Indian Institute of technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Basic Cognitive Processes

Lecture – 14
Psycho- Physics Measuring Sensation

By
Dr. Ark Verma
Department of Humanities and Social Science
Indian Institute of Technology Kanpur

Hello and welcome to the course called basic cognitive processes I am dr. Ark Verma from IIT Kanpur.

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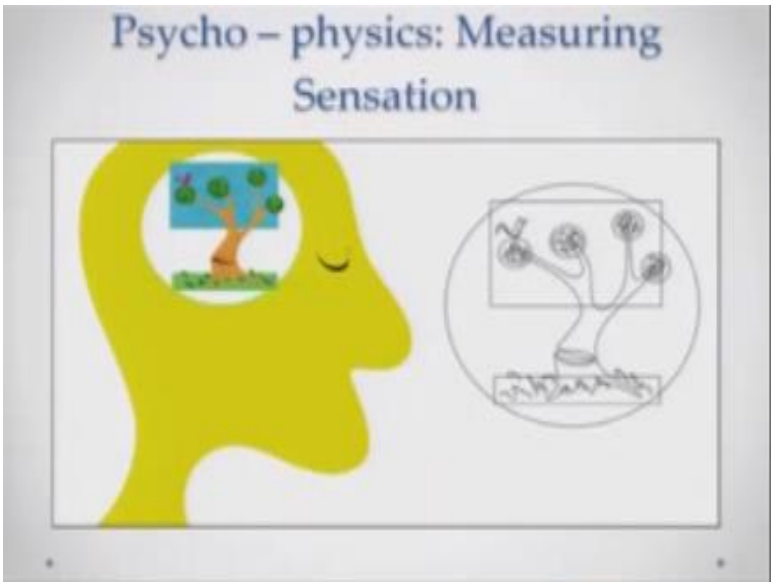

So what is psychophysics psycho physics is actually about measuring these different sensations measuring the input that is coming from various senses.

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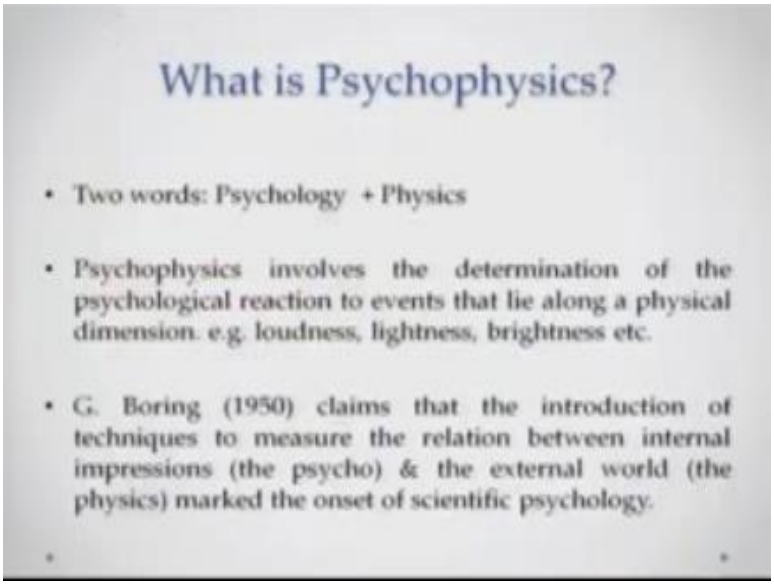

Now what is size of physics psychophysics as the name says is psychology + physics so psychophysics basically involves the determination of the psychological reaction to you know events that lie along a physical dimension, so changes in loudness changing inviteness, lightness changes in you know a pressure temperature those kind of things and how do we really experience them that is pretty much what the discipline of psychophysics about gee boring basically you know claims that the introduction of these techniques.

You know to measure the relationship between internal impressions that is the psychological experience and the external role that is the physical events that is what actually mark the you know onset of scientific psychology if you remember in one of the earlier lectures we have talked much in detail about this that how cognitive psychology came into being how we started really measuring what is happening in the mind space psychophysics is certainly at therefore front of you know the beginning of this revolution.

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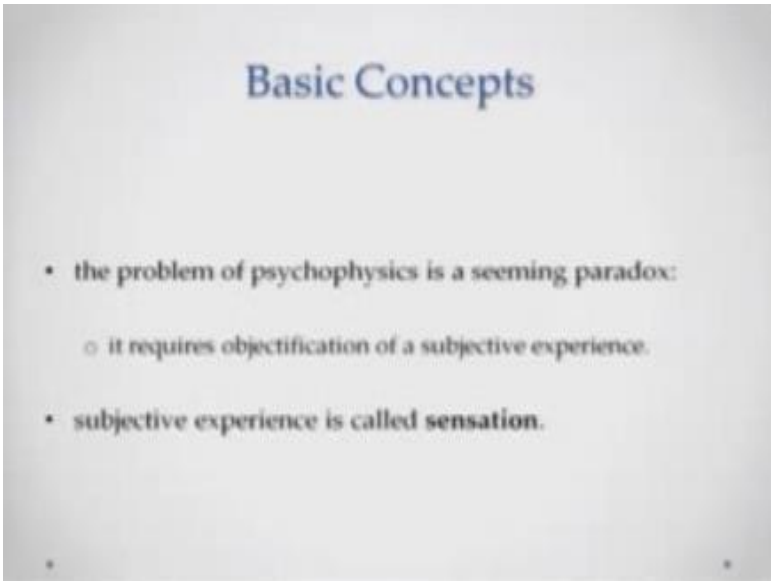

Let us talk about some basic concepts in psychophysics the problem of psychophysics actually is a bit like a paradox you know it requires you to objectify something which is actually a subjective experience, so your experience of you know a loud mess or color etc…

A subjective experience but we are trying to do what we are trying to do in psychophysics is to measure these subjective experiences so what is the subjective experience of most basic subjective experiences any sensation or any information that is you know impinging on you know five of your senses.

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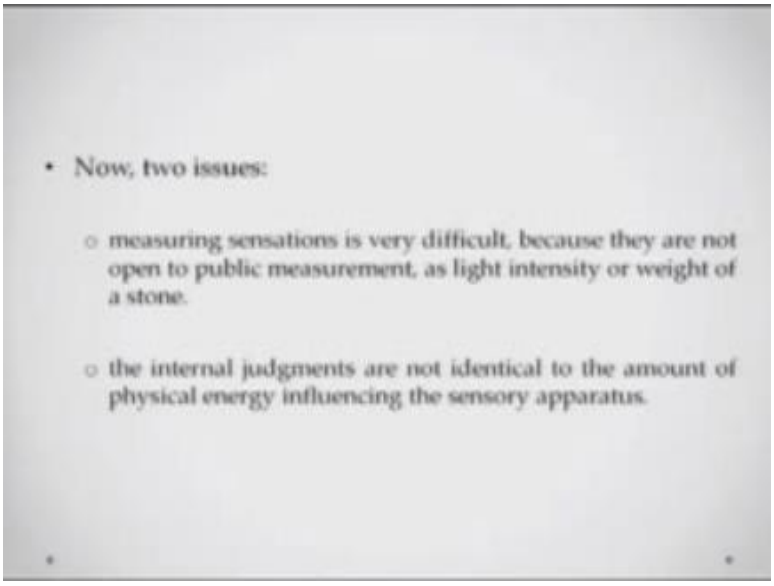

So measuring sensations in that sense is a rather difficult task you know because not really open to public measurement you will not really measure you know discreetly how much pain somebody's feeling or how much light you know you are feeling when you lift up a particular you know stole or how bright you are actually feeling the light to be sometimes you are very tired and you actually feel that the light is too bright even though the light is the same that you have been using every day of your ear is not it.

So it is this subjective experience that we want to measure and that is what we use psychophysics for the internal judgments the ones which I was talking about are not really identical to the amount of physical energy influencing the sensory apparatus so it is not like you are 10% of you know a particular physical energy in let us say light or weight or something is directly proportional to that you are feeling 10% weight you know that can actually vary quite a lot I talk about that in more detail as we go ahead.

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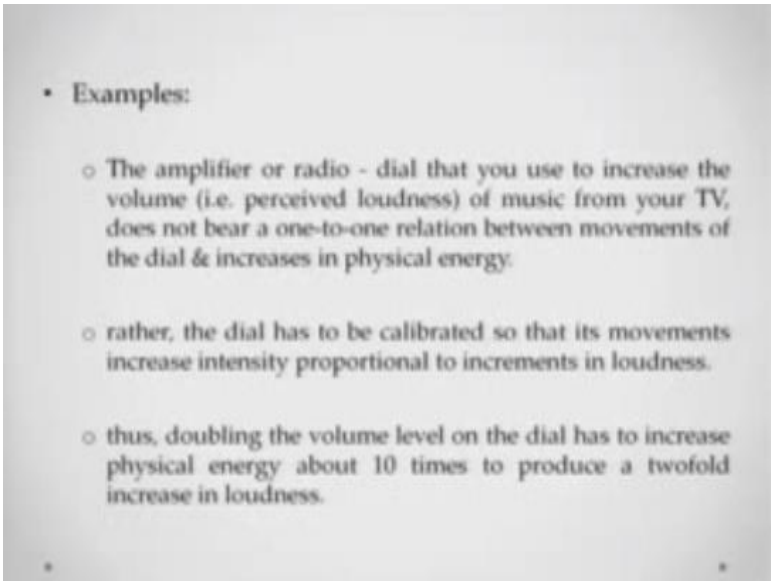

Let us take this example of you know a radio dial say for example if there is a stereo in your house and you have a dial to really increase or decrease the sound or volume of this what is volume is basically is perceived loudness how loud the sound is appearing to you so you have a dial there is a recorder is playing some music you have this dial you can turn this dial you know towards the left or towards the right to increase or decrease the loudness of music from this dial okay.

Now you realize that this movement of the dial it does not be a one-to-one relation to how loud you are actually you know feeling the music to be rather this dial is very cleverly calibrated so that each movement increases you know intensity proportional to increments in loudness, so you move the dial one steps and you feel that the loudness has increased you move the dial another step you feel that out loud noises increase further thus doubling the volume level on the dial has to increase the physical energy by about 10 times to produce a two-fold increase in loudness.

So for you to wear you know a thing that something is now twice as loud does not need the physical energy to multiply just by to it rather needs the physical energy to be multiplied by ten, so that you can you know experience twice loudness this is what I am talking about when I am

saying that there is no one-to-one relationship between the amount of physical energy and you know corresponding psychological experience that you are having.

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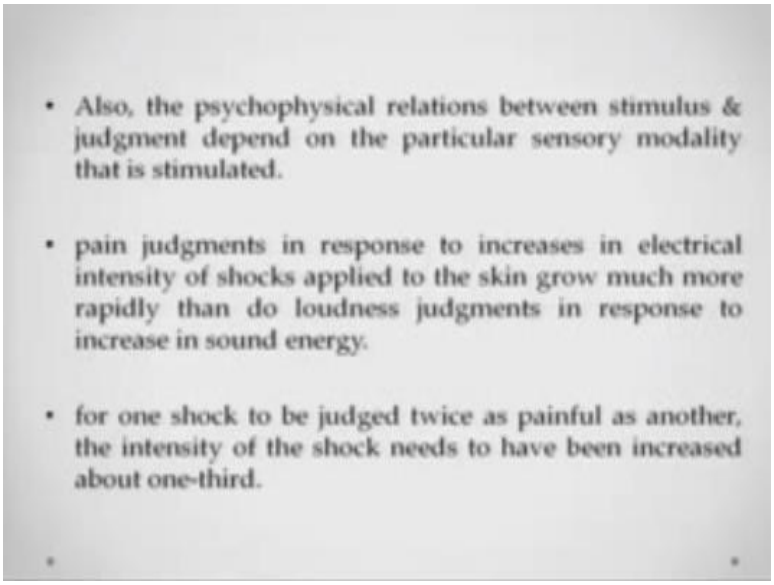

Also the size of physical relationships between the stimulus and the judgment depend on the particular sensory modality so you might have a particular their sensitivity of judgment when it comes to light or sound but you might have a very different in a sense of judgment when it comes to you know the pressure stimuli like pain etc…

Pain judgments in response to you know increases in electrical intensity of shocks applied you know to the scale grow much more rapidly than say for example loudness judgments I told you that you have to really you know multiply the physical energy of sound by10 to perceive twice among the of loudness but you have to really multiply the electrical energy only by 1/3 you know only raise it by one third of the time to actually you know make you feel twice as painful you know that twice as painful a shock as the original time okay.

Now psychophysics basically tries to solve this problem by closely linking perceptual experience to physical stimuli what you are experiencing versus what you are getting the basic principle

here is to use the physical stimuli as a reference system okay the stimulus characteristics are you are carefully and systematically manipulating and observers are asked to report how they are perceiving that particular system.

I will come to you know a demonstration of that in a short way the art of psychophysics however is to formulate such a question that can get the simplest of answers.

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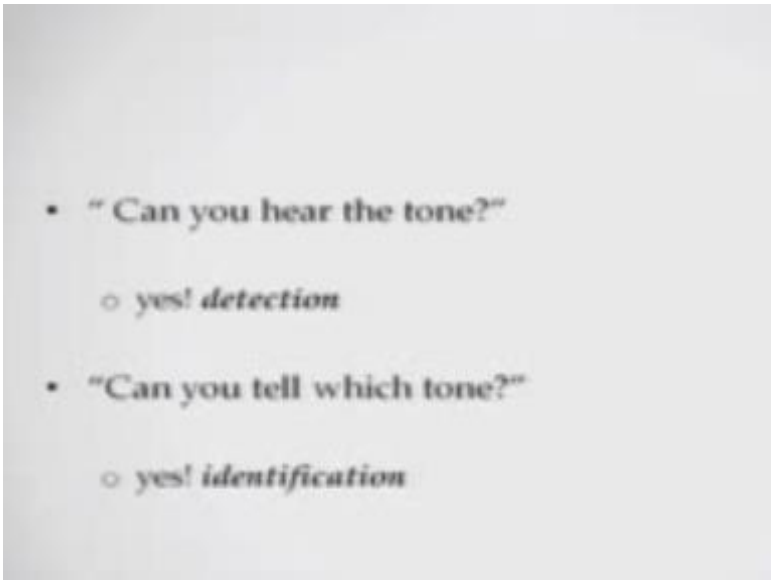

You know, so the questions are very simple questions like can you hear the tone the person just has to say yes or no and the person says yes you know that the person has detected the stimulus on the other hand can you add you can also ask questions like can you tell which tone which tune which songs tune I am playing then the person can say yes and then you will know that the person has identified the tone you remember we are talking about detection and identification in the research methodology lecture. So these are two slightly different processes.

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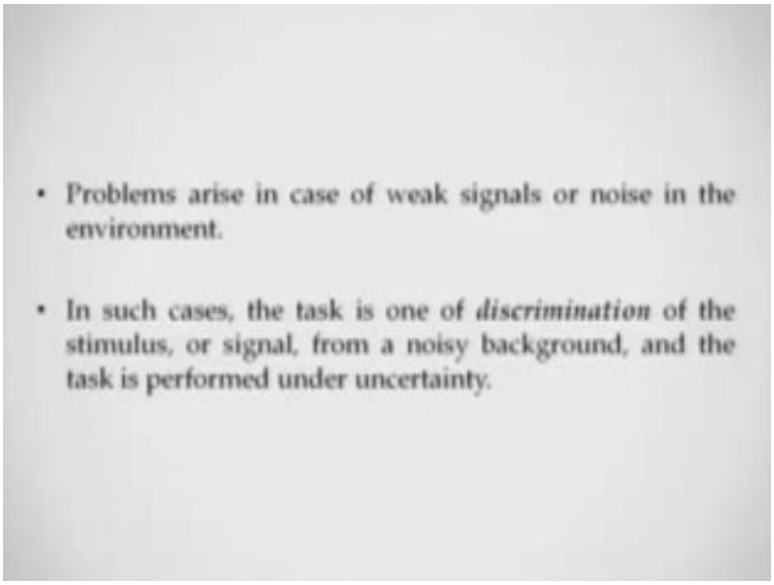

Now problems of detection and identification may rise in cases of when the signal is too weak and there is too much noise in the environment you know recall any party in which you are there may be one of the processions like Bharat or something and try talking to you know your friend or people around you and you will discover that it is very difficult to really you know gauge what the conversation is about in the when there is so much noise in the background.

In such cases what one needs to do is one needs to do the task of discrimination, so you have to actually discriminate the voice message that is coming from your friend from the background of the blaring noise of the band and stuff okay that is what is discrimination so what you have to do is you have to discriminate a signal or a stimulus from the noisy background and this task is generally performed under the uncertainty there is a lot of noise you have to really pick just the signal that you intend to from this lot of background noise.

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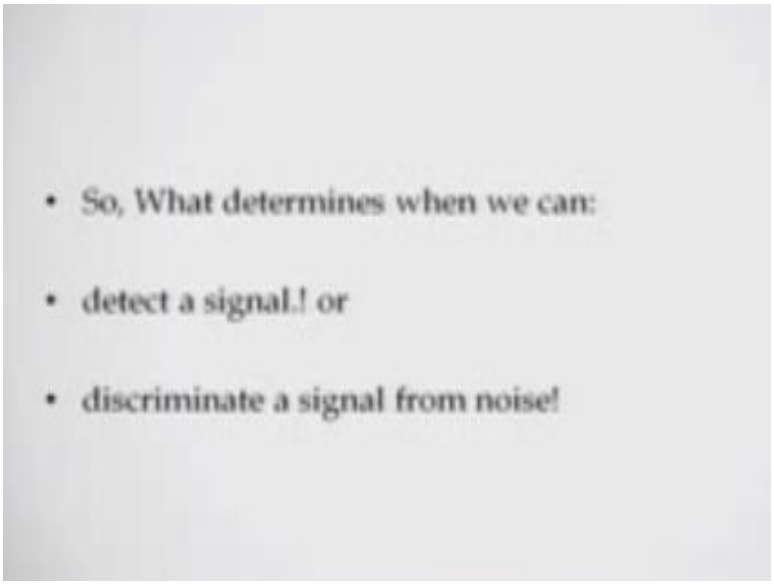

So on what does it depend that we can you know detect a signal or discriminate a signal from noise what are the factors that decide it.

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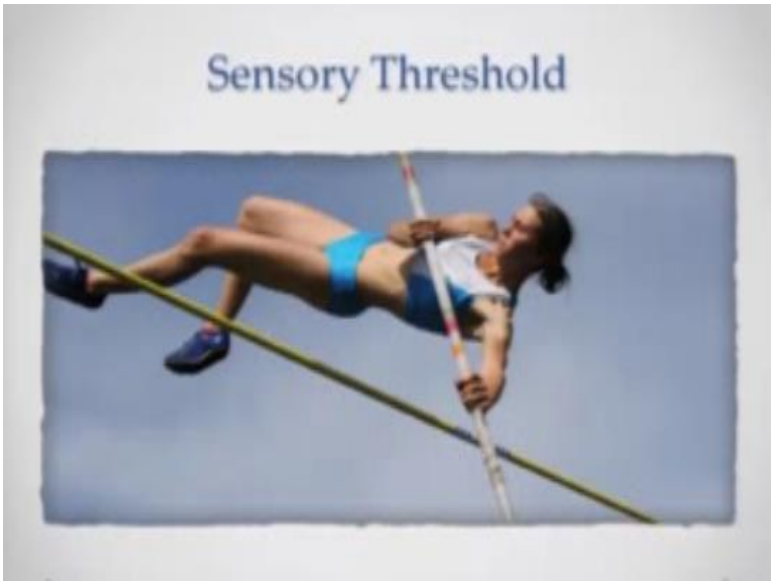

One of the factors that decide you know whether you will be able to detect the presence of a sound or a signal is a threshold if you are looking at this figure here you notice that this just threshold you know that this pole-vault is that this you know at least has to jump over if she misses it she will not be able to go to that side I mean that is not counted as a valid jump so this you know horizontal pole is that kind of threshold which really you know takes the person across and you know converts a particular jump to a valid you know countable jump.

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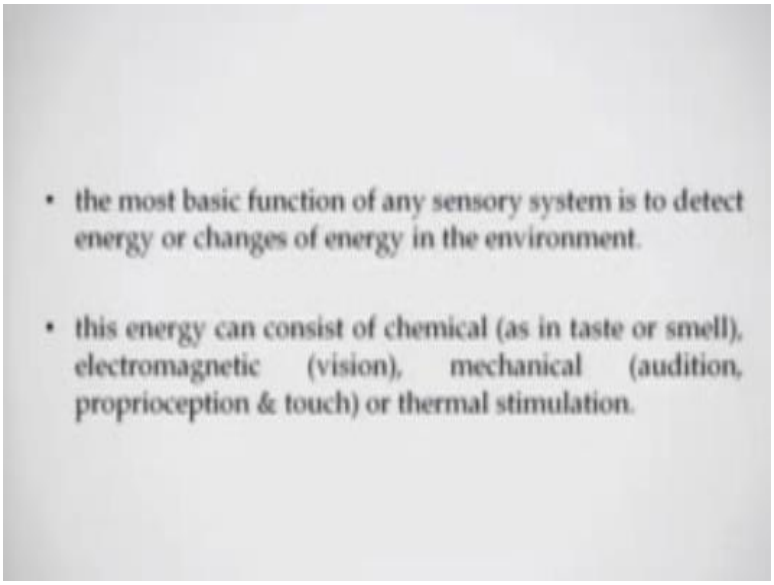

It is rather similar to what our sensory you know processes are like, so the most basic function of any sensory system is to detect energy or changes in the environment okay, so if there is a change in temperature you will start feeling a hot or cold depending on how the changes if there is a electric shock if there is a change in the loudness you know all of those kinds of things they have to change beyond a certain point for you to be able to detect it that certain point is your threshold.

So this change in energy can be of many kinds it could be chemical say for example in taste or smell how much sugar you need to add before it starts feeling sweet how much you know light you want to have till you start seeing something clearly or mechanical say for example you know how loud the sound how much is strong the sound wave should be or even thermal stimulation you know how hot is something for you to feel hot you know so this is basically this all changes energy and you have to feel them in a way beyond the particular limits.

So that you can actually tell that ok now I am feeling colder or hotter and those kind of things that limit basically which we are talking about is your sensory threshold.

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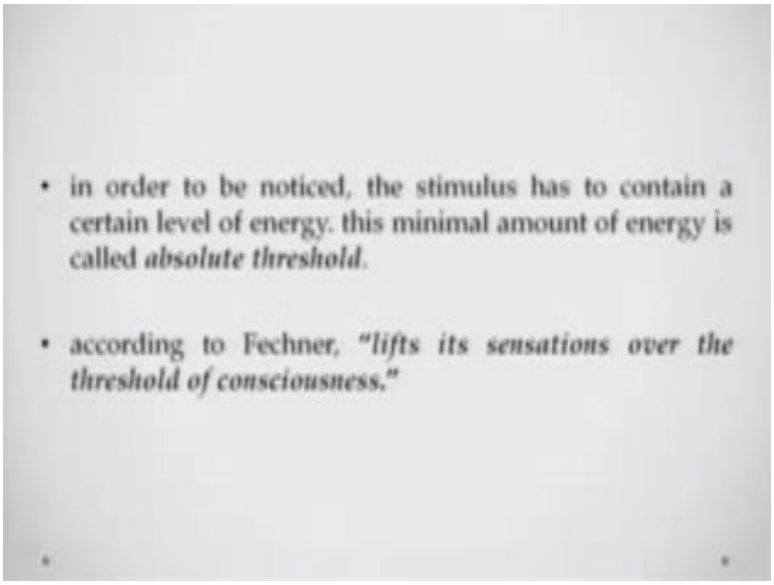

Now in order to be notice the stimulus has to contain a certain level of energy this minimal amount of energy in order to be noticed is absolute threshold, so just the point where you can actually feel that you know I can detect this stimulus now is the absolute threshold factor says just enough to lift the sensation over the threshold of consciousness once you are aware of something that it is there some sensitive information that is enough to say that the information is cross is absolute threshold.

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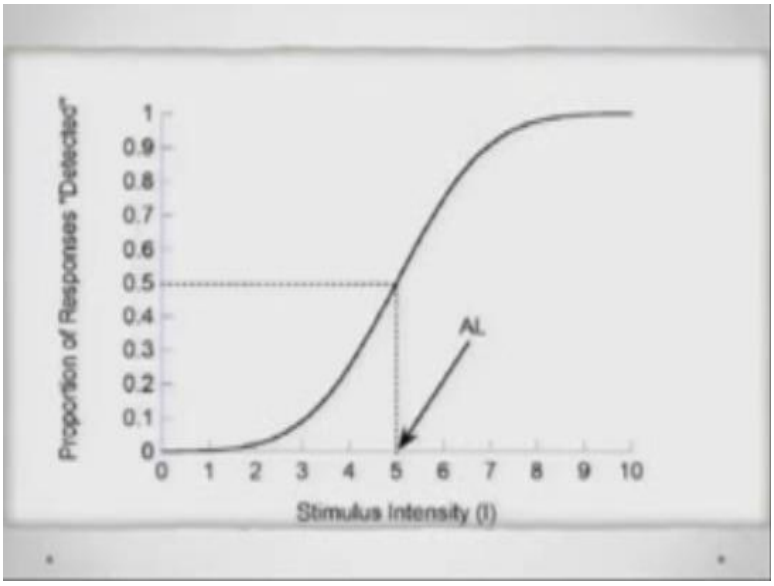

Something like this if you can see this figure here you will see as soon as the percentage of detected responses go above 50% that is pretty much the time where this absolute threshold is there and on the x-axis you can find stimulus intensity – stimulus intensity is increasing and in proportion to that the amount of detected responses are plotted on they-axis and at the point when the proportion of detected responses pass 50% that is chance that is a bit more than just 50/50 that is where you have reached your absolute threshold.

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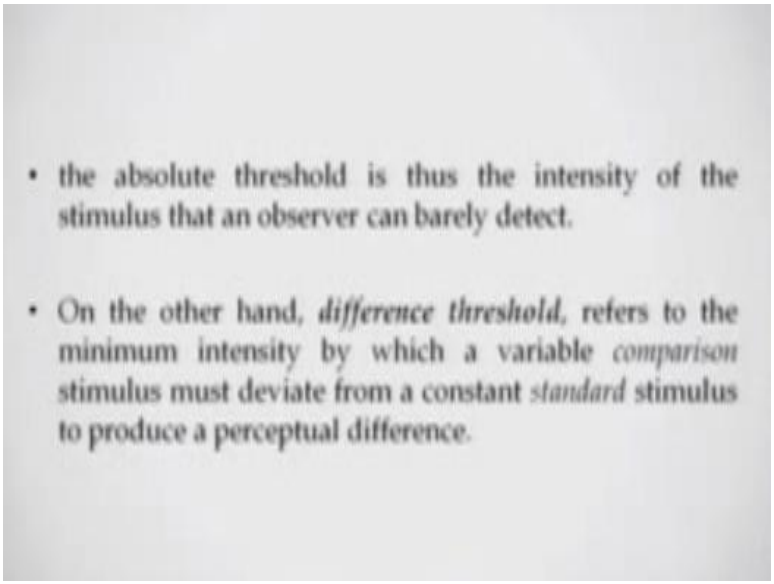

The absolute threshold does is the intensity of the stimulus that the observer can barely detect on the other hand there could be something like a difference threshold what is the different threshold difference threshold refers to the minimum intensity by which a variable comparison stimulus much it must deviate from a particular standard stimulus to produce a perceptual difference.

So suppose you are holding two stones in your hand one of them is the standard stimulus one of them is the comparison stimulus I ask you whether the comparison stimulus is heavier or lighter than the standard stimulus at the point when you can detect that this one is just heavier or just lighter that is pretty much what is your difference threshold like.

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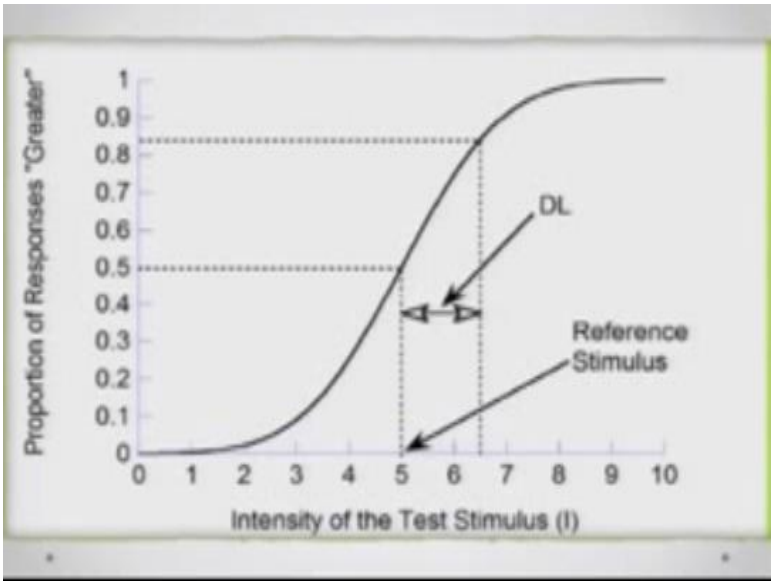

Here you can see there is a reference stimulus and then there is a difference similar and the difference has to be at least about 35% by this figure here which is basically or by actually a 35% times when the person can say that this is greater or heavier let us say that is where your difference threshold likes the difference is plotted horizontally by these arrows the DL symbol.

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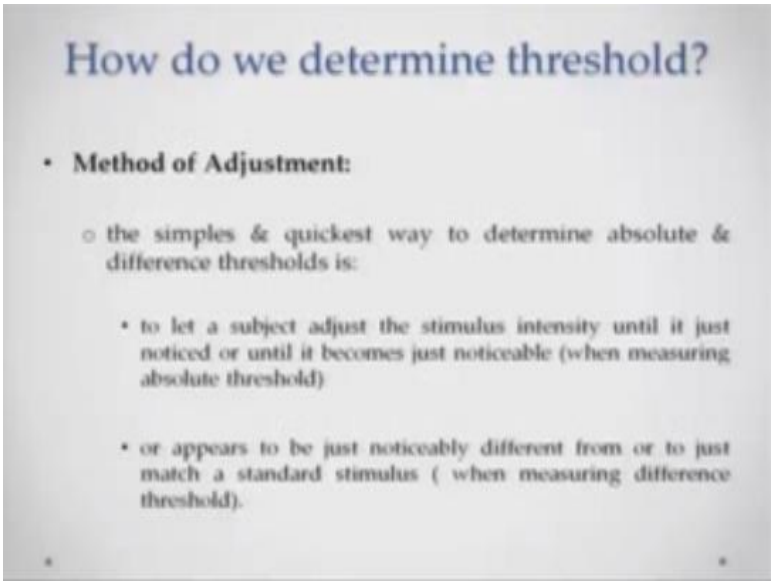

Now how do we determine the session how do we determine the absolute threshold for a particular sense or a different threshold for particular sensory information there are methods to do that the first method or the simplest method is the method of adjustment this is the simplest method in which you actually ask the participant or you ask the subject to adjust the stimulus intensity himself or herself until it is just noticed or until it becomes just noticeable.

You know say for example until it becomes just noticeable may be or when you are measuring your absolute threshold until it is just noticeably different from the comparisons there from the standard stimulus is when you are actually talking about difference threshold okay the kind of same examples which I was talking about.

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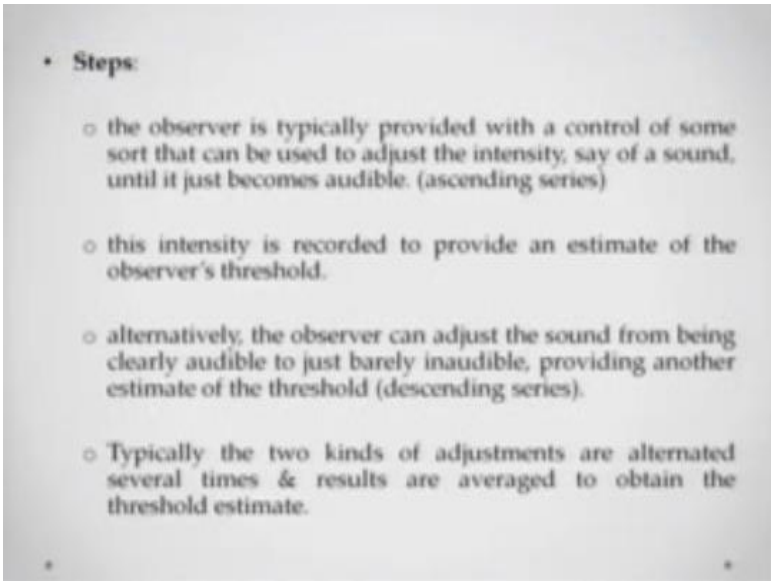

How do you do it let us go into the steps so the observer is typically provided the control or some sort and that control can be used to adjust the sound say for example if you are talking about sound until it becomes just audible, so the partner the participant is say you know changing the dial in small steps and as soon as the participant reports yes I can see you can stop that and then you can note down that value this intensity is you do it multiple times and this average of this overall thing can be supposed to be either can be supposed to be what is your absolute threshold.

If you are talking about you know you can also what you can do is you can actually start the observer from a higher value when the sound is very detectable and it means to ask him to bring it down in small steps then it becomes not noticeable up just one step after it becomes not noticeable that is also one kind of value will get typically these two kinds of values are alternated several times and an average is taken to get the point where you can actually barely detect something. So that is how you determine over a series of trials your absolute threshold.

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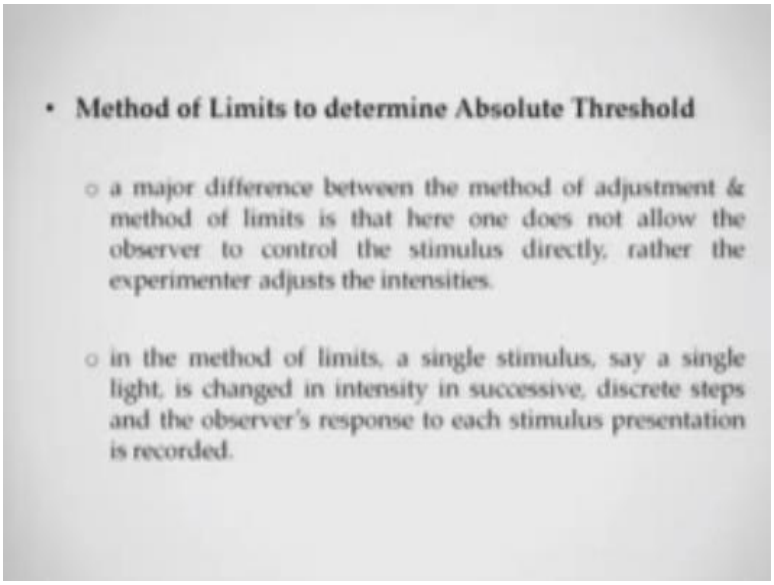

Another method to determine absolute threshold is the method of limits so a major difference by the way between a method of adjustment and method of limits is that here one does not allow the observer to control the similar straightly but the experimenter does it himself, so if I am the experimenter and you or the participant I will have the control and I will change the dial towards the left or towards the right.

And I will keep asking you the same question did you detect it or did you not you will give me answers at particular points I will note that down and I will probably do the same as I did with the absolute threshold procedure I will probably go a once in an ascending way increasing steps once in a descending way decreasing steps and I will take average of those values okay.

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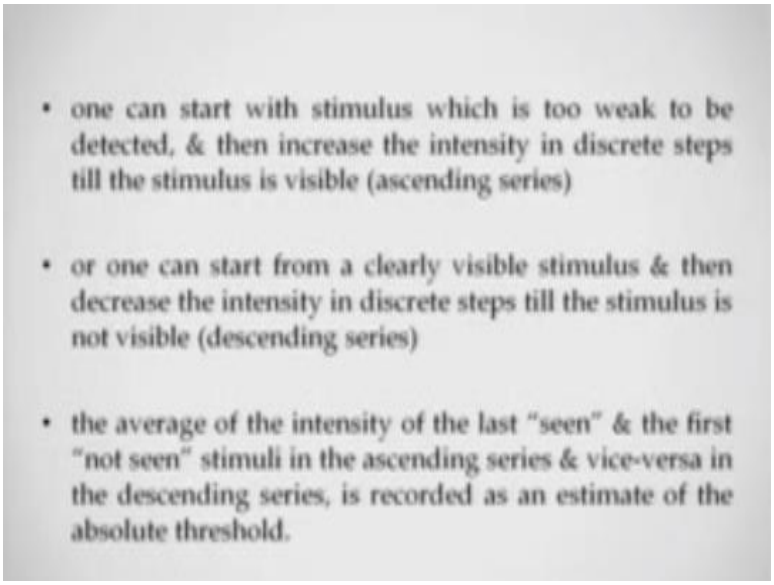

This average of you know average of the intensity of the last scene and the first not seen assembly in descending this and descending series is then recorded as the absolute threshold.

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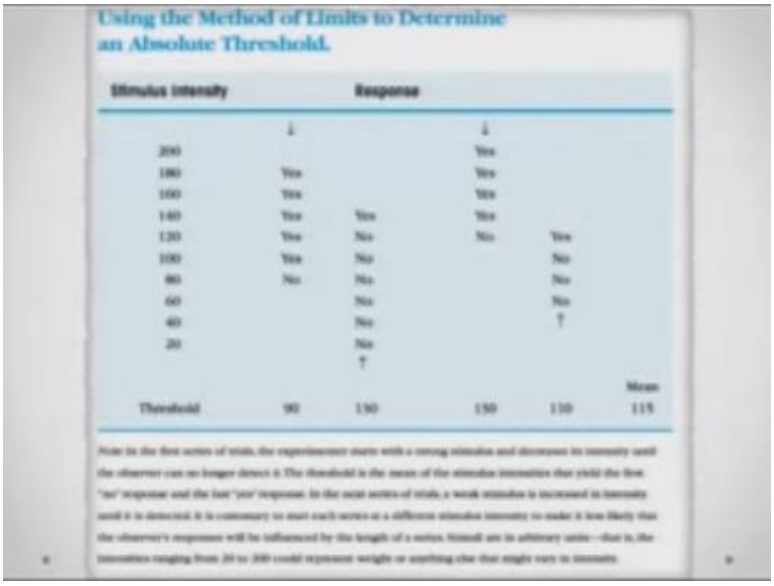

Here is an example so say for example I am talking about stimulus intensity let us say the stimulus VX I start from values starting at a very top 200 I start from180 you say yes 160 you say yes you say yes on 140, 120, 100 and at 80 you say no then I start from the bottom I start from somewhere around 20 and I go up to140 from 120 to 140 you said yes so I note that value that values 130 I do it again from 200 again a value comes I do it from 1 or 10 again a particular value comes all of these values are actually average and you get a mean value of 115 which is your absolute threshold.

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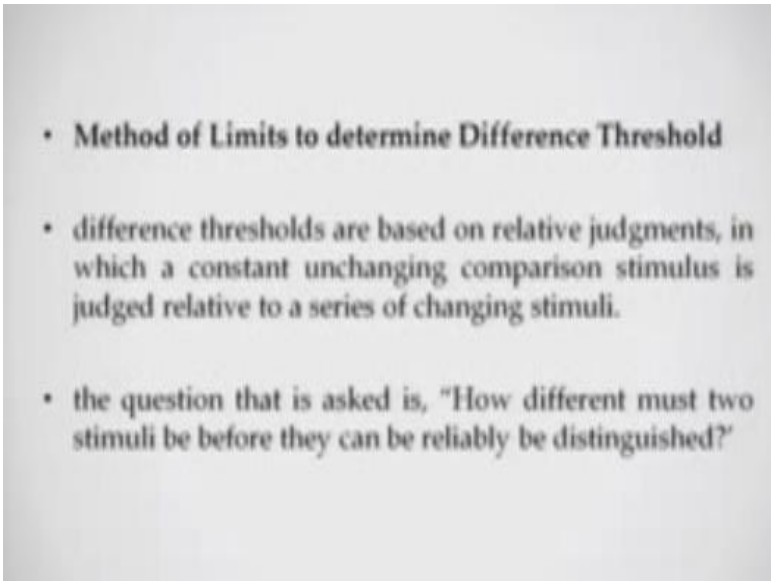

How do you use the method of limits to determine difference threshold the difference rules basically are based on relative judgments in which a constant unchanging comparison stimulus is judged related to the series of changing stories I will give you one break to hold in your hand I will keep giving tricks of different weights and I will ask you when does the break feel higher or lower no something like that the question that is asked is how different must the two stimuli be before they can be reliably distinguished.

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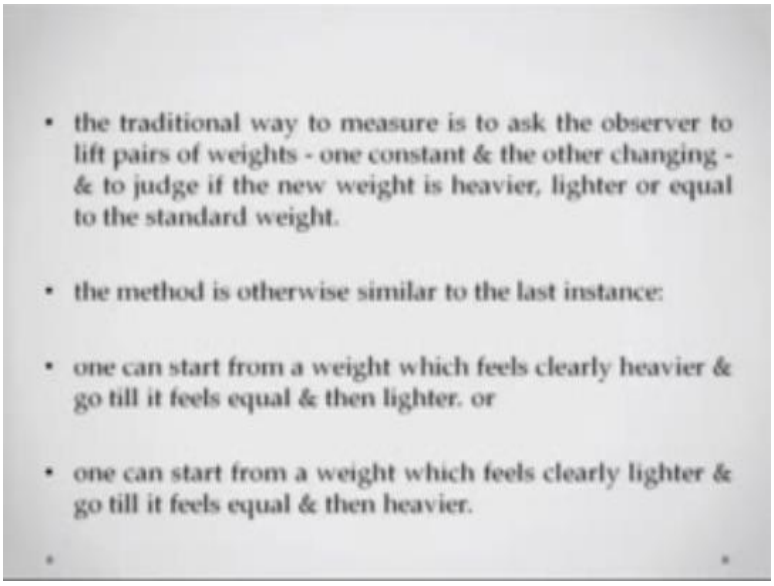

The traditional way is to measure to ask the observer lifts pairs of face as I said one is constrained or that is changing and to judge if the new weight is heavier or lighter the method is otherwise similar to the last instance of method of limits or method of you know method of limits and no one can start from a weight which feels clearly heavier much now you know the weights of the two things are very different and go till it starts feeling slightly equal and then lighter or one can start from a weight which is much lighter than then starts feeling equal or heavier in the next step.

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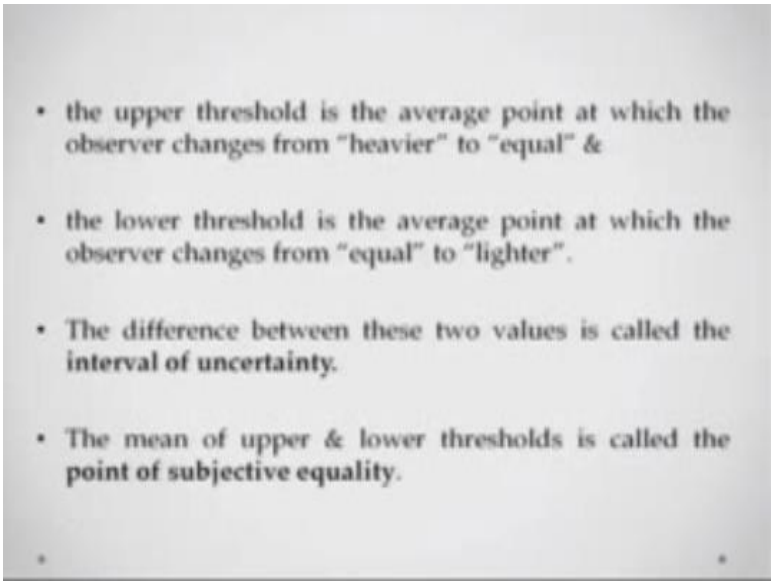

The upper threshold you know is the average point at the one at which the observer says it was equal and then heavier the lower threshold is when the observer says it is equal and then in the next step lighter this difference of these two values is called the interval of uncertainty the mean of these upper and lower values is called the point of subjective equality where you are thinking that okay you have got somewhere equal to this equal to the standard stimulus.

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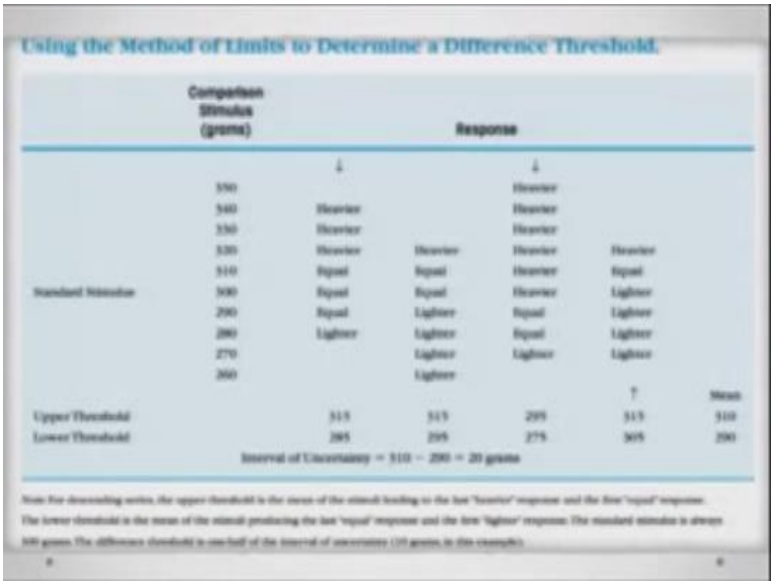

This is a demonstration so you know have a weight which is the probably around 300 grams or so and you start from 350, 340, 330, 3 you find it heavier and 320 to 310 you find it equal so the value of feet and the average of 320 and 310 is 315 that is recorded next you start from lighter 270 and you then go upwards then you get this value of somewhere around 315 similarly you do this again and again 3, 4 values you take mean of all of them.

So that is the mean of your upper threshold when you are going in the higher series ascending series and then the lower threshold is when is coming down. So you take the mean of the upper threshold and the lower threshold and that will be your point of subjective equality now this is again one way of determining this.

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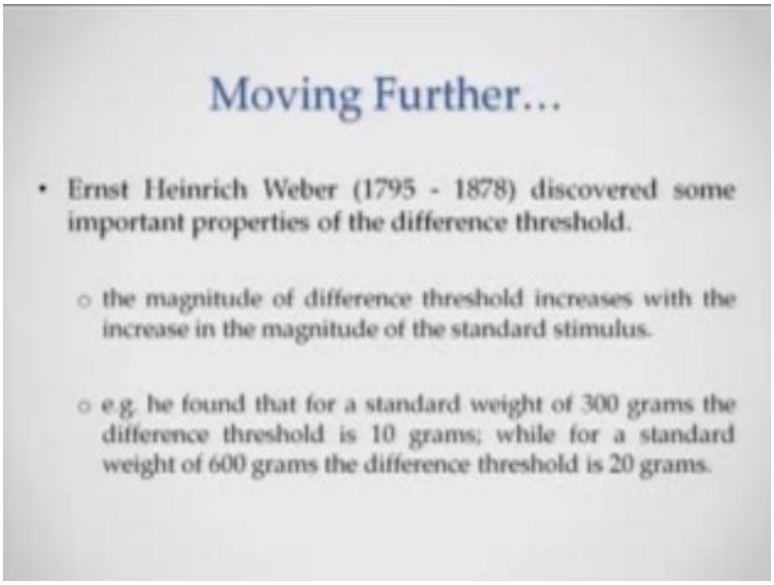

Now let us move a bit further Ernst Heinrich Weber basically discovered some important properties of difference threshold what did he find he found that the magnitude of the difference threshold increases with increase in magnitude of the standard stimulus so you are asking you to detect the difference of a particular stimulus from a very you know light stimulus that is say for example 10 grams of something then say for example if I you know want you to tell me whether something is heavier or not here or lighter than a 300 gram stimulus.

And the difference threshold will be around 10 grams if I ask you to you know give me the same comparison for a standard stimulus of 600 grams then the difference threshold will be around 220 grams similarly if I go to 3, 900 grams the different threshold will be around 30 grams.

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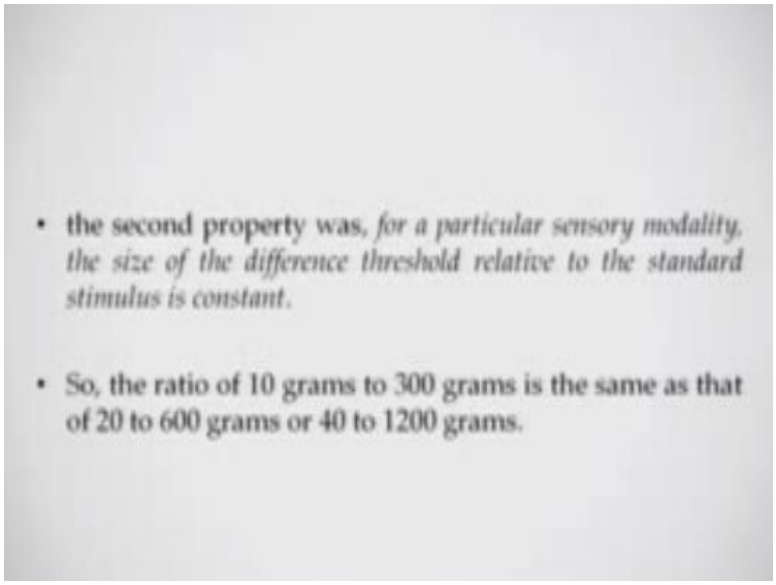

Now if you also noticed what I am talking about is that for a particular sensory modality the size of this difference threshold is really related to the standard stimulus is constant so the ratio of 10 grams to 300 grams is the same as the ratio of 600 grams to 20 grams of 40 grams to1,200 so that ratio remains constant.

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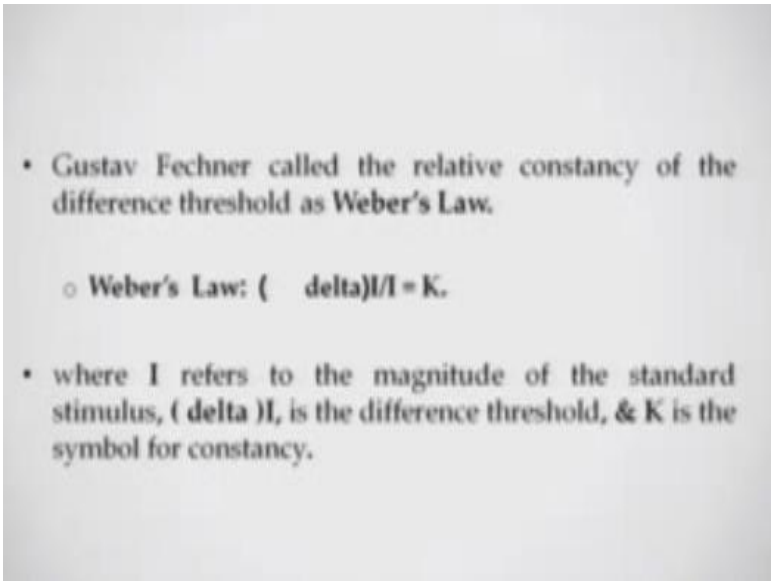

Gustav Fechner gave a formula for this kind of a situation any fine he called it Weber's law, so there is this Delta I divided / I which is equals to a constant that is your Weber's constant when I so here I actually refers to the magnitude of the standard stimulus Delta I is your difference threshold and K is the constant now this is something which is not really going to change and you saw in the earlier examples that this is actually the case.

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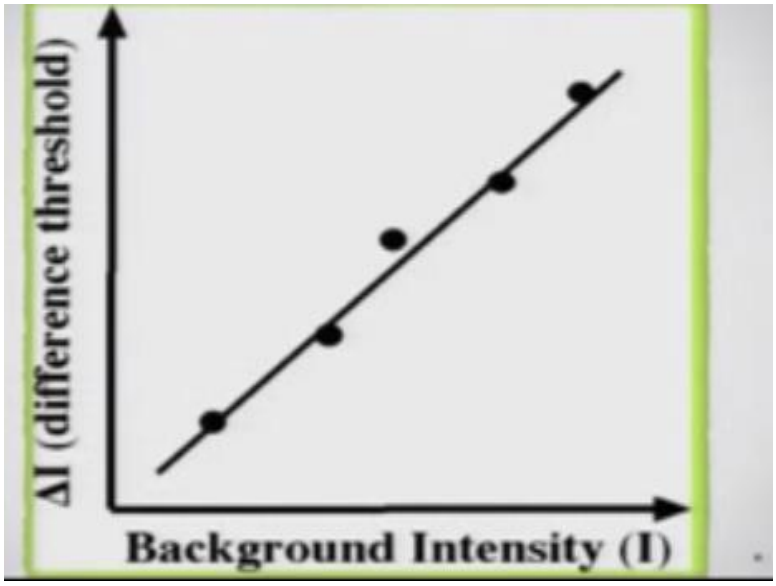

Here you can see and you know there is this direct linear increase in you know the difference threshold as compared to a standard you know stimulus which is probably let us say background intensity or something.

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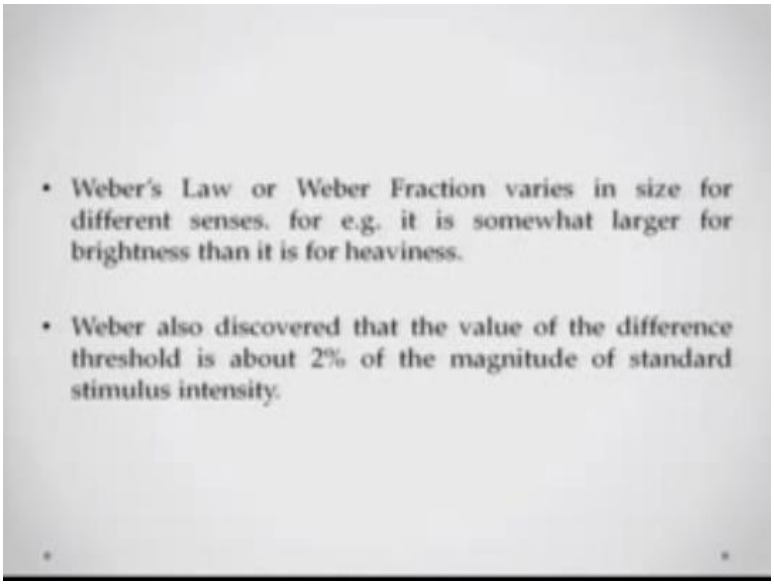

Weber's law or the Weber's fraction basically varies in size for different senses though, so it is somewhat larger for brightness than it is for heaviness they were also discovered that the value of the different threshold is about 2% of the magnitude of the standard stimulus intensity okay around that value.

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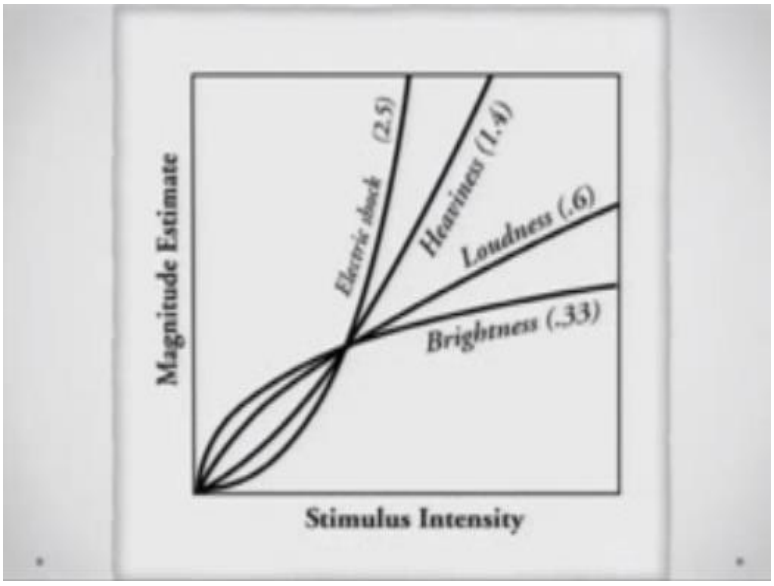

Here you can see the difference thresholds for different you know sensory modality, so electric similar for an electric shock the difference threshold is slightly higher for heaviness it is around 1.4 for loudness it is just 0.6 so this is you know something which you can see that how this differentiates across different sensory modalities.

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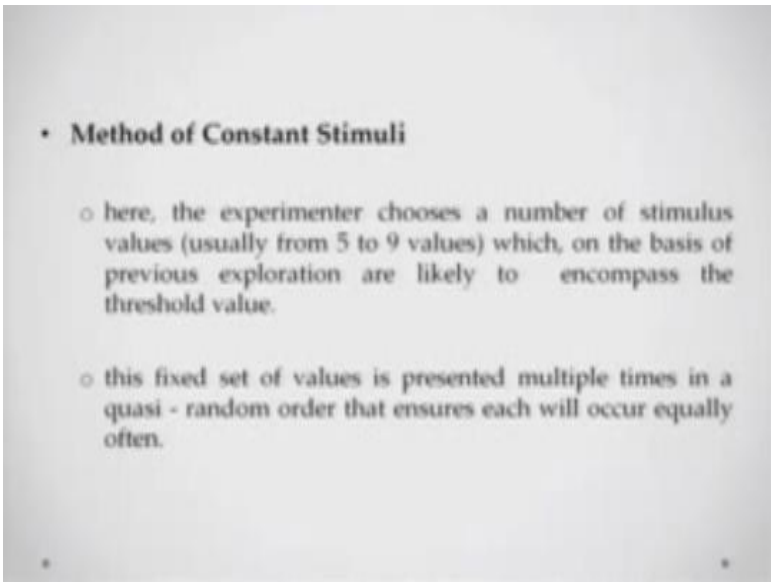

Now coming to another method the method of constant stimuli here what happens is that the experimenter chooses a number of values arbitrarily that okay I will give these values 5, 6, 7 values 9 values and on the basis of previous explanation basically they are you know suppose that the threshold will lie somewhere amongst these values so let us say if I guess that a threshold for a particular stimulus will be around 10 so have all the numbers around 10 I will probably I will 11, 12, 14 and 9, 8, 7, 6, 5.

I will present these values again and again this fixed set of values I will present the multiple times and in a quasi random order and I will see when you can detect or you cannot detect this.

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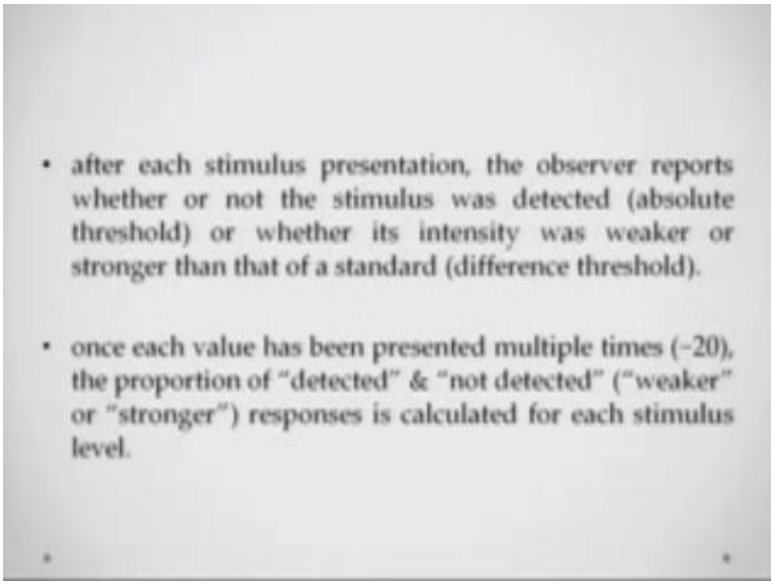

So somewhere and after each stimulus presentation you know as an observer I ask you to report whether or not you detected this stimulus or whether it is intensity let us say in case of difference threshold was weaker or higher than a particular standard amount now once each value I have presented more than a particular number of times let us say 20 to 25 then what I do is the proportion of detected or not detected responses is calculated for each stimulus level so how many responses were detected at level 10 how many are detected at 12 how many are detected at 13 something like that then.

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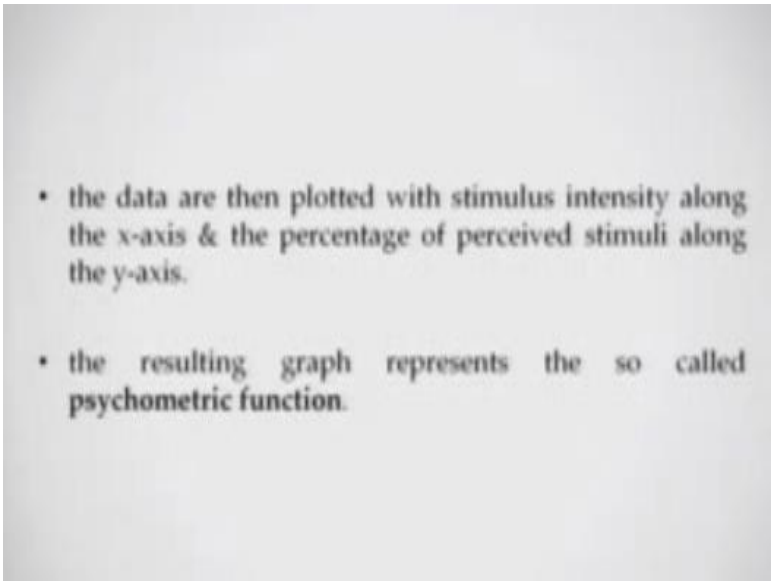

what we do is we plot this data along with stimulus intensity at the x-axis and the percentage of perceive stimuli along the y-axis this kind of function is basically called the psychometric function the psychometric function tells you that around what point the subject definitely perceives a given stimuli I will show you how it is done.

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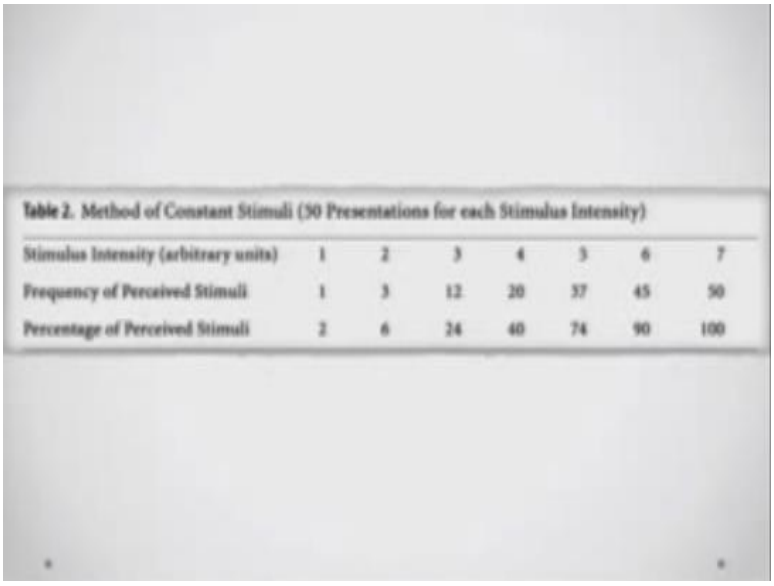

Table 2. Method of Constant Stimuli (50 Presentations for each Stimulus Intensity)

Stimulus Intensity (arbitrary units)	1	2	3	4	5	6	7
Frequency of Perceived Stimuli	1	3	12	20	37	45	50
Percentage of Perceived Stimuli	2	6	24	40	74	90	100

So for example here you have a particular you know a stimulus let us say you know stimulus intensity is there that these many values 1, 2, 3, 4, 5, 6, 7 they are these values and then you have you know you presented them so many times you originate one time you presented 2, 3 times you presented 3, 12 times something like that the percentage of the perceives to be at all of these values is also calculated how many times the percent the perceived the stimulus at level one or how many times you perceive the stimulus at level 7.

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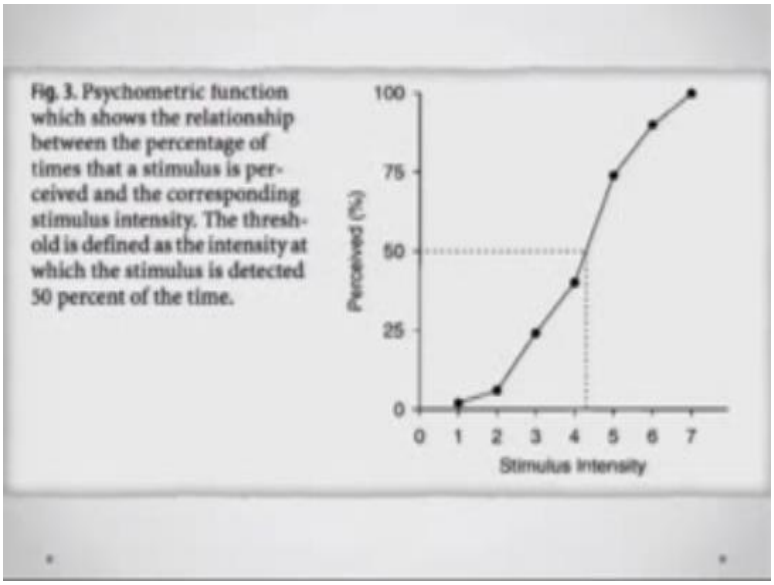

All of this is plotted in a particular graph which you can see right here you can see that the in a amount of times the person perceived the value increases above 50 % at around 4you know 4 and a bit more than 4 by around 7 the person a person is passing the stimulus almost 100 % of the time this is again one way of determining you know the point at which the person can always 100% perceive a particular stimulus is again.

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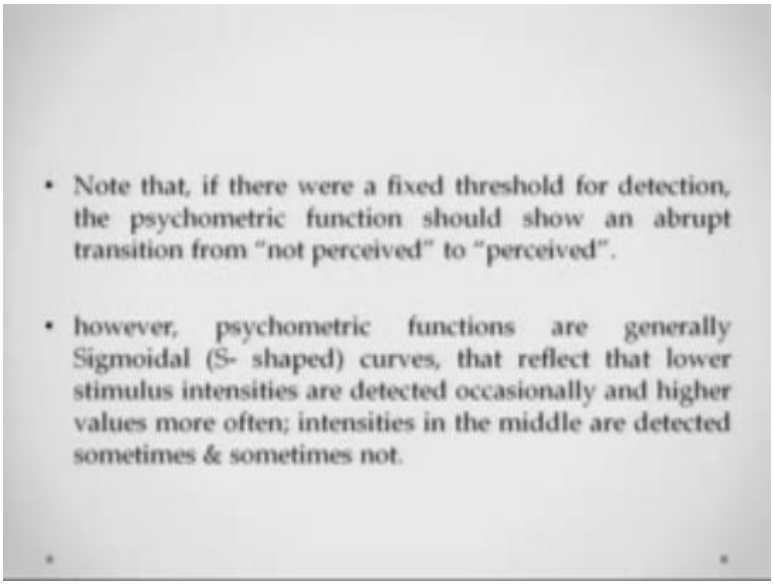

One way of really determining the absolute threshold now.

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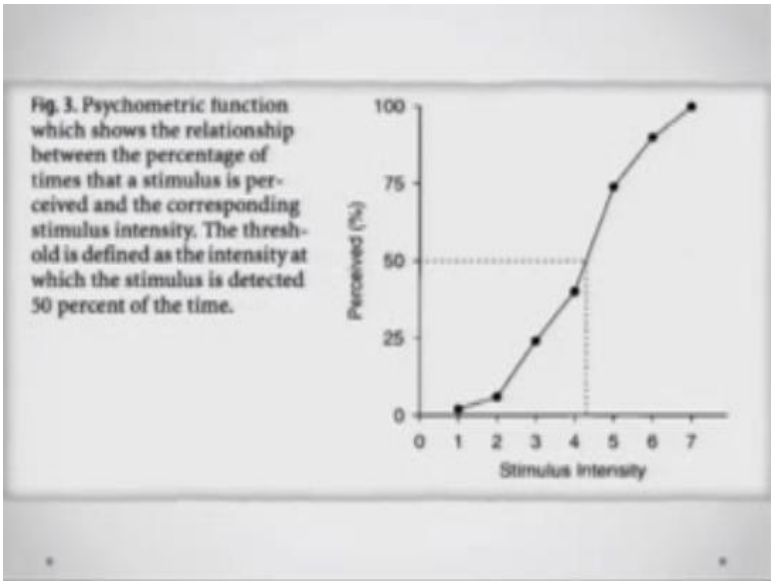

If you notice I am going back to this figure if you notice that this figure is slightly you knows-shaped it is not really a steep you know thing if it if say for example there was a steep difference between the absolute threshold and the not you know detectable value then probably it will be an abrupt change the for example will probably be more z like thing okay but it is slightly s-shaped and why is it like that.

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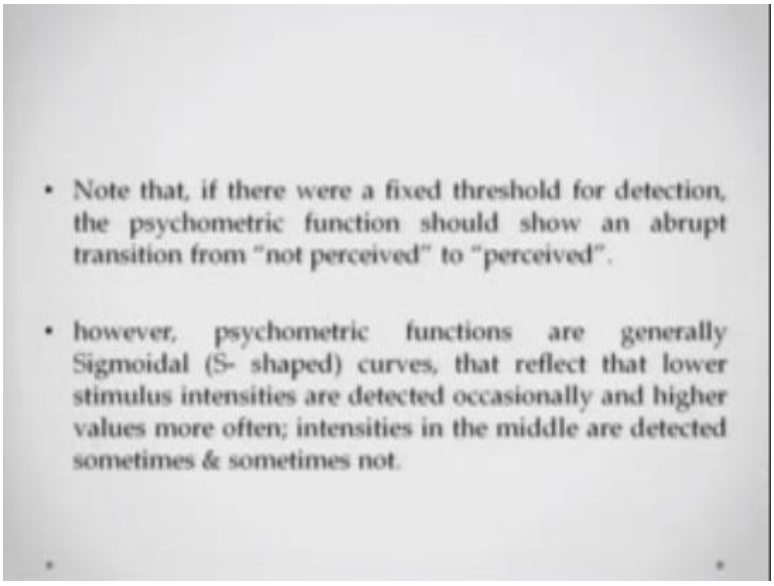

This the psychometric functions generally are a sigmoidal or s-shaped because of the fact that no stimulus intensities are sometimes detected occasionally highest you know values are detected more often and the intensities in the middle are detected sometimes and sometimes also that 0.5 the thing is always there it is detected at nearby chance something's not detected by chance at others so it is not a clear distinction between the point where you cannot certainly detect a stimulus and where you can certainly detect a stimulus.

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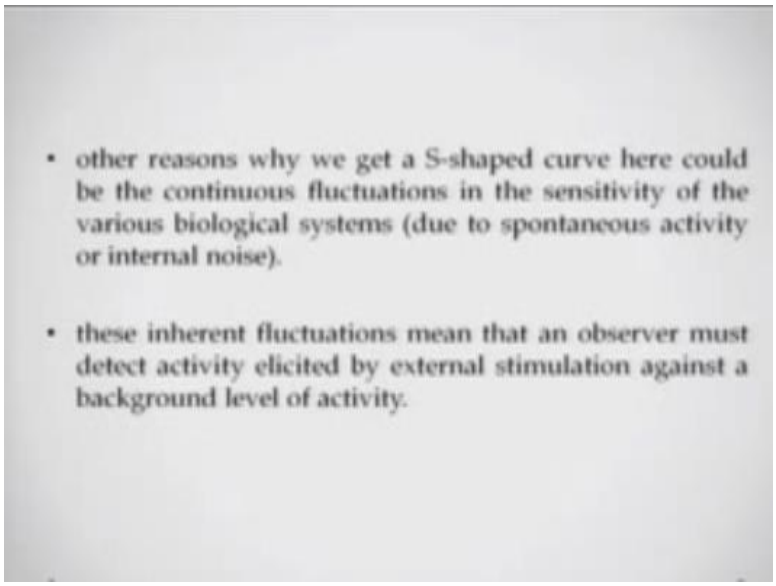

Other results where you could get an s-shaped curve in these kind of functions it is probably because there is always continuous fluctuation in the sensitivity of various system say for example the amount of information or the discreteness with which your ear is registering the loudness information also can have a bit of a fluctuation you know due to spontaneous internal noise and stuff like that you are thinking of something you know your attention is varied a little bit all of these kind of factors.

These inherent fluctuations mean that an observer must detect alien activity elicited by an external stimulation against the background level affected so for example if you are trying to listen to a bird and you are sitting in a park what you are trying to do is you are trying to you know detect that particular signal from so much of background noise that is already going on in that case your psychometric function will never be a steel function will always be a sigmoid s-shaped curve.

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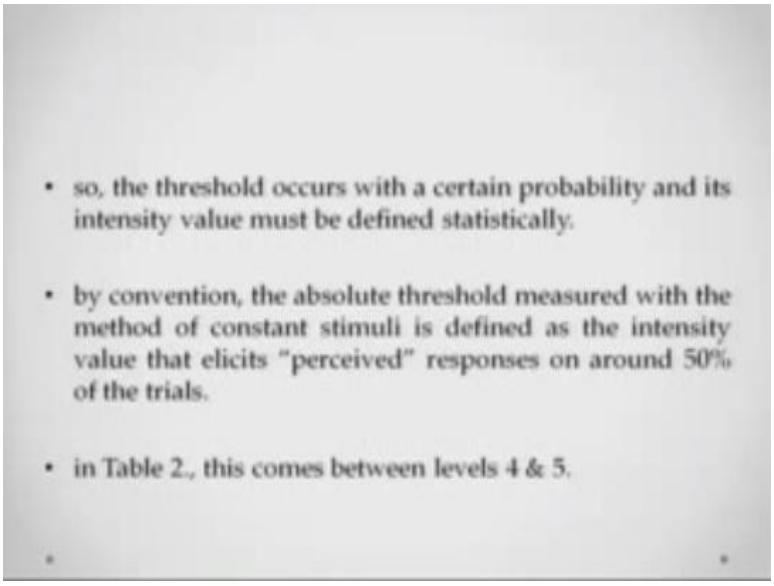

So the threshold occurs with a certain probability and it is intensity value then must need to be defined you know in a statistical way by convention the absolute threshold is you know defining a measured got with a method of consensually is defined as the intensity value that elicits perceived responses around 50% of the trials so if just above 50% you can detect something that is pretty much what your absolute threshold will be okay.

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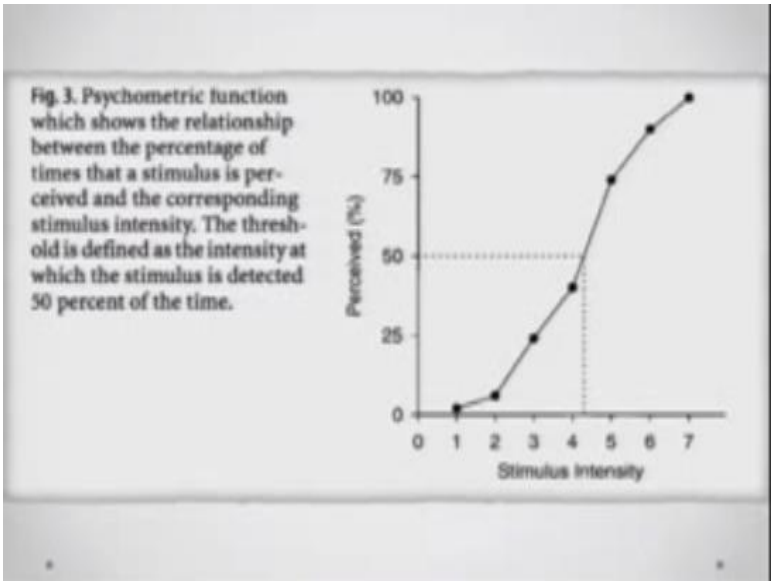

So in table 2 which you just saw you can see that this value lies somewhere between 4 & 5 make sense another method you can use to determine absolute threshold is the staircase method what is the staircase method it is an adaptive testing procedure basically used to keep the testing like close to the threshold ring , so for example you have a good idea of what the threshold might be so what you do is you follow a staircase and everything so you take hold of some values and you actually present these a very small range of 4, 5, 6 values again and again to the participant you ask him that whether you detected this similar or you did not detect this illness.

Every time the person gives the response you change the value okay so a smaller range of values is there so that and this is a rather efficient way of doing it because you are not doing testing hundred times this is therefore called the staircase method so I will show you how it is done so an observer we can start from an ascending series or a descending series each time those what is saying is you change this intensity just by one step this continues until the stimulus becomes too weak to be detected.

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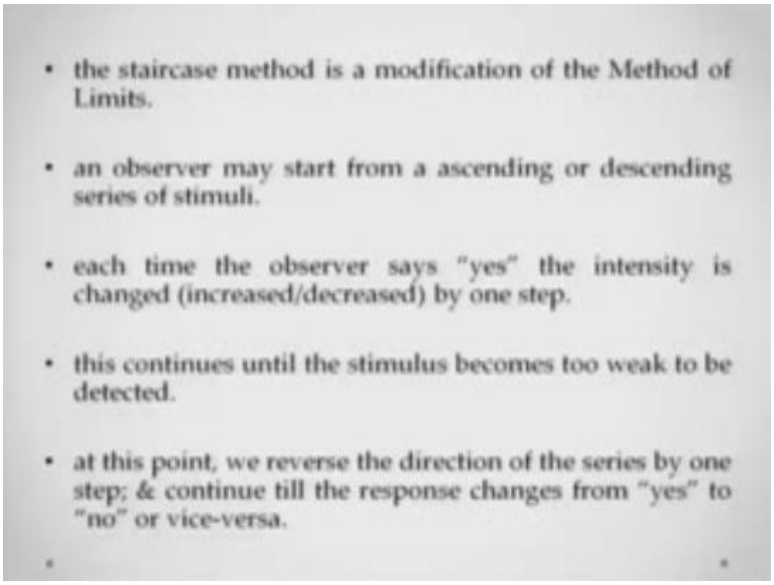

In a descending series in an ascending when it becomes you know detected finally at this point so you reverse the direction you continue the response in the person says yes now I detect it or if you are coming from the other direction you do it till the person says no so you keep alternating this direction.

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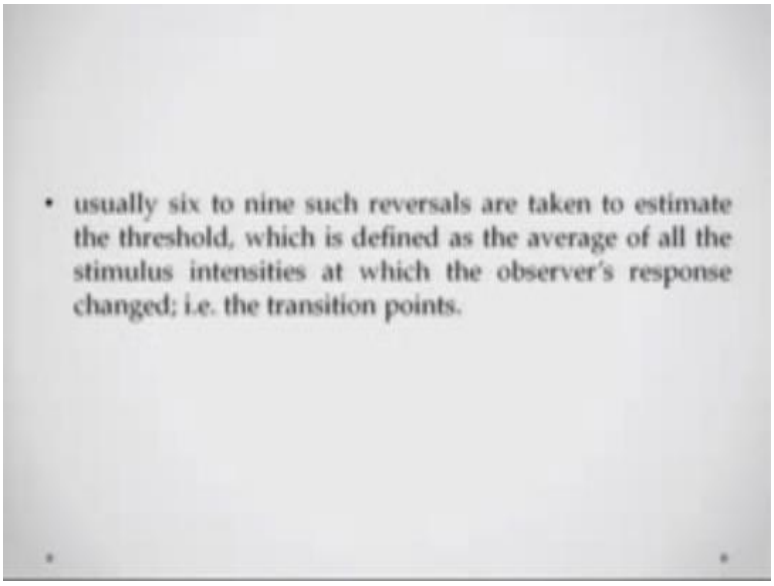

Usually after 6 to 9 such kind of reversals in direction you are actually you know good to estimate the threshold now the threshold here is divided as the average of all the stimulus intensities that you presented at which the observers response change from yes to low or from you - no – yes and these different points are called transition points I will show you how it is done.

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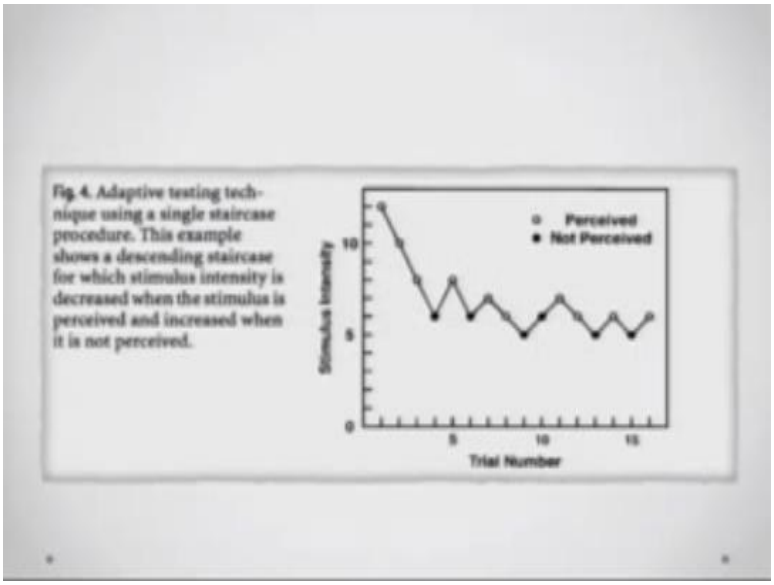

Say for example in this figure you can see that you can start from a high intensity to a point when the observers response goes to not perceive then you again go one step further observer says perceive you come back when the observer again say is not perceived and you do this you know a particular number of times you must take the average of this eventually and that becomes your threshold.

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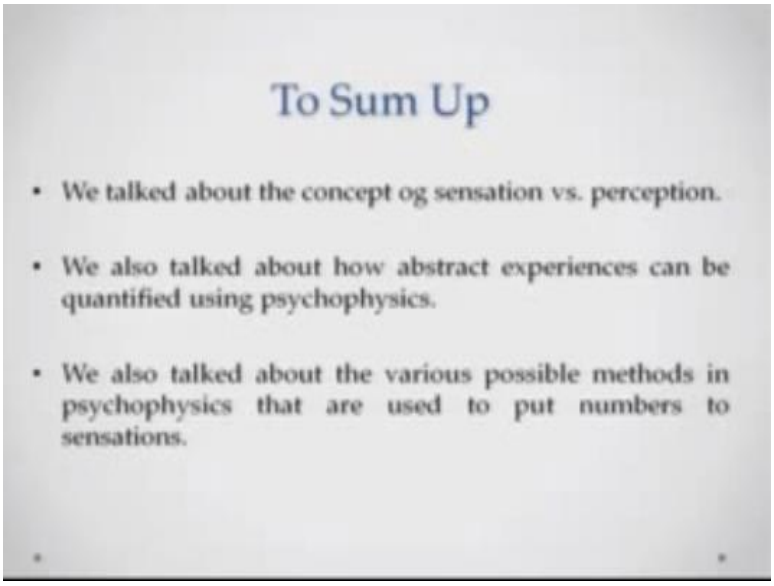

Now to sum up what did we talk about today we talked about the concept of sensation versus perception what is sensation it is a part of what perception is what is perception it is a constructive process through which we actually make use of whatever sensory input we are getting from the world you also talked about how using psychophysics you can actually put numbers to these subjective experiences you also talked about a variety of methods using you know within psycho physics that are used to determine these thresholds of experience both absolute thresholds and different thresholds thank you.

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