPJ), and the medial parietal cortex.

Further, as memory is also an important aspect of self-referential processing, the temporal lobe is also an important for the sense of self. Also, there are brain regions and networks that facilitate our ability to understand others, which include the amygdala, and its interconnections with superior temporal sulcus, the medial prefrontal cortex and the orbitofrontal cortex, the ACC that is the anterior cingualr cortex and the fusiform area these are regions which are typically associated with mirror neuron systems, the temporal poles, temporoparietal junction, and the medial parietal cortex.

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Deficits in Social Cognition

- Several individuals having *autism spectrum disorders* (ASD) demonstrate deficits in social behavior. Typically, individuals exhibit impaired social interaction, along with other related deficits. These disorders include *autism, Asperger's Syndrome, childhood disintegrative disorder, Rett syndrome and* other pervasive developmental disorders.
- Individuals suffering from autism are less interested in other individuals or social interactions and focus more on their internal thoughts or inanimate objects around. Autistic individuals prefer to be engaged in repetitive, routine behaviors and get upset when these behavior are disrupted.
- Further, instead of looking for social interactions, autistic individuals engage in these repetitive behavior by themselves and sometimes display head banging behavior, or rocking their bodies. Autistic individuals may sometimes also be hypersensitive to sensory stimuli.

Let us talk a little but about the possible deficits in social cognition. Several individuals having autism spectrum disorders demonstrate deficits in social behavior. Typically, individuals exhibit impaired social interactiom along with other related deficits. These disorders include autism, Asperger's Syndrome, childhood disintegrative disorder, Rett syndrome and some other pervasive developmental disorders.

Individuals suffering from autism are less interested in other individuals or social interactions and they focus more on internal thoughts and inanimate objects around. Autistic individuals prefer to be engaged in repetitive routine behaviors and get upset when these behaviors are disrupted. Further, instead of looking for social interactions, autistic individuals engage in these repetitive behavior by themselves and sometimes display head banging behavior or rocking their bodies.

As a way to develop and cling on to those routines. Autistic individuals can sometimes also be hypersensitive to paticular kinds of sensory stimuli. For example, they might be irritated

by too much light or too much sound, they might be irrtitated by particular temperature conditions, etc.

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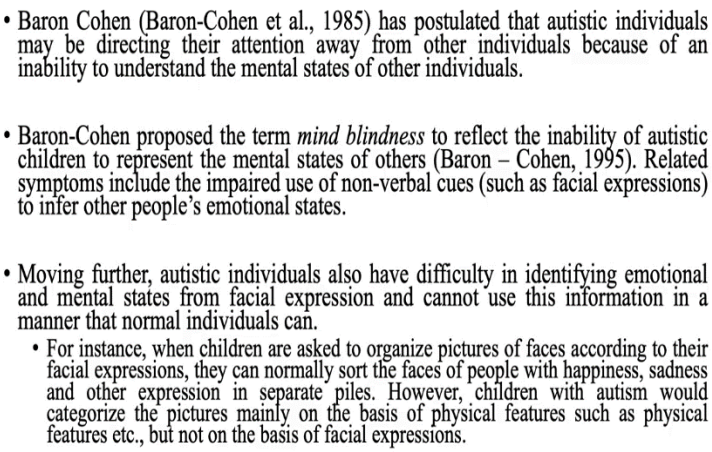

Baron Cohen has postulated that autistic individuals may be directing their attention away from other individuals because of an inability to understand the mental states of other individuals. Baron-Cohen proposed this term mind blindness to reflect the inability of autistic children to represent the mental states of others. Related symptoms include the impaired use of non-verbal cues to infer other people's emotional states. Moving further, autistic individuals also have difficulty in identifying emotional and mental states from facial expression and cannot use this information in a manner that normal individuals can.

For example, you and me if we come across a particular person, we will look at the particular person's mannerism, maybe his facial expressions, his hand movements, etc and we will be able to very qucikly estimate that okay the person is angry, he is happy, he is in a good mood, or in a bad mood. We can use that information to tone down or tone up our interactions in a particular way. We will use that knowledge to basically, plan the way we are going to interact with that person.

But autistic individuals have real problem with these things. Listing an example, when children are asked to organize pictures of faces according to their facial expressions, they can normally sort the faces of people according to their expressions. Say for example, happy faces in one pile, sad faces in other pile and so on. However, children with autism will not be able to categorize these pictures of faces on the basis of emotional expressions or facial

expressions.But, rather on the basis of their physical features such as the overall shape of the face, the color and so on.

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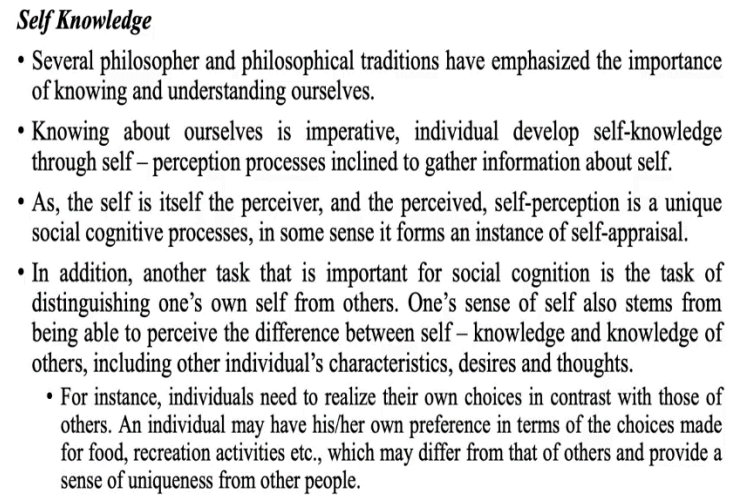

Now, let us talk a little bit about self knowledge. Several philosopher and philosophical traditions have emphasized the importance of knowing and understanding ourselves. Knowing about ourselves is imperative, individual is imperative and individuals develop self-knowledge through self-perception processes that are inclined to gather information about ourselves.

For example, as the self is itself the perceiver the perceived, self information is slightly unique social cognitive process and in some sense forms an instance of what is called self-appraisal. In additional another task that is important for social cognition is the task of distinguishing one's own self from the others. One's own sense of self also stems from being able to perceive the differences between self-knowledge and knowledge of others.

It is almost like you will have to create a category or you willl have to create a contrast to understand that this is what I want, this is what somebody else wants and because this is a choice that I have made I am different from the other people. For instance, individual, so that is bascially what I was saying. For instance, individuals will need to realize their own choices in contrast with those of others. An individual may have his or her her own preferences in terms of the choices made.

Say for example, for food, recreation acitvities, choice of clothes, choice of words in how you want to say something, etc. Now, this may be different from that of other's choices and therefore they will provide you with a sense of uniqueness from other people.

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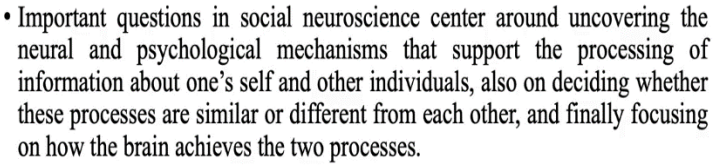

Several important questions basically in socual neuroscience center aroud uncovering the neural and psychological mechanisms that support the processing of imformation about one's self and other individuals. Also on deciding whether these processes are similar or different from each other, and then finally focusing on how the brain achieves these two processes bascially which are perception of the self and getting knowledge about oneself and then perception of others knowing their mental stage, understanding them so that you can have proper social interactions with people around.

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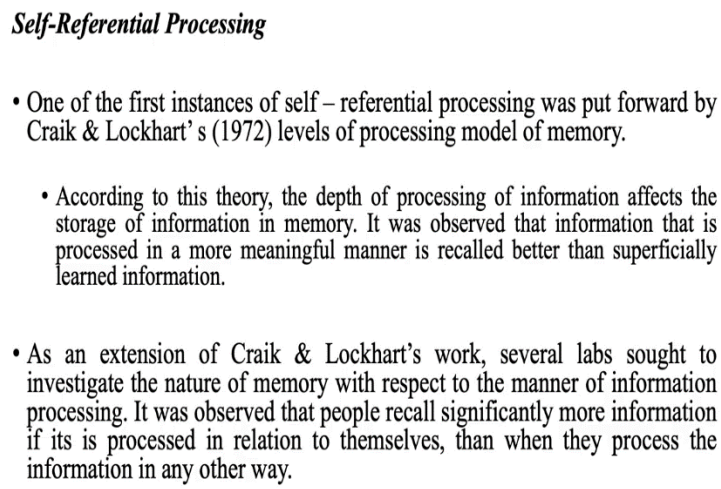

Let us first tallk about self-referential prcoessing, now one of the first instances of self-referential processing was put forward long ago by Craik & Lockhart' s levels of processing model of memory. If you remember from psychology class, according to this theory, the depth of processing of information basically affects the storage of information in memory. In their experiments Craik and Lockhart, (())(10:31) they observed that information is prcoessed in a more meaningful manner.

Information, that is processed in a more meaningful manner, has a better chance of being recalled than superficially learned information. As an extension of Craik & Lockhart's work several labs basically sought to investigate the nature of memory with respect to the manner of information processing. How are you going to store some information and the way that you store particular information and how is that way going to, let us say influence the recall or use of information at a later point in time.

Now, it was observed that people recall significantly more information if it is processed in relation to themselves, than when they process the information in any other way. So, if you remember something and you say, okay this is relevant to me in some manner. Let us say, if it is a cloth that you like too much. If it is a list of places, maybe somebody is asking you to rememeber and some of these places you have already been there and you have some memories attached to it. So, you kind of process them more personally. That is where that list or say for example, atleast those places where you have been to and you have a personal connect will be remembered better.

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- For instance, it was found that individuals were more likely to remember an adjective say, happy, sad or punctual if they are asked to determine whether and how well it describes themselves as compared to when they are asked that how well the adjective describes others.
- This enhanced ability to remember information processed in relation to the self is known as the ***self-reference effect***.
- Two different proposals have been offered to explain the reason behind the self-reference effect.
  - One of the proposal suggests that the self may be a unique cognitive structure having unique mnemonic or organizational elements that allow processing in a different way than other cognitive structures.

Say, for instance again I am giving another example. For instance, if it was found that individuals were more likely to remember an adjective say, happy, sad or punctual if they were asked to determine whether and how well it describes themselves as compared to when they are asked that how well the adjective describes others.

This enhanced ability to remember information processed in relation to ourselves is known as the self-reference effect. Two different proposals have been offered to explain the reason behind the self-reference effect. One of the proposal suggests that the self may be a unique cognitive structure having unique mnemonic or organizational elements that allow processing in a different way than other cognitive structures.

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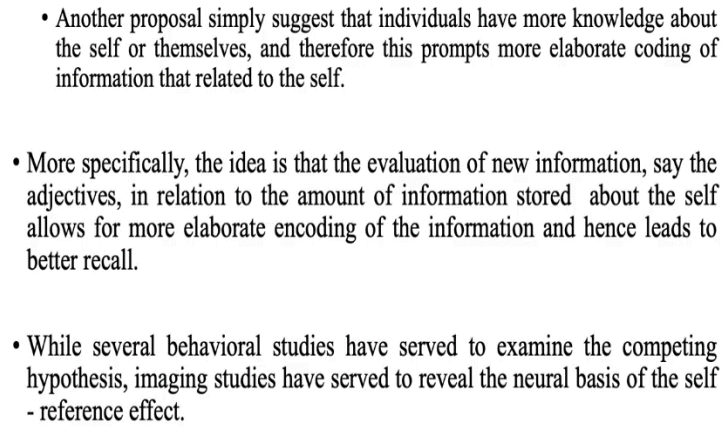

Another proposal simply suggest that individuals typically have more knowledge about themselves, and therefore this prompts more elaborate coding of the information that is related to the self. More specifically, the idea is that the evaluation of new information, let us say the adjectives in this case, in relation to the amount of information that is stored about the self allows for more elaborate encoding of the information and hence leads to better recall.

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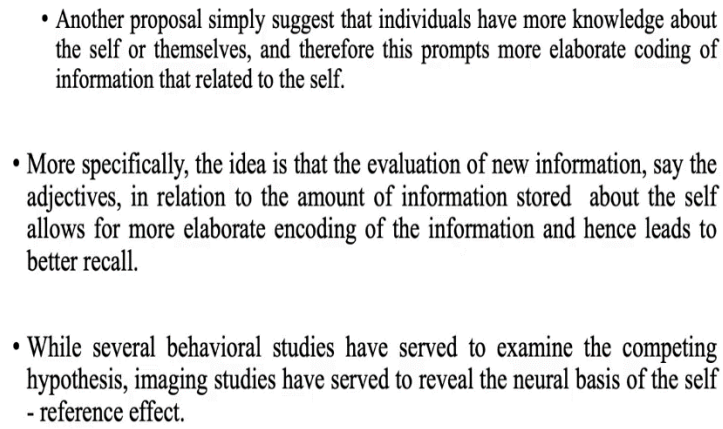

Let us look at this example in a bit more detail. Suppose, you have to remember list of adjectives and one of the adjectives is punctual. Now, the thing is if you want to remember the adjectives better and you have to sort of process them in reference to yourself. One of the

things you will do is, let us say you will try and recall all the instances where you have been punctual and use that to basically store this adjective nicely.

And tell yourself that, yes I am punctual because I have so many of these examples. Now, what has happened is that on the basis of your older memory you have anchored this adjective very well. The list recall time comes, when somebody is going to ask you about the adjectives in the list. You will have remembered this adjective particularly well because you have stored it in that manner.

Now, while several behavioral studies have started to examine the competing hypothesis, imaging studies have served to reveal the neural basis of the self-reference effect. So, imaging studies have been particularly important in actually telling us with respect to the brain which are the areas, which are responsible for this kind of self-reference effect.

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- To look at the possibilities in more detail, if the self were a distinct cognitive structure and has its own unique information processing, then distinct neural regions should be activated in relation to the self – reference effect.

- Kelly and colleagues (2002) conducted an fMRI to test the above hypothesis.
  - In their study, participants judged personality adjectives in three experimental conditions: in relation to the self ("Does this trait describe you?"), in relation to another person ("Does this trait describe George Bush?"); or in relation to its printed format ("Is this word presented in uppercase letters?")
  - As per the results, the participants were found to be more likely to remember words from the self condition and less likely to remember words from the printed-format condition.

Now, look at some of these possibilities in more detail, let us say if the self were a distinct cognitive structure.It has its own unique information processing, then distinct different neural regions should be activated for the self-reference effect. Say for example, other regions will be acitivated when you have to code information that is not self relevant. Now, Kelly and colleagues in 2002 they conducted an fMRI study to test the above hypothesis. In their study, participants were asked to judge personality adjectives in three experimental conditions, first in the relation to their self. Say for example, does this trait describe you?

Let us say, are you punctual in relation to another person, does this trait describe, let us say a famous person like George Bush or finally in relation to just its form in a more superficial sense. Is this word presented in uppercase or lower case? Now, as per the results, the participants were found to be more likely to remember words from the self condition and less likely to remember words from the printed-format condition.

Again, this is defintely according to the predictions that Craik and Lockhart had made that once your processing information in relation to themselves you are having more elaborate and more space coding and you will remember this information better.

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- As regards the brain areas, the medial prefrontal cortex (MPFC) was found to be differentially activated in the self condition as compared to the other two conditions. The MPFC activity was later found to predict which items would be remembered on the surprise memory test.
- Further, the relation between the MPFC and self – reference effect was also found to extend to instances where participants were asked to view themselves through another person's eyes.
- Moreover, self – referential processing has also been found to produce positive-moving shifts in ERPs that emerge from a midline location consistent with the location of the medial prefrontal cortex (MPFC).
- Hence, it is established that the self – reference effect is strongly linked with the processing in the medial prefrontal cortex (MPFC).

Now, with respect to the brain areas, the medial prefrontal cortex was found to be differentially activated in the self condition as compared to the other two conditions. The medial prefrontal cortex activity was also later found to predict which items would be actually remembered in a surprise memory test.

So, items that have basically that showed medial prefrontal cortex acitvity while they were been encoded. It predicted that okay these were the items that will be remembered better. Now, further the relation between the medial prefrontal cortex and self-reference effect was also found to extend to instances where participants were asked just to view themselves through another person's eyes.

Moreover, self-referential processing has also been found to produce positive-moving shifts in ERPs that emerge from a midline location consistent with the location of the medial

prefrontal cortex. So both from fMRI studies and ERP, you can see that the medial prefrontal cortex is being implicated in self-referential processing or the self-reference effect. So, in some sense it is established that the self - reference effect is strongly linked with the processing in the medial prefrontal cortex.

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Self – Descriptive Personality Traits

- Another important instance of self related processing concerns the self – descriptive personality traits.
  - For e.g. asking the question of whether a particular trait describes you or others.
- It has been observed that individuals have a better memory for traits that they judge in relation to themselves or opposed to those judged in relation to others.
- Indeed, when one has to decide about whether a trait is self – descriptive, one draws on the instances of self – perceptions that provide us with a summary of our personality traits, whereas judgments in relation to others usually only draw from a few specific episodes or instances from our lives where the concerned individuals have displayed behavior exhibiting the said traits.

Now, let us talk about the self-descriptive personality traits. Another important instance of the self related prcocessing concerns the self-descriptive personality traits, the adjectives. For example, asking the question of whether a particular trait describes you or others. I could give list of adjectives, let us say I was talking about punctual. Let me take a different adjective now, let me say if the adjective is conscientious. I could ask you, does the word consicentious describe your personaility well.

Let us say, it descrirbes the personaility of you know another famous person, you can think about a film star, a cricketer or whatever. Now, it has been observed that the individuals typically have a better memory for traits that they judge in relation to themselves as opposed to those judged in relation to others. Indeed, when one has to decide about whether a trait is self-descriptive, as I was saying earlier one draws on the instances of self-perceptions that provide us with a summary of our personality traits.

Whereas judgments in relation to others usually draw from a few specific episodes or instances from our lives where the concerned individuals have displayed the behavior exhibiting the said traits. Let me explain this to you in a better selfs, now if you have to answer that whether you are conscientious or not. You will have you know a large amount of

data spanning your you know entire life and so many so many instances where you have behaved in a particular manner. That would suggest that you are conscientious or let us say you are not conscientious.

Now, when you have to answer this question with regards to the other person, let us say a close friend or another famous person. Let us say somebody like you know national leader or a bollywood star or somebody. And suppose, somebody asks you that does x seems conscientious to you. Now, basically that will obviously will be based on a very few instances in let us say you know the course of your life that you saw some behavior by these individuals.

Which would suggest that whether they are conscientious or not. In that sense you know the coding is rather superficial because you are not really personally very attached to that entire thing. So, you will not be super sure and in that sense your memory or the traces of memory that will be formed, will be that much more weaker.

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- Klein & colleagues (1992) conducted a study to investigate whether self – description judgments rely on the recall of specific autobiographical episodes.

- Participants were shown a personality adjective on a computer screen and were asked to rate it for self – descriptiveness ("Are you punctual?") or just to define the adjective ("What does punctual mean?"). As control, participants were shown a blank screen with no adjectives.

- After this initial task, participants described a particular instance from their own lives when they demonstrated the personality characteristic. Here, the researchers recorded the time that was taken by the participants to arrive at the said description. For the control condition, participants described an episode when they demonstrated a trait that they had not been asked about ("Give an example of an instance when you were lazy.")

Klein & colleagues in 1992 decided to conduct a study to investigate whether self-description judgements actually rely on the recall of specific autobiographical episodes.

Participants were shown a personality adjective on a computer screen and they were asked to rate it for self- descriptiveness. Say for example, the sentence would be, are you punctual? Rate it on a scale of 1 to 5 or 1 to 11 or whatever. You could just alternatively be asked to

just define the word. So, what does punctual actually mean? As a control condtion participants were shown a blank screen with no adjectives.

After this initial task, participants described a particular instance from their lives when they demonstrated the given personality characteristic. So, what are the instance of your life where you have been very punctual. Now, here the researchers recorded the time that was taken by the participants to arrive at the said description. How easy or difficult or how much time does it take you to come with those instances of punctuality.

Suppose, there are a very few instances that you have been punctual. It will take you more time, suppose there are many many instances that you have been punctual. You will be able to recall that instance very quickly. For the control condition, participants described an episode when they demonstrated a trait that they had not been asked about. So, giving an example of when you were lazy. Okay, so you have not been asked about lazy in the list apparently and then you are just asked to describe this.

Then, you basically, again the time you spent in arriving that description will be measured and compared to the other earlier scenario.

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- The idea is that if self-descriptions depend upon drawing from episodic memory for specific instances, participants may be found to be faster to recall an episode where they exhibited the personality characteristic that they already had been asked about, having just done the same while performing the self – descriptive judgment.

- However, the researchers could not find any difference between the self – judgment, definition and control conditions. These results led the researchers to conclude that judgments about self-descriptiveness of characteristics or traits does not depend upon recall of instances from episodic memory.

- Such an assumption leads to the possibility of being able to have sense of self, even in cases where there is a loss of autobiographical memories.

So, the idea behind this experiment was that, let us say if self-descriptions depend upon drawing from episodic memory of specific instances from your life. Participants may be found to be faster to recall an episode where they exhibited the personality characteristic that they already had been asked about.

See, in the second instance if you have already been asked about you know this in the list of the adjectives, you know whether this describes yourself or not. You will be able to quickly recall that, so this is basically we will form the whole time taken in the arriving at that description thing. However, the researchers could not find any difference between the self-judgment, definition and the control conditions.

These results led the researchers to conclude that judgments about self-descriptiveness of characteristics or traits may not depend upon the recall of specific instances from episodic memory. So, they say it is something else that is possibly driving this self-reference effect and not really you know picking up of information from episodic memory. Such an assumption would lead us to the possibility of being able to have sense of self, even in cases where there is a loss of autobiographical memories.

So, for example, even if you do not have a lot of autobiographical memory remaining. Suppose, you are suffering from amnesia or some accident. Even then, you will still retain the sense of self. If the sense of self were entirely based on your memories then, as soon as the memory goes. Let us say, you have any of these syndromes, Korsakoff's syndrome injury or stroke. You will sort of remember, you will also lose your sense of self.

But, that is not what happens with amnesia patients. They have very well defined sense of self, even though their memories are lacking. So, this is, in some sene of self you try and understand it, it is fairly intuitive.

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- The same has been demonstrated in patients who had dense amnesia. Two patients were considered, one having anterograde and another having retrograde amnesia.
- Patient D.B.'s memory problems happened after a heart attack as a result of the transient loss of oxygen to the brain – hypoxia.
- Patient K.C.'s memory lost his memory as a result of a motorcycle accident which caused extensive brain damage.
- Although neither of the two patients could not recall anything from their earlier lives, they were found capable to describing their own personality very well, as also verified by other family members.

Now, the same has been demonstrated in patients who had dense amnesia. Let us talk about two patients who were considered, one had an anterograde amnesia severe and another having retrograde amnesia severe.

And the patient's name were D.B. and K.C. patient D.B.'s memory problems happened after heart attack as a result of the transient loss of oxygen to the brain that is hypoxia. So, his amnesia was basically rooted in hypoxia of the brain. Patient K.C.'s memory lost was basically as a result of a motorcycle accident which caused extensive brain damage. Although neither of the two patients could not recall anything from their earlier lives, they were found capable of describing their own personalities very well.

As also verified by other family members. So, they were able to give descriptions of, let us say if they were lazy or punctual. Whether they were conscientious or they were not and those kind of things.

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- However, this result can also be interpreted as the preservation of a more general social knowledge, rather than the preservation of self – knowledge. Such a pattern is observed in patients with Korsakoff's syndrome.
- Although typically patients with Korsakoff's syndrome have extreme difficulty in recalling old events. In a study, patients with Korsakoff's syndrome were presented with pictures of two men and were narrated a biographical story of each. One of the men were described as a good guy, whereas other was described as a bad guy.
- A month later, it was found that most patients preferred the picture of the man described as a guy, even though they could not recall any of the biographical information about either of the two guys.

So, this result can also be interpreted as the preservation of a more general social knowledge rather than the preservation of self-knowledge. So, in some sense you know you can say it is okay, maybe it is not really the sense of self that is as speaking out here. It is basically a general social kind of knowledge.

Generally about how people are and how they behave and so on. Although typically patients in Korsakoff's syndrome have extreme difficulty in recalling old events. In a study, patients with Korsakoff's syndrome were presented with pictures of two men and were narrated a

biographical story of each. So, one of the men were described as a good guy while the other was described as a bad guy. So, this story was narrated.

A month later, it was found that most patients preferred the picture of the man described as a guy, even though they could not recall any of the biographical information that was read about him.

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- Klein's work indeed led to useful insights about the nature of self-knowledge processing (Klein & Lax, 2010).
  - It led to the observation that trait-based self-knowledge is considerably robust and can survive several types of brain injury or damage.
- The work establishes the fact that not only self-knowledge is a unique type of knowledge, rather it is not a single entity but that is distributed across multiple systems.
- Indeed, different systems have been discovered that are dedicated to processing different aspects of self-knowledge.
  - For instance, one system is found to be dedicated to episodic memories about self, one for a sense of personal agency, one for the ability to recognize your body in the mirror and also several other system dedicated to other aspects of self – knowledge.

So, Klein's work basically led to useful insights about the nature of self-knowledge processing. It led to the observation that trait-based self-knowldge is considerably robust and can survive several types of injury or insult or something to the brain.

This work also establishes the fact that not only self-knowledge is a unique type of knowledge, rather it is not a single entity but that is discribed through multiple systems. Indeed different systems have been discovered that are dedicated to processing different aspects of self-knowledge. For instance, one system is found to be dedicated for episodic memories about one self. Another system for you know sense of personal agency.

Like, I am in control, I am doing these things and I am not doing these things and so on. One is dedicated for the ability to recognize your body in the mirror and also several other system dedicated to other aspects of self- knowledge.

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Self-reference as Baseline Mode of Brain Function

- Recent neuroscientific research has suggested that the medial prefrontal cortex (MPFC) has unique physiological properties that may allow self-referential processing even while we are not actively engaged in a task of thinking about ourselves.

- It has been observed that even at rest, i.e. when participants are not performing any task, activation of specific brain regions, as measured by the MRI apparatus, was found to be steadily increasing, and comparable to the activation of other specific brain regions when they were actively engaged in a cognitive task. When participants were later asked about these period, their answers typically referred to some kind of self – referential processing.

Now, let us talk about self-reference as a baseline mode of brain function. Now, what has happened is in recent times, recent neuroscientific research has suggested that the medial prefrontal cortex has unique physiological properties that may allow self-referential processing.

Even while you are not actively engaged in a task of thinking about yourself or we are not actively engaged in a task of thinking about ourselves. It has been also observed that even at rest, that is when participants are not really performing any task, the activation of specific brain regions, as measured by the MRI apparatus, was found to be steadily increasing, and comparable to the activation of other specific brain regions when those regions were actively engaged in performing certain task. Now, when participants were later asked about these period.

You know, you go the particpant and ask them. We saw that your brain was specially actve or these regions of your brain were specially active between timestamps this and this. What were you doing at this time? Mostly, participants answers, basically gave a hint that they were engaged in some kind of self-referential processing. They were either planning their day ahead, the lunch they are going to have next. What is going on in their lives and things like that.

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- Indeed, a network of brain regions including the MPFC, has been found to have higher metabolic rates at these periods of "rest".
- Raichle , Gusnard and colleagues (Gusnard & raichle, 2001) have proposed that even while the brain is "at rest", several areas of the brain are continuously engaged in a number of physiological processes which has been referred to as a default mode of brain function. These brain regions have been called the ***default mode network***, and is supposed to consist of the MPFC, precuneus, TPJ, medial temporal lobe, lateral parietal cortex, and posterior cingulate cortex.
- It has been proposed that this higher metabolic rates in the medial prefrontal cortex indexes self – referential processing such as our current and future course of action etc. This view is referred to as the ***sentinel hypothesis***.

Indeed, a network of brain regions including the medial prefrontal cortex, has actually been found to have highermetabolic rates at these periods of rest. When the brain is not really actively engaged in doing some tasks. Raichle, Gusnard and colleagues have proposed that even while the brain is at rest, several areas of the brain are continuously engaged in a number of physiological processes which has been referred to as a default mode of brain function. These brain regions have been called the default mode network and it is supposed to consist of the medial prefrontal cortex, precuneus, temporoparietal junction, medial temporal lobe, lateral parietal cortex, and posterior cingulate cortex.

So, these are the regions which are basically part of this default network of the brain, which basically is also active while you are at rest. Now, it has been proposed that this higher metabolic rates in the medial prefrontal cortex indexes some degree of self-referential processing. Say for example, thinking about our current and future course of action etc.

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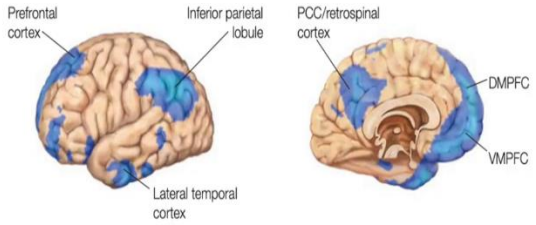

FIGURE 13.4 The Default Network.
Combined data from nine positron emission tomography (PET) studies showing the regions that were most active during passive tasks (in blue). The lateral (left) and medial (right) surfaces of the left hemisphere are shown.

Image source: Gazzaniga, Ivry & Mangun (2014). Cognitive Neuroscience – The Biology of the Mind. Pp 569, W W Norton & Company.

This view is referred to as the sentinel hypothesis. Here, you can look at the regions which are involved in the default mode. So, you can see the prefrontal cortex, the inferior parietal lobule, lateral temporal cortex. The posterior cingulate cortex, the dorsol medial prefrontal cortex, the ventral medial prefrontal cortex.

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- The default mode network has been found to be most active when our attention is focused away from external stimuli and towards internal mental states.
- This network is found to be connected to the medial temporal lobe memory system, which can explain why we often consider the past in the default ramblings.
- The default mode network is found to be deactivated when individual are actively engaged in performing tasks that engage our cognitive resources.
- However, while individuals are performing active tasks that involve self – referential judgments, the MPFC is deactivated to a lesser extent.

Now, the default mode network has been found to be most active when our attention is focused away from the external stimuli and towards internal mental states.

This network is found to be connected to the medial tcmporal lobe memory system, which can explain why we often consider the past in the default ramblings. So, basically because

this is some draws on memory sources. It is, in some sense but natural that we will think about the past or let us say because we are thinking about the past, we are drawing from these regions. Now, the default mode network is found to be deactivated when individuals are actively engaged in performing tasks that engage our cognitive resources like, attention. etc.

So, for example, some people have this tendency of starting to think about themselves too deeply or starting to getting lost in day dreams. Typically, what they are doing in these day dreams is that, they are basically thinking about themselves. What have they done right? What have they done wrong? What should they do further? What have they done you know in the past, that was not so correct. What are their life prospects and so on.

So, what happens is, sometimes people have a tendency to get lost in these kind of thoughts. But, that is basically, what is probably prompting these kind of activations in the medial prefrontal cortex regions as we just saw. But, if people are engaged in task and demand their full attention and they engage their cognitive resources. Then, this default mode network sort of gets slightly deactivated because the resources are channeled to other areas of the brain which are basically being involved in doing the task at hand.

So, however while individuals are performing active tasks that involve self referential judgments, the medial prefrontal cortex is deactivated only to a lesser extent. Okay so, we are talking about a base line where there is some activation already going on. Okay so, it becomes deactivated when you are doing some actively engaging tasks. This deactivation is much lesser when you are doing tasks that actually do require self-referential judgements.

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- Several studies have shown that various tasks activate a set of regions remarkably similar to the default mode network. This includes tasks like autobiographical memory tasks, tasks envisioning the self in the future or navigating to a different location and tasks that evaluate personal moral dilemmas.
- Moreover, similar regions of the brain are also found to be activated when individuals are thinking about the beliefs and intentions of other people – *theory of mind*.
- Hence, the default mode network seems to be involved in more than just self – referential processing.

Now, several studies have shown that various tasks activate a set of regions remarkably similar to the default mode network. This includes tasks like autobiographical memory tasks, tasks envisioning the self in the future or navigating to a different location and tasks that involve personal moral dilemmas. Moreover, similar regions of the brain are also found to be activated when individuals are thinking about the beliefs and intentions of other people.

Hence, the default mode network seems to be involved in more than just self-referential processing.

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- If one looks at he tasks that engage the default mode network, the core component of the tasks is to be able to adopt an alternative perspective. Say for e.g. "Imagine if you are going to a very important meeting and you get stuck in a traffic jam."
- Each of these kinds of situation requires an individual to focus on thoughts that are removed from one's current surroundings.
- This is exactly the same kind of processes that are involved when one needs to infer the mental states of others.
- It seems therefore that the processes that give rise to our understanding of other peoples mental states and thought processes overlap significantly with the processes that are invoked in the speculation of our own mental states and activities.

Now, if one looks at the tasks he or she engages in and the tasks that basically engage you know the default mode network, the core component of these tasks is to be able to adopt an alternative perspective. Say for example, imagine if you are going to a very important meeting and you get stuck in a traffic jam.

What would you do? How will things happen? Each of these kinds of situations basically requires an individual to focus on thoughts that are removed from one's immediate surroundings. You know they involve some kind of antcipating, what will happen if, let us say you were studying for the exam. What will happen if there is a powercut? Do you have enough backup? How will you do things? Are you prepared to you know read in lesser light and so on and so forth.

This is exactly the same kind of processes that are involved when one needs to infer the mental states of others. Basically, it is very similar to how you want to infer the mental states of others because you do not have something happening in your immediate surroundings. You have to anticipate, okay let us say if a boy or a girl is thinking about it. So, if I propose this person x, what is the possible feeling that they will go through? What will be the possible response and things like that.

It seems therefore that the processes that give rise to our understanding of other peoples mental states and our own thought processes overlap significantly.

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- Jason Mitchell a Harvard University suggests that the high activity observed at the resting states may signal the fact that the human mind naturally prefers simulated scenarios over the immediate external environment.
- Mitchell has further proposed that the increased activity of the MPFC, TPJ, and the medial parietal cortex interferes with nonsocial forms of thought. For instance, if the default mode network is always prepared for social interaction and rumination and does not quite down during an active task it can cause considerate disturbance.
- According to Mitchell, the solution to this cognitive problem may require interrupting the spontaneous mental processes that otherwise would induce a readiness for social thought. It would work to our benefit and enhance our interactions with nonsocial aspects of our environment if we control the natural tendencies to ruminate about our own situations and the social environment.

Jason Mitchell at Harvard University suggests that the high activity observed at the resting states may signal the fact that the human mind naturally prefers simulated scenarios over the immediate external environment.

It seems like that the human mind prefers this kind of day dreaming, this kind of anticipation to some degree. Mitchell has further proposed that the increased activity of the medial prefrontal cortex, temporoparietal junction and the medial parietal cortex interferes with nonsocial forms of thought. So, if these regions which form the default network are overactive and overindulgent all the time. They will start you know interfering with other non-social forms or sort. For example, maybe just doing your work.

According to Mitchell, the solution to this cognitive problem may require interrupting the spontaneous mental processes that otherwise would induce a readiness for social thought. So, the idea is that if your mind is susceptibe to this kind of self-referential thought processing and it happens spontaneously everytime you have some time in your hands. It might be useful that the solution to staying ahead of this is to always engage in tasks. To basically try and interrupt these spontaneous mental processes.

And this interrupting of these mental processes would actually work to our benefit and enhance our interactions with the non-social aspects of our environment. Things like which are munding which are not necessarily social, but you will get better at them because you are now controlling this whole tendency of your mind to start rambling about itself. Basically, that is what I wanted to say.

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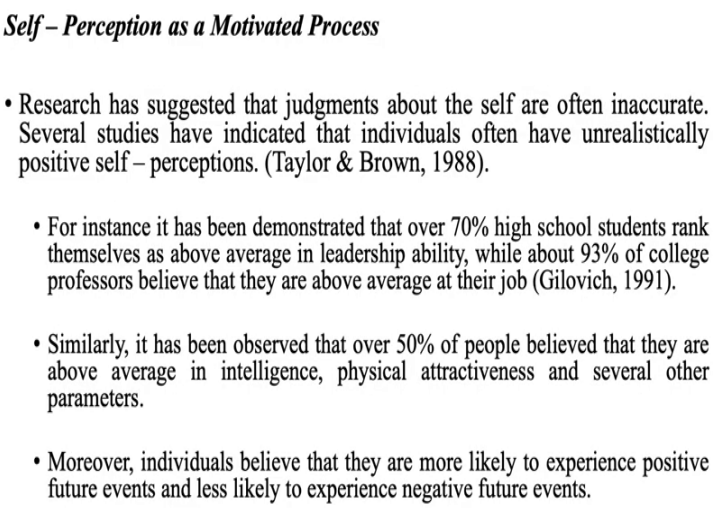

Now, let us talk about self as a motivated process. Now, research has suggested that judgments about the self are sometimes inaccurate, they are often inaccurate actually. Several studies have indicated that individuals have unrealistically positive self-perceptions. For instance it has been demonstrated that over 70 percent high school students rank themselves as above average in leadership ability, while about 93 percent of college professors believe that they are above average at their job.

It's people congratulating themselves. Maybe, just to keep the tempo high, maybe just to keep themselves in good sprits. Similarly, it has been observed that over 50 percent of people believed that they are above average in intelligence, physical attractiveness and several other parameters. So, it seems that people like to tell themselves, good story about themselves. In some sense, it would biase you to think in a certain manner.

Moreover, it also seems that individuals believe that they are more likely to experience positive future events and less likely to experience negative future events. I can take a current example, I am sure everybody is probably watching the lecture from their homes on their mobile phones and this is the time where the coronavirus pandemic has struck the world. One of the reasons why a lot of people are getting infected or you must have heard so much about what happened in Italy.

Once, that people went out and they met their friends and they did all kinds of social activities, thinking that it cannot happen to them. So, people generally have this idea of that,

okay if there is something bad, it will certainly not happen to me. And there are people, say for example in India, there is a whole concept of wishful thinking Indian immunity is very good and because of our very good Indian immunity, we will not catch coronavirus.

Even though on the contrary, we are also sort of seeing so many cases and count of infected person and also the dead count is increasing day by day. So, this is one of the tendencies that people usually do.

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- Some research has indicated that distinct higher order prefrontal regions allow individuals to focus selectively on positive aspects about themselves.
- In an fMRI study conducted by Moran & colleagues (2006), participants were asked to make a series of self – descriptive judgments similar to earlier self – reference studies.
- As expected participants tended to select more positive tendencies and fewer negative tendencies as describing themselves.
- Differences in activity in the ventral anterior cingulate cortex were found to be associated with judgment of positive adjectives as compared to negative adjectives, and this difference was found to be more pronounced for adjectives selected as self – descriptive.

Now, some research has indicated that distinct higher order prefrontal regions allow individuals to focus selectively on positive aspects about themselves. So, it is basically the higher order prefrontal regions that are allowing this to happen.

They are basically allowing individuals to focus selectively on only the positive aspects about themselves not the negative aspects. In an fMRI study conducted by Moran & colleagues, participants were asked to make a series of self-descriptive judgments similar to earlier self-reference studies which you have just seen. As expected participants tended to select more positive tendencies for themselves and negative tendencies describing, as say for example describing others.

Now, differences in activity in the ventral anterior cingulate cortex were found to be associated with judgment of positive adjectives as compared to the negative adjectives, and this difference was found to be more pronounced for adjectives selected as self - descriptive. So, most positive adjectives were self-descriptive, even within that the positive adjectives

were basically judged as self-descriptive and the ventral anterior cingulate cortex was found to be (())(39:21)

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- In another fMRI study researchers found that a similar region of the anterior cingulate cortex was activated differentially when participants were asked to imagine experiencing a positive event for the future as compared to a possible negative event. (Sharon et al., 1997).
- Several similar studies indicate that the anterior cingulate cortex is an important region of the brain that allows distinction between positive self – relevant information from negative self – relevant information, allowing people to focus more on the positive information.
- Further, research suggests that even though self – perceptions are slightly biased towards the positive side they are not completely removed from reality.

Now, in another fMRI study researchers found that a similar region of the anterior cingulate cortex was activated differentially when participants were asked to imagine experiencing a positive event for the future as compared to imagining a possible negative event. Several similar studies indicate that the anterior cingulate cortex is an important region of the brain that allows distinction between positive self-relevant information and negative self-relevant information.

Allowing us to prepare, basically to focus more on just the positive sides and the postive information. Further, research suggests that even though self-perceptions are highly biased towards the positive side they are not completely removed from reality. So, there is a sense, even though we typically are more biased towards ourselves. Let us say, there is atleast some amount of truth in that postive side.

For example, accurate self- perception is a very important aspect for appropriate social behavior. Individuals need to be informed about their own behaviors to be certain that they are following social norms and avoiding social mistakes. Basically not making a fool of themselves in social situations. However, patients with orbitofrontal cortex damage are observed to have these unrealistically positive self-views along with inappropriate social behavior.

So, they have this extremely good view of themselvess but their behavior is sometimes socially inappropriate. To explore this possibility Jennifer Beer and colleagues in 2006 videotaped healthy control participants, patients with orbitofrontal cortex damage and patients with lateral prefrontal cortex damage, while these participants were engaged in a structured social interaction with a complete stranger, wherein the conversation was being driven by the stranger who was posing up a series of questions.

And these individuals were asking and conversing about it. It was found that patients that people with orbitofrontal cortex damage tended to bring up impolite social conversation topics. Something that they had just agreed to that, this is poilte and this is impolite. Then, once they start talking they unknowingly almost bring up these impolite conversation topics.

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- After the initial conversation, participants were asked to rate the appropriateness of their answers, considering that they were talking to a stranger.
- While the patients with orbitofrontal cortex damage, believed that they had performed very well on the task, they were embarrassed when they were shown the videotaped interview.
- Such a result suggest that the orbitofrontal cortex may be involved in having spontaneous, accurate self – perceptions and also insight into their own behavior as regards the following of social norms.

After the initial conversation, participants were asked to rate the appropriateness of their answers, considering that they were talking to a stranger.

Now, their talk is done and now you tell us, what did you feel about your behavior. While the patients with orbitofrontal cortex damage, believed that they had performed very well on the task, they were actually later embarrassed when they were shown the videotaped interview where they had commited these errors more and more. They had crossed the line, so do speak a few times. Such a result basically, suggests that the orbitofrontal cortex may be involved in having spontaneous, accurate self-perception.

Also, it may have insight into their own behavior as regards the following of social norms.

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Predicting Our mental States

- When participants are asked to make predictions about theirmental states in noel scenarios, fMRI studies have revealed that they consistently engage the ventral region of the medial prefrontal cortex (VMPFC).
- Studies performed with patients having damage to the VMPFC support the idea that this region sub serves the predictions about an individuals own likes and dislikes.
- For instance, in a study by Fellows & farah (2007) three groups of participants were tested: patients with orbitofrontal/ventral portion of the media wall of frontal lobe damage, patients with DLPFC damage and healthy controls.
- Participants were asked about their preference between two actors, foods or colors. For e.g. "Do you prefer Ben Affleck or Matthew Broderick?"

Let us talk about how this information can be used to predict our own mental stage. Now, when participants are asked to make predictions about their mental states in normal scenarios, fMRI studies have revealed that they consistently engage the ventral region of the medial prefirontal cortex that is the VMPFC.

Studies performed with patients having damage to the VMPFC supported this idea that this region sub serves the predictions about an individuals own likes and dislikes. For instance, in a study by Fellows & Farah, three groups of patients were tested: patients with OFC damage, patients with DLPFC damage and healthy controls. Participants were asked about their preference between two actors, foods or colors.

For example, do you prefer Ben Affleck or Matthew Broderick? Do you prefer Dosa or Uttappa, soemthing like that.

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- It was found that while the preferences of healthy controls and DLPFC damage patients were stable over time, patients with VMPFC damage made inconsistent choices and wanted to change their preferences repeatedly.
- Activity in VMPFC is also found to be involved when participants are making judgments about their mental states w.r.t future events.
- Researchers could predict the extent to which participants would make short sighted monetary decisions by looking at the magnitude of VMPFC reductions.
- These results indicate that the VMPFC is involved in the ability to simulate future events from a first-person perspective.

References

- Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2014) *Cognitive Neuroscience – The Biology of the Mind* .W W. – Norton & Company.

It was found that while the preferences of healthy controls and DLPFC damage patients were stable over time, patients with ventromedial prefrontal cortex damage made inconsistent choices, they were all over the place and also wanted to change their choices repeatedly. So, it seems that there is some problem making these choices here.

Activity in ventromedial prefrontal cortex is also found to be involved when participants are making judgments about their mental states with respect to future events. Researchers could actually predict the extent to which participants would make short sighted monetary decisions by just looking at the magnitude of VMPFC reductions. So, in some sense, this test or this procedure is also you know predictive of participants future behavior.

These results indicate that the VMPFC is involved in the ability to simulate future events from a first-person perspective. It kind of gives you the sense of what might happen in the future, what will you feel like and so on and so forth. So, I hope this basic introduction about self-referential processing and self-knowledge would have been clear to you, obviously you know I am following Gazzaniga and book by Gazzaniga called Cognitive Neuroscience, thank you.