Introduction to Psychology

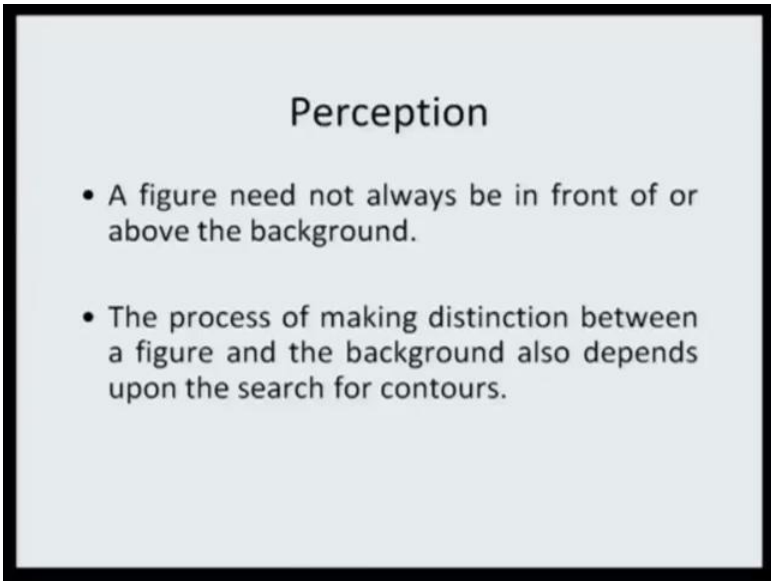
Prof. Braj Bhushan
Department of Humanities and Social Sciences
Indian Institute of Technology, Kanpur

Lecture – 07
Perception Theory of Signal Detection

Let us now recapitulate whatever we have discussed still now. First lecture we focused on sensation, second lecture we looked at the concept of liman or threshold, we looked at absolute difference and terminal liman, then we talked about wavers law and we took certain live examples I would say to understand how the concept threshold and how the concept of intensity of the stimulus the way it is described in wavers law, how that makes an important type of a contribution in terms of our physical (Refer Time: 00:56).

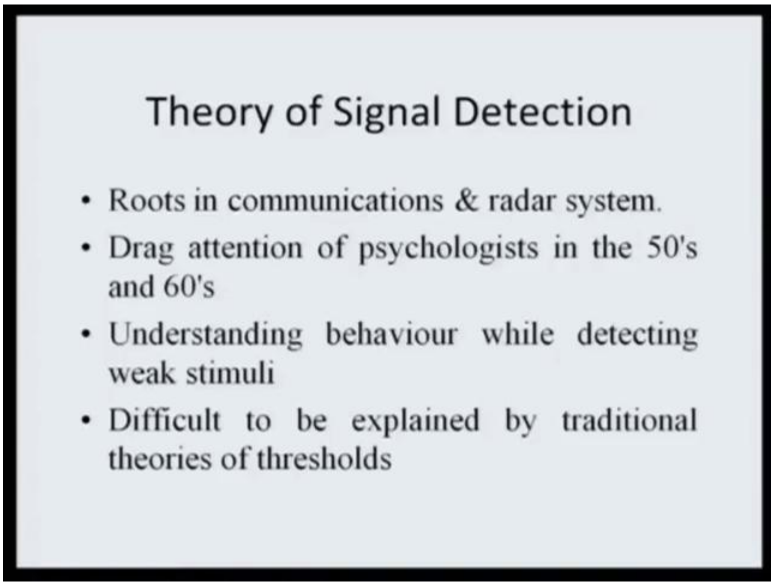
Then we ended the second lecture saying that always you one has to know figure out one has to extract the figure against the background. And this very idea of categorizing figure was is the background is an important phenomena in perception. We also said that figure and background could be interchangeable and we always look for contours if we are able to establish it will and good if we are not able to establish it we have confusion. Little later I think towards the end we would also take some of the examples of reversible figure.

(Refer Slide Time: 01:41)



Reversible figure means, if you look at it from one point of view then you see another type of an impression we merging out. So, something half of the figure becomes the background and remaining half becomes the figure and then it keeps changing. And depending on what you consider as background the figure changes, but that we would see little later. Right now, we are again looking at the strength of signal. Let us come to an interesting theory.

(Refer Slide Time: 02:09)



Basically this very theory has it is a routine communication and radar system, but in 1950's 60's it drag the tension psychologist because psychologist were interested in understanding human behavior. And they tried to understand the extent of the signal and its role in detection of the stimuli especially in conditions where the intensity of signal is very weak. What was realized that wavers law (Refer Time: 02:46) law these laws were not sufficient enough to explain how human beings respond in situations when the signals are week. And this lead to what is called as Theory of Signal Detection.

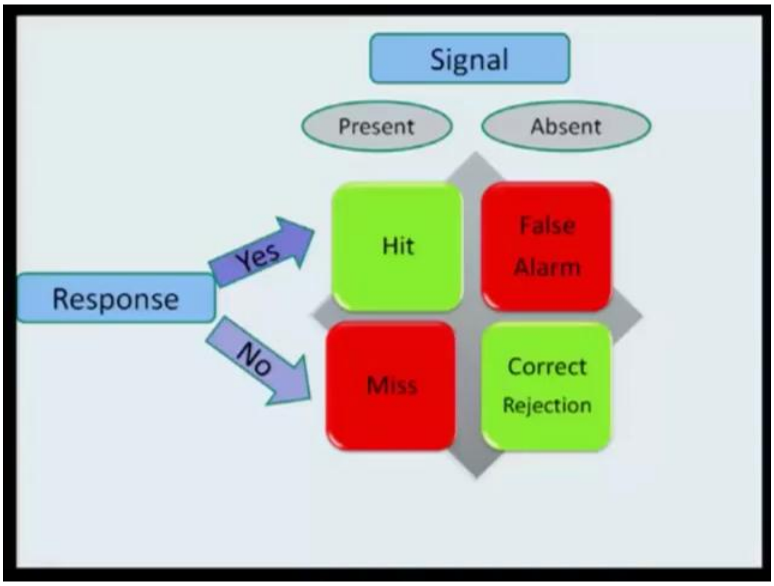
(Refer Slide Time: 03:03)

Now look at this screen, you see fighter aircraft, the radar system. And the radar of course, has to be sensitive enough to receive this signal back from the flight and finally signal has to be detected by a human being.

(Refer Slide Time: 03:35)

So, when you look at the radar system everything seems very nice, but the problem with the human operator is that he or she has to figure out the presence of the signal. Again some type of a noise. Noise in psychology here is whatever is not your intended target is the noise. Let us understand this very theory by taking this example.

(Refer Slide Time: 04:08)



You make a grade it is a two by two grade, so whether the signal is present or the signal is absent that is category one. And category two in terms of the human response the operator says yes or no. So, yes versus no in terms of human response, presence versus absence in the case signals. What are the possibilities? First, when the signal is present and the person responds yes it is present. This is called hit condition. Second condition when the signal is absent and the respondent says that yes signal is present. although signal is absent. This is called false alarm.

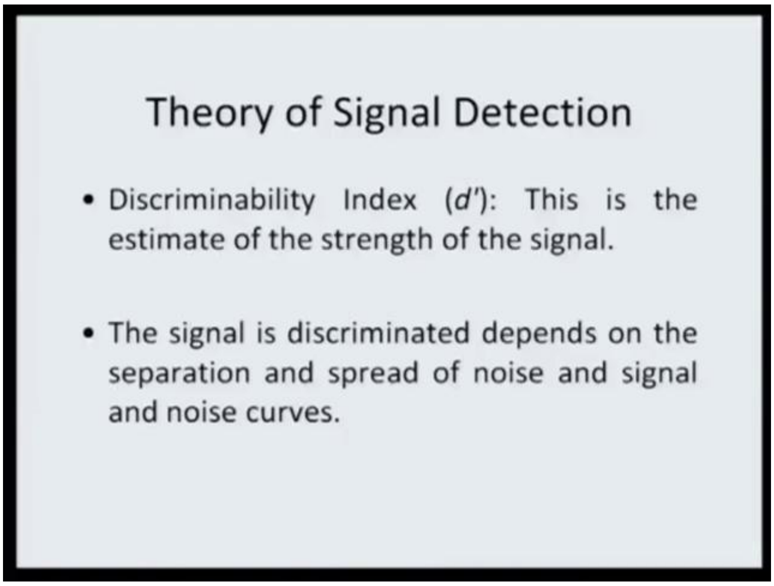
The third situation when the signal is not present, and the respondent says that it is not present, this is correct rejection, and the four situation where the signal is present, but the persons says the operators says that no it is not presented. This is a miss condition you have miss detecting signal.

Now, why this is so important from of course communication prospective, the radar system it make sense because the radar is suppose to detect the signal so that it can make distinction between the own aircraft versus enemies aircraft. But signal in itself does not make any sense, the human operator has to detect the human operator has to say the fine I have identified this signal which we are saying that this is hit condition or the signal is not present you say that find signal not present it is a correct rejection. These two conditions are fine. But thing of two other conditions that is marked red here, that the signal is absent and you say it is present it is a false alarm.

What would this mean? If you have a system for no combating the enemy aircraft that is forcibly entering into your territory and you are the operator who based the understanding of the radar signal gives a signal, that find the enemy aircraft has entered into our territory. The field guns will start firing at that very aircraft. You committed a mistake. When the signal was absent you said that is there is a signal and therefore you raised a false alarm against which the support system started combat operation. And the second case is again far more dangerous where the signal is present but you said, no it is not present, then enemy comfortably enter the you territory. There is the big prize that the country pays for that.

So, you realize that the role of the human respondent is extremely important in terms of detecting the signal. And that is reason why signal detection theory is taken into account when we look at the perception mechanism. Now in terms of detection of this signal what is very very important is the strength of the signal. Remember in the second lecture also we were saying that the strength of the signal has to play role and because the signal has to be detected therefore it is called that fine this is the discriminability index.

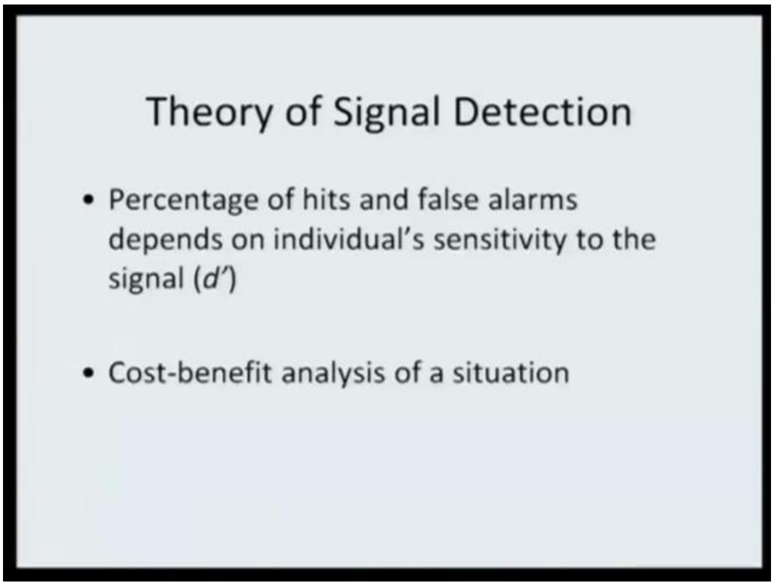
(Refer Slide Time: 07:41)



This is the strength of the signal and the way you estimate it and accordingly that would shape you response. So, the signal is discriminated depending on the separation and spread of noise in signal and the noise curve.

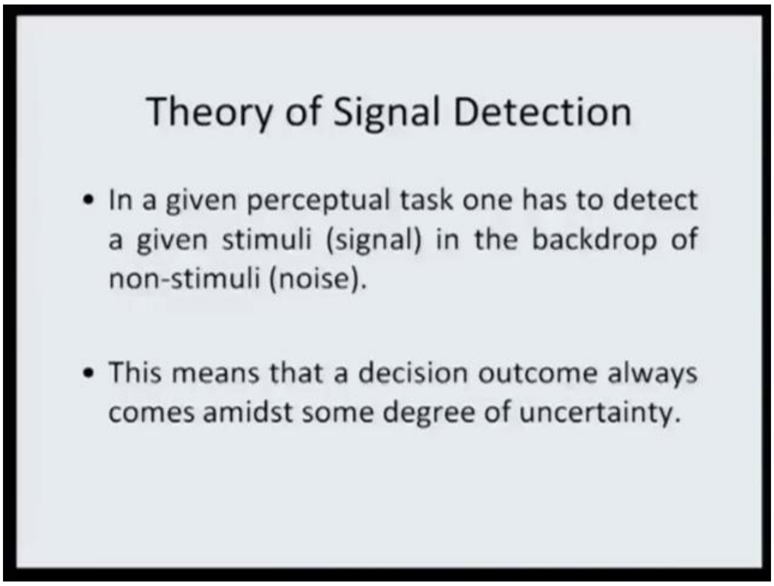
So, you take one experimental example here and then you would move to graphical plotting of the response in this very situation what is called as the ROC curve.

(Refer Slide Time: 08:14)



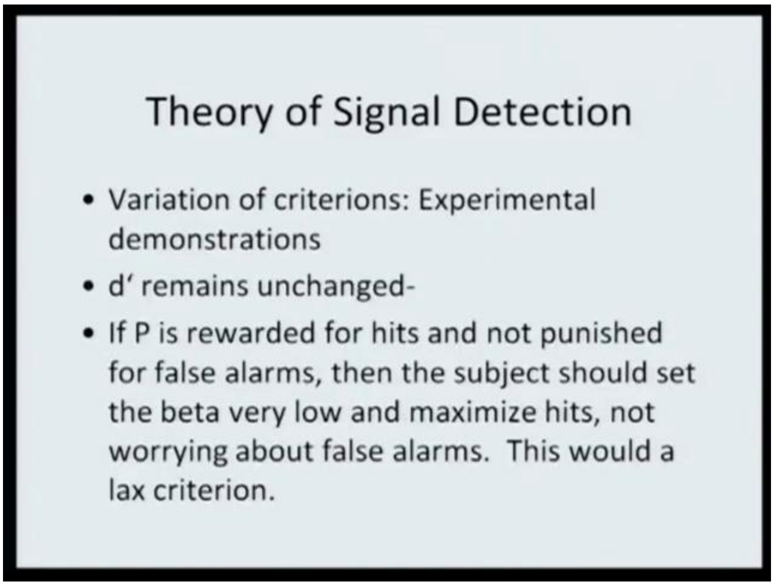
Now, the percentage of hit and false alarms depends on the sensitivity of the operator to the signal. Signal has strength that we have discussed still now and we have said that find it is the strength of signal which plays an important role. Stronger the signal higher are the chances that we will detect it, but besides the strength of the signal what is also important is that I as an operator how sensitive I am. And that would be dependent on the cost benefit analysis. What would be the cost benefit analysis? I am rewarded or I am punished for the response that I (Refer Time: 05:51), therefore, cost benefit analysis will always play an important role.

(Refer Slide Time: 08:57)



So, in a given perceptual task one is always suppose to detect the signal that is the stimuli against the non signal that is the noise. And this means that decision outcomes always comes amidst certain degree of uncertainty. You are not very certain, the strength of the signal plays an important role, and your sensitivity plays an important role.

(Refer Slide Time: 09:17)

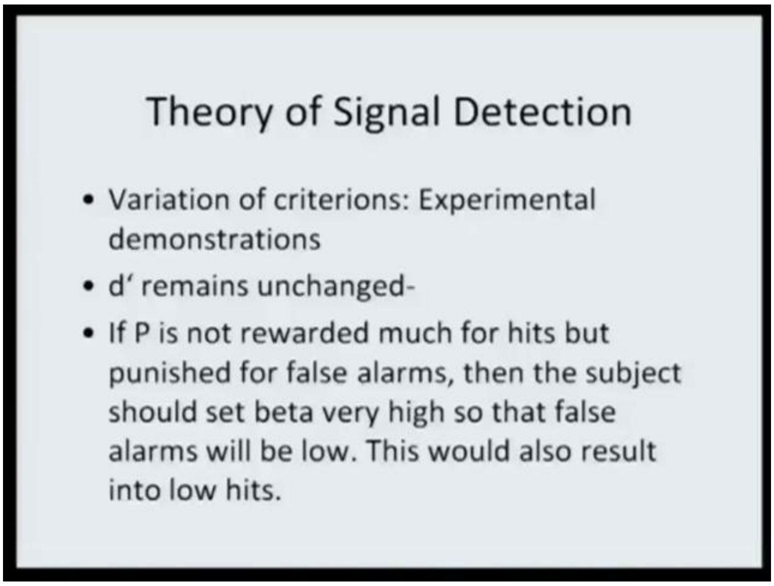


Let us look at one of the experimental demonstration of this. We are taking a case that fine now the strength of the signal remains constant. In the first case what we were saying was that the strength of the signal changes and therefore it has an impact on the response. Now we are saying that strength of signal is a made constant and it is cost benefit analysis that you make as operator, fine.

Now, if the operator is rewarded for hits, but he is not punished for false alarms then the beta value that one sets is very very low. And this, what happens is it will maximize the number of hits because the operator is not worried about false alarm. The reason he is rewarded for hit, but he is also punished for the false alarms. Even though I committee an error I do not get any adverse remark for it and if I succeed fine it is very good. So, what I would do I would relax my criteria. Earlier if I was using a very very stringent filter to say that whether the signal was present or absent now I do not do that.

What has happened to me? My relaxation of the criteria which leads to maximizing of hits because I am not worried about the false alarm is primarily guided by this cost analysis that I am making that I am not paying a cost, but I am always deriving a benefit out of it. So, cost benefit analysis comes into play here. Think of the other situation de prime was not changed now.

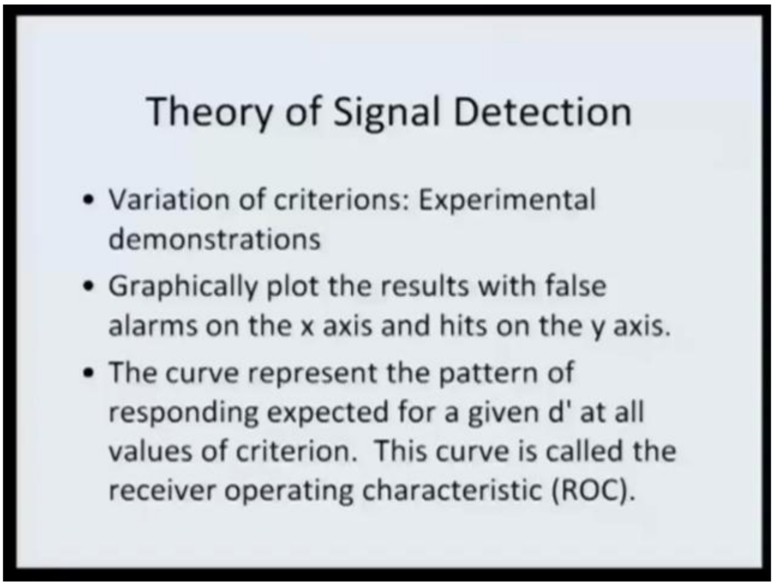
(Refer Slide Time: 11:07)



So, the strength of the signal has not changed but I am not rewarded much for hit, but I am punished for false alarms. What would I do? My beta will be very high. So, that the false alarms also become low. This of course would also result into low hits. So, if I am told that find whether you go for a hit you correctly identify the signal is important but it is not as important as if you committee an error while doing that. Take situations; say in the court of law two attounies are arguing against a possible client who is likely to get death penalty. The cost involved is very very high. And therefore, what happens you suddenly realize that your beta is now very high because you do not want to create a false alarm, you do not want to argue saying that he is culprit because you know that prove and guilty the court will give him a death penalty. So, you walk with extreme degree coition.

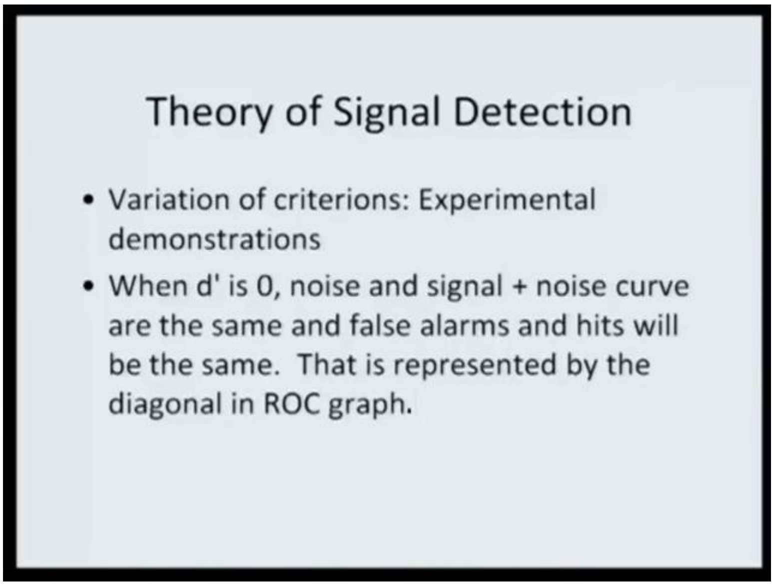
The previous example of the aircraft and radar warning system that we were taking, if your signal by default now you press a button raising an alarm and in tern it know trigger air trick you would be very very cautious; because false alarm the prize that you play for it is very high. You understand this situation now. Case one, when hits are rewarded and false alarms are punished. In second case when hits are not rewarded, but then for creating false alarm you receive punishment.

(Refer Slide Time: 13:16)



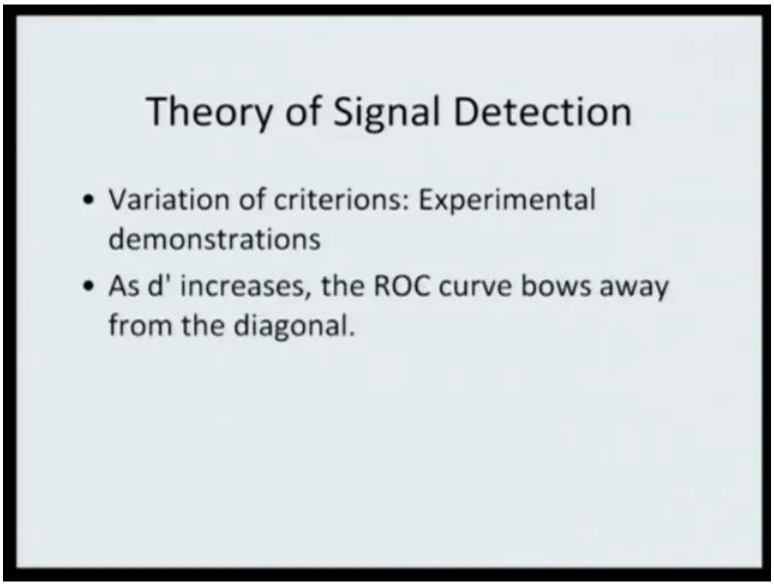
Now, if you graphically plot the result with false alarms on the x axis and the hits on the y axis you get a curve and this curve is called the ROC curve; the Receiver Operating Characteristics curve. This curve represents the pattern of responding expected for d prime of all values of criteria, so you change your criteria. The d prime remains the same and then you see that how depending on the criteria that you have selected and the value those criteria the curves will change.

(Refer Slide Time: 13:50)



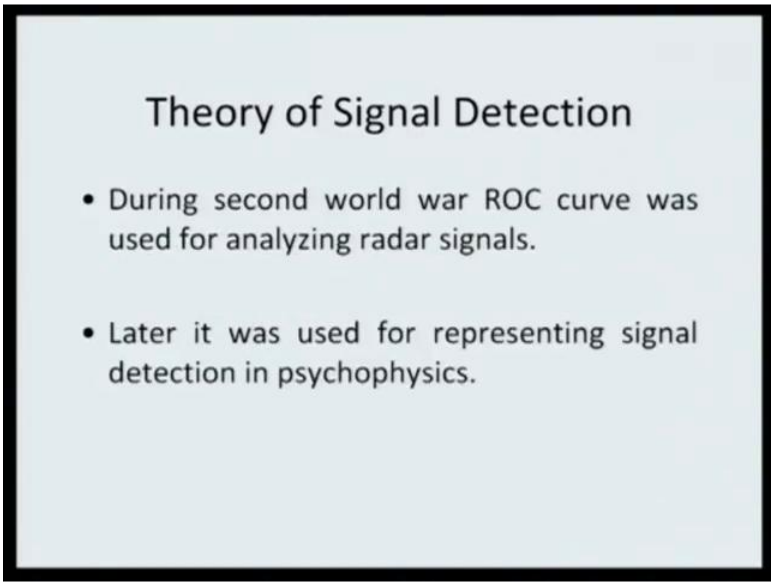
Now when d prime is 0, noise and signal as noise curve are the same and false alarms hits will be the same. That is represented by the diagonal in ROC graph.

(Refer Slide Time: 14:06)



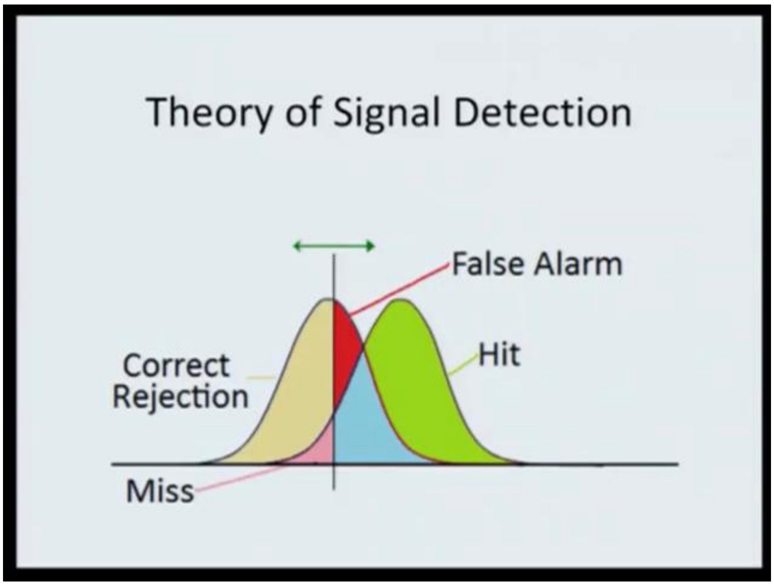
If d prime increases the ROC curve bows away from the diagram.

(Refer Slide Time: 14:12)



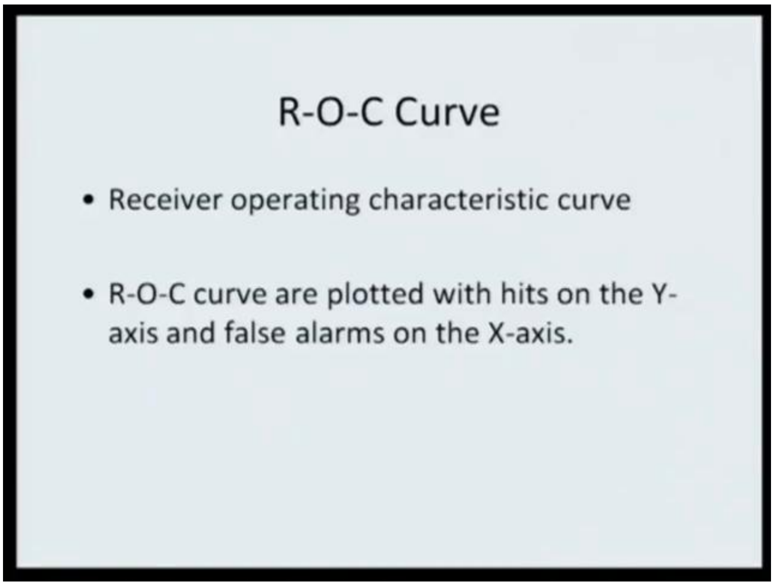
And you would realize the practical implication of it of the fact that during the Second World War ROC curve was used for analyzing the radars signals. Of course now we talk about it now fondly discussion on signal detection in psycho physics.

(Refer Slide Time: 14:32)



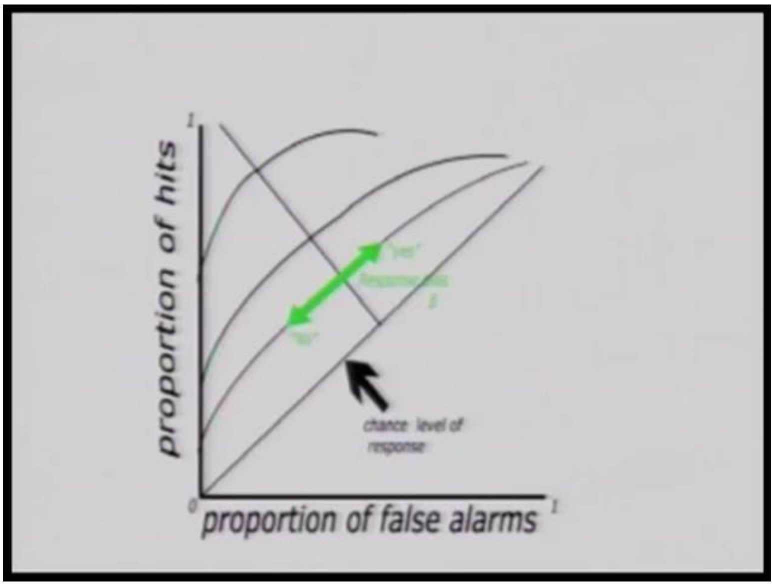
So, you see the graphical representation here, the correct rejection, false alarms, hit and the miss that is find by the Theory of Signal Detection.

(Refer Slide Time: 14:46)



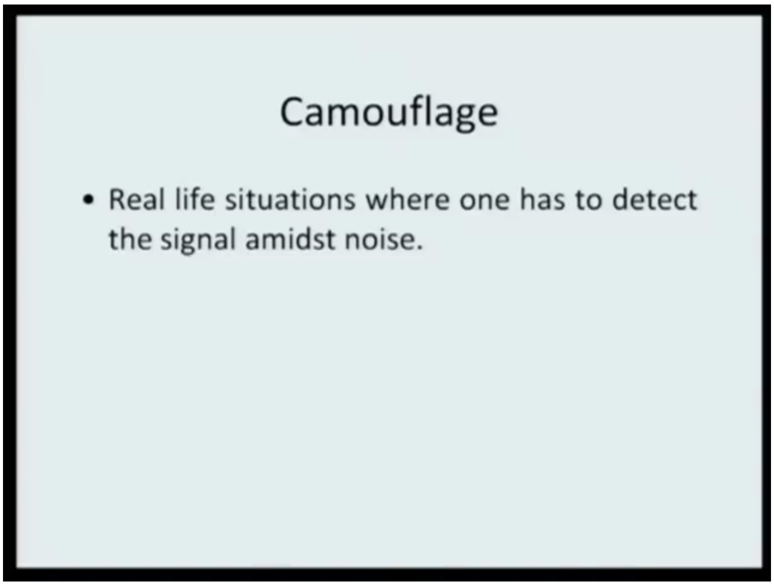
And now look at this very video which explains ROC curve.

(Refer Slide Time: 14:54)



Look at this graph now you have the proportion of the hits and then you also have the proportion of the false alarms and then of course you have the chance level of response wherein know depending on the d prime as such, you give your hits and the false alarms. So, the detection of the signal will actually dependent on your ability to discriminate between the in the signal against noise, the stimuli against the non stimuli. Think of the other example; in real life situation where one has to detect signal and miss the noise in the best example in the present day would be camouflage situation.

(Refer Slide Time: 15:38)

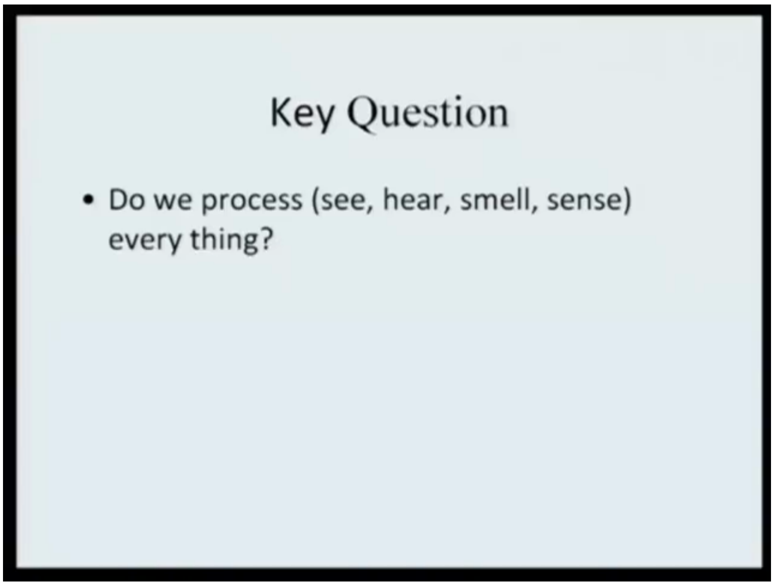


When you try to make the signal of the stimuli is weak enough so that the figure and the ground cannot be detected as two separate situations.

(Refer Slide Time: 15:52)

You must have seen movies, in real life's, several images where you have an individual who will put different colors on the face or put some bushes on the hair will add some bushes the body also, uniformed at the way were they also multiple colors. And then when you make a survey when you look at the object from a distance you are not able to detect the background and the stimulus. So, the object is not very clearly perceived against the background that against which is seen.

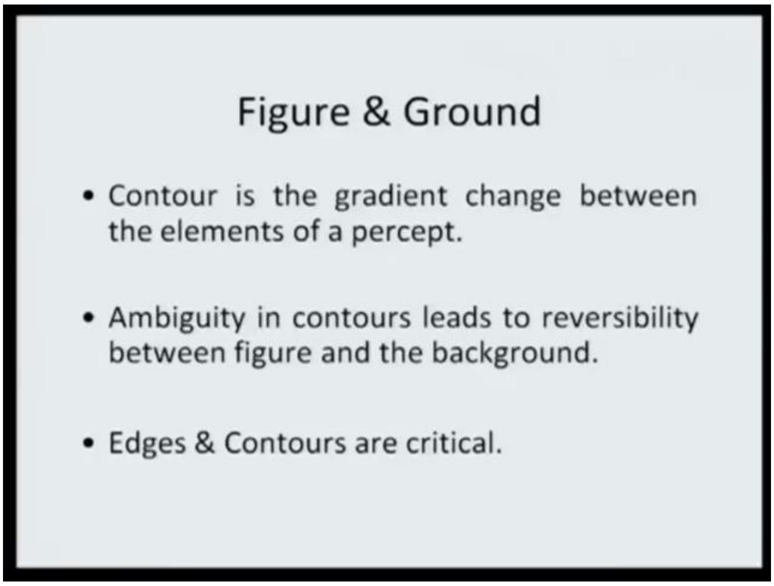
(Refer Slide Time: 16:39)



So, coming back to our key question that we initiated in our second lecture; do we process everything? What do you say now, what we have discussed till now that it is the intensity of the signal that we receive in the environment that would determine whether we would be processing it or not number one. But number two what we have also seen is that the characteristics of the criteria evolved by the user the individual who responds also important. So, the intensity of the stimuli and one two what I decide the criteria that I said for responding both these things will have its importance when it comes to responding to a given situation.

Now that we have understood that fine, the intensity of this signal and the criteria that we set both of them have a role to play. And fact we are now saying that all images all figures have to be extracted out of the ground. What is important once again we are coming to this concept that you have to draw a line difference the contours.

(Refer Slide Time: 17:57)



Now, basically contours are nothing but these are change in the gradient between the elements of a perception. So, ambiguity in contours leads to reversibility and I said that little later we will see few examples of reversible images. But in reality in most of the cases we have the edges and we have the contours. If you are able to establish this distinction then you would be very easily able to see visual image against a background and similarly you can hear a sound against the noise that you are hearing.

(Refer Slide Time: 18:36)

Look at this very example; a famous example that you find in all text books. What do you see here, is all know mix of black and white patches, it is extremely difficult to decide for what is object and what is the background just concentrate at it. Are you able to see? Now let us we help you out. Try to look at this very area, can you see the object now? Answer is yes. How you can now detect the object, because in this case this was the area that you are shown and very conveniently now you can look at these black and white patches and you can make out that you are looking at a dog against familiar type of background. Exactly similar type of thing was when it comes to human beings.

(Refer Slide Time: 19:37)

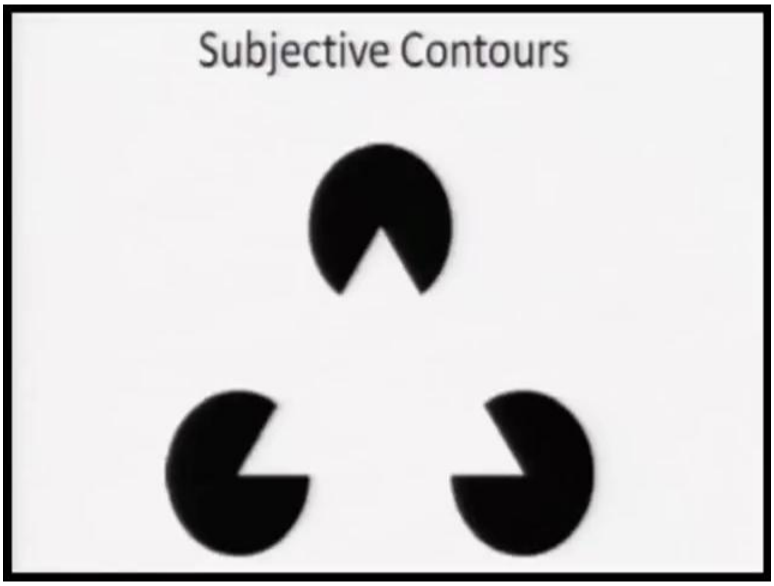
Now, look at this very example. This is a photograph published in news paper where an Indian army soldier is shown in a (Refer Time: 19:46) and he is basically taking part in an exercise Sudarshan Shakthi in somewhere in Barmer district in Rajasthan. Now if you look very clearly it very difficult if the same soldier is put on the ground and you look at the background there making distinction between the figure and the background becomes very difficult.

Now if you compare all this, the first case where when we are trying to look at the flying aircraft and somebody sitting in front of the radar screen who is suppose to detect the stimuli how difficult it would be. You saw the back and white patches where you are suppose to look at the dog is the similar background how difficult it was. And again here you see it would be extremely difficult if you are not told what you are actually looking at and that to where looking at a very close shot. If nothing of this information was given any you are looking at this very objective from a distance it would have been extremely difficult to extract the image the figure out of the background.

Now coming back to the example of subjective contours, these where the cases where contours are still available. The strength of the signal makes that very difference. And of course you are sensitivity. So, one is your sensitivity other is the d prime value these two things would make a difference. But, he says where the contours are missing what do we do? And it has been observed that as human beings we create our subjective contours.

And subjective contours play extremely important role the reason being that what you actually see in environment does not have that line of distinction, and because you have to read the figure against the background. So, what would be the possible figure and what would be the possible background would depend primarily on the fact how you are subjectively training to draw that line of distinction what is called as controversy. Look at this vary video to understand subjective contours.

(Refer Slide Time: 22:15)



Look at this image, what do you see? If I ask you are you looking at white triangle lead over three circles, the answer could be yes for many of you. Or you just then perceive that no it is actually three independent circles with a piece cut out from each of them, but there is no triangle as such.

So, it could be very easily interpreted as if you actually look at three independent black circles with the piece of cut out of them and there is no triangle such. But even though the background is white I am sure all of you would when you look at this image you automatically draw a line to complete the triangle. To perceive that there is a white triangle no this is subjective contour.

We have already seen this image let us look at it again look at the three black circles in the triangle. You can see a sharp gradient change between the circles, triangle and the background. Now move the triangle and super impose it over the three triangles, you still see the triangle by filling creative subjective lines. You do not see three circles with piece cut out of them. Well, you where aware that the triangle was super imposed on the circles. Now see these three circles, they all have a piece cut out of them all those this time a triangle has not been super imposed you still a white triangle a put over three blacks circles. This was an example to demonstrate the concept of subjective contours.

Now that we have understood subjective contours in the next lecture we would be focusing on perception of form, how do we make out the form that we see in the world, shape, size, and all this things.