Virtual Reality Engineering

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Lecture – 41
Psychophysics of Visual Perception

Welcome back. In the last lecture we introduced the concept of psychophysics, and we looked at how we can measure experience. Specifically, we came up the concept of for threshold, and JND, the Weber's law, Fechner's law and then Steven's law. These are the fundamental concepts which can be applied to the entire sensation. In this lecture, we will look at the psychophysical laws whatever we have discussed earlier apply to visual perception. Before we go into applying this concepts to visual perception, we look at couple of terminologies clarify.

Now, let us look at how visual perception is happening. Let us break the whole visual perception into smaller steps. The first step in understanding the visual perception or any perception is starting with stimuli characterized in the stimuli, and then how that is related to the experience is what we have learnt in the last class, the foundations of the psychophysics. We will apply the same thing to our visual perception also.

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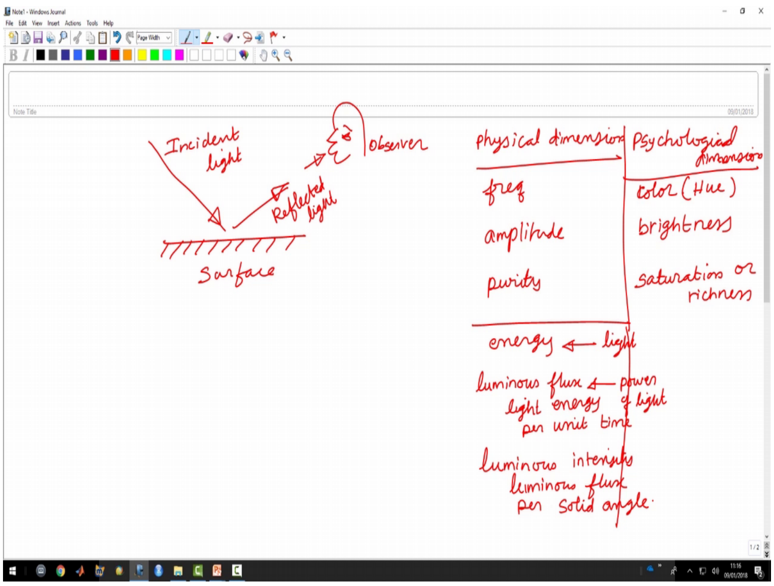

The visual perception there is a surface, and there is a incident light, incident light, and it is surface is reflecting the light, reflected light, and there is a perceiver, let us say. He is seeing the object let us say he is an observer.

So, that light itself has physical properties, if you look at other physical dimensions of light. Frequency, amplitude, purity; Corresponding to the, prefer this physical dimensions, there are psychological dimensions, may be call it is a psychological dimensions. So, the frequency is what we call as colour. The technical name for the colour is hue, hue, ok. The technical name for colour is hue.

The amplitude of the light is termed is perceived as brightness. The purity of the light is perceived as saturation or richness. You can see that the light has the physical dimension, and after it is perceived, we have a certain terminologies. Now, this is only this psychological dimensions, we are going to talk about another dimensions which is called the you know psychophysical dimensions ok.

This is the basic physical dimensions of the light. There are more inward dimensions of the light we will see. Another physical dimension you can say is the energy, right? Energy that is what we call it a self-light; this is what usually we call it as a light. Luminous flux, this we call it as a power of the light. Luminous flux is the light energy per unit area; unit time, light energy per unit time and then luminous intensity. This is called a luminous flux per solid angle, per solid angle.

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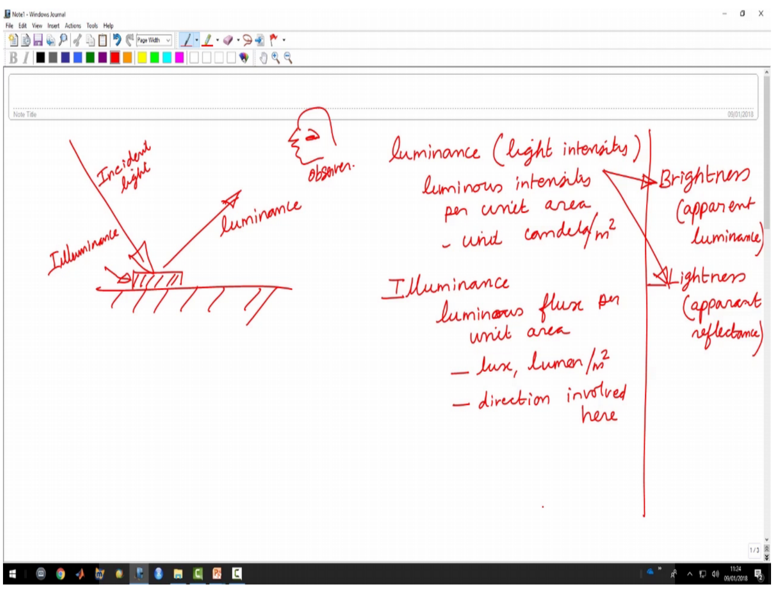

And then and then we have a luminance itself. Luminance is called the light intensity. Luminance is nothing but the luminance intensity per unity area, as intensity at unit area projected on a given area on direction. This is the unit of this is one of the main important terminologies will come again and again. So, we will focus little bit on this. It is unit is candela per metre square. And then there is another property call illuminance, luminous flux per unit area.

This is what we call it as flux or lumin per metre square or lumen per metre square. So, the main difference between this and the luminance is that there is no direction involved over here. Then what (Refer Time: 08:11). So, these are the involved physical properties of light, some of the technologies may be confusing. So, I will try to clarify little bit when we have the surface, that when the light is inciding incident on the surface, suppose if you measured that light over here suppose this is our sensor, the sensor measuring the incident light is called the illuminance sensor, this a incident light. So, this is measuring the illuminance, that is measuring the flux.

How much amount of life is falling on to the surface per unit area that is luminance? When the light is reflected on the user is over here observer over here. (Refer Time: 09:23) Among the direction where the observer is the reflected light look differently. So, that property of light that depends on the direction is called the luminance. There is light intensity. So, you can see that light intensity after falling of the surface and getting reflected coming to the observer is the luminous. How much light is coming to the observer is called the that luminance.

So now, luminance is also called the brightness. Luminance is a physical quantity where is when it is perceived by the observer then becomes the brightness. Brightness is a psychology quantities; right, this objective that is another term we can also call it as a apparent, some it is just say apparent luminance. There is also another term to capture the psychological dimensions of the light when it is reflected of the surface is called the lightness. This also you will come across lightness. This is called the apparent reflectance.

So, the lumin may result into 2 psychological parameters. Let us say a it can be either brightness or the lightness. So, if you can see that we are trying to characterize the light physical properties, and then see what are the psychological dimensions of the lights.

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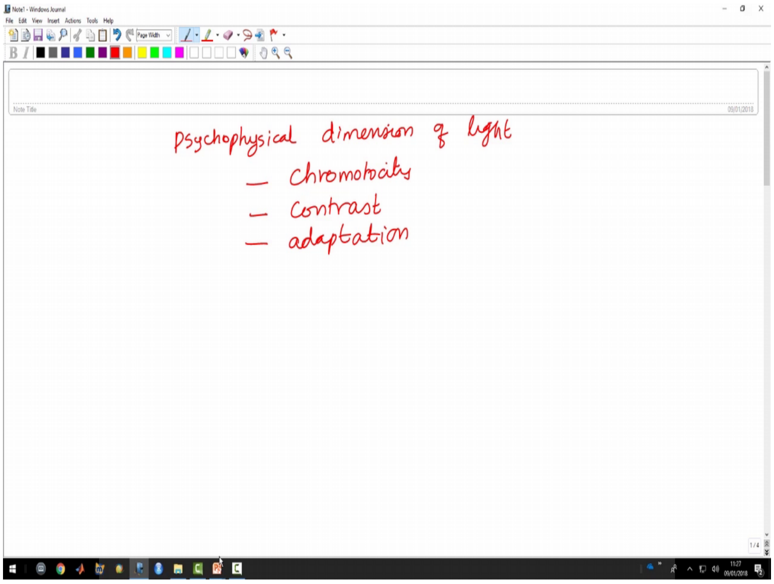

The third dimensions which we are talking about; this is psychophysical dimension of light. Brightness is a psychological dimensions, but there are much more. So, when you relate the psychological concepts with physical dimensions, then it becomes psychophysical parameters.

For example, colour it is called the infected it is called the know chromaticity, will this is a chromaticity, we will see in one of the next lectures. Contrast talks about the apparent appearance of the light when there is two different intensity are involved. Adaptation; so, over a time when the night is exposed to the photoreceptors or how it is a response is actually changing. That is the adaptations. These are all psychophysical dimensions of the light which we need to be aware of. So, given this basic background on the physical properties of the light; psychological concepts of the light and psychophysical dimensions of the life.

Now, let us look at some of the experimental data available for us for visual perception is concerned. We will relate the experimental data to the concepts what we had had seen in the last lecture about the 3 physical; 3 psychophysical laws, Weber's law, Fechner's law, Stevenson's laws. I am going to show you series of graphs from which we can see the psychophysical dimensions of the light ok.

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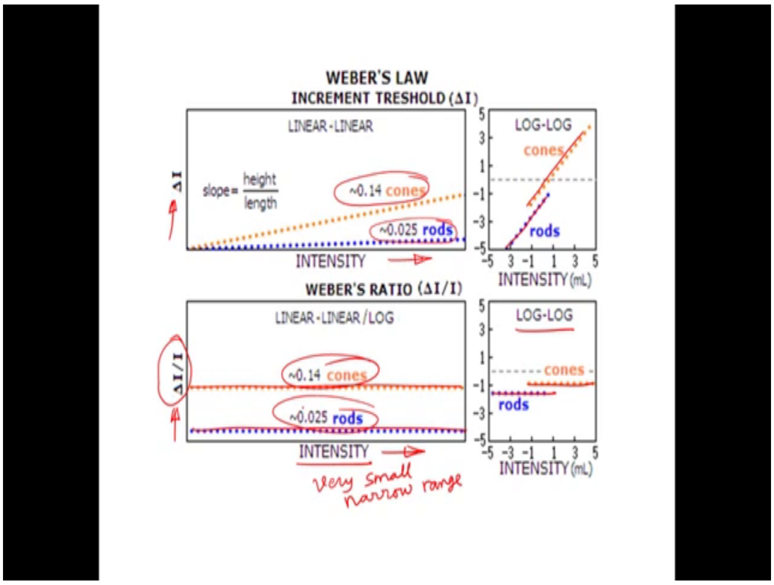

On the slides you are seeing the Weber's law for the light intensity increment threshold. So, in the x axis you can see that, in the x axis you are seeing this light intensity. And the y axis you are seeing the change in the light intensity that can be perceived. Basically, you are talking about the difference threshold, that JND as we mentioned in the last class if you remember.

So, this graph shows the light intensity JND for cones separately and then rod separately ok. So, for the cones it is 14 percent, usually the JND is mentioned in terms of the percentage ok. And rods it is a 2.5 percentage, the same graph of when it is a made as a log log graph, you can see that that is almost of 45-degree slope, both rod and cones have 45-degree slope. Only the y intercept and x intercept of the define.

According to Weber's law that del I by I, that is the JND, that is a Weber's fraction must be constant. Say again, when you plot intensity in the x axis, and the fraction del I by I in the y axis, you can see that that is a straight constant Weber's fraction for both cones and rods. Either linear graph or log just satisfies, in the log log graph, you can see that again that is a now constant like.

This graph demonstrates the intensity of the light in a very small narrow range. It is not for a very large arrange, it is very narrow range. For this very narrow range, this numbers of 14 percent and 2.5 percent and holds good correctly. But when we go over the range this numbers change. That is what the recently the researches have come up with.

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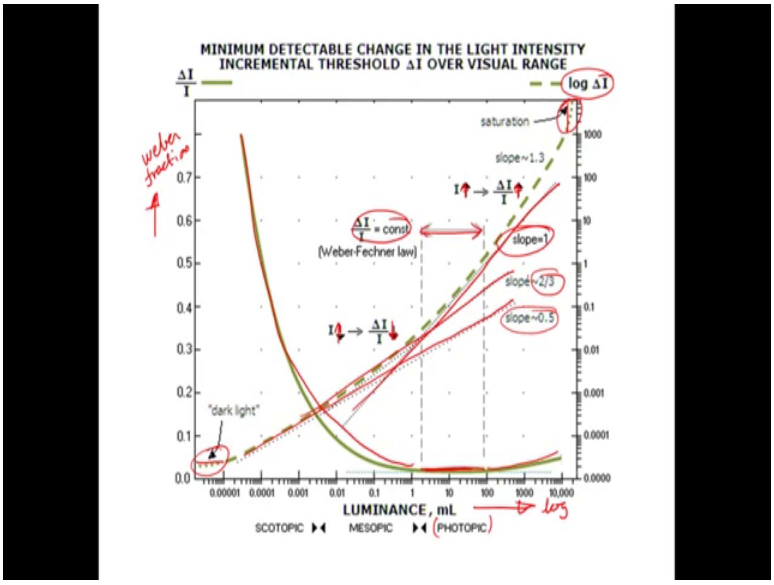

So, the same graph it is shown in the next graph for a much larger range. Again, you can see that x axis luminance this product, luminance if you remember is a light reflected from the surface, that some measure of the light reflected of the surface of the surface. Just before the light reaches the observable, what is the amount of the light ok? It is a luminous intensity per unit area candel of the metre square is what we have seen it.

So, that is mentioned in the log scale, on the y axis I can just fraction is Weber's fraction is mentioned, Weber's fraction. So, Weber's fraction is supposed to be constant as we have seen in the earlier graph. Here, only for a very small range this Weber's fraction is constant; that to in the scotopic region. So, when we coming to the mesopic and scotopic region, you can see that this Weber's fraction is actually changing and essentially it is it is decreasing from a large number, from the 70 percent or 80 percent it is coming down to 2.5 percent or 3 percent ok.

And after this region, you can see that the fraction starts increasing. So, this is a small range where this is a range in which this is constant. And below this range as I increases, the del I by I decreases (Refer Time: 18:43) and after this region, when I is increasing del I by I also is increasing. The slope is; so, that the green line which talks about is the only log of del I. The change in the intensity, if you check the log that is what is mentioned in the green line. The green line you can observe that this is again it is not constant, del I itself is actually changing over there luminance.

So, these graphs capture the dominant over a very large area, very large range and you can see that the Weber's refraction is actually changing. So, the both extremes there is a saturation and the dark light where luminance is almost not luminance, in this is the del I is almost constant over here there is almost vertical over here.

In between and you can see that the slope is actually slowly changing from 0.5 slope, and then it becomes one, this slope and then it becomes more, and this is another slope 0.75 and then it increases to 2 1.

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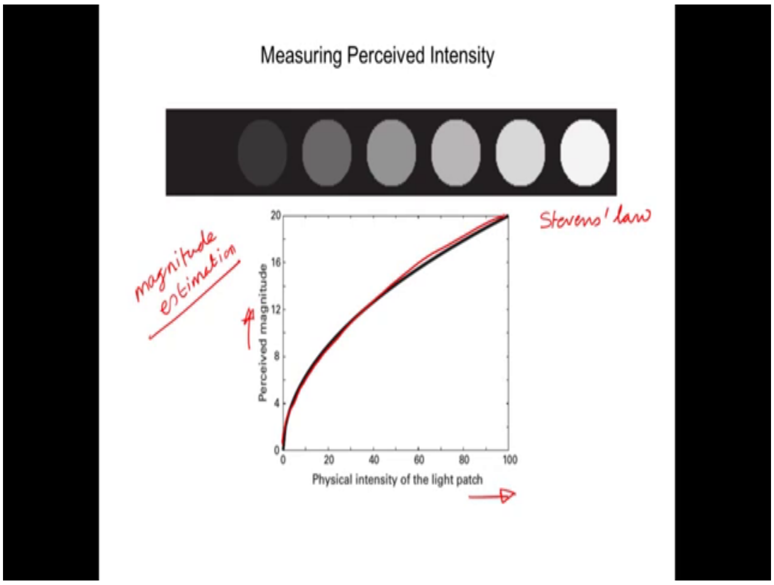

Now, when that light is perceived as a Weber's fraction and the graph shows, Stevenson law status same thing in a slightly different way. As we mentioned in the last class, Stevenson law uses the magnitude estimation, estimation magnitude estimation to remind you that the experimental task is to ask his subjects to given number compared to a reference intensity in this case.

So, the y axis is perceive this is using the Steven's law; Y axis the pursuit magnitude, excessive the physical intensity of a light. And you can see that at it follows a power law.

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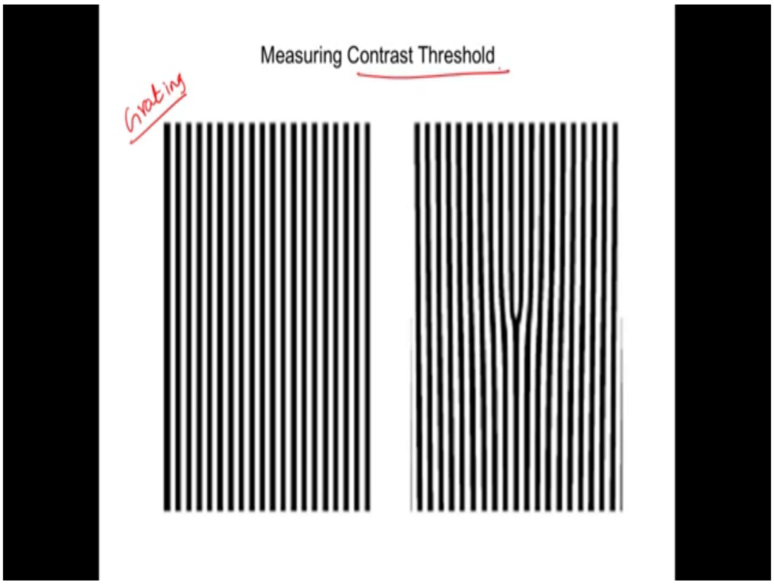

And to measure the perception of light when there is an alternating patches of light of different frequency, such as like a greeting. This is a this is greeting; where alternative black and white are display. Now in this greeting, if you want to measure what we can measure is the their contrast threshold.

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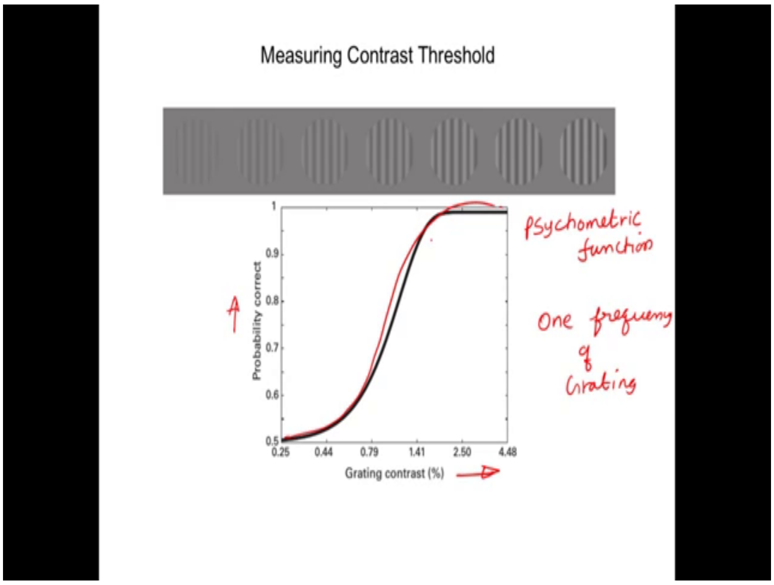

So, this alternating stripes as a great is display in various contrast and shown to the subject, and then subjects are ask to check if they could a identify the patches. As you remember from the earlier class this is a psychometric function, function x axis is the grating contrast and y axis is the probability of s answer. And this is the now s curve. You can no recognise this is a psychometric function. But the whole thing is for one particular frequency, one frequency, frequency of greeting. What is it change the frequency? The whole s curve will be changing it.

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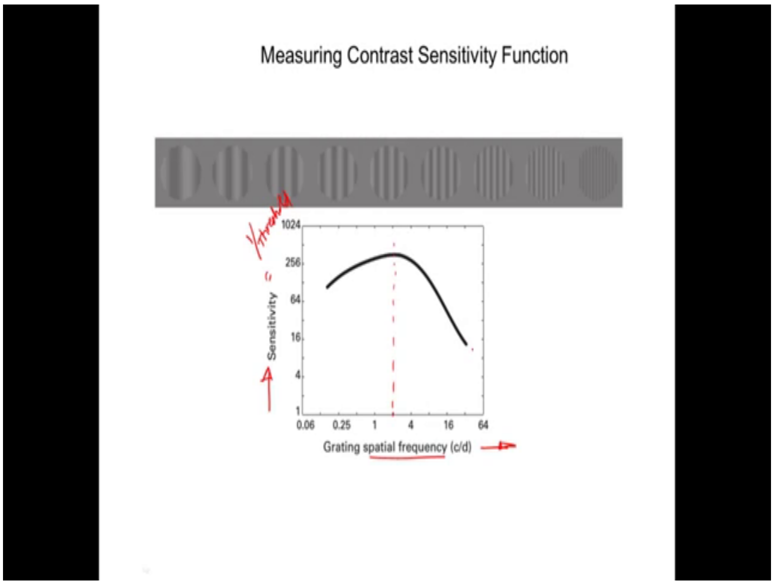

Then next graph shows. How the psychometric function changes. Another terminology you have to learn in this course is this sensitivity. Sensitivity is nothing but 1 over the threshold

So, lesser the threshold the more sensitivity more the threshold lesser sensitivity; Sensitivity is one of the inverse of threshold you can say. So, us the special frequency of the grating increases, you can see that until certain maximum the sensitivity increases and then drops drastically.

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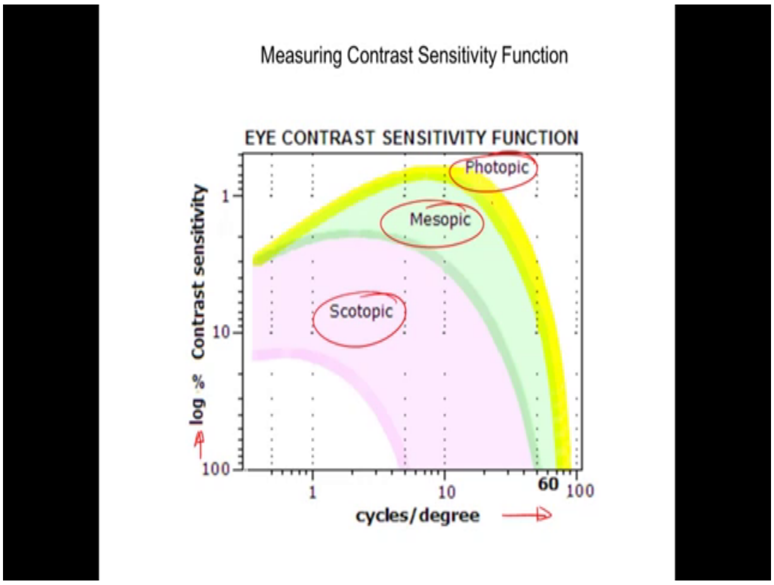

In fact, this sensitivity it is called a contrast sensitivity function, because it takes care of many grating frequency. Suggests a contrast sensitivity function has been the study for various photoreceptors separately. For example, I will photopic region and mesopic region and then scotopic region people have identify, both access or in log log. You can see that at in the photopic and mesopic and scotopic, the sensitivity function curve is a vastly different.

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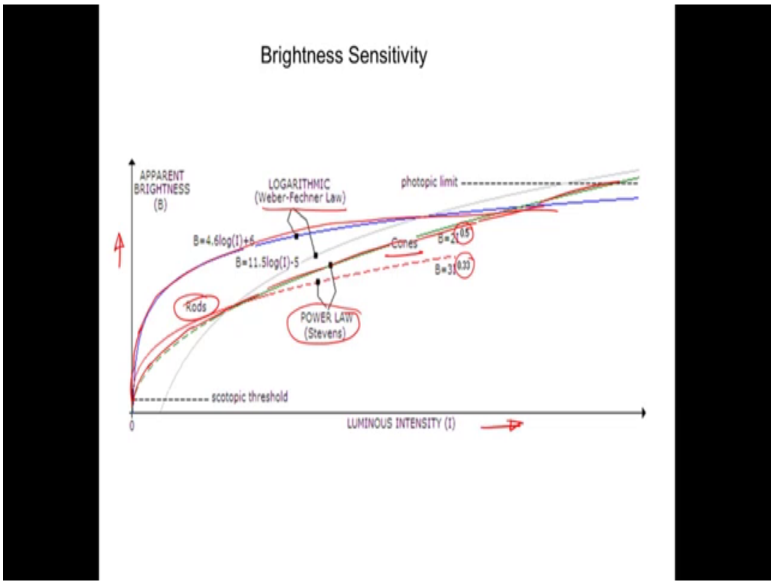

Now, coming to the brightness, again we can weather use Steven’s curve or Stevens law or the Weber’s or Fechner’s equations laws ok. Suppose if use x axis luminous intensity and y axis the brightness that apparent luminance, then this blue curve shows the Weber Fechner’s law in the literature you will say that Weber-Fechner’s law. Together as mentioned as one name because Fechneries student of the Weber.

So, Fechneries use the Weber’s equations to derived his laws. So, it is usually named as the Weber’s Fechner’s law. That Stevenson law is usually mentioned as power law. You can see that the power law for rods and cones are mentioned as green and red separately. So, Weber’s Fechner’s law starts with very high slow, and then slowly saturates ; whereas power law starts with let us lesser slow, but it does not saturates as much as the Weber’s Fechner’s law.

You can see that this 2 laws or from 2 different experiments. The Stephenson laws is using the magnitude estimation, where is the Weber’s Fechner’s equation is using the JND. So, you should see that these are 2 different tasks. So, that results in and not to different curves the exponent of the cones, and exponent of the rod is given is over here both are less than 1.

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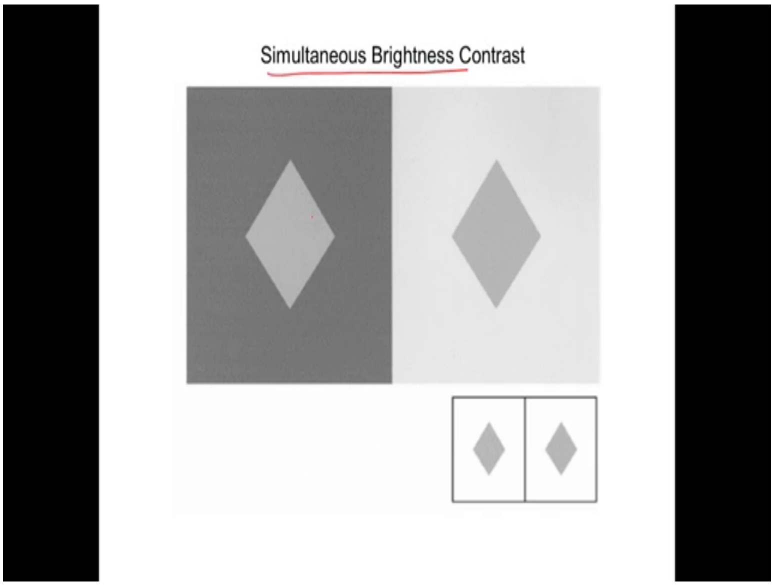

Then another psychological concepts as far as the light is (Refer Time: 27:38) is the simultaneous brightness contrast; where you will see, light patch surrounded by another different contrasting light patch. The apparent lightness of the surrounded light patch will take different. This is simultaneous brightness contrast. If you look at this graph, the centre piece centre light patch looks different depending upon the surrounding, then left image because the surrounding is darker, the centre patch looks brighter. And in this second right side patch, the same centre patch looks darker because surrounding light patches lighter.

In the bottom one can see that the same light patches used and it looks same in both are boxes. People have been wondering why, what is the mechanism for this apparent behaviour. Many scientist have try to reason it out.

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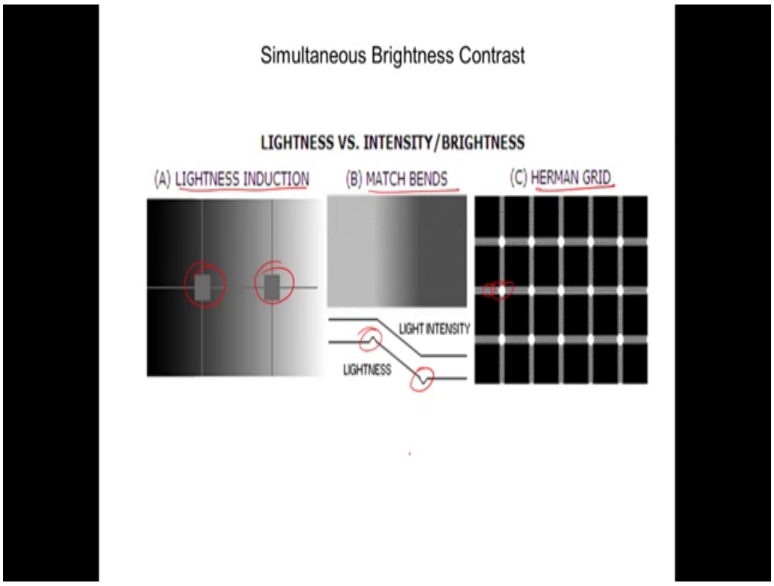

The same thing can be observed in many illusions. This is also known as the lightness induction in many literature. You can see this the same light patch looks different, and it is a match bends where the light intensity is uniformly decreasing, but we can see that there is a small band over here. In the Herman grid, you can see that the same grey colour it appears white at a at the grid at a 4 junction.

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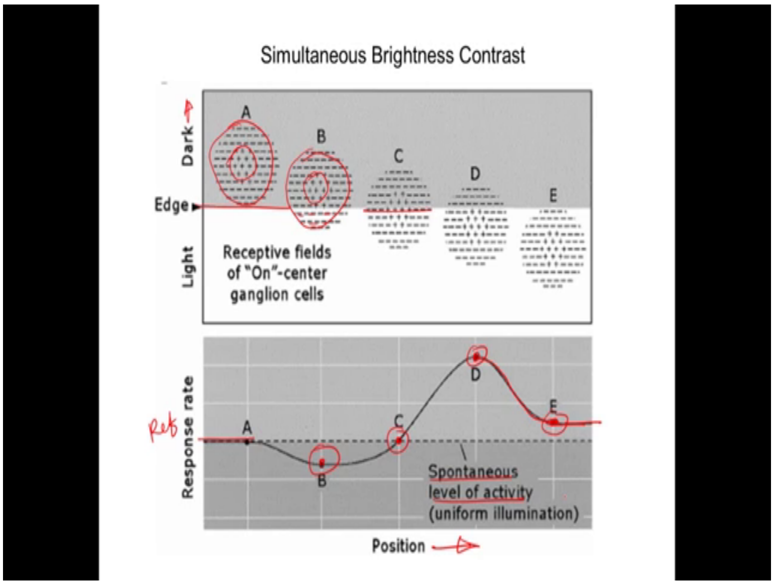

What could be the reason? People have try to reason it out. We will see without that reason is correct or not. Our eyes rods and cones have this on centre and off centre receptive field.

Each of the photoreceptor has a receptive field, on centre and off centre. So, those receptors that are completely for falling on the dark side. There activity let us say it is some quantity, let us say it is some 0-level quantity reference, this is a reference. There are partially falling on the light field feel, because they all only negative centres.

So, the spontaneous level of activity is actually lesser over here and here equal number of positive and negative ganglion cells are fallen on there both light and dark so, that will get cancelled. So, it is back to the their reference position. When more on centres are on the lighter side, then a spontaneous level activity is actually higher over here. And then and more and more negative can. So, here so, it starts decreasing and finally, this richest a uniform or study state responds of those photoreceptors falling in the light alone. This is a position we are talking about.

This is the explanation which is given and most of the textbooks and research peoples. But recently researchers have found that this does not explain the simultaneous brightness contrast very well.

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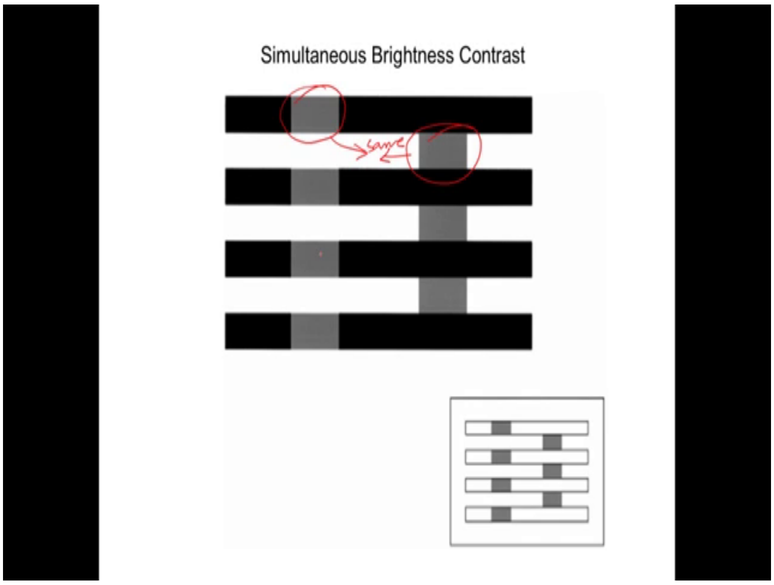

One example is this one. Let us say this types of black and white, and then vertical stripe of grey band. The grey band in the black, you can see how it is lighter when compared to the same grey band and in the white background. So, according to the on and off receptive field theory of the ganglion cells. This should be resulting in the same both should be the same, both should be the same, but it is not same.

So, the theory of receptive field is not explaining the simultaneous brightness contrast very well. So, researches are still searching for a convincing answer.

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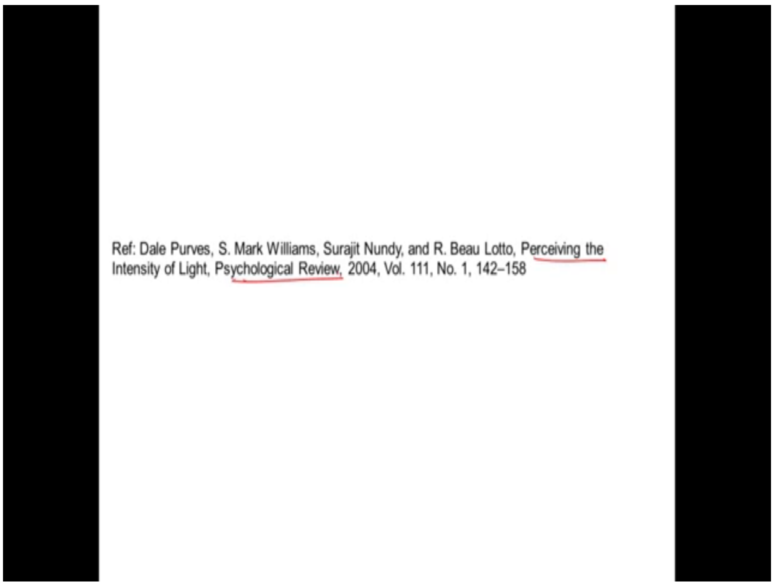

If you are interested you can go through this, this a paper and find out more details about it. So, we will stop here. So, in today's lecture we have looked at the fundamentals of the visual perception psychophysics. The psychophysics of visual perception is divided into is starting with understanding the physical properties of the light. The psycho psychological properties of the psychological concepts of light, and then psychophysical concepts of the light; we looked at psychophysical concept such as the contrasts and contrast sensitivity.

We looked at a couple of psychophysical curves, data's from Weber's law and Stevenson's laws, and then we compare compared them. In the next lecture we look at some of the psychophysical concepts of colour, and the adaptations if you remember this are the 3 psychophysical dimensions of the visual perception. Colour is a psychophysical concept or chromaticity.

In fact, is a psychophysical concept we will see in detail in the next lecture. Contrast we have seen in today's lecture, adaptations we will see later.

Thank you.