Introduction to Brain and Behaviour
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Lecture 19
Mechanisms of Attention

Hello, and welcome to the Course Introduction to Brain and behavior. I am Ark Verma from IIT, Kanpur, Department of Humanities and Social Sciences, and also at the Interdisciplinary Program in Cognitive Sciences. Now, this is week four of the course and we are talking about mechanisms of attention.

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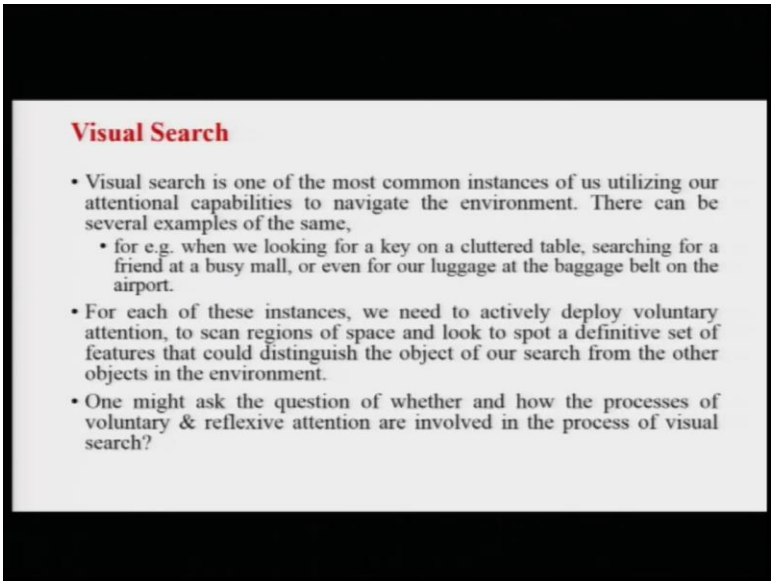

One of the main mechanisms of attention is actually visual search. Now, visual search is something that all of us have engaged in at different points of time. Say, for example at a table or researching for a friend at a busy mall, or say for example, when you are waiting at the baggage belt for your particular suitcase to arrive from the bunch of, you know different other languages that are there for different passengers.

Now, for each of these instances, we actually what do we actually do? For each of these instances, we need to actively deploy voluntary attention to scan regions of space and look to spot on a definitive set of features that will distinguish between the object of our search and all the other objects. So everything else becomes a distracter.

And the thing that we are looking for is actually the goal is actually the target that we looking for. Now, one might ask the question of whether and how does the process of voluntary and reflexive attention involved in this process of visual search, so this is a phenomena that we are engaging ourselves with all the time. The question here is to ask whether voluntary spatial attention or reflexive spatial attention is playing an important role in the aspect of visual search.

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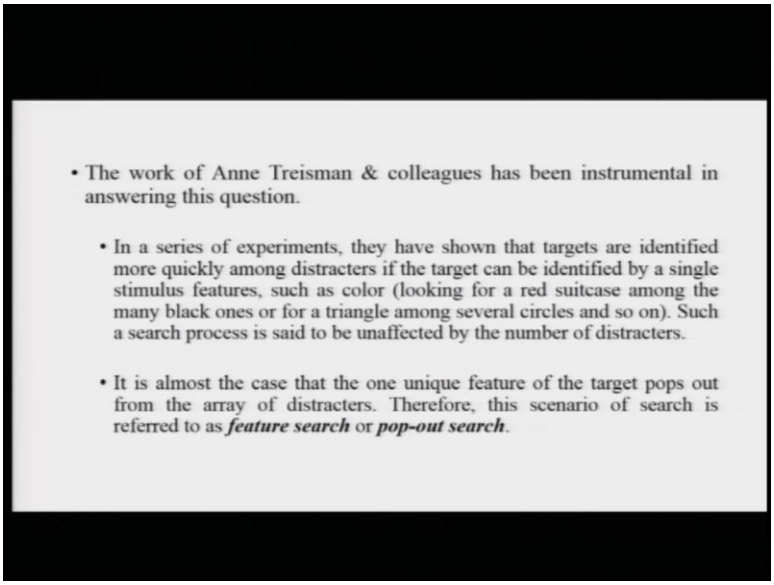

Now, the work of Anne Treismann and colleagues is actually been very, very important in answering this question. To sum up, in a series of experiments, what they have shown is that targets are identified more quickly among distractors, if the target can be identified by a single stimulus feature, such as color or shape or motion. Such a search process is said to be unaffected by the number of distractors. And its usually very fast.

Its almost, why is it so fast? It almost happens that if there is just one unique feature of the target, it almost pops out from the army of distractors. Say, for example if I am looking for a red colored circle, in the army of let us say, green colored triangles, the red colored circle will actually pop out from this army of green colored triangles. And that is basically how the search will be much faster. It could also be said that the search is actually methodically only searching for one specific feature of a stimulus that distinguishes the stimulus from the other, you know, distractors.

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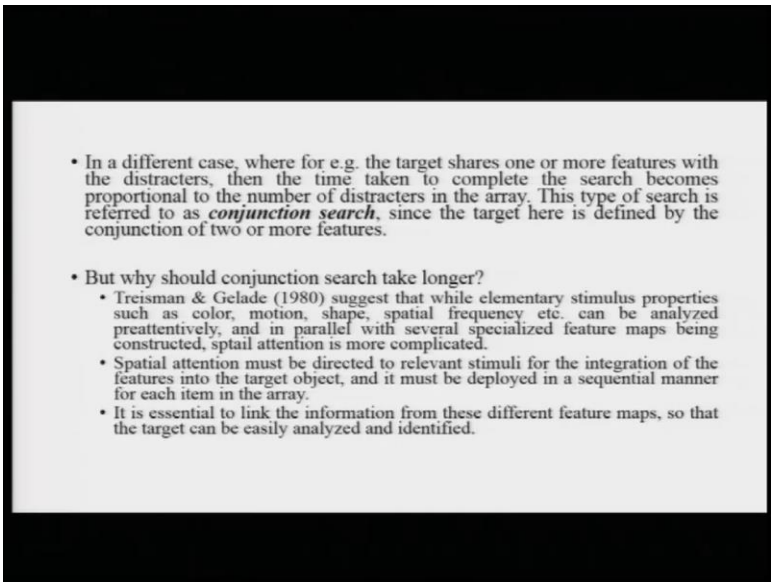

In a different case, say, for example, when the target shares one or more features with the distractors, then the time taken to complete the search actually becomes slightly slower. Also, the time that you are going to spend in you know, in detecting this target will basically now interact with or will become proportional to the number of distractors in the search area. This type of search is called conjunction search. Again, let us take an example.

If I am looking for red colored triangle in an army of green colored triangles. Now, what happens is there is at least one feature that is shared by the target and the distractor. And consequently what it will do is it will increase the time that you are going to spend in search. Now, why should conjunction search searches take longer than feature searches.

Treisman and Gelade in 1980, they suggest that while elementary stimulus properties such as color, emotion, shape, spatial frequency etc, can actually be analyzed almost pre attentively and in parallel, basically the several feature maps are generated and they are compared and that is why you can do this much faster.

Spatial attention is slightly more complicated. Let us say how? Spatial attention must in case of conjunction search must be directed to relevant stimuli for the integration of these various features into the target object. And therefore and then it must be employed in a sequential manner for each item in the array. So, this is what is kind of you know making you take the extra time.

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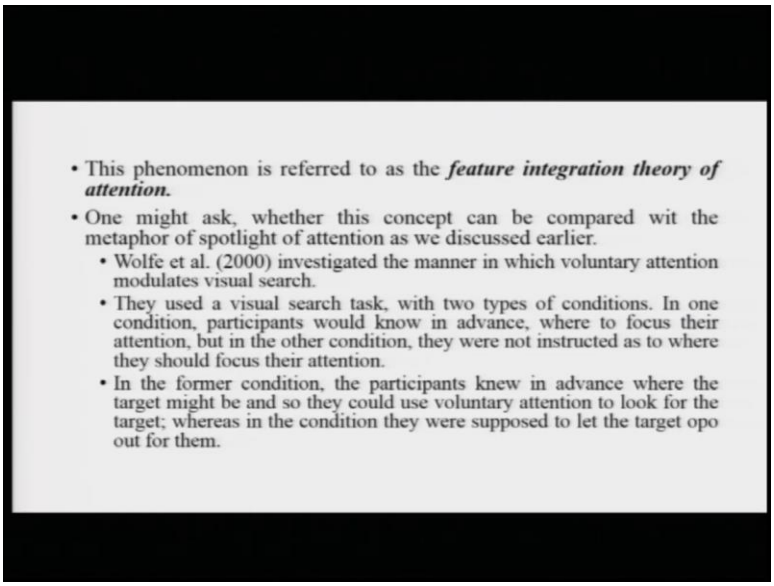

Now, also in case of conjunction search, it is essential to link the information from these different feature maps. So, that the target can be easily analyzed and identified. This phenomena which sort of dictates the integration of features to detect you know this target is referred to as the feature integration theory of attention. Now, one might ask whether this concept can be compared with the spotlight metaphor that we have been talking about. Jeremy Wolfe and colleagues in the year 2000 wanted to investigate the manner in which voluntary attention effects visual search.

What they did was, they used a visual search task with two types of conditions. In one condition, participants would exactly know in advance where to focus their attention. But in the other condition, they were not instructed where the target would come and they have to sort of rely on their own as to find the target.

In the formal condition, when participants knew in advance where the target might be, they could focus their voluntary attention to look for the target. Whereas in the latter condition, they are actually just let you know, they were actually supposed to let the target pop out itself. So, in one case, you know, what you are looking for, and you sort of know the region where you actually looking for this target. In the other, you sort of allowing yourself, you know, to scan the entire array, and hope that the target will pop out at you.

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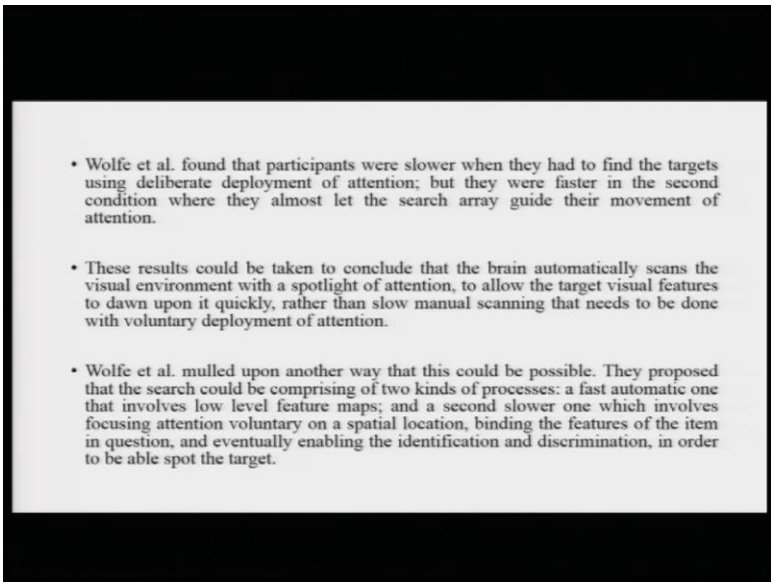

Wolfe and colleagues found that participants were actually slower when they had to find the targets using deliberate deployment of attention in the voluntary condition, but they were faster in the second condition where they almost had no clue and they had to let the search array guide the moment of attention.

This is a little bit counterintuitive. But say for example, these results would be taken to conclude that what the brain probably does is that it automatically scans the visual environment with a sort of a spotlight of attention. And it allows the target visual features to dawn upon it as quickly as possible, rather than, you know, rather than using a slow manual checking or manually done with voluntary deployment of attention. So, I hope this sort of makes the distinction clear.

Now, Wolfe and colleagues also mold upon another way this would be possible, so they proposed that what could be happening is that the process of visual search comprises of two stages. One is a fast automatic one that allows low level feature maps and the second slower one which involves focusing voluntary attention on the spatial location, binding the features of the items in question and then eventually enabling the identification and discrimination of the target. So, these could be the two processes by which let us say, conjunction searches are supposed to be slightly slower as opposed to feature searches.

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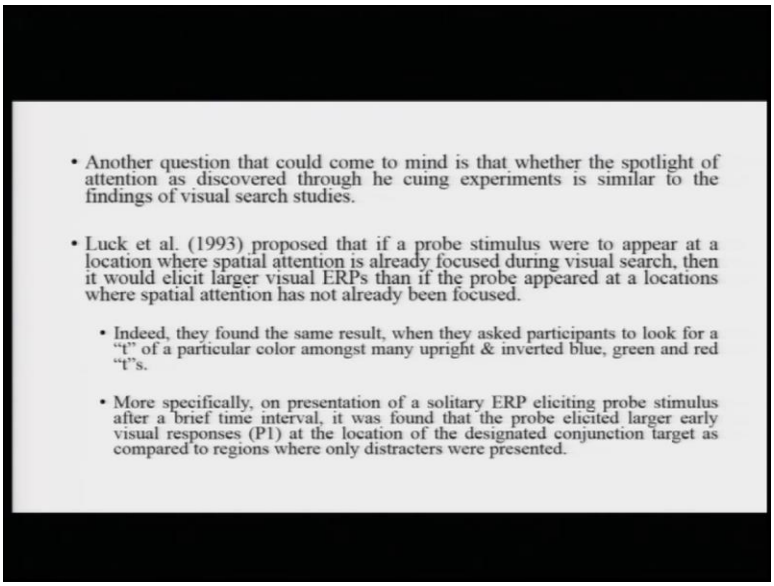

Another question that could come to mind is that, whether this spotlight of attention that, you know the brain is kind of roaming around with, as discovered through the queuing experiments is similar to the findings of visual search studies. What are their findings? Luck and colleagues proposed that if a probe stimulus were to appear at a location where spatial attention is already focused during visual search, then it would elicit a larger visual ERPs than if the probe appeared at a location that was not being focused or that was not part of the attended location.

Indeed, they found the same result. So, when they asked the participants to look for T of a particular, let us say a green T or a red T amongst many upright inverted blue, green and red Ts, they basically found the same kind of pattern. Or specifically on presentation of a solitary you know, ERP eliciting probe stimulus after a brief time interval, it was actually found that the probe elicited larger early visual responses, which is, you know the P1 waves at the location of the designated conjunction target as compared to the region where only distractors were presented.

So, just let me repeat this for you. When they presented a solitary ERP eliciting probe, so they basically presented one probe stimulus at, you know for a brief time interval. This probe actually elicited larger visual responses depending at when this was presently at the location of the designated conjunction. Say, for example, if this target has been cued, if the probe comes there, it elicits a larger response than say, for example, where only the distractors are being presented. So,

location, which was sort of cued or expected is there and then the probe is being presented there is getting better responses.

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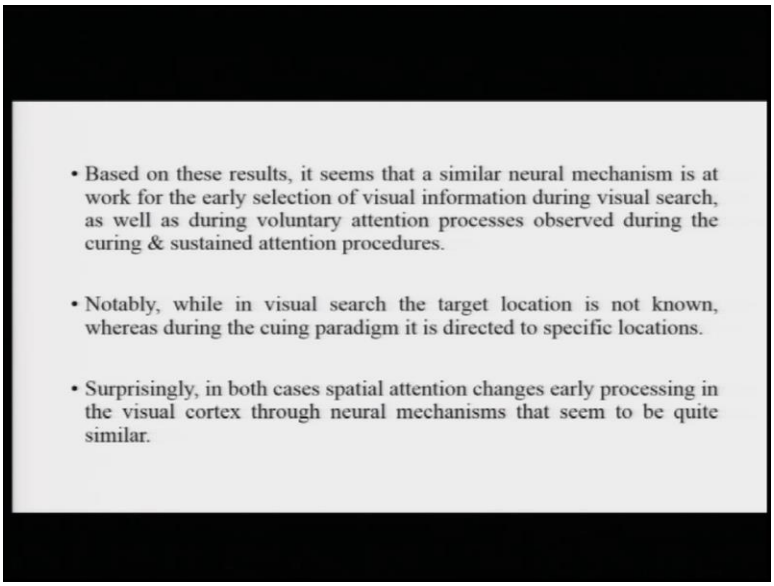

Now, just combining these results, it seems that there is a neural mechanism, which allows for the early selection of visual information during visual search, as well as during a voluntary attention processes observed during the cueing and the sustained attention procedures. Now, just note while in visual search, while in visual search, the target is not known, whereas in the cueing paradigm, the target is sort of expected at the cued location.

Surprisingly, in both these cases, in the visual search, where the target is not known, and the cueing paradigm where the target is known a spatial attention changes early processing in the visual cortex through neural mechanisms that seemed to be very similar to each other. So, we were already seen in the last lecture that spatial attention does influence the processing at the you know, even the earlier visual areas. So, this is basically also found to happen during visual search phenomena.

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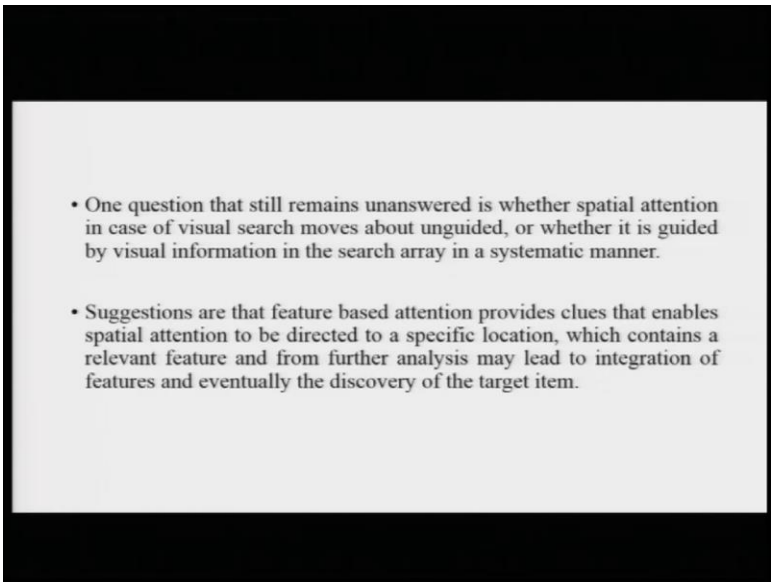

Now, one question that, sort of still remains unanswered is, that whether spatial attention in case of visual search moves about unguided or whether it is actually being guided by the visual information in the search in the, you know, search array in a systematic manner. So, for example, are the properties of different items in the search array sort of guiding the visual, you know sort of guiding the movement of visual attention in some manner, or that they are not.

Now, suggestions are that feature based attention actually provides clues, that enables spatial attention to be directed to a specific location, which contains a relevant feature. And from further analysis, it might lead to the integration of features eventually leading to the discovery of the item.

So, what is happening is that spatial attention sort of is being guided by feature based attention or specific features of items in the array, which grab this, you know attention for a bit. And then when, when whether attention is there for some time it eventually, or further analysis basically would lead to the discovery of the actual target item.

So, it is not that you are randomly scanning the entire search array or the entire visual field that contains the search array, but there is some, you know, properties of the search array that are actually guiding this movement of attention.

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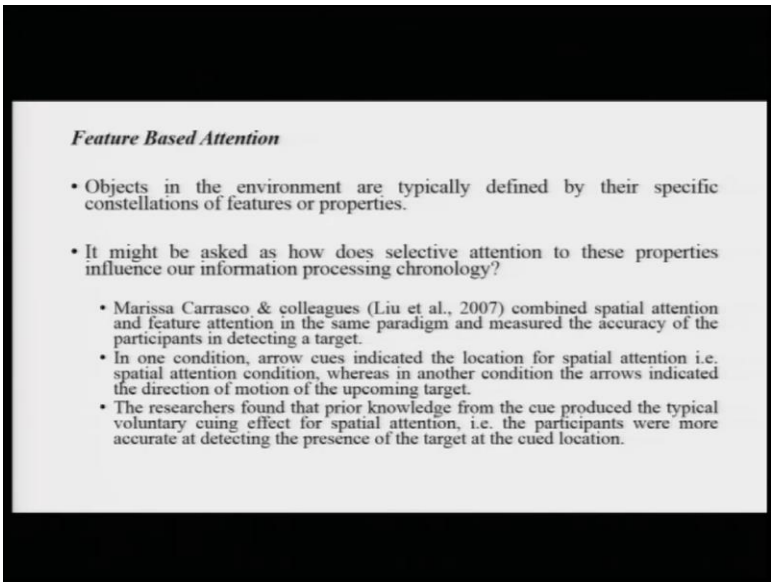

Now, lets talk a little bit in detail about feature based attention. Now, objects in the environment are typically defined by the specific constellations of features or properties. It might be asked how does selective attention to these properties influence our information processing chronology as far as visual processing is concerned? Now, Marissa Carrasco and her colleagues combined spatial attention and feature attention, feature based attention in the same paradigm and they wanted to measure the accuracy of the participants in detecting particular targets.

So, what happened? In one condition, arrow cues indicated the location for spatial attention, which is the spatial attention condition. Whereas in other conditions, the arrow cues indicated the direction of the motion of the upcoming target. So, a feature based property of where the of what the target would look like, but not the location of the target.

Now, the researchers found that prior knowledge from the cue produced the typical voluntary cueing effect for spatial direction that is the participants were more accurate at detecting the presence of target at the cued location that is one.

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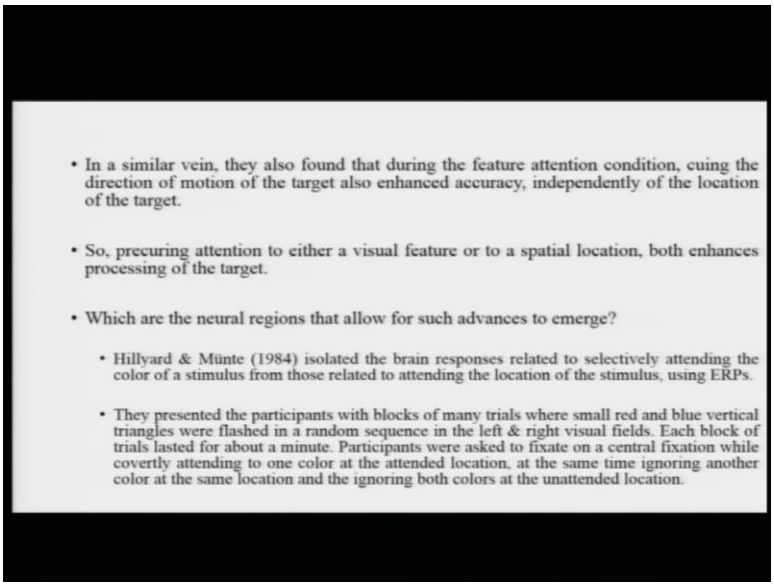

In a similar vein, they also found that during the feature attention condition, cuing the direction of motion also enhanced the accuracy for you know, detecting this target independently of where the target was appearing in the left or the right visual field. Now so, this precuring of attention to either a visual feature or a spatial location, both has been found to enhance the target processor.

Now, you can ask which are the neural regions, which are the regions in the brain that allow for such kind of benefits to emerge? Now, Hillyard and Munte in 1984 isolated the brain responses to selectively attending the color of a stimulus from those related to attending the location of the stimulus using the ERP method. Now, they presented the participants with blocks of many trials with small red and blue vertical triangles for flash in a random sequence in the left and right visual fields.

Each block of trials would last for a minute and participants were asked to fixate on a central fixation point while covertly attending to just one color at the attended location. So, if the cue is like this, you have to covertly attend without moving your eyes to this, you know, to the target at this location. So, at the same time, they were ignoring or asked to ignore another color at the same location or say, for example and ignoring both colors at the unattended location.

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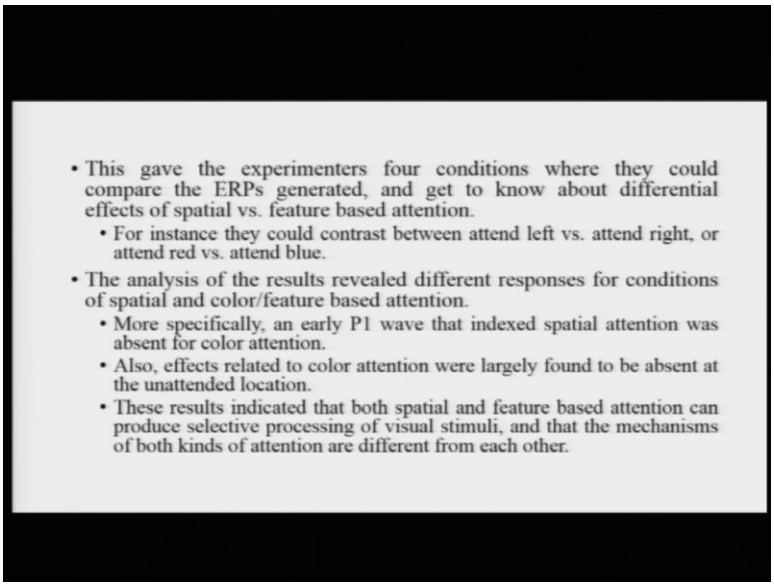

Now, this sort of setup gave the experimenters four conditions where they could actually compare the ERPs generated and get to know about differential effects of spatial attention versus feature based attention. Now, for instance they could actually contrast now attend left versus attend right. So, for example if the attended location is on the left or the right or they could actually also compare between attend red versus attend blue.

So, attend red versus attend blue provides a contrast of color, attend left versus attend right provides a contrast of spatial attention location. Now, the analysis of the results actually reveals differential responses for conditions of spatial and feature based attention. More specifically, an early P1 wave that indexed spatial attention was absent for color condition.

Also effects related to color attention were largely found to be absent at the unattended location. So, if you put these results together, it indicates that both spatial and feature based attention can actually enhance or improve the performance or improve the selective processing of visual stimuli. Also that the mechanisms of both spatial attention or feature based attention are very different from each other.

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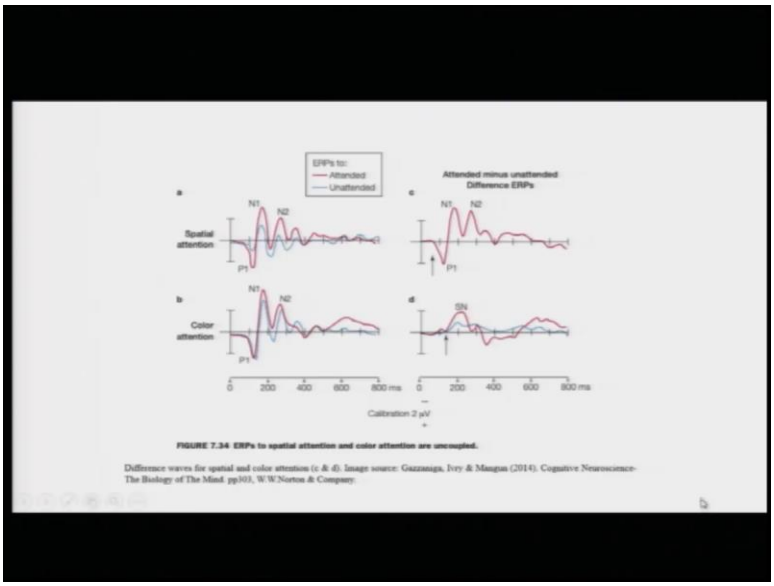

So, here you can kind of look in the different waves that this is the spatial condition where you see this early wave P1 whereas this is, this early wave P1 is absent from the color condition. So, this is just an example of how this really plays out.

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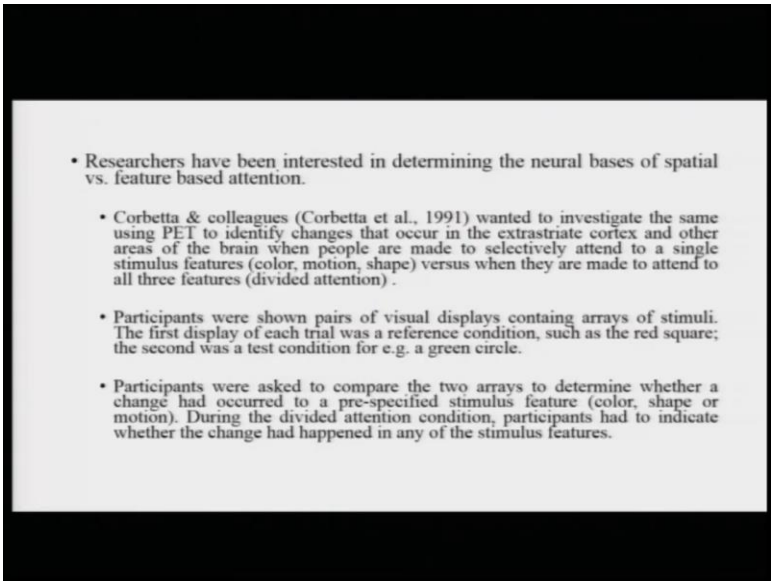

Now, researchers have really interested in determining the neural basis of spatial attention versus feature based resonation. So, Corbetta and colleagues actually in 1991, they wanted to investigate the same question using PET to identify changes that occur in the extrastriate cortex and other areas of the brain. When people are made to selectively attend to a single stimulus

feature, like color, or motion, or shape, or when they were made to attend to all three of these stimulus features at the same time.

In their task, participants were shown pairs of visual displays containing arrays of stimuli. The first display was basically of each trial was a reference condition. Suppose let us say you will present a red square and then the second condition was a test condition. So, because you present a red square here, I can change the thing and I can basically present a green square. So, the changes happening only in the color, I could present a red triangle. So, the changes happening in the shape.

Similarly, I could you know present forward moving or a backward moving triangle. So, I could change the properties that are different from the reference condition to the test condition and that will give me my measures of whether the participants brain activity is changing in response to color change, motion change, or shape change.

Now, participants here were asked to compare the two arrays to determine whether a change had actually occurred in the pre-specified stimulus feature. So, they could say that in this blog, you have to look for color, in this blog you have to look for shape changes, or in this blog, you have to look for motion changes. Now, during the divided condition, they could indicate any change that they notice, whether the change was in shape or color or motion. They were not told that, look for this kind of change.

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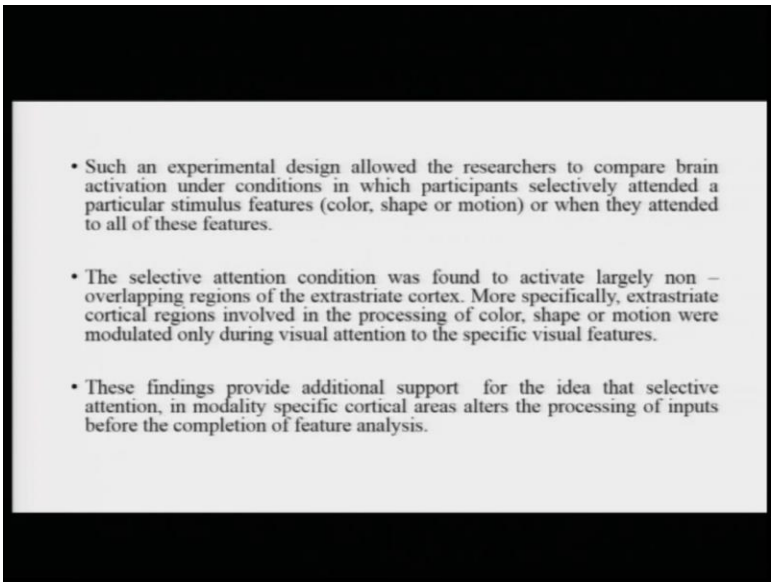

Now, this kind of experimental design allows the researchers to compare brain activation under conditions in which participants are selectively attending one particular stimulus feature, either of color, or of shape, or of motion, or when they attended to all of these features

When there is sort of no real difference. Now, the selective attention condition was found to activate largely non overlapping regions in the extrastriate cortex. So, what is actually happening is extrastriate cortical regions involved in differential processing of color, shape, or motion, or modulated only during visual, only during the time when visual attention was focused to these specific visual features.

So, when you are attending to color, regions that are responsible for processing color will get activated. When you are attending to shape then regions that are responsible for shape processing are activated. When you are, you know, attending to motion, then regions responsible for processing motion are activated.

These findings actually provide additional support for the idea that selective attention in modality specific cortical areas alters the process of inputs even before the completion of each analysis. Basically what I am trying to say here is that the way visual attention modulates you know as processing in the visual cortical areas is basically differential with respect to the features that are being attended.

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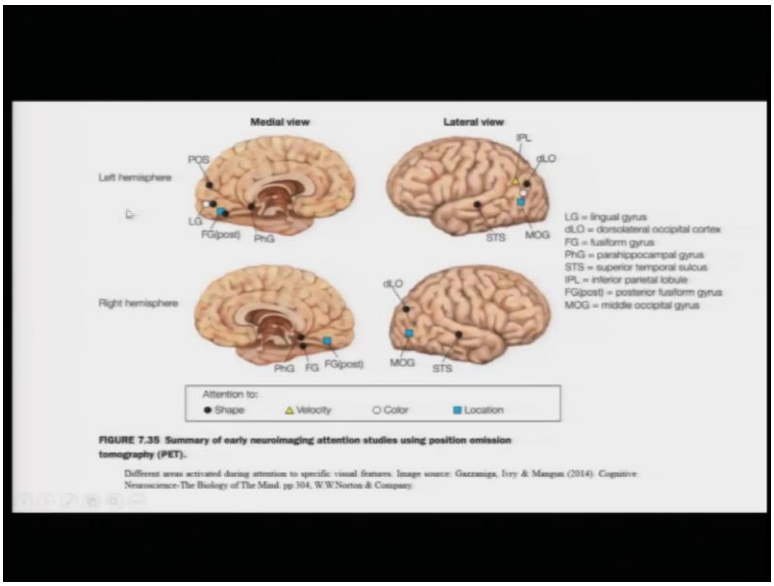

So, here you can see that these are the regions which are reacting to shape. So, it is the POS. Its the frontal gyrus, it's the parahippocampal gyrus. Similarly, the fusiform gyrus and the parahippocampal gyrus for shape, you can see that this is happening both in the left and the right hemisphere.

Similarly, you can see that, say, for example, the fusiform gyrus in the posterior part is, is basically responding to location. The middle occipital gyrus is responding to location, and so on. So, you can sort of study this figure to see that different regions of the cortex are responding to different properties of the stimulus. Now, another question that you can ask is whether or at what point do these various attention effects start occurring during visual processing?

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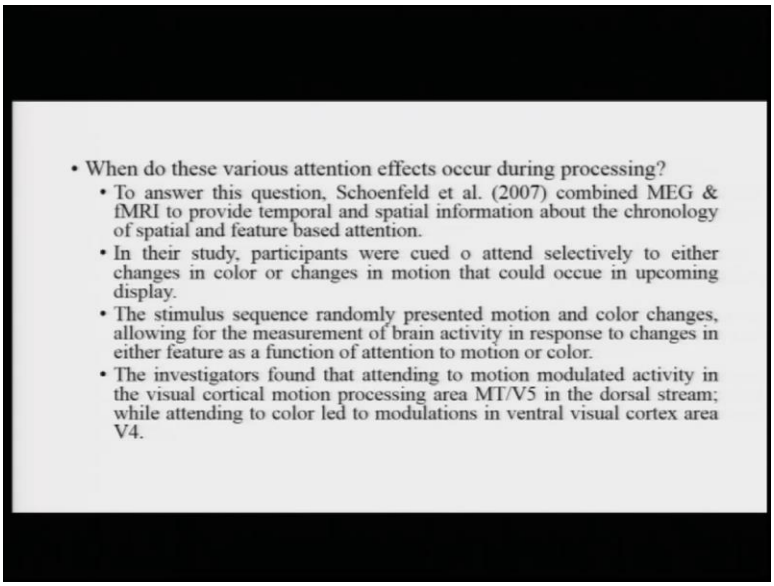

To answer this question, Schoenfeld and colleagues combined MEG and fMRI to provide a good temporal and spatial information about the chronology of spatial and feature attentions, feature based attention. Now, in their study, participants were cued to attend selectively to either changes in the color or changes in the motion that could occur in the upcoming display. The stimulus sequence randomly presented motion and color changes, allowing for the measurement of brain activity in response to these changes in either feature as a function of attention to just motion or just color.

In this study, the investigators found that attending to motion modulated activity in the visual cortical motion processing area which is the MT or the V5 in the dorsal stream, while attending the color lead to modulation as well ventral visual cortex area V4. Again, if you remember from the last chapter, we've talked about these areas as being specialized for motion and color respectively.

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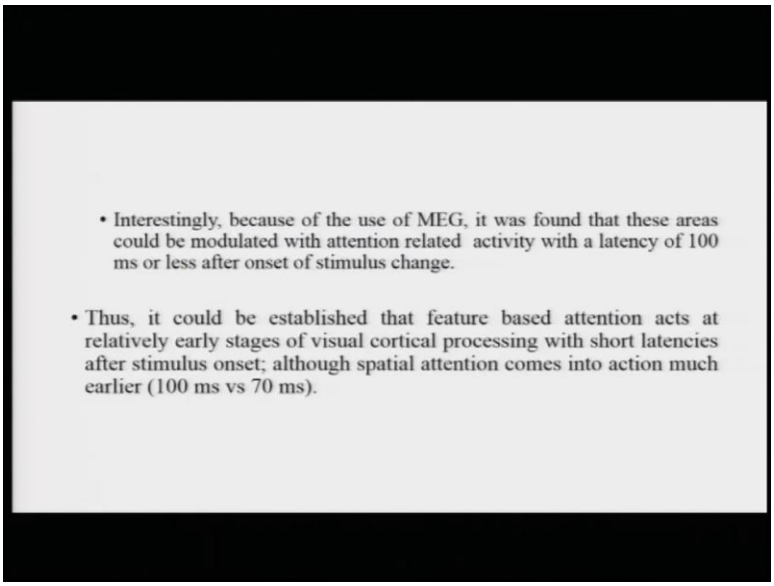

Now, interestingly because of the use of the MEG, it could also be found that these areas can be modulated with attention related activity much faster with a latency of just around hundred milliseconds or less after onset of stimulus change. So, these areas sort of catch up to these features very, very quickly. And there is attention related modulation in these areas that is starting to happen at very, very early after stimulus onset.

So, it could be established that feature based attention actually acts as relatively early stages of visual cortical processing, with very short latencies after stimulus onset. Although spatial attention basically comes into action much earlier. So, it probably happens, lets say around 30 milliseconds faster than feature based attention.

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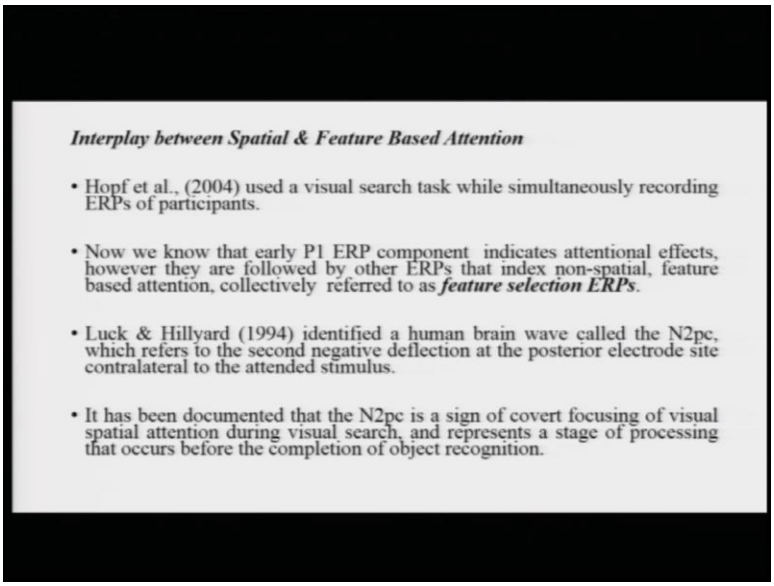

Now, let us talk a little bit about now, let us talk a little bit about the interplay between spatial feature based attention. Now, Hopf and colleagues in 2004 used a visual search task while simultaneously recording the ERPs of participants. Now, we know that the P1 ERP component indicates spatial attentional effects. However, there are other, the P1 wave is also followed by other ERPs that index non spatial feature based attention and they are collectively referred to as feature selection ERPs.

Now, Luck and Hillyard in 1994 identified a brainwave called the N2pc, which refers to the second negative deflection at the posterior electrode side contralateral to the attended stimulus, so, something that happens in the contralateral hemisphere to the attended stimulus. Now, it has been documented that N2pc is actually a sign of covert focusing of visual spatial attention during visual search. And it represents a stage of processing that occurs before the completion of the object recognition. So, it is something that sort of tells us that where is just our attention oriented covertly.

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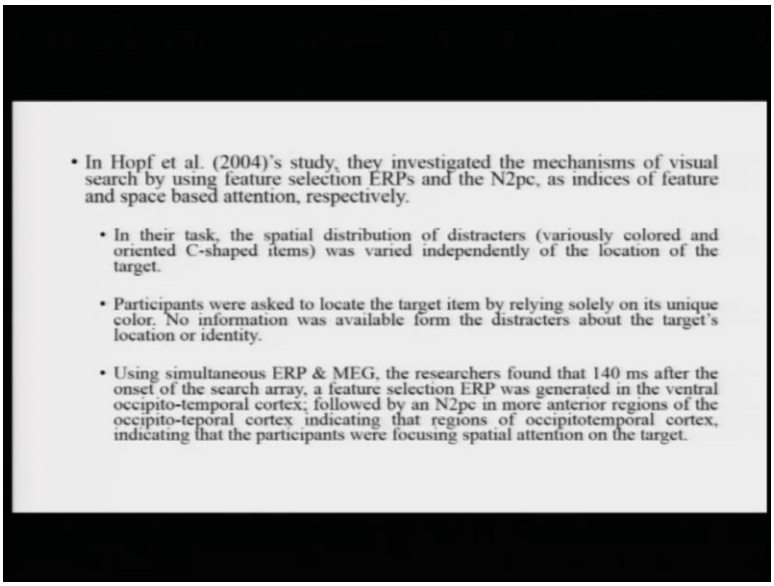

Now, in their study, they investigated the mechanisms of visual search by using feature selection ERPs and the N2pc component as indices of space based attention and as indices of feature attention and space based attention respectively. Now, what kind of tasks did they give? In their task, the spatial distribution of distractors, which were variously colored, you know, and variously oriented C shaped items, was varied independently of the location of the target.

So, for example, how they were arranged is basically being, you know, is manipulated. Now, participants were asked to locate the target item by relying solely on its unique color. So, you just have to attend to the color of the target and that will help you identify this, you know, this specific target. No information was available from the distractors about either the targets location, or its identity, so they have to sort of do it without any help from the distractor side.

Now, using simultaneous ERP and MEG, the researchers found at around 140 milliseconds after the onset of the search array a feature selection ERP was generated in the ventral occipitotemporal cortex, followed by N2pc wave that is generated in more anterior regions of this occipitotemporal cortex, indicating that regions of the occipitotemporal cortex are basically involved or activated when the participants were focusing spatial attention on the target.

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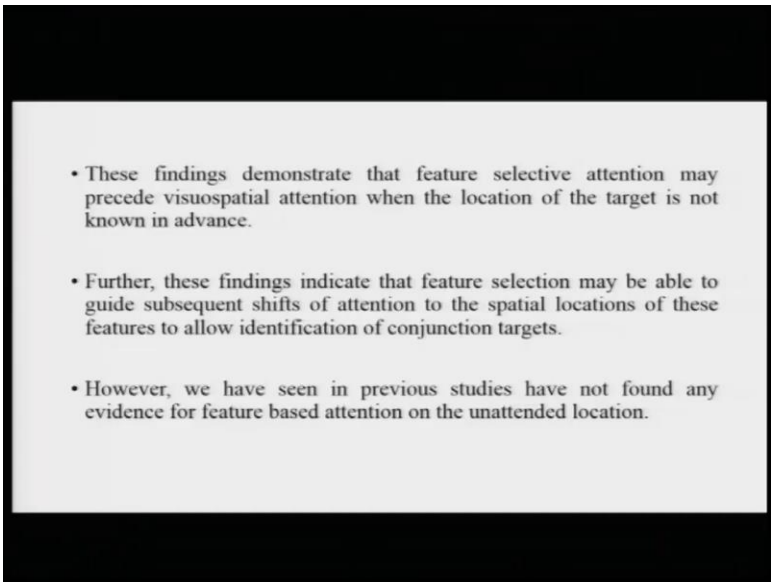

But you can see that these two waves are being generated from different sources in the occipitotemporal cortex. Now, these findings demonstrate that feature selective attention may actually precede visuo spatial attention when the location of the target is not known in advance, not in the case of voluntary goal directed attention. But when the location of the target is not really known in advance, then feature selective attention or detection of features probably is happening much earlier than the modulation bias visuospatial attention is happening.

Now, further these findings indicate that feature selection may be able to guide subsequent shifts of attention to the spatial locations of these features, which allow the identification of the conjunction targets. Remember where we started with, we are talking about whether the search array or properties of the search array or features in the search array can actually guide our attention or can actually guide the movement of spatial attention.

Now, this is you know, the result that is actually showing that, indeed, that may be the case. So, as we have seen in previous studies, people have not really found any evidence for feature based attention on the unattended location. So, that is something that is not really been established.

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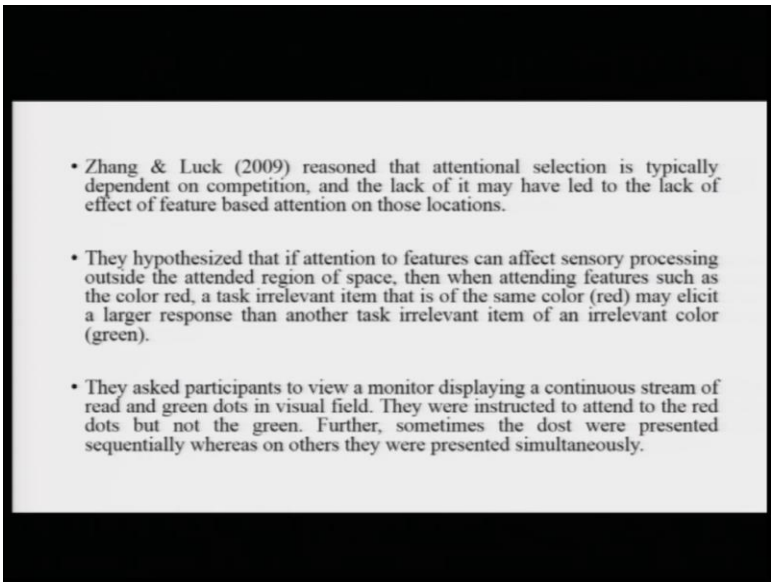

So, Zhang and Luck basically were intrigued by the scene. And the reason that what happens is that attention selection is typically dependent upon competition. And the lack of it may have led to this finding or to the lack of this finding of or the lack of this effect of feature based attention on those unattended locations that were there.

So, what they do is they hypothesized that if attention two features can actually affect sensory processing outside the attended region of space, then when attending features such as let us say color and a task irrelevant item is presented that is of the same color and it is presented at the attended location, it will basically elicit a larger response that another task irrelevant item of an irrelevant color let us say green.

Just read this again. If you are looking for a red colored object, and there is, this is the region of space, this is the attended location, this is the unattended location. Now, first in the attended location, if there is another object that shares the relevant property, then the response to that object will be higher.

In their task now what they do is that they asked participants to basically monitor display that contains a continuous stream of red and green dots in the visual field. They were instructed, the participants were instructed to attend to the red dots and ignore the green dots.

Further, sometimes the dots were presented sequentially. So, first the red dots will come, then the green dots will come, then again the red dots will come, then again the green dots will come or

they could be presented simultaneously. So, for example a mixture of red and green dots is presented to either the left or the right visual field.

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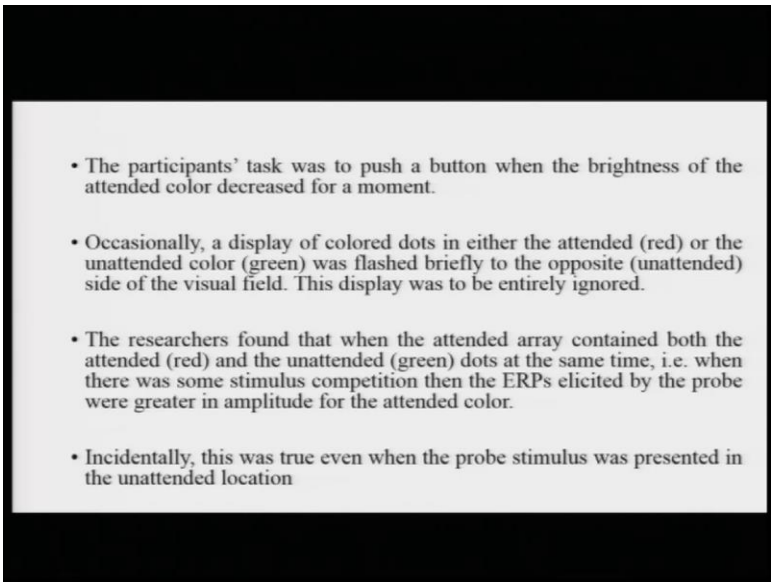

Now, the participants task was to push a button when the brightness of these attended colors suppose you are attending to the red color, suddenly the brightness of the attended color will go down. And that is where you have to present this press this button. Occasionally, what was happening was that a display of colored dots in either the attended color or the unattended color was flashed briefly to the opposite of the cued location to the unattended side of the visual field.

Now, this display obviously, this is the uncued location. This has to be completely ignored. Now, what did the researchers actually find? The researchers find that when the attended array contained both the attended and unattended dots at the same time, say for example, when there was some case of stimulus competition, that in the same attended visual field you have red dots and green dots and both are competing for your attention, then the ERPs elicited by the probe were greater in amplitude for the attended color.

So, red colored dots would elicit larger ERPs. Now, incidentally, this was also found to be true when the probe stimulus was actually presented in the unattended simile. So, this probe stimulus could either be presented in the same visual field which is the attended visual field or this probe stimulus could be presented in the unattended uncued visual field. Interestingly, the visual ERP was found to be higher to this attended color, to this red color in the unattended visual field also.

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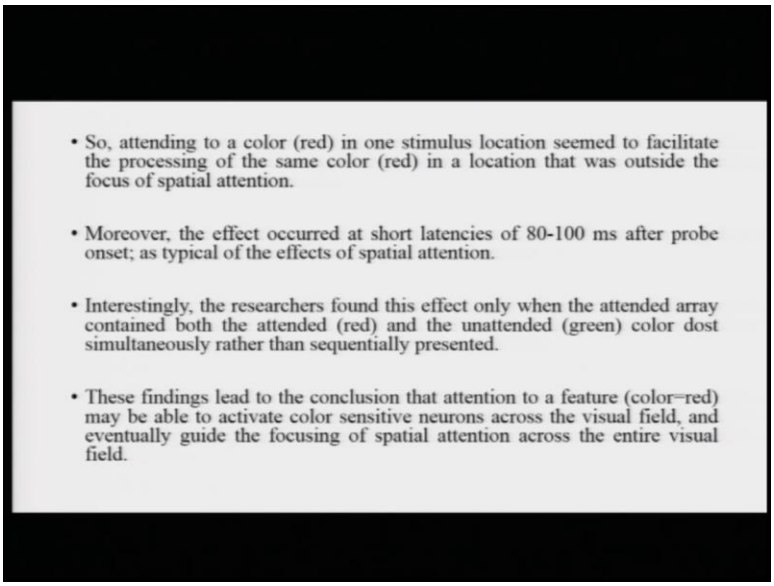

Now, this must be a bit puzzling to you. What basically is happening is that you are supposed to ignore this entire visual field. But if the property that you arre looking for sort of figures in the unattended visual field, you are responding to that. So, attending to a color, red let us say in one stimulus location seems to facilitate the processing of the same color even in the unattended location, or even in a location outside your sphere of attention or outside your region of attention.

Now, moreover the effect occurred at shorter latencies of 80 to 100 milliseconds after probe onset, as typically the effects of spatial attention have been occurring. Interestingly, the researchers found this effect only when the attended array contained a mix of both red and green dots. So, when there is competition, then what you are actually seeing is these larger visual ERPs in response to the attended color, irrespective of the location, whether it is at the cued location or the uncued location.

Now, if you look at these findings, these findings can be taken to conclude that attention to a feature, let us say red color may be able to activate color sensitive neurons across the entire visual field, and basically, eventually guide the focusing of spatial attention across this entire field.

So, wherever, you know, this particular feature that you are looking for is present, your attention will automatically be grabbed there. So, you do not have to always voluntarily search for the

targets. I hope this is sort of making sense. I am just connecting the things that we have said in the earlier part of the lecture.

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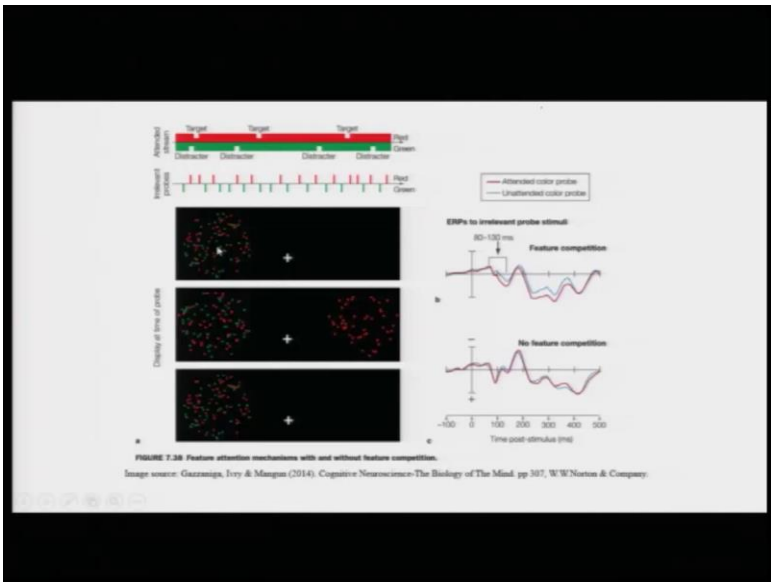

So, here you can sort of see the example of the display. This is the cued location. This is where say for example, the uncued location, the probe, you know, appears at some times.

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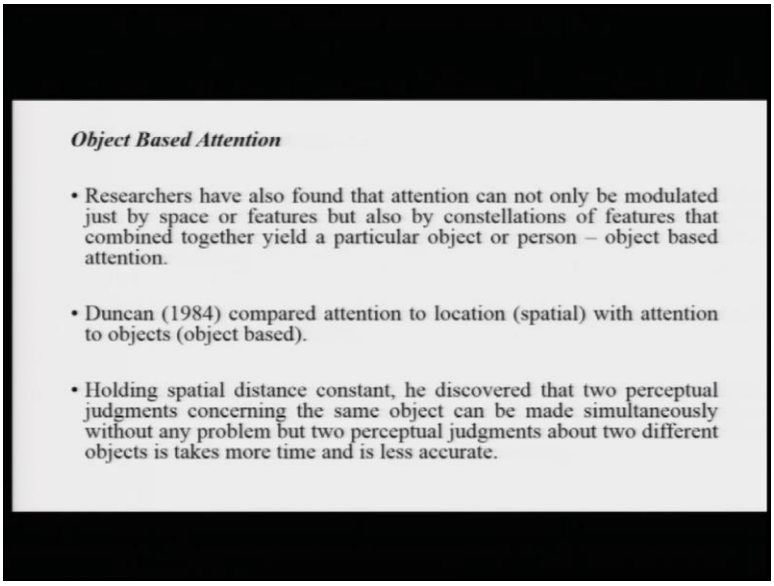

Now, let us talk about object based attention. We have talked about space based attention. We've talked about feature based attention. Now, let us talk about object based attention. What is object

based attention? Now, researchers have found that attention is also modulated by constellations of features that when combined together can yield a particular object or person, which is called object based attention. Say, for example, I can talk about a horizontal bar and a vertical bar and another horizontal bar or actually two vertical bars and a horizontal bar.

Now, these are different features. But when I combine all of these together, it will kind of gives me the shape of a table. So basically, what I am talking about is whether the table as an object has the capability of grabbing my attention. Now, Duncan in 1984, compared attention being paid to locations, spatial attention, or attention being paid to objects that is object based attention, so he kind of tried to compare attention to the two kinds of stimuli.

Holding spatial distance constant, he discovered that two perceptual judgments concerning the same objects can be made simultaneously without much problem, but two perceptual judgments about different objects to be made at the same time actually becomes problematic, it becomes much slower and less accurate.

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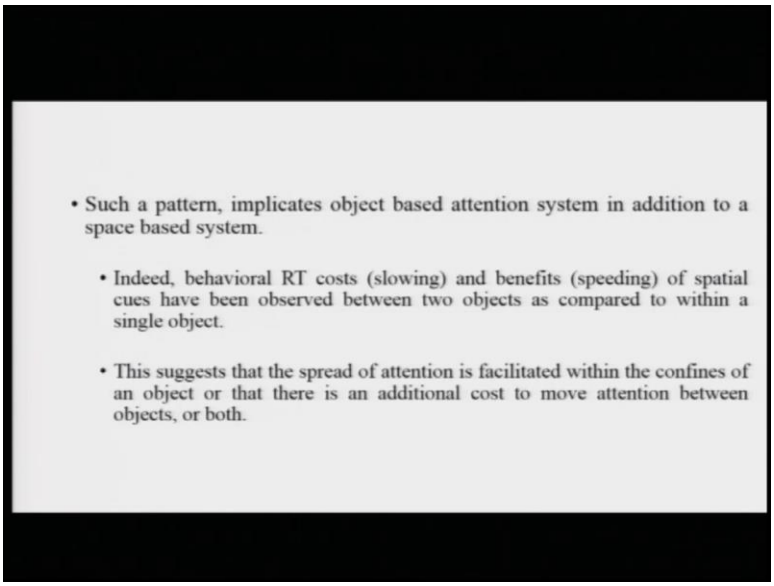

Such a pattern implicates that object based attention, you know, implicate, sort of the operation of object based attention system in addition to a space based attention system. So, what basically happens is, indeed, a behavioral reaction time costs or slowing of the reaction time and benefits of or speeding of the reaction time or in responses to facial cues have actually been observed between objects as compared to within a single object.

So, for example if you are asked to, you know, shift your attention from one object to the other, you will slow down for making perceptual judgments. If you are asked to shift your attention just within the same object you will find to be, you will be found to be faster. This is basically coming from studies done by Egli and colleagues in 1994.

Now, this pattern of findings suggest that the spread of attention is actually facilitated within the confines of the object boundaries, or that, and that is why there is an additional cost to move the attention from within this object boundary to the boundary of another object.

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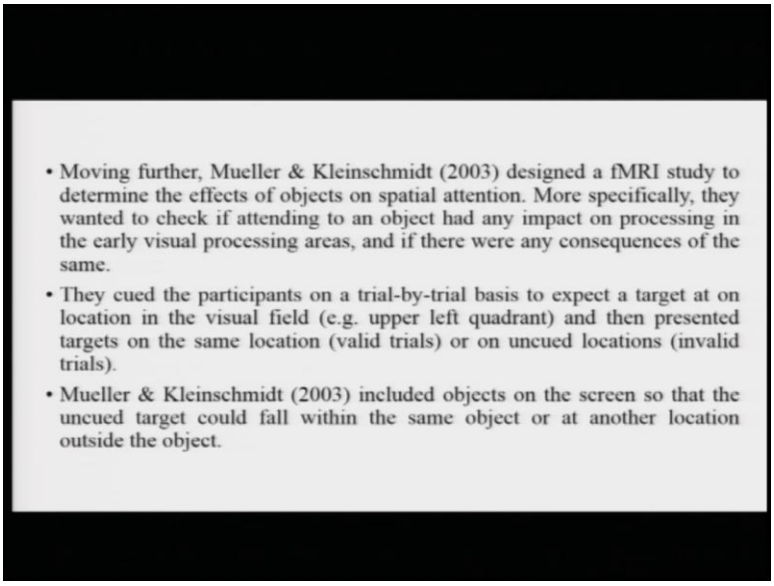

Let us look at how this happens. Mueller and Kleinschmidt designed an fMRI study to determine the effects of objects on spatial attention. More specifically, they wanted to check if attending to an object had any impact on processing in the early visual processing areas, and if there were any consequences to this.

So, they cued the participants on a trial to trial basis and basically they asked the participants to expect a target at one location individually, say for example, the upper left quadrant and then presented targets most of the times at the same location, but sometimes at the uncued or the uncued locations. Now, Mueller and Kleinschmidt found included objects in the screen so that the uncued target could also sometimes fall within a particular object, or can fall outside this particular object. Let us look at their display.

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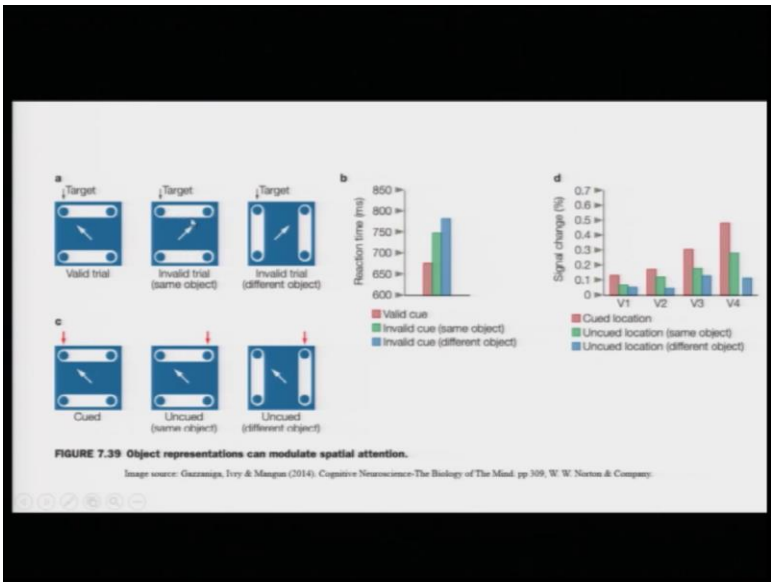

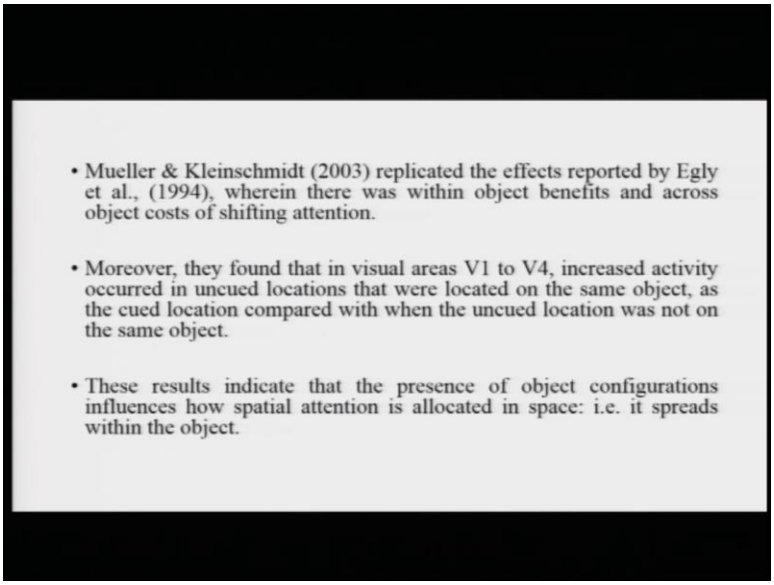

So, you can see that the uncued object can fall within the same object, or it can actually appear in a different object altogether. So, this is basically what they wanted to do. Now, what did they find? Muller and Kleinschmidt replicated the effects reported by Egly and colleagues wherein there was within object benefits and across object costs of shifting attention.

Moreover, they found that in visual areas V1 to V4, there was increased activity occurring even in the uncued locations that were actually located within the same object as compared to the cued location, as compared to you know, when the uncued location was not on the same object.

Say, for example there will be different activity, the uncued location here versus this uncued location here which is basically on a different object. This pattern of results actually indicate that the presence of object configurations influences how spatial attention is actually allocated in space, what does it do? That it spreads inside or within the complete object.

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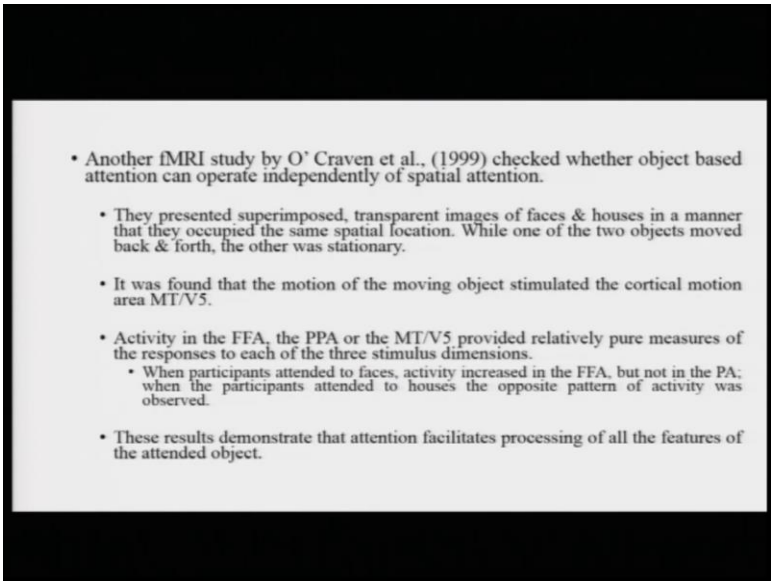

Now, another fMRI study by O'Craven and colleagues in 1999 sought to check whether object based attention can operate independently of spatial attention. So, what did they do? They presented superimposed, transparent images of faces and houses in a manner that they occupy the same spatial location. So, spatial location is held constant, whereas the object features are now different because one is shape, one is, you know, house and one is a face.

In this setup, while one of the two objects were supposed to be moving inwards and outwards back and forth, whereas the other was kept stationary, and which object was moving at what time was counterbalanced across blocks. Now, it was found that motion of the moving objects stimulated the cortical motion area MT or V5 as we have seen.

Now, activity in the fusiform face area, the PPA or the MT or V5 actually provided relatively pure measures of the responses to each of these three stimulus dimensions. So, when they were attending the face, the fusion face area was activated. When they were attending to the house, the parahippocampal place area was being activated, or when they were just attending to the motion, the MT or V5 area showed activation.

These results if you put them together and if you try and you know zoom out and analyze, demonstrate that attention facilitates the processing of all of the features of the attended object. So in the same object, if there are, if the shape is, if the house is present, then that is being attended and regions which process the house are being activated. When the face is being presented, the regions that process the face are being activated. And that is basically how the, you know, this object based attention is working.

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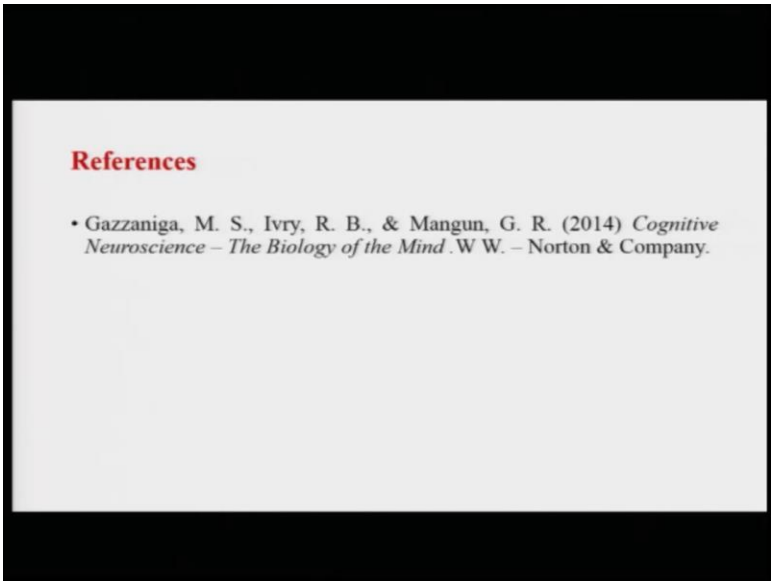

I think that was all I wanted to talk about these different kinds of attention. We will meet in the next lecture, and there I will talk about a different topic.