Social Behavior and the Brain: An Introduction to Social Neuroscience
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Week - 02
Lecture – 08

Hello and welcome to the course Social Behaviour in the Brain and Introduction to Social Neuroscience. I am Dr. Ark Verma, Associate Professor in the Department of Cognitive Science at IIT Kanpur. This is week 2 and we are now in the 8th lecture of the course. In this lecture, we are going to talk about the ideas of retrieving personal knowledge and understanding how aspects of personal knowledge are represented in various areas of the brain. Let us continue our discussion of the three fMRI experiments I described in the previous lecture which was done by Gobini and colleagues and let us try and understand those results in a little bit more detail.

So, the further modulation of the hemodynamic response to familiar faces based on the different types of familiarity in the faces. that was observed in the anterior parasingulate cortex, the temporoparietal junction and in the posterior cingulate cortex. So, remember the previous three experiments they actually manipulated the type of familiarity that the individuals would have with these faces and on the basis of that they actually showed that this specific type of familiarity actually moderated the neural response that was gained therein. This hemodynamic response was modulated in specific areas which are the anterior parasyngelate cortex, the temporoparietal junction and in the posterior cingulate cortex.

Now, familiarity or the type of it was actually found modulate activity also in the anterior anterior parasympathetic cortex, the temporal parietal junction and PCC with a stronger response to personally familiar faces as compared to faces of famous familiar individuals and to faces of strangers. Also, a stronger response to the face of one's own child as compared to the face of a familiar unrelated child and a stronger response to familiar children as compared to completely unfamiliar children was observed. Now, you can see that these seem to be the areas that are responding to the degree of familiarity or the degree of richness and sophistication of the knowledge or person related knowledge that is to be gained through these contrasts. Remember in the last lecture, I was mentioning that when you are meeting a familiar individual, there is a plethora of knowledge about these individuals, a plethora of experiences, memories, your impression of the individual, your estimation of their intentions and goals, all of that comes into play when you are actually observing the faces of these familiar individuals. And in that respect, you can see that the responses in the APC, the TPJ and the PCC are actually getting

moderated with respect to the degree of familiarity that the participants had with these kinds of faces.

Now, these two regions the APC and the TPJ have been identified as consistently getting activated in neuro imaging experiments exploring the theory of mind also independent of the modality of input. So, you know whether they encounter auditory stimuli or visual stimuli the APC and the TPJ have actually been found to be involved in the regions of the brain which are activated during the theory of mind task. Remember, theory of mind refers to the capacity that allows one to explain and to predict someone else's behavior based on one's construal of that person's mental states. So, the idea is, remember, when you are talking about personal, you know, or familiar faces, you basically have much more knowledge about them. You have some knowledge about their intentions, probable, and their things are a little bit more predictable.

Also, you invest a little bit more in trying to understand their mental states, their emotions, their feelings and so on. Therefore, it should not be very surprising that the APC and the TPJ are activated when people are viewing these familiar faces. Authors actually proposed that this activity in the theory of mind areas and the PCC is associated with neural representations of information about familiar individuals, things like personal traits, intentions, attitudes, transient mental states and the biographical information that is spontaneously evoked during the act of recognition. So, again basically in continuance with the previous lecture we see that when you are trying to recognize the face of familiar individual a bunch of these you know specific characteristics also come into play and therefore, they moderate the regions mentioned like the APC, the TPJ and the posterior cingulate cortex. Also, the author's hypothesized precuneus in the posterior cingulate cortex plays an important role during the recognition of familiar individuals and in the acquisition of familiarity with faces.
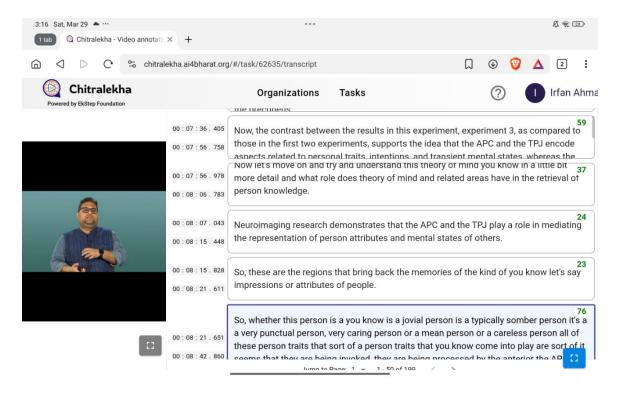
So, it seems generally that the PCC plays a role in the retrieval of episodic information and imagery from long-term memory. Now, when you are recognizing, when you are interacting with familiar individuals, obviously you have a lot of episodic memories associated with them. Maybe you have had sort of, you know, you have had a vacation with somebody, let us say if you are talking about friends for that matter, you studied with them, you have several memories of the classes you have taken with them and so on. In case these are members of your family, so you will probably remember some of the best memories that you will have. Maybe sometimes not so many, but the idea is that the amount of information that comes with this package when you are seeing a familiar face, let's say the face of your loved one, face of your mother, father, sibling, partner, all of that.

It brings together all of those memories and it therefore sort of brings together a lot of images you know maybe say for example if it is your parents maybe one of the

significant events in the family that would have happened so you have imagery associated with that a bunch of episodic memories sometimes daily you know memories or sometimes memories of significant you know events or episodes that would have occurred or that you guys would be sharing. So, in their fMRI experiment the authors had used this implicit task that did not really require an explicit identification of the pictured individuals. Hence, the pattern of modulation of responses by familiarity during the performance of such an implicit task suggests that personal knowledge is retrieved spontaneously when we see someone we know. So, the kind of task that was used in these experiments did not explicitly ask individuals to you know recollect or recognize information about these individuals. It was you know relatively unrelated task which would not you know otherwise invoke this knowledge, if this knowledge is not automatically and spontaneously invoked as soon as you see the face of such an individual.

Now, in the third experiment, remember what they had done? They had actually experimentally induced familiarity by giving a behavioral training to the participants, shown them a bunch of faces and then compared those faces with some novel faces. So, in the third experiment, the faces that were visually familiar but were not really associated with a lot of personal knowledge. Now, remember these are the people whose faces have just been shown to these experimental participants. They do not know them from before, they are not their friends, they are not their relatives, They're not their close family members. And therefore, while the faces are visually familiar, people can recognize, oh, I've seen this person an hour ago or minutes ago in this lab itself.

It does not bring with itself that rich baggage that I'm talking about. The personal knowledge that, you know, seems to get automatically invoked when you're seeing, you know, long term familiar face. However, simple visual familiarity did evoke a strong response in the PCC as compared to novel faces. So, while personal knowledge seems to moderate the activity of APC and the TPJ, simple visual familiarity seems to moderate the response in the posterior cingulate cortex and the precuneus. Now, the contrast between the results in this experiment, experiment 3, as compared to those in the first two experiments, supports the idea that the APC and the TPJ encode aspects related to personal traits, intentions, and transient mental states, whereas the PCC and the anterior temporal regions are typically involved in the retrieval of episodic memory, biographical information.
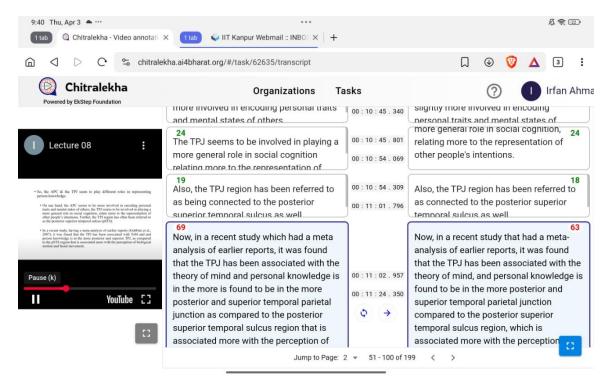
Now let's move on and try and understand this theory of mind you know in a little bit more detail and what role does theory of mind and related areas have in the retrieval of person knowledge. Neuroimaging research demonstrates that the APC and the TPJ play a role in mediating the representation of person attributes and mental states of others. So, these are the regions that bring back the memories of the kind of you know let's say impressions or attributes of people. So, whether this person is a you know is a jovial person is a typically somber person it's a a very punctual person, very caring person or a mean person or a careless person all of these person traits that sort of a person traits that you know come into play are sort of it seems that they are being invoked, they are being processed by the anterior the APC and the temporo parietal junction. Now a range of task that require the you know interpreting and predicting someone else's behavior.

These tasks are found to activate both of these areas so it seems that you know some kind of personal knowledge is certainly moderating the activity in these areas interestingly a stronger hemodynamic response has been recorded in these areas when subjects were asked to read stories or to look at cartoons that required understanding that their characters beliefs are false and when subjects view animations with geometrical figures in a way that implies specific mental states as compared to figures moving in random ways and when subjects play competitive games against human partner as compared to computer and also when subjects make moral decisions that involve awareness of the direct consequences to a victim who is clearly represented as an individual. So, in all of these contrasts what is basically the critical factor? The critical factor is you know the in some sense understanding of the personhood of a particular individual. So, you can see

the first thing is when subjects are reading stories or cartoons that require understanding that the character's beliefs are false. So, you are evaluating critically considering you know person the target person's beliefs in other cases you can see when subject viewing animations with geometrical figures interacting in a way that they have some kind of an intention rather than just randomly moving or also when people are playing competitive games against a human versus against a computer now see what is the difference here when you are playing a game against a human you can attribute certain kinds of mental states to them you can try and infer some kind of mental states from them However, when you are playing just against a computer then you are not attributing any personhood, any anthropomorphization with these individuals. So, it seems you know very clearly that the theory of mind areas are critical to interacting with these faces.

So, the APC and the temporoparietal junction seem to play different roles, slightly different roles in representing person knowledge. On one hand, the APC seems to be slightly more involved in encoding personal traits and mental states of others. The TPJ seems to be involved in playing a more general role in social cognition relating more to the representation of other people's intentions. Also, the TPJ region has been referred to as being connected to the posterior superior temporal sulcus as well. Now, in a recent study which had a meta analysis of earlier reports, it was found that the TPJ has been associated with the theory of mind and personal knowledge is in the more is found to be in the more posterior and superior temporal parietal junction as compared to the posterior superior temporal sulcus region that is associated more with the perception of biological motion and facial movement.

So, you can see that there is a systematic connection or systematic change of information between the temporoparietal junction and the posterior superior temporal sulcus as well. Now, this spontaneous retrieval of you know information about personal traits, intentions, mental states and attitudes of someone you know we know in the act of recognition seems to prepare one to interact appropriately and effectively with that individual. Remember, when you are looking at faces, I mentioned this in much detail in the previous lecture that a face is a biologically and socially very important stimulus and it is it plays a very important role in the way social communication also happens. So, when you are looking at a face of an individual, you are basically trying to get all the information that is to be that is available with you about them. It may begin with a simple impression formation if you are meeting a new person, but if you are meeting a known person, a familiar person, it may start with bringing to the fore the personal knowledge, the biographical information, the personal traits, mental intentions and so much more that sort of comes into play.

This way the brain basically makes us more ready it sort of prepares us in a way to be interacting with these people most appropriately and effectively you can take an example you know for that matter suppose as a child you are you know waiting at home in the evening for your father and your father comes home in a great mood and this is the time you know automatically by looking at his face even without a lot of discussion you know having happened that oh today is a right time to ask for money for that trip that I want to go or let us say bike that I want to buy and so on. But on the other hand if your father comes home with a slightly sour mood you will be able to also look at that and be able to decipher and make sense of that oh this does not seem to be the correct time to be asking these questions. Now, this is basically being moderated by the APC, the TPJ and the PCC areas which are sort of bringing all of this knowledge to the fore when we are interacting with individuals. Now, there is another very interesting aspect that we just mentioned you know when you are interacting with the familiar faces there is an aspect of episodic memory that seems to come to the fore. What does this episodic memory do? Let us talk about it.

So, the PCC, the posterior cingulate cortex or the precuneus is seemingly activated by a variety of familiar stimuli independent of the modality of input. So, whether it is audio or whether it is visual, the PCC seems to be engaged, it seems to be involved whenever we encounter familiar stimuli. For example, familiar faces, familiar voices and names as compared to unfamiliar faces, voices and names are found to evoke a stronger hemodynamic response in this region. Also, tasks that require long-term memory or imagery are also found to activate the PCC or the PC. Neuroimaging experiments from the authors have shown that the posterior cingulate cortex or the precuneus gets activated strongly to familiar faces even in the absence of associated personal knowledge.

So, it seems that this region sort of works with the degree of familiarity does not necessarily necessarily have to have all of that episodic memory all of that you know biographical information with it, but if you are familiar with this person you are interacting with the PCC will get activated. However, unlike the effect of familiarity upon the APC and the TPJ the PCC is also modulated by simple visual familiarity something that we said moments ago. Lesion studies of the anterior temporal areas have demonstrated impairment in assessing semantic information about people. So, simple semantic information that oh this is my brother, this is my sister, this is my teacher, this is my classmate, this is my colleague. simple semantic information about individuals also sort of you know gets affected when there are lesions in these anterior temporal areas that we are talking about.

In addition, several imaging experiments have also shown a consistently stronger neural response to familiar stimuli faces, names, landscapes and so on in the anterior temporal regions suggesting that these areas may be involved in the representation of biographical or autobiographical information as well. Finally, stronger activations for more familiar faces recorded in the PCC and or the PC and in the anterior temporal regions might indicate the involvement of these areas in the retrieval of episodic memories and biographical information associated with familiar individuals. Again you can see there is a bunch of this information that you know comes to the fore when you are interacting with faces and it is aspects of that that may selectively activate these different areas. So, the APC and the TPJ are getting activated with a lot of episodic visual imagery those kind of information whereas, the PCC and the anterior temporal regions are getting activated with retrieval of episodic memories and a certain degree of biographical information. Let's talk a little bit about emotional response.

You know, when you meet somebody, there's a nascent emotional response that one has. You meet some people, you feel happy. You meet some people, you don't feel so happy. You meet some people, you actually feel, you know, repelled by them. A very interesting cue to recognizing people is how you're feeling, you know, when you meet them, because when you meet familiar people versus unfamiliar people, you have this sense of happiness or joy, which, you know, does not happen in the case when you're meeting unfamiliar people.

So, simple visual familiarity with faces even when the visual familiarity is induced in an experimental setting like experiment 3 is sufficient to induce a weak response in a amygdala as compared to novel faces. Similarly, personally familiar faces as compared to famous familiar faces and to faces of strangers also evoke a weaker response in the amygdala. Now, remember in one of the previous lectures we have talked about the fact that the hemodynamic response typically is interpreted by its increases, but it can also be interpreted by virtue of you know the decreases or the responses getting weaker. Now, here is another case where we are seeing that when people are familiar with certain kinds

of faces, familiar with certain individuals, that familiarity weakens the response that is gained from the amygdala. According to a range of neuroimaging studies, the amygdala is sensitive to the emotionally relevant stimuli with both positive and negative valence.

So, you will get a certain kind of response when we are you know viewing these spaces with the positive valence, you will get another kind of response when you are viewing these spaces with the negative valence. Let us dive in. Studies with non-human primates and case reports of human patients with selective lesions of the amygdala have suggested that this anatomical structure in an important role in determining our social interactions. Zooming in, mature macaque monkeys with bilateral amygdala lesions are found to exhibit socially uninhibited behavior and a lack of fear for stimuli that should ideally represent a potential threat. If you put all of these findings together, these findings suggest that the amygdala must be functioning as a social break and plays a role in establishing a cautious attitude when you are approaching a new environment or interacting with new faces or new individuals.

So, patients with amygdala resection especially in the left hemisphere do not really show an enhanced perception for aversive stimuli. So, it seems that a degree of you know cautiousness, degree of being careful is basically you know coded or you know modulates the activity in the amygdala. When we are interacting with people we do not know much about or you know people who might be a threat to us to a certain degree. So, patients with bilateral amygdala lesions rate typically unapproachable or untrustworthy faces as trustworthy. So, you can see these people are because of their amygdala lesion are not able to understand the basic quality of whether these you know faces that we are interacting with are trustworthy or not trustworthy or if they have a quality about them that should tell us to not believe them.

In normal people, however, perception of untrustworthy faces elicits activity in the amygdala both during the explicit and implicit processing of faces. So, you can put these findings together and what does it tell you? It tells us that you know it supports this hypothesis that the amygdala must be sensitive to unexpected or unfamiliar events with the patient with the potential biological importance such as unfamiliar faces. See, if you are going to a new place and you are surrounded by several unfamiliar people, unfamiliar faces, it obviously keeps you at guard. But in cases where these unfamiliar faces might start representing some kind of threat, suppose you are walking alone in a slightly, you know, deserted neighborhood, then it should put you on some kind of, you know, alert. So, activate all the potential alarm mechanisms that you have in your you know brain body and that is basically the precise role of the amygdala when you are interacting with the unpleasant unfamiliar faces.

Now, this is one side of it. On the other hand, reduced amygdala activity is found in response to most familiar faces such as relatives or friends as compared to famous

familiar faces. Now, what is difference between them? Both faces are familiar, but famous familiar faces like for example, Bollywood people or cricket people or politics people, they might be familiar to you, but you do not know or you are not invoking any personal knowledge related to them. But if you are very familiar faces such as your relatives and friends, it weakens the amygdala activity in some sense signaling a degree of you know putting down your guard or being a bit relaxed around such individuals. Also, weakened amygdala activity is observed when you compare the famous familiar faces to the faces of strangers. And also say for example, when it happens when you are you know looking at the face of a loved one, it also puts you on guard, it relaxes you, it sort of you know shuts down weakens the response from the amygdala.

Now, this reduced activity of the amygdala in response to personally familiar faces might reflect as I was saying a lower level of vigilance when encountering someone we know whereas, the increased activity in response to unfamiliar faces in the amygdala could reflect a more cautious and a more wary attitude when you are encountering somebody new. So, you can see again repeating this whole idea of social cognitive neuroscience being really critically evaluating context and the various nuances of the context. We were talking about personal faces, we were talking about personally familiar faces and personally unfamiliar faces, but you are also comparing the different nuances that may exist. Faces can be familiar to different degrees, the type of familiarity can be different, but the type of unfamiliarity can also be different, which is potentially threatening or not so threatening. And you will see that the amygdala for example, reacts differently to people whose faces you know, people who you sort of have a degree of relationship with versus totally unfamiliar faces where the response will be heightened and you will be encouraged to be more cautious, more aware and let us say on the alarm.

Now, and this kind of activity is observed across the board. So, you see this viewing familiar unrelated children as compared to unfamiliar children was also found to induce a weaker response in the amygdala wherein consistent with the general effect of familiarity that viewing the face of one's own child evokes a stronger response in the amygdala. Now the stronger response in the amygdala when you are seeing your own child may reflect both strong positive emotional attachment which you were seeing with familiar faces but also the vigilant protectiveness of maternal feelings. So, so far what we were describing is that individuals show a weak amygdala response when they are interacting with familiar faces. They show a heightened amygdala response when they are interacting with unfamiliar faces.

But when you are watching the picture of your own child, it has to be a mix of both and that is what we are saying here, the authors are saying here actually. that when you are, you know, watching the picture of your own child, there is both a strong positive attachment that comes to the fore, but also the protectiveness, you know, and the maternal feelings of being very careful, you know, that the child does not come to hurt

and all of those feelings of care also come up that put you a little bit on the guard. So, this is a very interesting stimulus that sort of has both positive and negative aspects to it and therefore, you can see a slightly stronger amygdala response in, you know, when such faces are observed. And, people have sort of wonder about this. So, viewing the face of one's own child has also been found to evoke a stronger response in the insula.

The insula appears to be associated with stimuli that evoke strong visceral sensations. It reacts more strongly when one is viewing the face of one's beloved or when viewing a loved one experiencing pain. suggesting that the insular might be playing a very important role in mediating empathic reactions. So, when you are actually looking at people who you are absolutely invested in, just like your loved one, your family member, your parents, your siblings, your partners, that is when there seem to be a more physiological response from the body which is being mediated or which is being registered in the insula. Imitations of facial expressions also evoke a very strong response in the insula.

Interestingly, negatively valiant stimuli such as expressions of disgust, or being treated unfairly during negotiation games have also been found to elicit this activity in the insula. So, insula also seems apart from the PCC, apart from the APC, apart from the TPJ a very important region of the brain where it is basically you know encoding a degree of visceral response, a positive visceral response to the stimuli it is interacting with. So, this intense attachment and protectiveness that characterizes the maternal relationship is reflected in an increased activity in both the amygdala and the insula and which is elicited by viewing the face of one's own child. So, again the complexity of certain social stimuli is there for all of us to observe and make a note of that even when we are talking about let us say familiar face of a familiar face . The familiar face will also have certain degrees you know watching the picture of your own child is let's say on one end of the continuum and watching the familiar face of let's say a famous personality is probably on another end of the continuum and you can see the responses actually vary in the different regions of the brain pertinent to observing these kind of stimulus.

Now another very interesting aspect of the studies that we have observed is this idea of visual familiarity. If you are vaguely even familiar with the contours of somebody's face and this visual familiarity if you remember was enough to elicit a response in the posterior cingulate cortex in the precuneus. Now people have also done ERP studies with this. So, evoked potential studies have actually shown that the modulation of the response by familiarity appears slightly later, chronologically slightly later than the first phase specific potentials.

Let us look at this. Whereas early phase specific potentials are recorded from posterior temporal locations, the later potentials that are modulated by familiarity actually happen in the frontal and parietal locations. So, initially the visual familiarity seems to be

processed towards the back of your brain and when you are talking about familiarity, it seems to be arising from more frontal and parietal sort of locations anterior to the you know temporal cortices. Now it seems therefore, if you look at this a bit more closely, it seems therefore that the early responses to faces may represent a rapid feed forward that does not carry information about familiarity in the initial visual analysis stage. However, recognition of familiar individuals might be achieved through interactions from other face responsive areas at a slightly later stage. So, if you are talking about so far you know we were discussing a bunch of neuroimaging studies where we were mainly talking about the spatial location, the regions of the brain that are involved.

But when you start doing you know ERP, you get this advantage of temporal resolution, you get this advantage of being able to build a chronology around interaction with the stimulus and this is what we see here. It seems very clearly that familiarity seems to modulate the reactions on the brain at a slightly later stage after the initial visual evaluations have completed. Further, neuroimaging research, coming back, neuroimaging research on familiar face recognition has displayed a complex non-monotonic modulation of the activity in the face selective regions of the ventral temporal cortex. So, what is it all about? Famous familiar faces have evoked, you know, have been shown to evoke a weaker response in the fusiform gyrus as compared to faces of strangers. Again, see familiarity is modulating the response in the fusiform gyrus as well.

Interestingly however personally familiar faces evoked an equivalent response as compared to the faces of strangers and a stronger response as compared to famous familiar faces so you can see the nuances of familiarity are modulating ah the responses from the fusiform gyrus as well faces of ah familiar unrelated children evoked a slightly weaker response familiar although unrelated children evoked a weaker response than the faces of entirely unfamiliar children. But, as we were discussing, the face of one's own child evoked a very strong response than the face of a familiar unrelated child. So, again, we were just talking about the face of, you know, one's own child actually carries both aspects. It carries protective, vigilant aspect as well as you know motherly affectionate you know aspect and therefore it shows a very strong response in the regions of the brain. Also faces that were just visually familiar without any associated personal knowledge evoked a weaker response than novel faces.

So just a hint of familiarity also seems to be lowering the response from the fusiform gyrus and amygdala as we have seen earlier. So, the authors put this together and they proposed that the areas that we have identified so far the APC, the PCC, the TPJ, the insula, the fusiform gyrus again you know seem to decode or seem to encode person knowledge and participate in the emotional responses to faces and they seem to be playing a rather major role in modulating the responses to familiar faces through feedback through the extra-striate cortex. So, initial visual analysis is done and then a feedback loop is operating which moderates the activity of the other regions based on the

kind of face you are interacting with, based on the degree of familiarity you have with the face that you are interacting with, the knowledge about the face that is available to you. So, the non-monotonic modulation of response by familiarity in the fusiform gyrus therefore may reflect both a weaker early response to visual familiarity caused by more rapid or efficient processing and a stronger later response caused by top-down modulation associated with personal knowledge and emotion that is linked to this particular individual. Moving on, there is also, you know, there are also studies that help us dissociate the visual response that is evoked by a face and just the visual response that is evoked by a familiarity of a face or if you know the face or if you are visually evaluating the face and so on.

So, we have seen that the recognition of familiar individuals entails recognition of the visual appearance, spontaneous retrieval of person knowledge and an appropriate emotional response. Together these seem to be the critical factors when you are evaluating a particular face for recognition. Now there has been evidence also presented for the fact that the recognition of familiar individuals is a result of a distributed process involving multiple areas of the brain and this kind of evidence has also come from neuropsychological studies of patients. These studies interestingly demonstrate that these multiple components that we just talked about and that participate in the face recognition are actually dissociable and that the impairment of any one of them might disrupt normal facial recognition.

Just presenting an example. So, these examples come from two kinds of patient studies. First is patients of prosopognosia. So, prosopognosia is a neurological disorder that is characterized by the inability to explicitly recognize the identity of a familiar person based on visual appearance. So, these people when you even say for example, this happens when fusiform face ADI is lesioned and there is lesion in that temporoparietal you know area of the brain. So, when you bring even familiar people to these you know familiar faces to these people they are not able to recognize them they are they have a sense of unless the person starts speaking something or they touch them and then these other modalities are used to aid the and bring back the person knowledge and only then these people can recognize these you know recognize the familiar faces.

And this is broadly what the research evidence suggests. But if you zoom in, research indicates that these patients can implicitly, not explicitly, but they can implicitly at least recognize these familiar faces. They will not be able to tell you that oh I recognize this person, but the implicit response of the body, for example, the augmentation of skin conduction response to familiar as compared to unfamiliar faces is actually observed. So, again you can see here, explicit recognition is damaged, implicit recognition is relatively preserved. An even more interesting scenario plays out when you are looking at patients of Capgras syndrome. Patients of Capgras syndrome are able to recognize the identity of a familiar face, but they cannot really verify the authenticity of such a face.

So, they portray a sense of familiarity with particular faces. They say, I know this person, I am sure I know this person, maybe he is a friend, maybe he is a family member, but I cannot really verify, it just does not feel right. So, what these patients actually believe is that these familiar people whose faces they are trying to recognize such as family members or friends have been replaced by imposters, aliens or robots and they cannot just believe them completely and this what does this tell us, it suggests that even when visual recognition is accompanied by an altered emotion response such as in these in these cases recognition of a familiar individual ah does not manifest normally. So, you can see here we talked about three components we talked about the ah you know the recognition of the visual appearance, spontaneous retrieval of personal knowledge and an appropriate emotional response. all three of them are critical factors in ah recognizing faces and in if any ah one of these three is damaged it basically leads to ah you know ah face facial recognition not operating properly in an individual. So, this is all from this lecture I will meet you in the next class and I will talk about something else. Thank you.