Human Behaviour
Prof. Naveen Kashyap
Department of Humanities and Social Sciences
Indian Institute of Technology, Guwahati

Lecture - 04
Sensation – II

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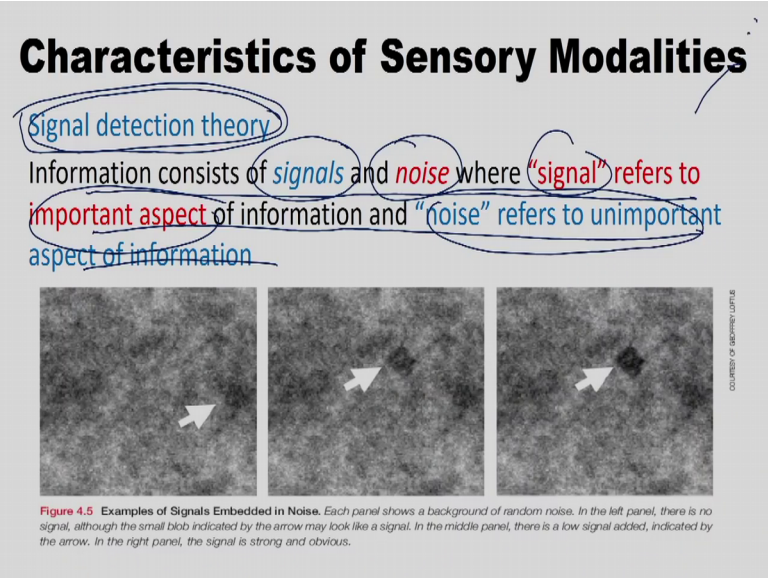

Hello friends, welcome back to this lecture number 4 on the course on Human Behaviour which is the MOOC's learn course. Now, as I have been telling you throughout the past three lectures, the course will focus on studying behaviour of your humans. And how do we going to do that? We are going to do that using the science of psychology. So, basically this course is focused on psychology. Now, before we start this lecture, what I will do is ill do a quick recap of what happened in the last three lectures. And since this is lecture number 4, so a recap is in place.

First lecture we started off by looking at the definition of psychology, what is psychology and what it does, and what it studies and what is its basic subject matter. And then we focus slowly onto the history of psychology, what is the history, how does we start. And then we focused on two branches are from which psychology comes in, one was philosophy and the other was physiology. We also focused those questions of philosophy which is carried on the psychology.

For example, the existence of the mind, the existence of the soul, and the existence of how the soul and mind interact to turn out to be behavior; questions like whether people are born with some efficiency is with some abilities or that nurture which is the environment in which they are they, the environment puts those abilities in people. So, those kind of questions, and those kind of our thoughts on topics was what was the focused of the first lecture.

With that we also looked at primary schools of psychology not only looking at philosophy and physiology as the originator of psychology, we also looked at some schools of psychology starting with structuralism, where we looked at psychology. When the point of how human behaviour can be explained as its basic structure in term to the physical and psychological world. Then we looked at functionalism which state that the behaviour is since adaptive in nature, if you want to study human behaviour you have to actually see it into action.

The third kind of field that we saw was behaviorism which said that human behaviour is basically an association and it is a conditioned response and so whatever people do. In this particular stimulus is actually kind of reflex. So, there is no thinking, there is no problem solving, there is no mind in between and thus what the behaviourist talked about.

And then we looked at it is like psychoanalysis and positive psychology and that kind of a things. So, in basically in psychoanalysis what was talked about was that psychology comes from or the human behaviour comes from basic unconscious processes, basic hidden desire which people have. And then we also talked about gestalt psychology which was field of psychology which is a branch of psychology which said that if you want to study human behaviour, you have to study behaviour in terms of it form, which basically means that the actual behaviour is composed of so many other behaviours, so you have to study the whole behaviour and path behaviour in separate ways, and then you can actually study the human behaviour.

Past that we look that new branch of psychology, for example, we looked cognitive neuroscience, we looked at psycho linguistics, and some and the field of neuropsychology, so that was what was the subject matter of the first lecture. In the

second lecture, we started off by looking it by some view points of looking at human behaviour.

So, within psychology we have different viewpoints; we have the biological viewpoint, we have the cognitive viewpoint, we have the behaviourist viewpoint and we have the subjective viewpoint, psychodynamic viewpoint and so there are 5 4 or 5 viewpoints which we actually looked at. And we decided or we evaluated one particular behaviour using these viewpoints. So, basically how one particular behaviour can be explained by different, different viewpoints in psychology.

Further to that we also looked at some 21st century fields in psychology which was the newer fields which came up with the and coming up with the newer machines and how behavior should be studied. Then towards the end of the second lecture, we looked at experimental methods of doing psychology and we started off by looking at the experimental method where variable is manipulated in some way, and so and its effect on some other variable studied. So, we establish cause and effect relationship and that is what is call experimentation.

So, we took an example of the hot beverage, and looked at how this hot beverage is supposed to affect academic performance. And based on that I describe the whole methodology of doing an experimentation. Further to that we also looked at what is observation, what is the observation method of doing research. We looked at what is correlation. So, correlation method of doing research and how correlation is not a cause and effect kind of thing. In correlations, if two variables are correlated which means they relate, they are related with one another, there are no there is no way to establish cause and effect relationship that is what we studied in that part.

We also looked at some other methods of collecting data in psychology or doing research in psychology, for example, naturistic observation. We looked at the survey method, we looked at literature reviews, and we looked at the clinical method of one person interview method or one person data method that is the single subject designer's call in psychology. So, that was the focus on the second lecture.

In lecture number-3 which we finished in the last lecture we looked at something called sensory processes. So, then we focused on what is sensory processes. Now, a very important thing in psychology is to understand how the information from the external

environment is grabbed and transformed into meaningful bits for people. For example, the example that I gave there is when you look at a tree through your eyes, it is not the tree that you are actually looking at, the tree is a manifestation, the tree is a reconstruction that the human brain does.

So, what you are actually looking at are packets of photons which are bouncing off from some object in the external environment. So, the external environment from external environment in terms of the physical environment, what actually is encoded or what actually falls into the eye are packets of photons.

Now, the process which takes these photons or the system which takes this photon and converts into converts it into or encodes it into a format which can be then later on interpreted as a tree is called the sensory process right. So, sensory process are those processes which make or which lie as a buffer between the physical world and the psychological world and that is why it is important.

Further to that we looked at certain qualities of the sensory process or sensory system. And basing the eye we looked at two important functions of the sensory process or two important characteristics of the sensory process. We looked at something called sensitivity and we looked at something called sensory coding. So, we describe what is sensitivity in terms of something called the absolute threshold and differential threshold.

And so what is absolute threshold? Absolute threshold is the minimum amount of stimulus that is necessary for any person or for any system or for any measurement system to say that there is a difference between no stimulus and yes stimulus. So, can a system detect between zero stimulus to one stimulus is what is called absolute threshold. And then we looked at what is something called the JND or just noticeable difference or the differential threshold.

And so what is differential threshold, it is the minimum amount of stimulus or minimum energy of the stimulus that should represent, so that people can say that there is a difference between one level of stimulus and next level of stimulus. So, how do people detect change between two between situation where a stimulus is present and next higher level of stimulus is present, then that is what is called the differential threshold.

We left off this particular question with the signal detection theory. Now, what is the signal detection theory? It is again a characteristics of the sensory modality. And so what signal detection theory actually tells you, signal detection theory basically tells you how people do errors and how to read those errors right. And so in what I explained in the last class is that, any information which comes to you can be in terms of signals and noises. And signal refers to the important aspect of information; and noise refers to the important aspect of unimportant aspects of information.

I describe the case of how doctors read a radiologist actually read an x-ray. And I tried to explain signal detection theory through that. Today, what will do is we will look at how signal detection theory actually works and look at some parameters of the signal detection theory. So, in the last class, we also explained how different doctors have different criterias for saying when a particular bone is fractured. So, different doctors use different kind of information or different doctors have different kind of characteristics and parameters on which they say a bone is fractured.

Now, liberal doctors will actually look at just one or two parameter in the x-ray and will say that the bone is fractured. On the other hand conservative doctors will take a number of test and based on that they will say a bone is fractured, but then both of them the liberal and the conservative have their own have their own good points and bad points.

The good point is that the liberal doctor will actually save you from a difficult situation. So, when he says that bone as soon as bone is fractured, you might get into a bandage and that will save your life in somewhere. But the problem is even the if the bone is not fractured; you might get into a bandage. On the other hand, the conservative doctor will spend a lot of money for him to say that a bone is not fractured, and so you spend a lot of money and after that you come to know that the bone not fractured and that way you lost a lot of money and so both of the doctors have their own problems.

Now, as I said sometimes what happens is these parameters that the doctor use is also coupled with a noise in the x-ray sheet itself. So, it might so happen the x-ray plate had some dots to start with. And so how does the doctor actually decide that the x-ray that the he is looking at is not the true x-ray of the patient but an anomaly in the sheet itself is what is about signal detection theory. So, signal detection theory is the process of how

doctors or how any person detects a signal or detects an information in environment, and how does it separate it from the noise so that is what we were doing in the last class.

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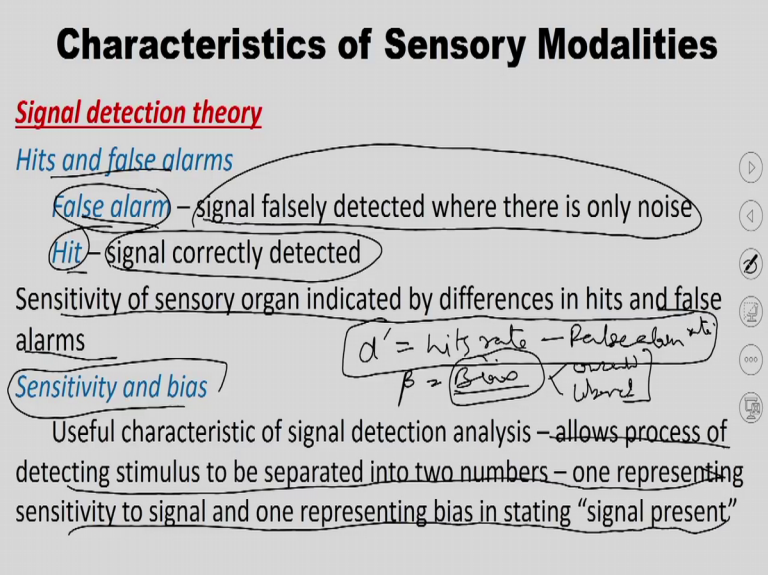

Now, in today we will today's class we will continue with what we were look looking at. So, let us first quickly understand this definitions of what signal detection theory and I will later on explain you what this theory is all about. So, signal detection theory has two functions or two parameters, one is called the hits and the other is called the false alarm.

So, what is this hit and what is this false alarm, we will quickly come back to that, we will quickly come back to what is hit and false alarm. So, this false alarm is thus when a signal is falsely detected where it is only noise is what is called a false alarm. So, false alarms are situations where the signal is not present and even if the signal is not present, people tend to say that the signal is present and that is what is false alarm. What is then what is hit; hit is when you correctly are able to detect the signal from no signal situations. So, signal correctly detected this is called a hit.

For now I will just ask you to remember this, what is false alarm and what is hit. So, as I said when a doctor looks at sheet at x-ray, when he is when he is able to detect the fracture in the bone, this is called the hit. But then if he has is falsely saying that there is no the bone fracture that is called false alarm. And so depending on the external noise what could happen is his detection will differ or his identification of the bone or identification the fact the bone is broken will differ.

So, we will come back to that. For now just remember what is false alarm and what is hit. So, it is correctly detecting the bone is fractured; and false alarm is detecting a bone is fractured when the bone is actually not fractured. And so if you increase the hit, the false alarm will increase. Now, let us try and understand in terms of the liberal doctor and conservative doctor. Now, in terms of the liberal doctor he will just use one or two characteristics to say the bone is fractured. And so he tells to always say that the bone is fractured.

And so what will happen is at times when the sheet or when the x-ray plate has some external noise in the sense that it has some mark to start with when the x-ray was taken. Then in this case if he increases the hit if it is too liberal what will happen is not only the hit will increase which means not only the time that he detects the fracture will increased also a number of times he will be falsely saying that fracture is there. So, not only hit will increase, a false alarm will also increase which means that if he is always saying that there is a fracture with one or two parameters, the chances that we detect a fracture, accurately detect a fracture will increase, and also the chances that when he incorrectly detects a fracture that will also increase.

Now, in terms of conservative doctor what will happen is he takes a lot of test and based on that he says that there is a fracture. And so in this case what happens is so he very with number of with very many number of parameters, he says that there is a fracture. So, if the hit decreases, if he takes lot of time or lot of parameters; based on that he says that fracture is there the false alarm also decreases, so that the error that he creates will also be less so that is the definition of what an false alarm is.

Now, sensitivity of a sensory organ indicates by differences in hit rate and false alarm. So, how sensitive a system is or how sensory organ is defined by and so this sensitivity is called d dash is actually the difference between hits rate, the rate of hits minus the rate of false alarm. So, sensitivity on many system is dependent on the rate of hits and the rate of false alarm.

And similarly there is another thing which is called beta which is called the bias of a system. And so sensitivity bias which is the next thing to come to. So, useful characteristic of a signal detection analysis allows processes of detecting stimulus to be separated into two numbers, one representing sensitivity to signals, and the other

representing bias in stating signal present. So, bias is how conservative or liberal. So, the fact that a person is conservative or liberal is what is the basis of defining the bias. So, bias is how conservative a person is or how liberal a person is and d dash is looking at how many hits you are doing and how many false alarm you are doing. So, do not worry we will try and explain it to you.

Now remember the candle experiment that we did. So, in that experiment what was there was there was a candle, and so that was lit. And so people were put in a dark room where single candle was there. And I will keep on adding the candle one to one. The job of the person was to tell when he sees the light. Now it so happens as I said that there is something called mental noise, there is a lot of noise in the brain.

And so because of that individuals or human beings are it is very difficult for them to detect zero light right. So, from 0 light to 1 light, and so it happens that there is since there is a lot of noise in the brain in itself it might take one or two extra candles to be lit before they actually say that they see light. And so this response keeps on differing.

Now, if that is what it is if the I the idea that if neural noise is there and human beings are not very good at detecting a changed from 0 to 1 in terms of detecting absolute thresholds what should be done. And so method was design in which method what happened is in some of those trials, there was no light to start with. And in some of those trials there was a light to start with. And so human beings were or people were put in an experiment where they had to say that they see the light.

Now, if human beings are able to detect light when no light is present that is called the false alarm right, and that is called a noise detecting a signal in a noise. And in situations when people are able to detect nose light when a light is present that is called a false alarm right. So, when there is there is so there are it actually makes four different parameter. So, let us try and plot this particular thing or plot this thing and try and understand about signal detection is already or signal detection theory is all about.

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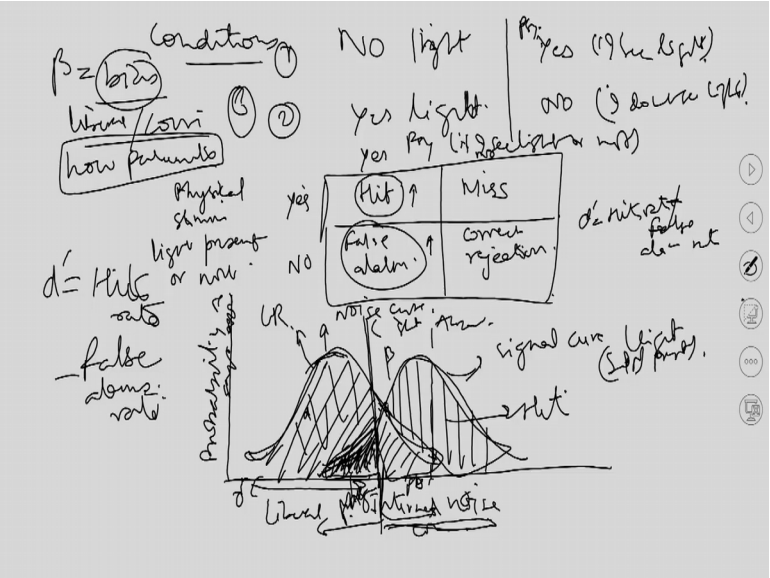

So, basically there are four things. In our in our experiment there are four things one. So, I have two conditions. No light number one, yes light number two. And then I have two responses to it I have yes I see light; and no I do not see light. So, let us make a simple table. This is my physical stimulus physical stimulus in terms of light present or not. And this is my psychological stimulus which is if I see light or not.

So, four conditions can occur as you can see the condition you this is the physical condition, and this is the psychological condition. So, the simple experiment in some trials, I have the light; sometimes I will do not have the light. And the subject is to tell whether I see the light or not in all the conditions. So, four things can happen. Light is present; no light is present; I say yes I see a light; and I see no, I do not see a light.

So, again an emphasizing what it is actually about we did a simple experiment, we do a simple experiment to find how sensitive system is. And in this case what happens is in some trials I have the candle. And the subject has to detect whether he sees light or not. In some conditions, I do not have the candles there is absolute darkness and the subject is asked to told or tell whether they see the light or not. Now, the four conditions arise out of it. One, the subject tells that he sees the light or the subjects tells that he does not see the light and this is called the psychological domain. On the physical domain, there are trials in which there is light and there are trials in which there is no light. And so this is a physical domain; this is a psychological domain.

If the light is present, and the subject says yes he sees the light, this is called a hit right. If the light is present, and subject says there is no light, what happens is miss; the light is present and the subject is not able to detect, it is called a miss. If no light is present and the subject says that he sees the light, it is called false alarm. Here there is no light and the subject is able to still tell the light. And then there is no light and the subject also response no I do not see the light it is called a correct rejection. And this is the easiest explanation of what signal detection theory is.

So, basically four parameters, physical stimulus present or not, psychological stimulus saying yes and no. Now, why does these all arise what is the need of all these. The reason is that the physical stimulus are constant, but the psychological stimulus which is basically psychological I see the light and I do not see the light is governed by your mental noise. So, at times you might see the light at times you might not see the light, and the reason by that happens is because you have mental noise. So, four different things can happen.

Now, if as you can see if you increase the hit the false alarm will also increase. If you tell that you see the light or if you are some so what I do is as you try to increase hit, the false alarm will try to increase. And so sensitivity of a system is explained in terms of hit rates minus false alarm rate, sorry hit rate minus, so it is minus here false alarm rate. And very simply speaking, if we plot these curves, these are the responses that the subject have.

If you plot this curve in terms of your internal noise and the probability of you saying that I see a signal or probability of you saying that I see a light, I will get curves like this. So, I will have two curves to start with I will have a curve like this, which is called the noise curve right. And this is called a noise curve or I will say light absent. Now, on this axis I have internal noise. I have another curve which is called the signal curve or light present. So, along this curve, if you look at it, along this curve, I have no light present physical stimulus is not present; and along this curve, I have light present, so it is called the signal plus noise curve actually because there will be inherent noise in the system, and so it is signal plus noise curve.

Now, it is an interesting case right. This is very interesting case. On this axis, internal noise; and on this axis, I have the probability of saying yes or accuracy probability of

you making a decision that is what on this axis is. Now, the interesting thing that you have to look here is that this internal noise is called the bias or it is called the beta value. What is this not at remember the experiment that we did with doctors, now some doctors are liberal and some doctors are conservative.

The more liberal a doctor is, the more number of stimulus the more number of stimulus trial has to come in for him to say yes, which means that with one or two candles, he will not say that he see the light, he will require at least 4, 5, 6 or 8 candles for him to say yes. And that happens because the internal noise or the characteristic that he uses for making this decision is higher, more number of parameters he will actually look at.

Now, if a doctor is liberal, then what will happen is with a very few trials or with a very few candle, he will say that he see the light. Now, why that happens is because the mental noise in this case in his cases low. If the mental noise is high, then the criteria will be more conservative; the mental noise is low, then the criteria will be more liberal. And it also depends upon people's criteria how much how much evidence do you want to say that a particular a stimulus has occurred or a particular event has occurred.

Now, the point at which you start saying yes and no right that point or in our case the point at which you start saying yes and no is what is called the beta value and that that decides how the hits and false alarms will actually function. So, if I just have to move it here because what has happened is that the rubber is not working here. So, see eraser so I will just remove this from here and remove this part from here again start with the pen. And so this is my curve for noise, and this is my curve for signal.

And so this is the beta values which basically means that if this is my zero noise and this is my five noise which means that I need 5 at least my criteria has 5 parameters only after 5 parameters I will say that I see the light or I see the bone broken. Now, I can also have these parameter values here beta values here this beta values are called the bias. And so if I if I move, the more I move this curve or this line from here to here, the more liberal become; and the more I move this curve from here to here it will become more conservative.

Now, the thing is if you look into it these are the two curves. So, this is a noise curve right. And so the point or the noise curve, when there is no signal present right. So, this part when there is no signal present, and you also say no that a because you are saying no

from here to here. So, you said no this is called a correct rejection. This is where signal is present, and you are saying no the signal is not present and this is called false alarm. This is where the signal is present and you also say the signal is present so noisier and you are saying yes. So, this is my false alarm.

This is my miss signal is present you are saying no. This part you are saying no, but the signal is present as you can see this curve is here, so signal is present. This here the noise is present plus the signal and you are saying yes. So, this is called the false alarm, and this is called the hit so four part. This part is called the hit this whole part, this is called the false alarm, because here noise is present with the signal and you are saying still the signal is present or that you can see the light.

In this part there is noise present since this is this is the criteria because above this you will say yes and below this you will say no. So, you are saying no, but signal is still present this is called miss. And here you are saying no and the signal is also not present, because this is a noise curve and this is called the correct rejection. So, four things to be looked at this is what it is.

Now look at for looking at sensitivity and bias. So, beta is called the bias, but bias as I said is dependent on how much characteristics or how much parameters do you actually required for saying yes to something. For saying yes that the signal is present or for saying yes the particular event happened. And that depends upon, so many doctors will as in the doctor example, they will require number of parameters, they will take blood test, they will take this, that, that 5-7 test, and based on that they say yes. Other doctors are they will just look at the x-ray and say yes the bone is fractured. And so they are liberal. And so this bias is actually a measure of the liberal and conservative a doctor is.

That liberal and conservative is determined by how many parameters do we require to say yes a signal is present, which in this case is yes the bone is fractured. Similarly, sensitivity of the system which is the d dash is dependent on the hits rate how many times you are correct minus the false alarm rate. How many times you said you are correct but then there was no signal to be determined. How many time so the sensitivity in terms of the popularity of the doctors. So, how is a doctor popular the doctor, who is popular is who has higher number of detections with lower number of false alarms lower number of wrong detection right.

So, as you increase the hits, the false alarm also increases. So, you have to optimize this. Now, there are a lot of things to be studied here, there are lot of variations of the signal detection theory, but we will leave it here. And this is I hope you understand what is signal detection theory. We can explain this or we can extend this idea of signal detection theory into looking at what liberals are, and how to move this curve from one side to the other side, and how the situations happen when the two curves are superimposed on one another and that kind of a thing or a roc curve, but we will leave it at here.

So, for your information, what happens is detecting a signal or detecting something in the environment is influenced by the sensitivity of system. And this sensitive system is dependent on how many times you are correct, how many times you are falsely saying you are correct. The lesser the value is the higher the higher the sensitivity is. And also in terms of beta of how conservative and how are liberal you are in terms of how many parameters you take.

If you take more number of parameters, you will never be famous. If you take lesser number of parameters you will be famous, but you have to be more accurate. And so liberals with highway with the high sensitivity are always famous doctor. So, we will end the discussion and that is how this basically hits false alarm and the signal detection theory actually works.

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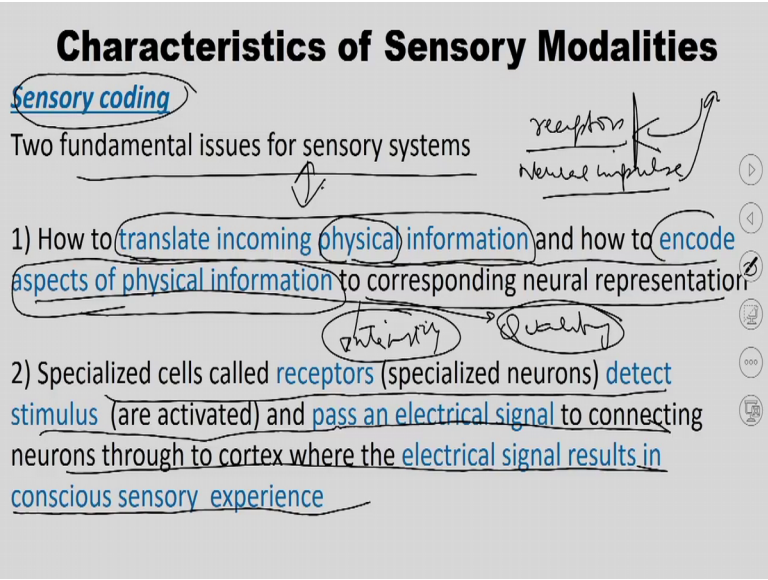

So, moving on the second part or the second characteristic of any sensory organ is called sensory coding. So, the first part was how the sensory system really works and what are its characteristics. The next part is how the, what is the biological phenomena through which the detection is encoded into the human brain. The sensory system actually takes in a signal and it detects a signal, and this signal which is detected is passed on to the branch of neurons into the brain. So, how does that process goes in or how does the what is the biological process behind encoding this signals or encoding this environmental stimuli is what is called sensory coding.

So, there are two fundamental issues for sensory systems, one how to translate incoming physical information, and then how to encode aspects of physical information to corresponding neural representation. So, this kind of problems of sensory encoding of how to encode sensor information has a two fundamental issues to look at.

So, the first issue is how to translate incoming information. What is the way and this is called transduction. So, an incoming information is first translated into of incoming physical information is first translated into a pattern or into a signal which the brain can understand, that happens in terms of the neural responses, that happens in terms of the how the nerves fibre nerves fire.

And how to encode aspects of physical information, and so there are some physical aspects of the incoming information. So, generally this process of translating incoming in physical information really works in terms of how neurotransmitters or how receptors really work. So, then the most sensory system have something call receptors. And what this receptors do is these receptors take in physical information of when in physical information follow this receptors, these receptors actually convert this physical information into neural information or neural impulses.

And these neural impulses and are then translated back to the brain, back to the areas of brain which actually process it and then they understand what kind of physical information is coming. For example, the light can only. So, if I send a bunch of air pressure or into the ear into the eye, it will not be able to encode it, because eyes are not specialize to encode air pressure, but then if I send a bunch of neurons sorry photons onto the eye then it will be able to register it, and this will be sensed off or this will be

encoded as light or this will be encoded as sight, and that is what the eye is all the about, so that is how the translation of physical information happens.

And how encoding specific aspects of physical information. So, there are two space specific aspect of physical information that has to be looked at; one is called the intensity how much of the physical information is there, and other is called the quality how better right. So, what is the quality of the physical information and what is the intensity, how bright and how dark it is, and in terms of quality how colorful it is kind of that kind of a thing in terms of the visual information. So, what is the quality of the signal and what is the intensity of the signal is what the sensory organs are dependent on.

Now, specialized cells called receptor, specialized neurons detect stimulus and pass an electrical signal to connecting neurons through the cortex where the electrical signals result in conscious sensory experiences. So, as I said what happens is that the specialized cells that are there in your sense organs in your sensory organs, you have something called specialized cell which are called receptor. Now, these receptors they react to a physical information.

So, the eye has the retina and these retina specialized cell which are called the photovoltaic cells. So, when photons passed on from the iris of the eye and I will just show you how that really work. So, it passes on from the lens of the eye and it falls onto the retina. The retina when it interacts with the photon, it sense a mini signal a miniature signal has changed in electrical current through the photoreceptors to the area of the brain which is called the occipital area, and this area then encodes this or this reads this.

So, how are these, these photoreceptors, how do they send the signal, there are specialized neurons which carry the small changes in electrical current from the photo voltaic cells or the photo voltaic receptors and the in the retina. And this signal is carried back to through the through the medium of neurons, they are carried back to somewhere in the occipital cortex. In the occipital cortex these signals are then recon verged or they are interpreted in terms of what do you see and what you do not see. It is a very simple version of looking at it and that is how a signals are passed from the specialized from your sensory organs onto the area of the brain which makes conscious experiences.

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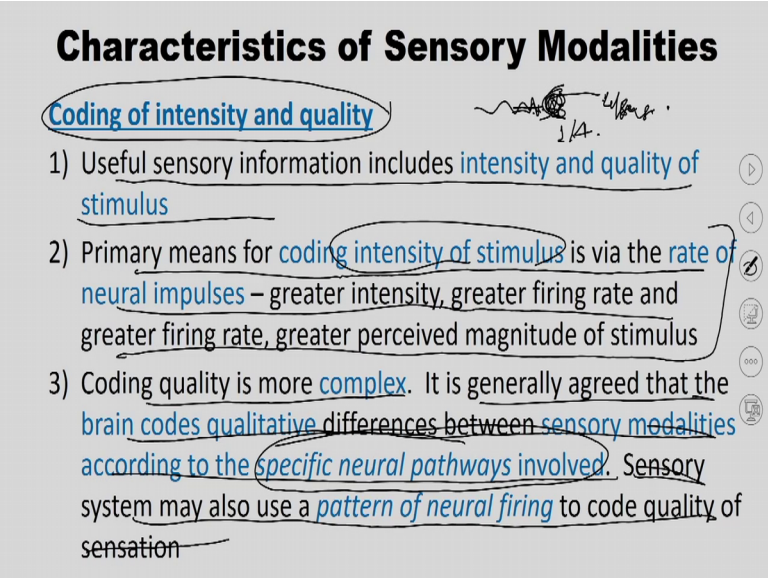

So, as I said there are two characteristics of sensory modality that has to be that the special the sensory organ has to code; one is called intensity and the other is called quality. So, how do sense organs actually encode sensitivity and sorry intensity and quality, now useful sensory information includes intensity and quality of stimulus. Any sensory information which passes on which falls on to the sensory receptors, they have two qualities; one is of intensity and the other is of quality. So, how does the sensory system encodes intensity and quality that is the question?

Now, primary means for coding intensity of stimulus is why the rate of neural impulses generate generating intensity greater firing rate, and greater firing rate generating perceived magnitude of stimulus. So, how does the eye actually encode bright light versus dim light? Now, as I said the eye is made up of something call a retina, a retina falls at the back. And what does the retina specialized in the retina is specialized in certain receptor cells which are called the photo voltaic cells right.

And so this photo voltaic cells or in terms of the eye, it is called the rods in the cones these photo voltaic cells are named as rods and cones. Now, cones are the one which actually see color, and rods are the one which cannot see color they see black and white and there is a primary distinguishing between that, so this photovoltaic voltaic cell.

Now, what is the photo voltaic cell first of all let me explain you that. You would have seen clocks, musical clock which actually turned off and turned on the music depending

on whether it is day and night. Now, that is a simple example of photovoltaic cell. At the heart of this system is a photo voltaic cell what does a photovoltaic cell do, when a when a light photon enters or hits the surface of a photovoltaic cell it registers it and it sends a signal to the musical clock to actually ring.

But during the night, there are no light particles, there are no photons and so when no photons fall on the cell, they do not sell, do not send any signal to the musical instrument to go on and off. And that is why when you will switch off the light these musical cock clocks do not work.

Similar to that a rods and cones which are at the retina and what is rods and cone actually do is they look at the intensity of light. They look at the light number of photons which are falling on them and send the signal back to the occipital cortex through medium of certain neurons which are called the specialized neurons for life for measuring light or for carrying a light related information.

Now, how do I measure intensity? How does the photons are how does the rods and cones they detect intensity of light or how a light light is brighter or dim? Now, what happens is the amount of firing, now these neurons as I said or these receptor as I said which are the rods and cones they fire. When a photon hits on to them the receptor binds. So, there is a receptor. So, if this is rod or this is my cone, and a photon comes and hits here, the moment it hits here or the moment it attaches itself to here, a signal is sent right.

So, if one photon is there the signal will be less, but let us say there are four photon which hit here, so four photons per second per millisecond in that case. So, what will happen is if the amplitude here is 1 here, 4 photons will produce 4 times the amplitude which will be 4 right and so the amplitude will go on increasing and so on and so forth. And so that is what actually happens. So, the more number of photons which actually fall on to this receptor the higher the firing and this higher firing the more higher, the firing is the more higher the eye perceives as higher the intensity of the stimulus right. So, the more number of firings per second that the receptor does the higher the intensity of the stimulus is believed to be.

Now, how does sensory system encode quality? Now, coding quality is more complex it is not that easy. So, it is generally agreed that brain codes qualitative differences between sensory modalities according to the specific neural pathways involved. Sensory systems

may also use a pattern of neural firing to code quality. So, for quality is not that easy and so for quality a number of neurons fire. Now, in this the case of specific neuron will fire, but in this case what happens if a specific a number of specific neurons fire in sequence first of all and then the what happens is specific neural pathways are involved.

Now, there are different pathways which are there and so a number of pathways are out there, and so when this pathways occur in sequence in time that specifies quality. So, one may be for let us say hue, the other may be for situation, the other may be for something else. And so all these cones all this type of cones when they fire together they specify the quality of how good a signal is or how bad a signal is, and that is how the sensory system biologically encodes both intensity and the quality of a signal or the quality of a incoming stimulus. That was what about the characteristic of any visual system was all about.

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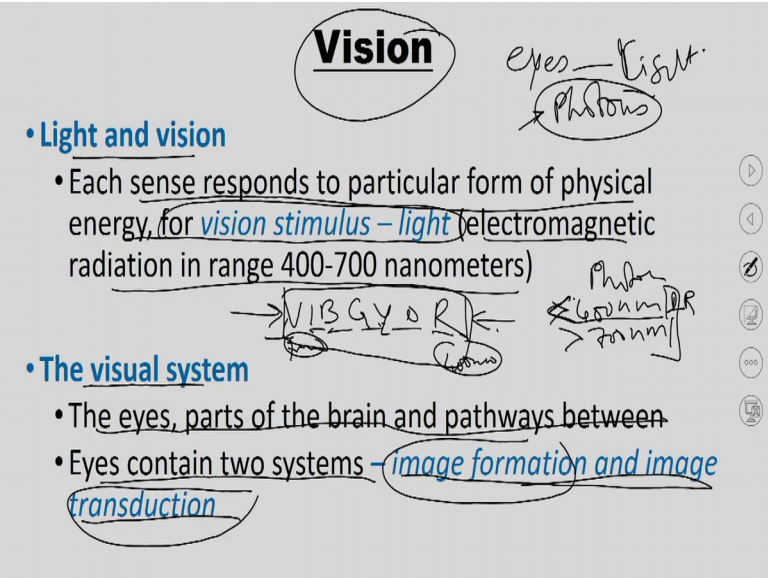

What I am going to do now is, am going to take a particular system which is called the vision. And based on this vision I will try and explain the visual system a little bit. And we will see how does the visual system work now this will make us clear of how sensory system really work, what is the functioning of sensory system. And we will try and open up the visual system a little bit try and explain to you how does vision actually works, the visual system actually works or how does the visual system makes understanding of

color, makes understanding of background, then foreground then all those kind of a thing.

So, basically what is the visual system first of all, let us see that. Light and vision - each sense response to particular form of physical energy for visual stimulus, it is the light. So, the visual stimulus or the eye in that case is actually responding to something called light. And what is light? Light is actually photons. So, number of photons falling on to the eye the receptor or the receptors of the eye is what produces vision. So, what produces vision, light produces vision.

Now, amazingly the electromagnetic radiation in the range of 400 to 700 nano meter is only the one which produces vision. Any electromagnetic radiation or any photons which are greater than 400 nano meter and sorry less than 400 nano meter, and greater than 700 nano meter will not produce any vision at all. So, less than 400 nano meter will be infrared; and higher than 700 nano meter will be ultra violet. So, these are the two ones these are the two systems which where humans cannot see.

So, humans can see between a range of 400 to 700. And within that they see different colors the different colors are V I B G Y O R which is the violet, indigo, blue, green, red, yellow, orange and red. And this is the alpha and infrared and this is the ultraviolet. So, between that human beings cannot see. And so between this is the range. So, you have on one end you have 400 nano meters; and the other end you have 700 nano meters to actually start with. Maybe it is the way around because I am not very sure whether red has 400 nano meter range. So, I am not very sure about that, but that is the range in which it is. So, it could be the reverse right.

Now, let us look at the visual system. How does the visual system actually function what is the way in which the visual system actually goes. And so we see light between this range only and these are the colors that we see and that happens because this photon fall out of the eye. Now, the visual system the eye parts of the brain and the pathway between them. So, the visual system contains of the eye first of all, then a certain part of the brain which is called the occipital lobe, the occipital lobe is back here, this is where the occipital lobe is. And so there are these two eyes actually send nerve fibers which cross somewhere here, and this is called the crossing right, this is the pyramidal neuron, it

crosses here. And the two fibers go on to two different parts of the occipital lobe which is somewhere here.

Now, that is the reason why the what the left eye sees is projected onto the right brain; and whatever the right eye sees that is projected to the left brain, and then it is sent to here the occipital lobe where this information are gathered by specialized neurons so that is what it is. The eye contains two systems; one is the image formation system, and the other is the image transaction system. So, the eye has two basic properties one is called the image formation and the other is called the image transduction.

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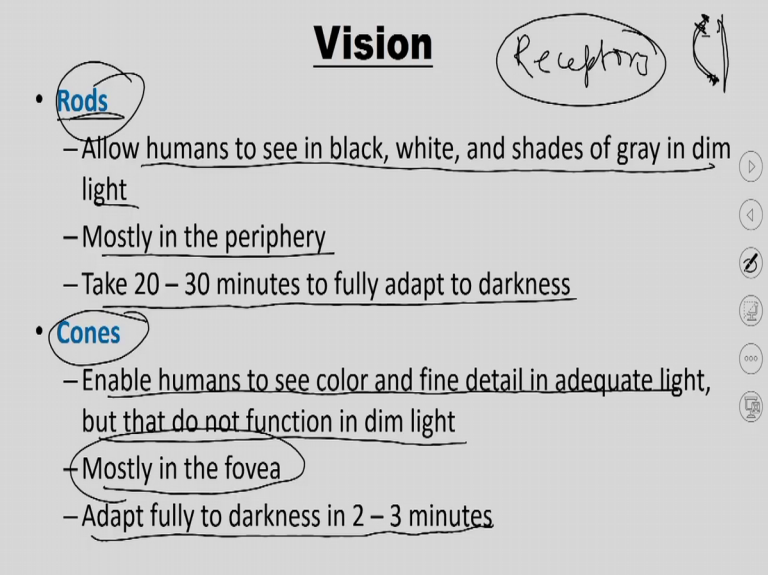

So, let us look at what they are. So, the eye has two receptors as I said there are two types of receptors in the eye. One is called the rods, what are the rods. They allow humans to see black, and white, and shades of grey and dim light. These are the same receptors in the eye, when you enter a dark cinema hall. What happens is when you enter a dark cinema hall or a dark room, initially you cannot see anything because you are coming from out and it was all light.

And so the slowly the pupils will open up, and then very slowly you will adapt. And you can now see inside the dark room, and that is wall is called dark adaptation, and that is because the rods actually make you see that is the reason why, rods does the main function of rods. What are so where are the rods so rods are generally in the periphery.

So, if this is my eye, if this is what eye looks like right, and so this is where the retina is at the periphery here itself is where the rods are there. And it takes almost 20 to 30 minutes for fully adapt in to dark darkness. So, rods will take 20 to 30 minutes to adapt to darkness, but within this 20 to 30 minutes, you can see most of the things in the dark region, and that is what is called adaptations.

And so rods are actually basically coming from adaptation. Long back when we could not see color, when there was no sun or the primitive organism were there which actually see no sun, they had rods. And the rod is actually a pass out or it is actually a carryover from those kind of organism.

In similar to that are cones, this is the one receptor which actually makes you see color. So, what is it enables humans to see color and find details inadequate light, but that do not function in dim light. So, cones actually let you see the world which is bright, it allows you to see brightness, it allows you to see color, it allows you to see everything bright. So, all world around you which is bright, which is colorful which is which is what everything means to you are cones.

Always remember human eye has more number of rods than the number of cones, because rods comes from adaptation, it comes from an evolutionary or theme, but cones are something which are developed in a adaptive process or in a cycle, where human being started growing up.

Most number of cones are found in the fovea. A fovea is a region of the eye, where large number of neurons these cones are there. And so when something is placed on to the fovea, when something is focused on to the fovea, you see the best. So, fovea is where the you should be focusing on or fovea is a region of the eye that you should be focusing all your photons on to, because it has more number of cones, and the brightest color are seen in the fovea.

They adapt fully to darkness in 2 to 3 minutes. And these can adapt to darkness in 2 to 3 minutes, but then they are not good or they have nothing to do with darkness. So, when in your dark light or in dark situation they will not be able to see anything.

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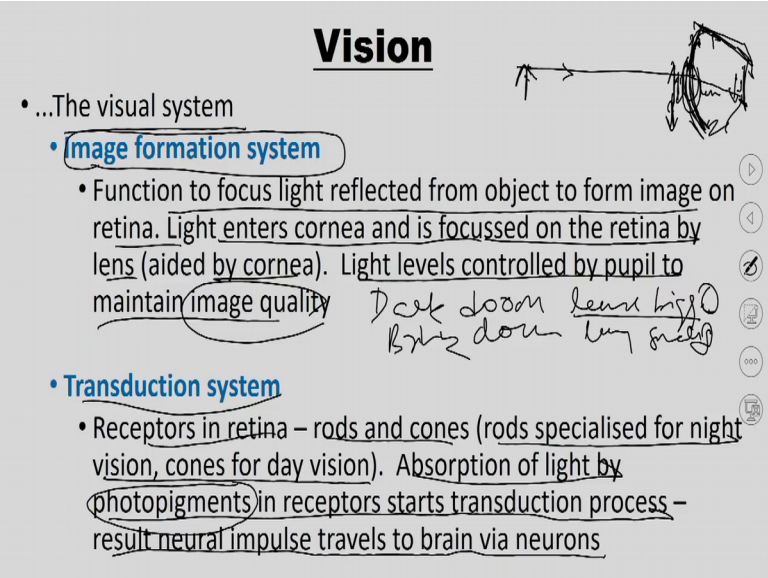

The visual system as we were looking at. Now, the there are two systems as we said. One is the image formation system, and other is the transduction system. Now, what is the image formation system with functions to focus light reflected from the object to form image on the retina.

So, this is how my eye looks like, this is where the lens is and this is where the pupillary pupils are sorry pupillary muscles are and this is where my retina is and so when an object in the external environment, it actually sends a signal here. This is first projected here, and so this is my light photons which are hitting the object in the external environment, then passing through the lens. And then image of this object is found on the retina right, because retinas will contains rods and cones.

Now, this is how the primary system is and so what happens is it functions as a concave mirror. Now, as you know that the functions of a concave mirror is no matter, where the object is an inverted image is formed. And so the brain itself, so whatever image forms on your retina is always inverted. And what the brain does is it re-inverts this image, and creates a upside down view right. And that is what a lot of experiments were done on psychology on inverted images, and it is very easy for you to see an inverted image and make a meaning out of it.

So, light enters the cornea, so this is called the cornea is focused on to the retina by lens this is where the lens is this is where the this part a small part here is called the cornea

sorry the small part here is called the lens, and then what is attached to it is called the cornea by lens aided by the cornea. Light levels controlled by pupil to maintain the image quality, this is called the pupil. So, this expands or contracts depending on how much light is entered. So, if you are in a dark room, this will extend; and so the cornea will extend, the lens will become bigger.

Now, in this is what will happen. So, the lens will become bigger, if you are in a dark room. But, this lens will become smaller, and this is controlled by this cornea. And this lens, so that that will tell you about the image quality. So, if in a dark room in a dark room, what will happen is lens will become bigger. But, in a bright room, the pupils will dilate. So, your pupil will expand, lens will become smaller. And so smaller light will enter in this case, large light will enter.

Now, the second system which the eye has is called the transaction system, which is the meaning system. So, receptors in the retina- rods and cones as we have discussed before, rods specifically specialize for night vision, cones are for day vision. Now, absorption of light by photo pigments in the receptor starts transaction process, which results in neural impulses travels to the brain by neuron.

So, I will explain this, what happens is this has rods and cones, and so this is rods and cones. These are photoreceptors right in this case this is called photo pigments in the receptors, which actually sense the light. And not only they sense the light, they send this light this information on to the brain which through a neural impulses, which actually makes meaning out of it.

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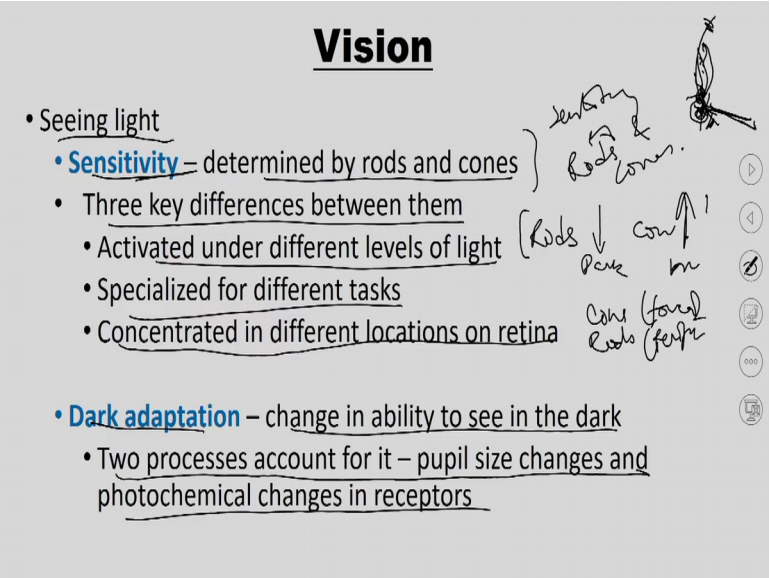

Seeing light, how do we see light? It is dependent on something called sensitivity, determined by rods and cones. Now, we see light because of the sensitivity of rods and cones. Three key differences between them they activated under different levels of light as I said rods are activated in darkness, and cones are activated in bright light right. Specialized for different task. Rods can actually see black and white, and cones can see color, and human think like that and concentrated in different locations of the retina. So, we have cones in the fovea, and we have rods in the periphery.

So, if this is my eye, this is where my rods will be if this is retina, and this is a region which is called the fovea. Here the maximum number of cones will be and the cones will be here all along. And here is something called the blind spot, this is called the blind spot, because from here the nerve fibers will go out. And since the nerve fibers there, so each of this is connected by a wire in neuron which actually then form a bundle, and then move from here which is called the bunch of fibers, which carry the signals from this blind spot on to the brain, so that is what the blind spot is all about.

Now, dark adaptation, what is the meaning of dark adaptation changes in the ability to see the dark. Two processes account for it. One is pupil size change, and the other is photochemical changes in the receptors. So, as I said seeing in the dark is dependent on two things, it is how much the pupil is opening or closing. If it is the people will open more, and put more light into it.

Also dark adaptation which means the seeing in the dark is also depend on which kind of receptor you are looking at whether it is rods and cones. Cones are ineffective, and rods are the most effective in dark. But, rod takes almost 30 minutes 20 to 30 minutes to adapt in the dark, but cones adapt fast in 2 to 3 minutes. So, initially the cones will be feeding information to the occipital cortex for seeing dark, but then after 20 to 30 minutes if this is the rod rods, which will actually.

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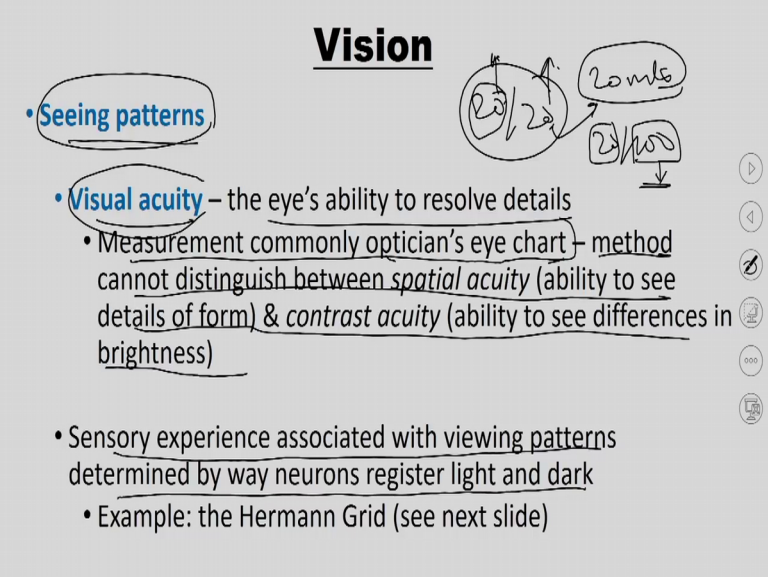

Seeing patterns, how do we see patterns? Patterns are find the details of any image, how do we see patterns visual acuity, one of the thing is visual acuity, if the eyes ability to resolve detail. Now, measurement commonly the so how does the eye see details. One of the ways in which the eye see details is looking at forming the foreground and background, and it depends upon how much rods and cones are and where they are placed that kind of a thing.

So, visual acuity is the eye's ability to resolve details. Now, one of the thing is you have something called as have you heard about something called as snells chart. What is a snells chart? If you go to an optician, and you will see that there is a chart there with letters bigger and smaller, this is a called a snell chart. And so measurement is common measurement commonly in optician's eye chart.

Now, method cannot distinguish between spatial acuity ability to say details in form and contrast acuity ability to see differences in the brightness. Now, snell chart can act can

actually give you the idea of how distance in at what distance you can see, and what distance you cannot see. For example, generally say generally it is believed that 20-20 is the vision, which means that somebody with a lens. And can see 20 at a distance of because at 20 meters is the distance at which people can see the objects. And so 20-20 means that the normal person can also see 20 with it.

But, if your vision is 20 by 100, which means that person with a lens will see a objects at 20 meters, when a person with no lens will actually seen an object at 100 meters, so that is the kind of calculation which is there. So, this that is what the measurement or that is what visual acuity is all about. So, visual acuity is how we resolved the details. And so the snell chart which is a simple chart at the optician is not able to measure this kind of thing.

Now, sensory experiences associated with viewing patterns are determined by the way neurons register light and dark. So, how do we see patterns, we see patterns because these neurons which register darkness and lightness that it is the interplay between the rods and cones, which actually see you let you see patterns. And the best example to look at is something called a Hermann grade.

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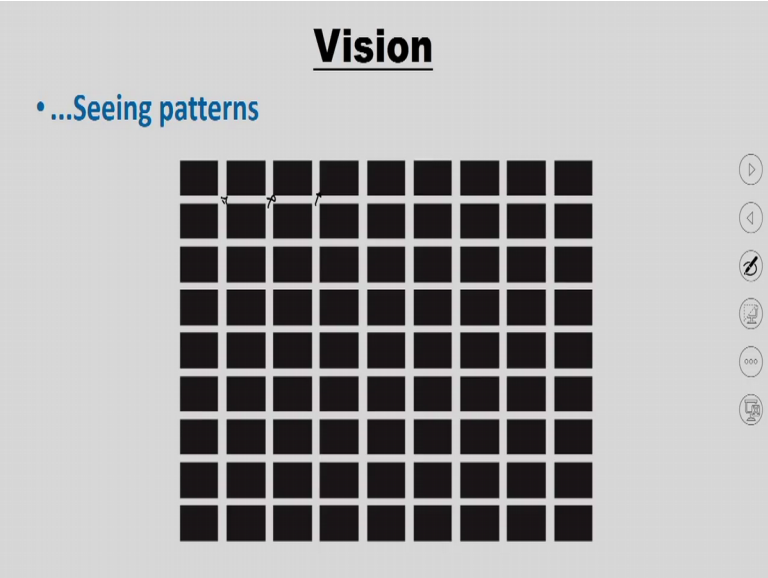

Now, look at this grade, what you will see is if you focus yourself, you will see there are blacks and whites, but then because the placement of the rods and cones are such that you will start seeing grey areas in between here. So, you will start seeing the grey areas

here, and that is what is that happens because there is a certain pattern in which the rods and cones are placed into your eyes. This Hermann grid is a good example of how visual acuity actually comes up, and then why we see a greyness here, this is because of the pattern in which these rods and cones actually appear.

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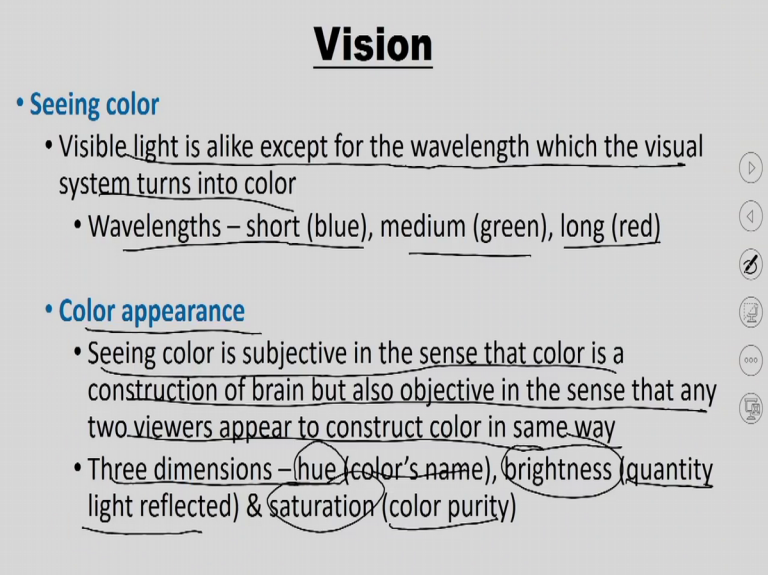

Now, how do we see color? Visible light is like is alike except for the wavelength in which the visual system turns out to be. Now, there are wavelengths which are short for blue, medium for green, and long for red. How does color so how do we see color appearance? Color appearances seeing color is subjective in the sense that color is a construction in the brain, but also objective in the sense that any two viewers appear to see construct color in the same way.

So, the see color the idea we see how do we see color is basically dependent on how the brain interprets the different wave wavelengths of light. So, basically on some level all most people will actually agree that there is a particular color, but the brightness contrast queue, and all those things will differ from people to people, because it is subjective, and in some way it is objective in nature.

Three dimensions of colors are there. One is called the hue, the other is called the brightness, and the third is called the saturation right, so that the hue is called the colors name, the brightness is called the colors light reflected, and the saturation is the color purity. So, on some level most people will agree that a certain color is there, but how

bright a color is or how saturated a color is how a pure a color is all these may differ from people to people, because the interpretations are different.

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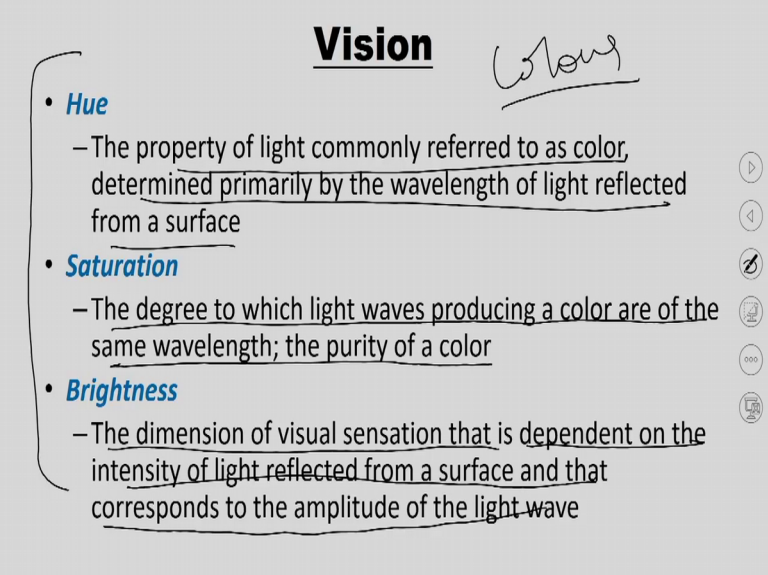

So, you generally have something called the munsell chart. Munsell chart actually tell you what color. So, what is the hue, the property of light commonly referred to as color is determined primarily by the wavelength of light which is reflected from a surface.

Similarly, saturation is the degree to which a light wave producing a color are of the same wavelength; the purity of a color. And the third is the brightness, which is the dimension of visual sensation that is dependent on the intensity of light reflected from a surface and that corresponds to the amplitude. So, these are the three characteristics of any color that we actually see.

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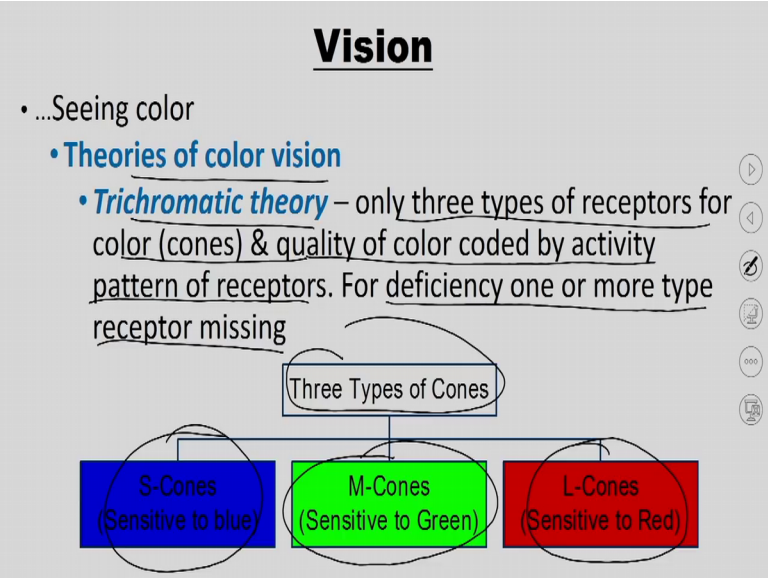

So, there are certain theories of color which are out there, how and why we see color. The first theory is called the trichromatic theory. And what is this theory, it is a very simple theory which says that only three type of receptors for color or cones are present and quality of color are coded by the activity of the presence of these receptors. For deficiency one or more type of receptor is missing.

Now, you have heard about color charts right people cannot see red and green color, and that is because certain cones are missing. And so what this theory says is that the cones are three types. One is called the S-cones which are sensitive to blue, the other is called the M-cones which are sensitive to green, and then there is something called the L-cones which is sensitive to red. So, because we see color because one of these cones response in a certain way that is the definition or that is the idea here.

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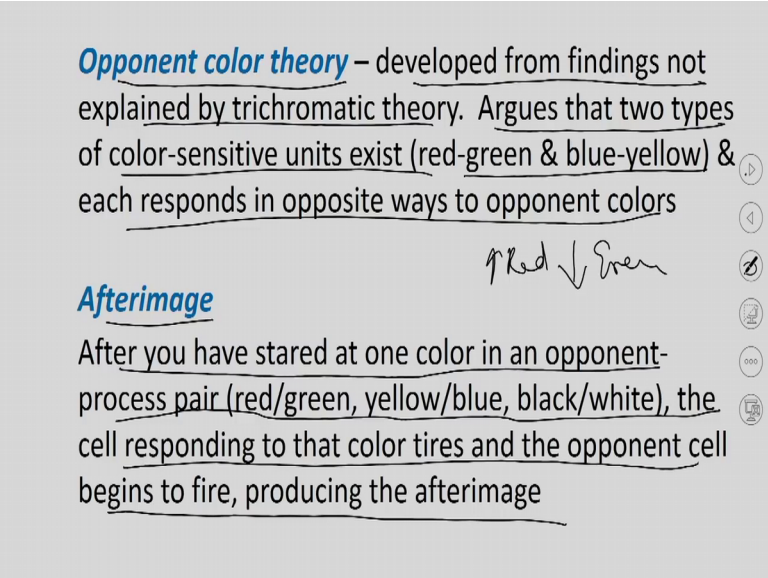

Then there is something called the opponent process theory, which says that develop from the findings not explained by trichromatic theory. And it argues that there are two types of color-sensitive units exists, red-green and blue-yellow and each response to opposite ways and opposite colors.

So, it says that when somebody says when somebody sees red, immediately starts seeing green a follow up as that which basically means that when you see bright red, the only color that you can see afterword is green, because the same neuron or the same receptor is coded for both read and green. So, if it is one is if the red cone or one side of the red cone is excited, immediately there will be a decrease and you start seeing the green color, and that is the opponent process theory.

Now, after images a good explanation opponent process theory. Now, after you have stared at one color in a opponent-process pair red and green, yellow-blue, black- white, the cell corresponding to the next color tires and the opponent cell begins to fire producing the after image. So, basically opponent process theory says that if you start if you are seeing the red for a longer period of time, immediately you will see green.

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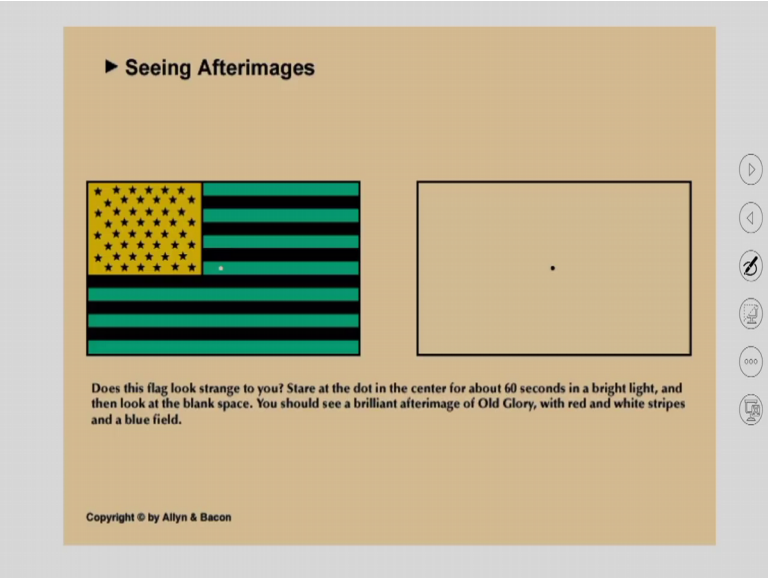

Example, so see this for let us say 1 second or 5 seconds, and then close your eyes, and then focus at the centre here. And what you will see, the green will actually become red right. So, you can do this in your own time, and you will see that this is called an afterimage.

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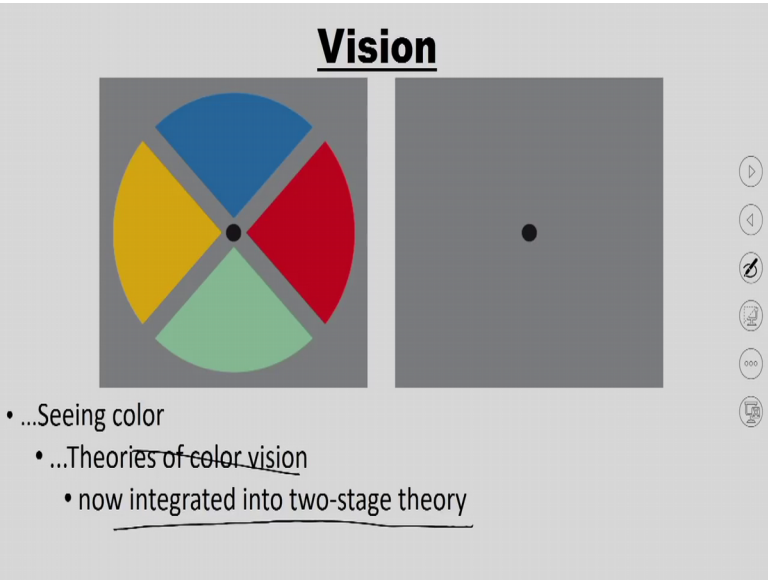

Similarly, if you see so theories of color vision, now integrate into two-stage theory. So, if you are seeing this colors, so focused yourself first here for 5 seconds. And when you

do that start focusing here, and you will see the opposite colors in this chart, and that is what is the theory of (Refer Time: 60:13).

So, let us recap what we did in this lecture quickly, since we want to end this lecture. So, in this lecture what I did was, I started by explaining where we left what is the signal detection theory, and what is the need for the signal detection theory, and what are the various parameters of the signal detection theory, what are the various systems in signal detection theory. I started by explaining what is heat false alarm, what is signal plus noise signal and correct rejection, and things like that then I explained you what is bias, and what is sensitivity in signal detection theory.

Later on we went on to understand the sensory coding of how the brain, interprets or the biological system in the brain, interprets, external, feedback or external environment. So, through several processes it encodes quality and intensity. So, later on we took a special medium, we took a special sense which is the vision in this case, and try to explain various forms of vision or various patterns of vision which are there. For example, how do we see things, how do we see color, how do we interpret color, what is image, and what is the various factors of color, and then also what are after images, what are the theories of color, and so on and so forth, so that brings us to the closure of this section on sensation.

And when we meet next, I will be discussing perception. So, that the only difference between perception and sensation is sensation feeds physical information into the brain, and perception takes the physical information and makes interpretation. So, sensation is the process through which light particles, which are hitting from a tree, enters into your eye, and then into your brain.

And perception is the process through which the brain takes this physical information, encoded in certain way, and says that it is a tree, so that is what perception does. And in the next class, we will actually see what is perception and then go into the basics of perception. So, till then we meet again, it is goodbye.