**Cognition and its Computation**
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**Lecture - 28**
**Disorders of Attention**

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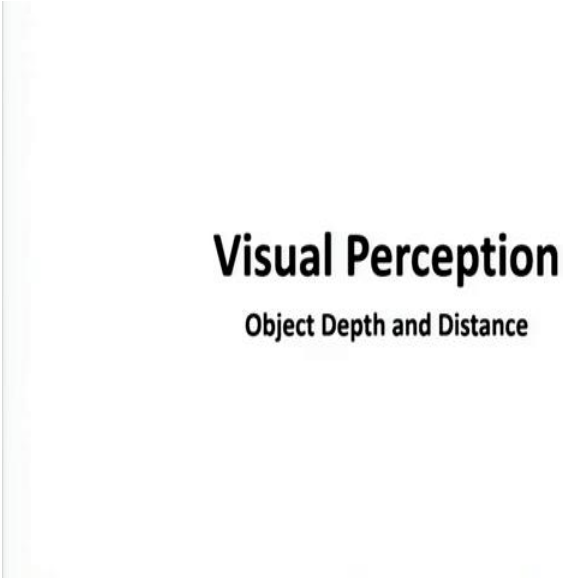


Hello and welcome back to this lecture on perception. So, today we are going to talk about visual perception object, depth and distance. So, how do we perceive things? Visual perception is one of the most common activities that we do for all of us who are who can visualize the world with our eyes and this is so, common that most of the times we take it for granted.

But it requires an intricate process of information processing to figure out to figure out what we what the sensory stimulus that we are receiving and making meaning out of it. So, visualization process or visual processing of whether it is form or depth or distance or movement requires to understand the in information from a 2- D perspective 2 or 3 D perspective and how does the brain do that.

Now, in today's discussion we are going to talk as I mentioned we are going to talk about form perception and depth and distance perception. So, visual perception may be

divided into three parts and they are number 1 with the three stages are first how visual process information is processed in the retina, how the information passes on to the brain and there is an interpretation of that information that is the second stage where the meaning is given to the visual information. And third finally, a recognition of what we are perceiving.

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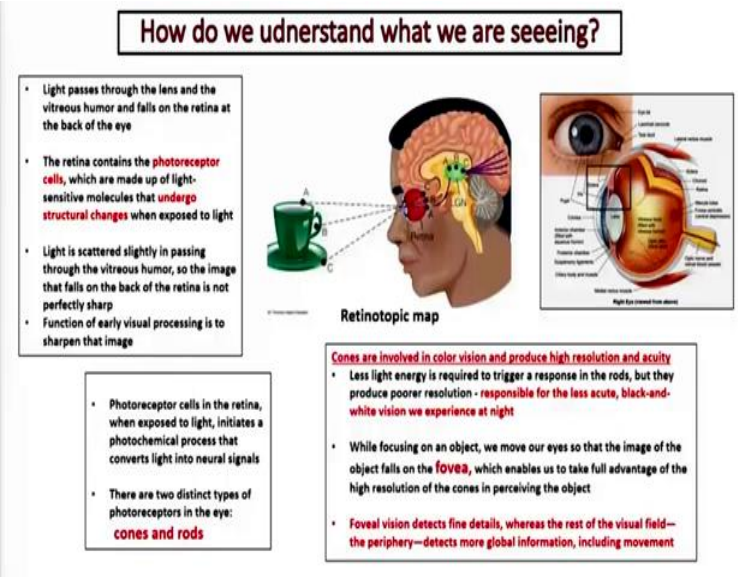


So, say how do we understand what we are seeing? Now if you notice the spelling of understand and seeing is wrong, but how many of you figured that out when we; when I read that or how many of you had a problem in understanding what was being said. Most of the times even if the spelling is wrong we some overlook it and if the first letter and the last letter is right we can understand we can figure out what is written.

Now, how do we do that? So, we must be having some kind of a template of that word and in our memory system now how do we do that? So, today we are not going to talk much about the language understanding, but this is a part of some of the laws of gestalt we will talk about it a little later. So, what happens when we are seeing something? The light passes through the lens and the vitreous humor and falls on the retina.

So, if you look at this figure of the eye at your right on the right side of the slide the light falls and its taken in from the pupil and it falls on the retina following several layers and the light is scattered slightly in passing through the victorious humor and the image falls on the back of the retina, but this image is not very sharp and this the one of the

objectives of early visual processing is to sharpen this image on the retina. So, the best position for the sharpest image is on the fovea centralis.

Or that is also known as the yellow spot and this has the maximum number of the cone cells the retina it has two kinds of cells or if these are known as a photoreceptor cells and these convert the light into neural signals and these cells are the rods and the cones. The cones are involved in color vision and produce high resolution in equity. So, the objective of early visual processing as I mentioned is to have the image fall on the fovea centralis where there are maximum number of cones.

And the rods are responsible for less acute, but black and white vision that is during that we experience at night. So, for dim light vision rods are active. Now many people have the idea that rods are for night vision and cones are for day vision. It is not like that they are receptive cells which are which receive information from the sensory stimulus that is the visual stimulus and they are activated with brighter light or dimmer light.

And that is how? So, even when you see colors at night if you are seeing something as of a reddish hue or a greenish hue at night that is the cones that are helping you to visualize it is not the rods because its night. So, it does not have anything to do with the diurnal variation now. So, how do we how do we look at an object on the environment in space? If you look at this retinotopic topic map you will see that there are light rays falling from different angles of the cup and saucer.

And once it hits the eye that is through the pupil, it the image is formed on the retina as a reverse image and from there through the optic nerve, it goes to the different parts of the to a certain part of the brain and again after that it travels back to the back of the brain where the secondary processing is done. I am going to explain this a little more.

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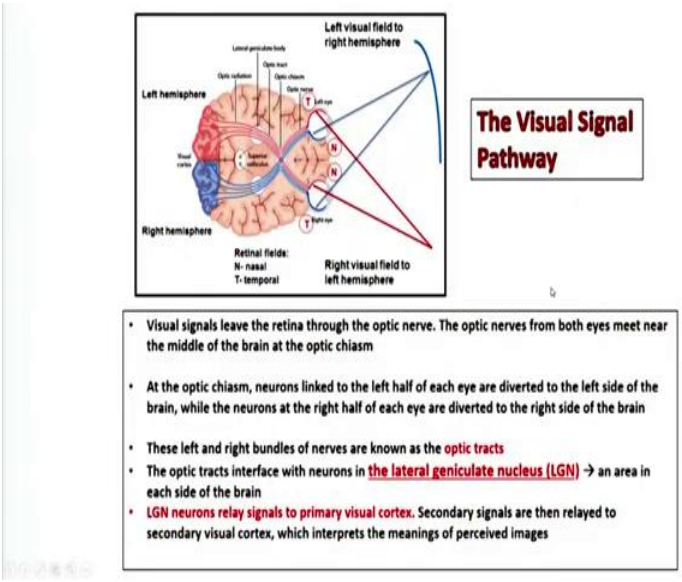


So, if you look at the visual signal pathway. So, here the eye is to the right the face is facing right. Now if you look at the left eye and the right eye what it does is it receives information and information they leave through the optic nerve ok.

So, the visual signals leave the retina through the optic nerve and the optic nerves both meet near the middle of the brain and this is known as the optic charisma or opticalism and from the opticalism you can see that we when I was small I had the idea that it just crisscrossed and moved on the opposite side that is not true a part of the information is carried all at the same side.

So, from the left eye if you see these red lines a part of it is going to the left side, but there is also a cross and it comes to the right side of the brain and its similar on the right eye. So, the retinal fields they do criss cross, but there is also an information from the same eye going to the same side of the brain.

So, at the same hemisphere and then these left and right bundles of nerves are known as the optic tracts these are the optic tracts and after the optic tracts interface with neurons in the lateral geniculate nucleus here is a place called the an object or I should say a body called the LGN or the Lateral Geniculate Nucleus on each side of the brain and this is actually the relay center.

So, it signals to the primary visual cortex and the primary visual cortex is here at the back of the brain you are already aware that it is in the occipital region of the brain and these secondary signals are then relate to the visual cortex which interpret the meanings of perceived images.

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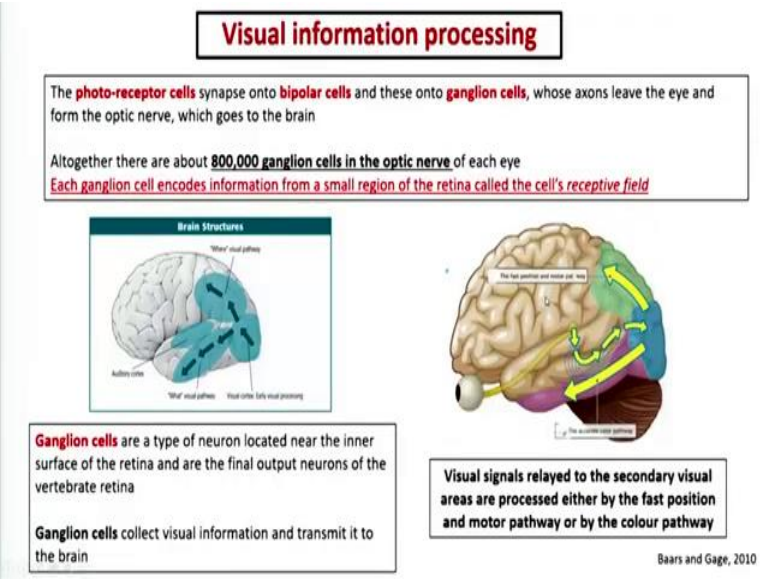


So, now let us look at the kind of cells that are required for this whole process we have already spoken about the photoreceptor cells or the rods and cones.

And these synapse onto the bipolar cells and these onto the ganglion cells are again the bipolar cells as well as the ganglion cells are very very important for visual processing. So, mostly we are familiar with the rods and cones, but beyond the rods and cones the ganglion cells and the bipolar cells are also very important for visual processing and the ganglion cells they their axons leave the eye and form the optic nerve.

So, that goes to the brain and there are around 800,000 ganglion cells in the optic nerve of each eye and each ganglion cell can encode information from a small region of the retina and this is called the retinals this is called the cells receptive field. Now you can already understand that if there are so, many cells how are they spread across its a very interesting phenomena now, but ok maybe we can discuss it some other time or maybe we can discuss it in the forum.

The ganglion cells are located near the surface of the retina and other final output neurons as you could well understand and these they collect visual information to transmit it to the brain through the optic nerve. The visual signals relate to the secondary visual areas are processed by two positions.

So, as you can see from the eye this is the pathway from the eye it is moving back to the air to the occipital areas and from here there are two pathways either by the fast position that is the motor pathway, its moving towards the parietal areas and for the color position the color pathway it moves towards the temporal areas.

So, there are two pathways that are generally followed by the visual signals and as you can see on the left side of the slide the fast position is more for the where pathway and if you are looking at what the object is. So, its more like the recognition of the object requires the color and the color processing it requires to move towards the temporal areas of the brain.

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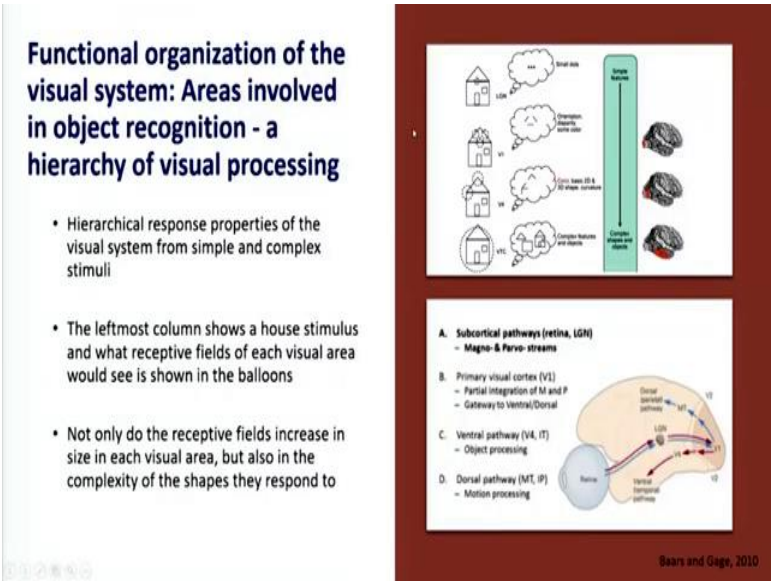


Now, so, say now if you are looking at an object ok and it involves a hierarchy of visual processing. So, the response properties of the visual system are from simple to complex stimuli. And if you look at this the this house initially, it is processed as dots and then there are some which some cells which look into the orientation disparity of the differences, in the directions the colors.

So, this is the V 1 area that processes these specific features and then the V 4 area is actually looking more towards color the 2- D dimension and 3- D shape the curvature. So, these are again some features that are identified by the V 4 area in the visual cortex of the visual areas.

And the VTC it looks again at more complex features what would they be is it what is embedded what is occluded. So, occlusion gives us an idea of what is in front what is at the back and so, if you look at this there are multiple features that are being processed from simple to complex and there are different areas of the brain that are responsible for this processing.

So, if we are looking at the subcortical pathways from the retina and the lateral geniculate nucleus, you will see that the primary visual cortex that is V 1 here at the back of the brain that is where partial integration is done and it is the gateway to the ventral pathway and the dorsal pathway. So, the where pathway and the what pathway and the what pathway is where the object processing is done. So, here we recognize objects we look at color, we discriminate objects and the dorsal pathway that is the parietal area.

The where pathway it helps us to understand movement, it helps us to understand the orientation where exactly the object is in the field of space and these two are combined to understand depth distance and form.

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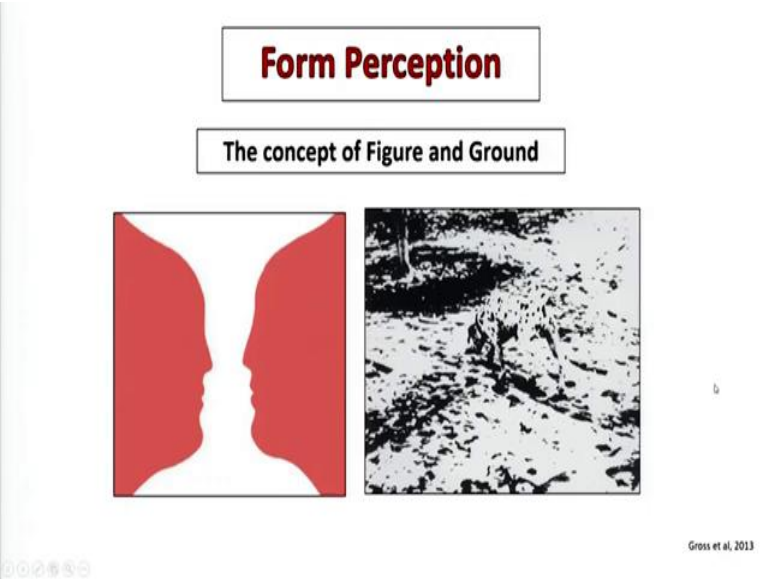

Now, when we talk about form perception. So, it is the studies that were initiated by way back by Hubel and Wiesel in 1962, they showed that these features need to be detected to understand form. And their work which of course, won them the Nobel Prize where from the primary studying or studies of the features of the perception of cats primary visual processing of cats and they were trying to detect the features and they found that there are specific kinds of neurons specific kinds of cells not sorry not neuron cells that actually look at edges, that look at straight lines and that look at curvatures.

So, as I was just mentioning about the features and these discriminate or these help in discriminating one form from the other. Now what happens in form perception is exactly this. So, it is so, the kind of features that the discriminates the edges of one form from the other. For example, if I have my mobile phone on my palm or let me just have my this pen on my palm you can understand this object on my palm because the edges are different this form is different the properties of this form is different from my palm.

So, when I put the object on my palm it is standing out now how does the eye understand that its standing out. So, its on the retina you have a 2- D image. Think about if you would need to draw this if you would have to draw this on a sheet of paper what would you do? You would use other features you would use shading, you would use occlusion. So, this part where this form is that is occluded.

So, that is that cannot be seen and you would use you know curvature shading for curvatures the texture is different the color is different. So, that is how the brain also input takes these feature detectors and inputs in processes information. Now the that is how the concept of figure and ground is created, but a very interesting thing is and this these get blended if the detectors if the features of the object if you see on the right side of the picture, the features of the object or of the form is not very distinct from the background.

So, the edges are not very distinct then it becomes a problem to understand and that is what we use in camouflage. Again if you look at the left side left image this image you will you will be able to see two faces in pink and a white bars now what is happening? This is a bi stable image now in such images the background is has a meaning by itself. So, mostly in forms the form stands out because the background by itself does not give us detailed meaning.

For example, if I put this here and if I just if this part has been removed if this part it the rest of the if I say that the rest of the hand does not make meaning it is like the pen is on the hand this is the background, but imagine look at this figure on the left you will see that the once the two faces become the figure, then the white is the background, but if you perceive the base or the bars you will see that the pink part becomes the background. So, these this the faces become the background.

Now so, here there is that is why the both the images demand our attention and that is why you know we have we can give interpretation to both the images. Now when we talk of form perception it is beyond the edges and bars right.

So, just by knowing where the lines and bars are located in space is not enough we need to know which ones go together to form objects. So, this is done by the brain following a kind of organization and this organization principles are known as the gestalt principles ok and gestalt principles of organization and why is it the gestalt principles?

Because a school of psychology called the gestalt school they came up with this idea about form perception. So, Wertheimer was gave it way back in 1912 in 1923, 1932 and he proposed that there are a set of rules or set of principles that actually help us to identify form. The most interesting thing is at that point Wertheimer worked from was a psychologist and the kind of principles that he spoke of. Now if you look at the way the cells coordinate information they also do it by clusters. So, they also follow the same principles.

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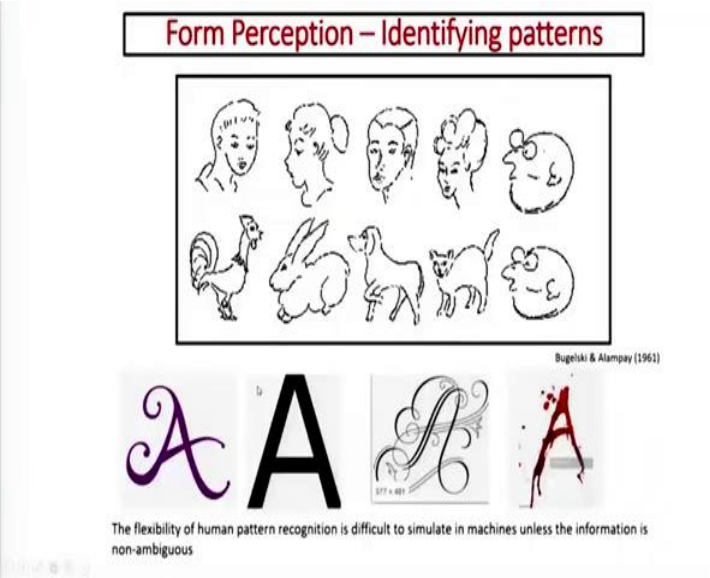


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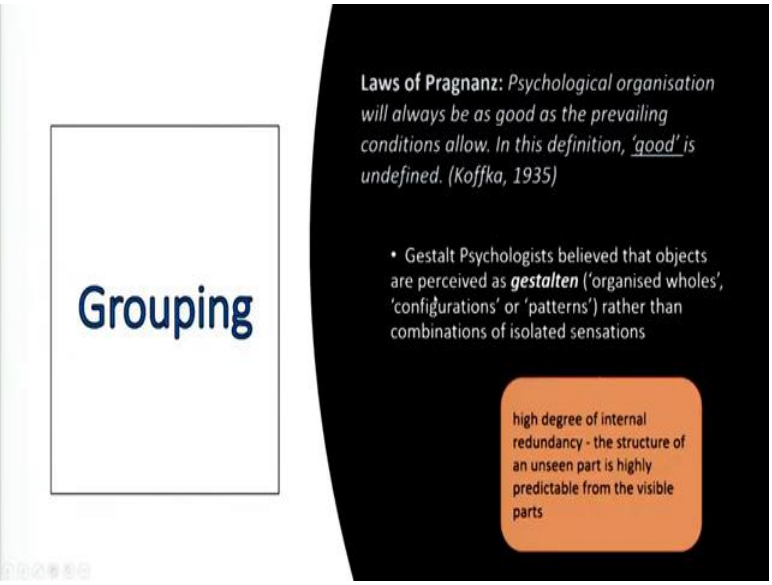


Now, let us look at these principles these are known as the Laws of Pragnanz and what does that mean? It is a psychological organization will always be as good as the prevailing conditions allow and in this definition good is pretty undefined ok what does that mean? When they say gestalten. So, it follows the rules of gestalten that is as organized holes or configurations or patterns.

And its not when we are perceiving something, it is perceived as an organization it is not a combination of isolated sensations. So, the gestalt psychologists they spoke of these

laws of psychological organization or grouping and they said that there is a high degree of internal redundancy and the structure of an unseen part is highly predictable from the visible parts.

So, you will often see that this is known as a concept of closure. So, if you are looking at a hat and a stick a black hat and a stick and a bow tie, its very easy to conceive that this is the image of Charlie Chaplin. But you are not seeing the image of Charlie chapter you are not seeing the face, but because of the other features you can predict the things from the visible parts. So, the brain tries to fill in the gaps.

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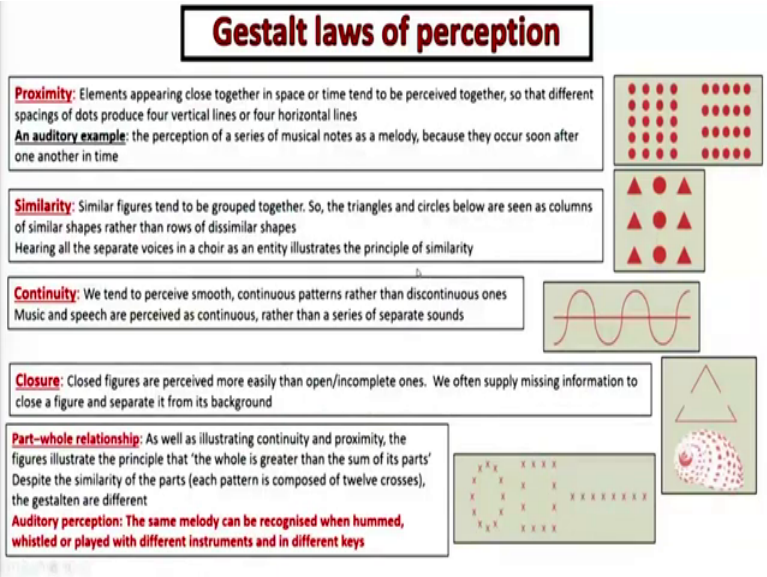


As we will see in these laws so, what are the gestalt talk laws of perception? Number 1 is proximity and elements what does that say? Elements appearing close together in space or time tend to be perceived together. So, that spacing of dots produce four vertical lines or four horizontal lines as you can see on the right side of the page. So, because of the spacing we see them as horizontal lines because again the inter dot space is more between the rows and between two objects its less we have perceived this as rows and these as columns right.

So, in auditory sensation the perception of a series of musical notes as a melody because they occur in sequence and this we can follow this in continuity. Continuity is again another gestalt law and if you look at this figure that we do not see these as a series of

curved lines. So, this is a half line and you know a crest and a trough a crest and a trough, but what we see this is a is as a curved line intersecting a straight line.

Now, this is also when we are in auditory sensation, when there is we do not perceive spoken words as discrete, but we can perceive that as a sentence even in music we do not hear of different instruments as discrete you know sounds or noise, but we perceive it as a continuation in music similarity is another gestalt law and it says that figures tend to be grouped together.

So, the triangles and circles in this case are below are seen as columns of similar shapes rather than rows. So, because they are similar one very interesting phenomena about how we use similarity in social perception. All Mongolian features people with Mongolian features we perceive them as Chinese we cannot discriminate between one Chinese individual and the other they all look similar to us ok.

So, we group them together even in social perception and in fact, many a times because of our generalizations about different kinds of groups, we have we form our stereotypes also. Now coming back to the other gestalt laws closure is another gestalt law and if as I was just mentioning about the picture of Charlie Chaplin or if you draw the specs of you know around specs, it will be seen by most as imagined by most as Gandhiji the younger population of course, may confuse it with Harry Potter.

But if you look at this image this though there are gaps this is not continuous, the lines are not continuous you will still perceive this as a triangle. As I showed you on the first slide the spelling understand and seeing were wrong, but because you saw it as a whole you know the template of how understand is written and how seen is written an extra e in the word or the positional change of n and d in the word understand did not stop you from reading it.

So, this is because our brain does the correction themselves itself. Now the final one is part whole relationship and here because of we spoke about the similarity we spoke about properties that have you know help us to group things together you will see that these crosses are not seen as individual independent units, but we do not see it as 12 crosses, but we see it as an oval a square and a straight line.

And this you know in auditory perception if somebody is humming a tune the same tune in different instruments, it does not or you know playing it in different instruments or humming or whistling it we would still understand that its the same tune and even if it is played on different scales. So, the there are some properties that are seen together and actually that is how you know the cells also process information. So, they features that are similar are represented in a space by you know together.

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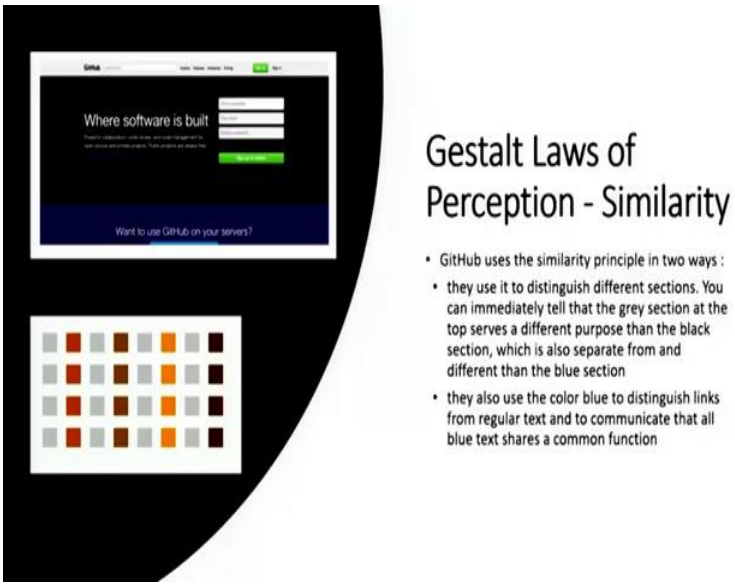


Now, gestalt laws of perception are pretty often used in advertising. So, if you look at the figure ground effect. So, that is the object coming out standing out and there is a background, this is used pretty often if you look at these angel list uses the figure ground principle in two ways and the text and the logo, you can go through these later because the slides will be provided to you here this follows the gestalt law of similarity.

So, GitHub uses the same principle and you know they use the color blue to distinguish links from regular text and to communicate that all blue text shares a common function. So, many times when we write our references we write it in a different text or you know different color on slides. So, that to indicate that well these are references.

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Proximity is used by most of these websites. So, you know following this principle of having things at a closer distance from each other. So, this implies that the corresponding text is coming communicates with the image that they are together each image and its text. And approximity is also used to distinguish between images headlines. So, this image with this headline comes together there is a gap and there is another image with a headline which comes together and that is how you know these are discriminated.

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So, common region again Pinterest uses this in fact, even Facebook. Facebook uses this gestalt principle to communicate that these are the comments likes and interactions are for this specific post. Pinterest does it by using each pin. So, the title the photo description contributor these all come under one thing.

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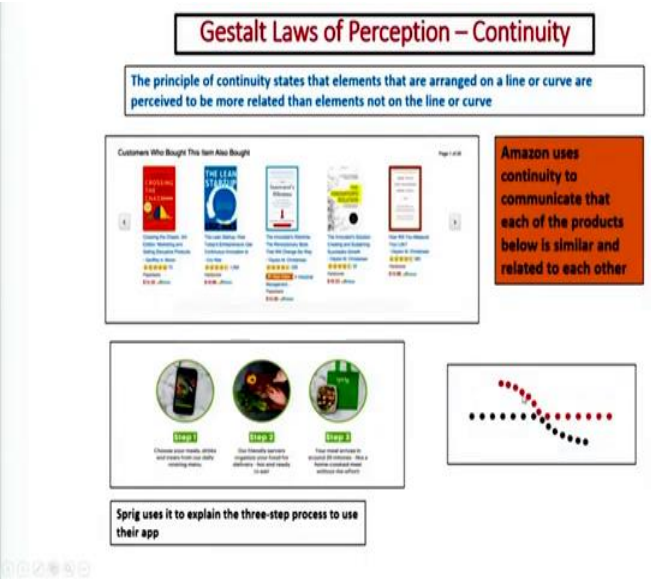


We already spoke about proximity, in continuity also it is similar to proximity and websites pretty often use it to show that these are of the same you know same genre. So, even sprig uses it to explain their three-step process to use the app. So, continuity as we saw that irrespective of the change in color you see you will see it as a straight line and a curved line.

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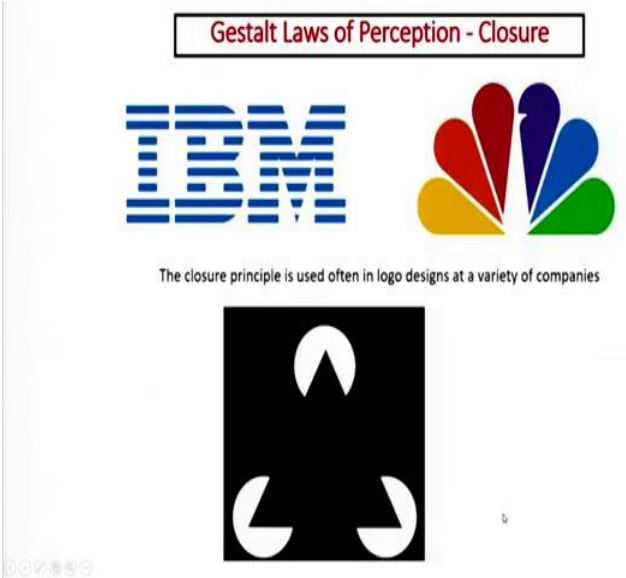


Closure this is again another very very common phenomena or for use by several logo companies IBM uses it and you look at this, can you see the black triangle coming out? So, this is a another common feature of you know Gestalt Laws that is used in advertising.

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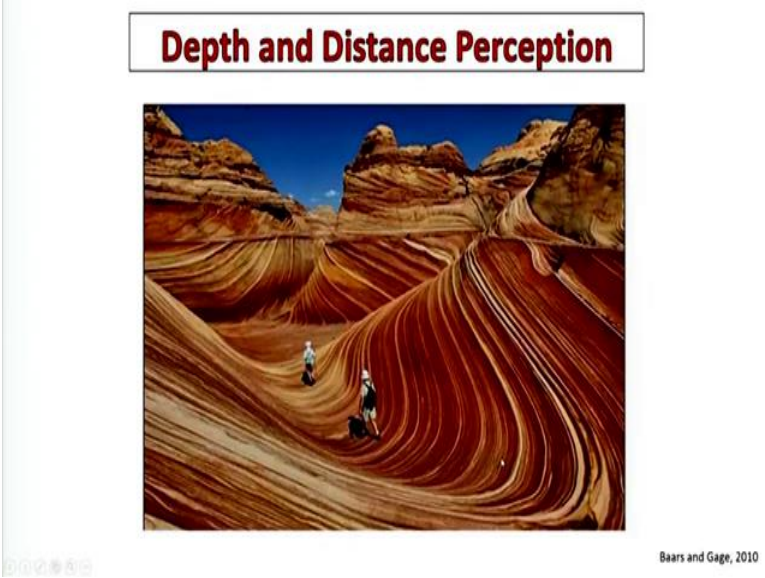

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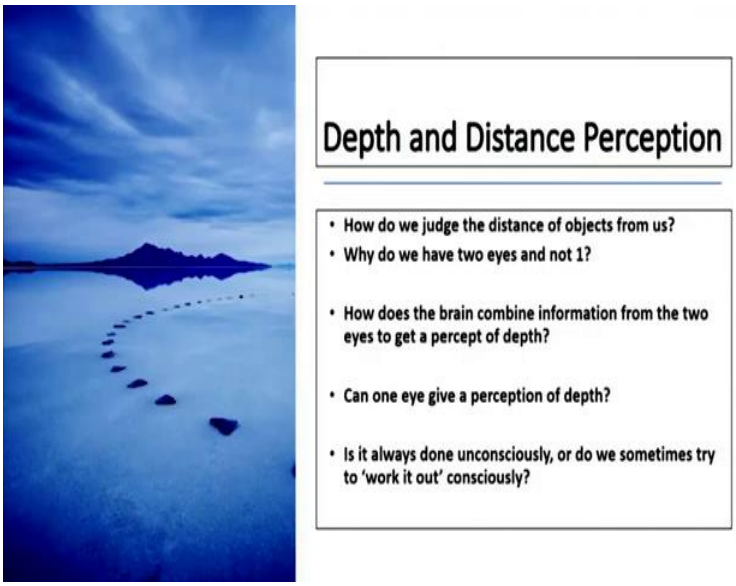


Now, coming to depth and distance perception so, again how do we judge distance of objects from us? And what would happen if we had one eye and not two? So, there are multiple questions that need to be answered when we are talking about depth perception. So, how do the how does a brain combine information from both eyes? Can one eye give us a perception of death? Depth is it always done unconsciously or do we try to work it out consciously.

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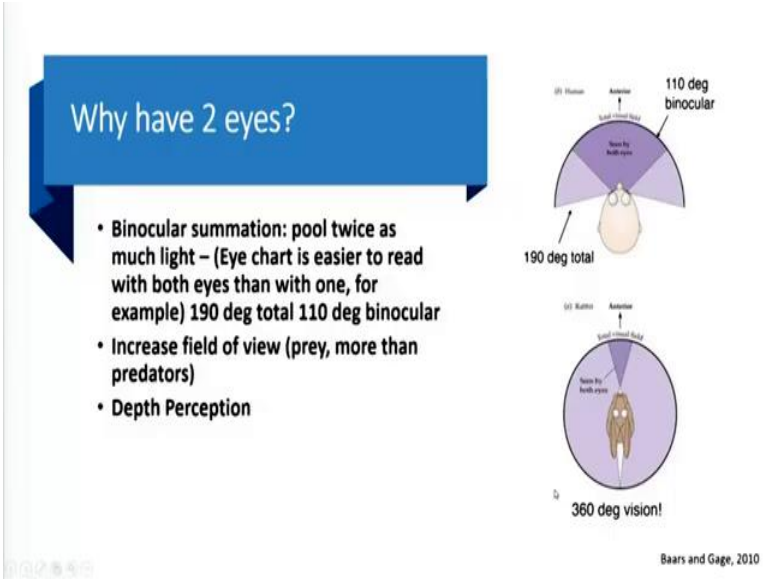

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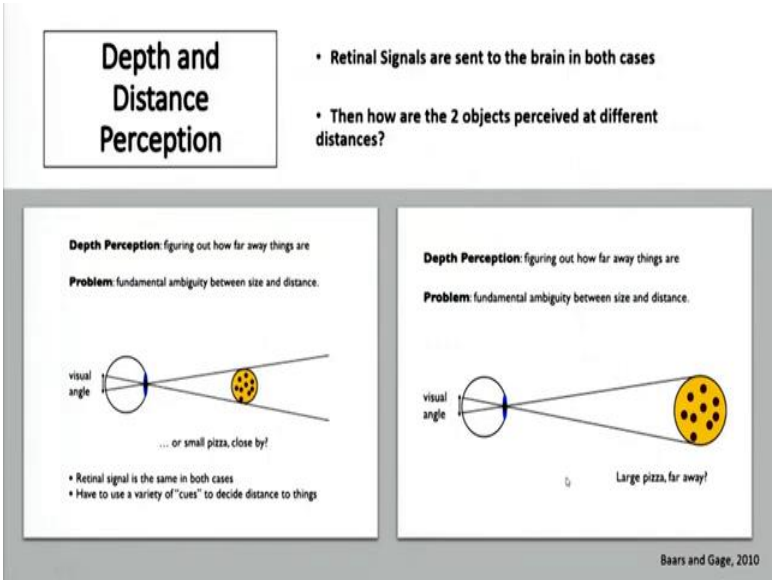


So, the two eyes give us when we are looking at what is the problem with depth perception? Because on a retina the retina gives us a 2- D image. So, the object is seen as a 2- D image. So, whether the object is this small or it is this big its seen as the same size on the retina.

Now, we need to the what is where is a problem? The ambiguity between the size and the distance. So, this is near and this is far how do we figure that out? So, if it is say consider this if there is if the angle is the same are we seeing this as big are we seeing it as big because the object is big? Or is it because it is far away or are we seeing this as this size as small this size because it is nearer to us or because it is small in size?

So, these are the confusions that one has from a 2- D vision. So, with only this amount of information we cannot process depth and distance.

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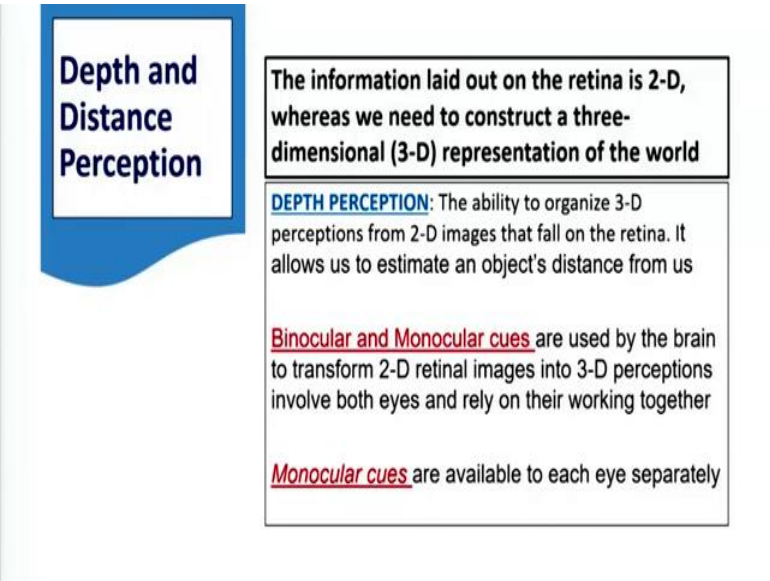


So, what do we do we take in different kinds of cues from the environment as well. So, there are two kinds of cues that are used to organize a 3- D perception from 2- D images and these are known as binocular and monocular cues.

So, binocular cues are used by the brain to transform 2- D in retinal images into 3- D perceptions and these involve both eyes working together while monocular cues are available to each eye separately. So, what are these cues?

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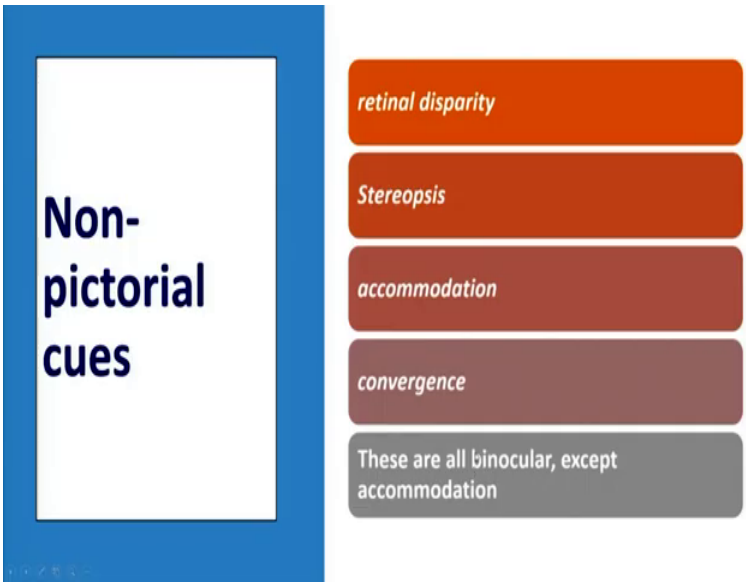

So, again they can be divided into pictorial cues and non pictorial cues. In the non pictorial cues as you understand the these are not pictorial cues would suggest that they are from the environment from the picture that you see around you.

Now, all these cues except accommodation is non pictorial cue they are all binocular cues and so, binocular means they require two eyes they are not pictorial cues they are not from the environment, but because of some of the anatomical changes or rather I should say anatomical structural positions, that give us the information of depth and distance, but and these require both eyes except accommodation which can be by just one eye that is a monocular cue.

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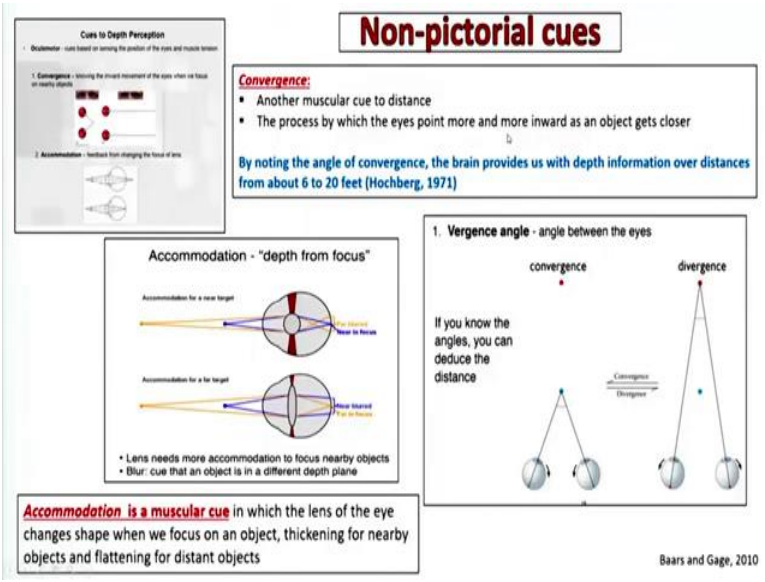


So, what are the non pictorial cues? There is the most too important are convergence and accommodation. So, what is convergence? When you are looking at an object you need to you know change the angle of your eye to perceive the object. Now if it is far away there is less convergence there is more divergence in this case if you look at this. If you look if you are looking at the blue object the eyes need to move more towards the nose.

So, an easy way is you put your finger straight ahead and you try and bring it closer ok. The more you bring it closer the more your eyes will converge this information goes to the brain and the angle between the eyes helps us to deduce the distance that input this non pictorial cue helps us to gauge the distance. Now accommodation is the other cue accommodation is a muscular cue and it can be from each eye independently.

In convergence as you can understand both eyes are required. In accommodation a single eye is important why that there is a if because as I mentioned when we are looking at visual information to get a better equity to get more a clearer image we need to we try and put it on the phobia center list. So, on the retina the best way we get the maximum number of cones. So, to get the best vision so, what do we do? We adjust ourselves adjust our positions.

So, we move our head forward to see it clearly or we move our head backward to see it clearly and similarly not only the head positions, the lens also thickens or stretches to such that the angle of the image falls on the phobia centralist. This is this can be done with one eye also independently ok and you know this input of how much there was a stretch in the ciliary muscles? How much of thickness was required for the lens? This input also goes to the brain to add to the concept of depth and focus depth from focus.

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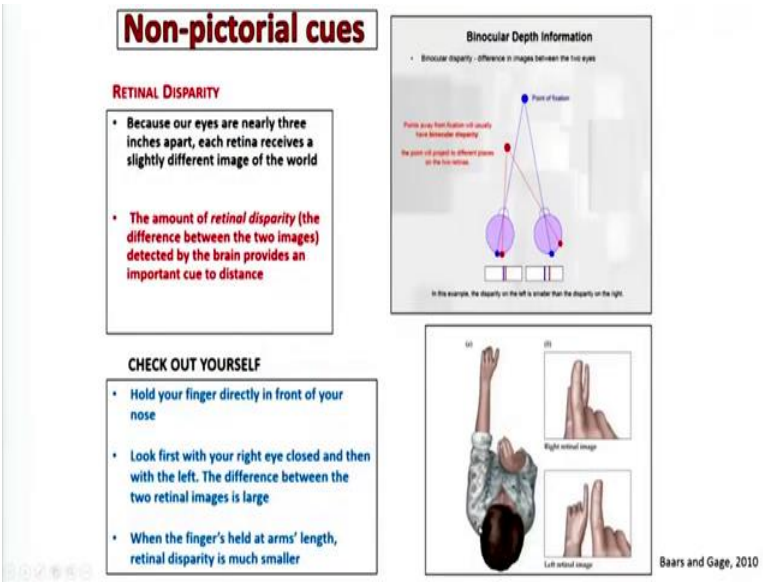


So, the other non-pictorial cues are retinal disparity now what is retinal disparity? Because our eyes are three inches apart if you look at an information from one eye you will see or you know one eye at a time you will see that there is a difference in the distance and this becomes more as you move your finger closer, you can check this out for yourself again if you are just doing it with one eye so, if you just close one eye and look at this finger ok.

And as you move it closer ok and then you look at it with the other eye the distance is very less, but as you move it closer ok you will see that the distance increases. Now this difference of how much of you know how much of difference is there between two eyes between the images of the two eyes tells you that you know how far the object is from you.

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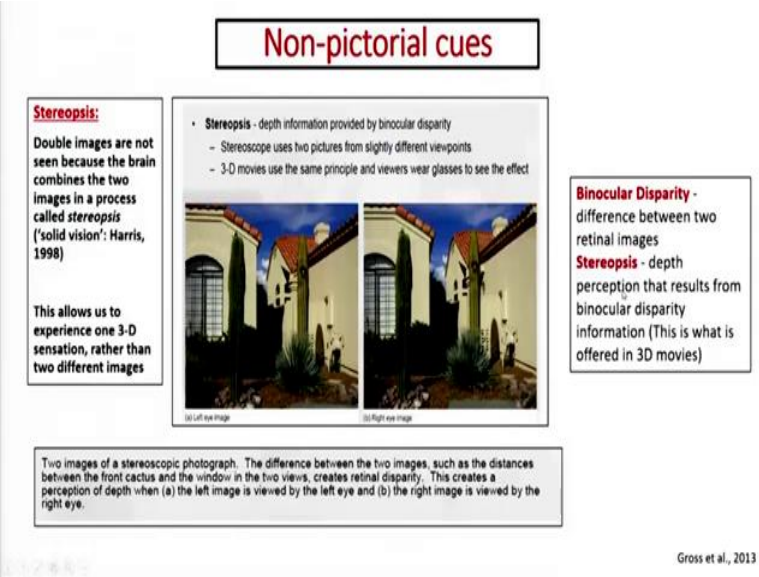


Now, another cue is stereopsis ok stereopsis is depth information provided by binocular disparity. So, if you look at an image you will see that the left eye image is slightly different from the right eyed image. The right eyed image will give you a little more details on the right side the left eyed image will give you a little more details on the left side. So, here you can see the whole window from the left side from the right eye you cannot see the whole window, but you can see a little more of the sky ok.

So, this angle ok now when we see an image when we have our both our eyes open we do not see double images because the brain combines these two information and for something called solid vision and this process is known as stereopsis. So, how much of information is gathered extra information is gathered from both eyes that also adds as an input to help us understand how far away what is the distance or how distant is the image.

So, as you can well understand that if it is further away the input from each eye will not be the added information will be less as compared to if it is nearer.

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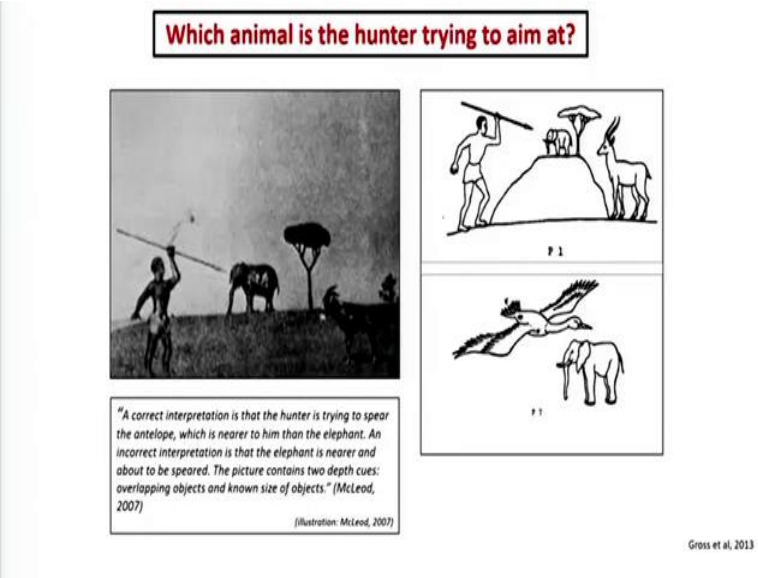


So, now let us look at this. So, which animal is the hunter trying to aim at? A correct interpretation is that the hunter is trying to spear the antelope which is nearby this one ok, but an incorrect interpretation is that the elephant is nearer why? Now if you look at this there are two depth cues overlapping objects and known size of objects.

So, these help us to understand that which is nearer and which is further. If you look at this image it is easier to understand. So, even if the bird is bird is seems bigger in size and the elephant seems smaller, we know this is because of the known size of the object we know that the bird must be closer and the elephant must be further away.

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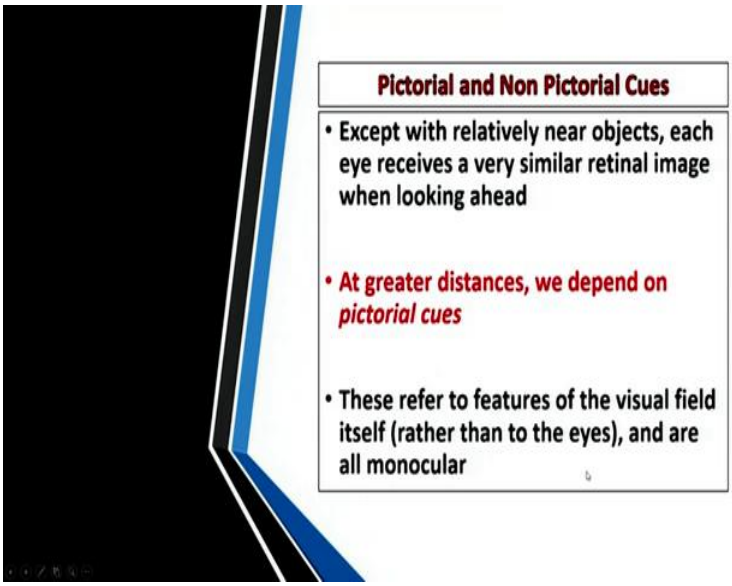


So, its not only the information that we are seeing in front of us, but it is also some of the information that is stored in our memory that provides us to have a better understanding of depth and distance.

Now, if an object is closer to us we rely more on non-pictorial cues, but if it is further away from us say if you are looking at a; at the horizon and trying to see something, we try and use more of pictorial cues and this refer to what are pictorial cues? These refer to the visual field and these are all these can be monocular these are all monocular cues.

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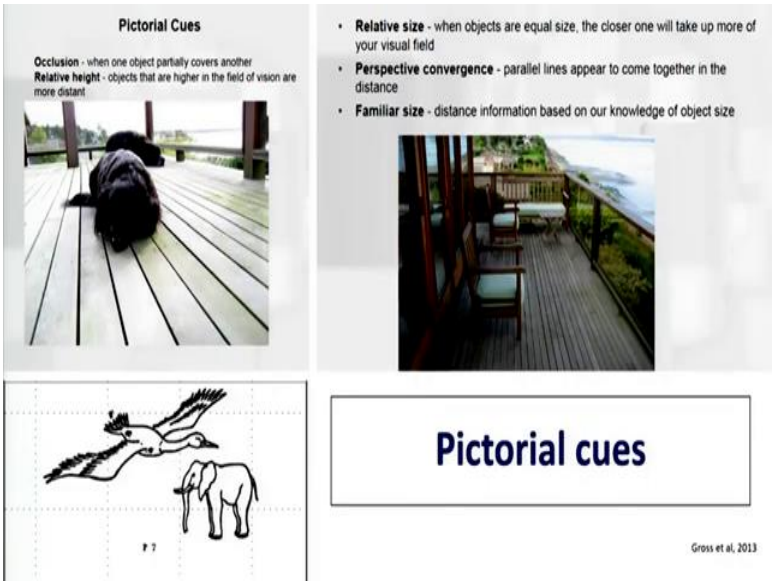

So, one is occlusion I already spoke of occlusion. So, if there is something that is being partially covered by something else then the object that covers something must be in front. So, here this dog is in front of the dog at the back how do we know from this 2-D image? Because a part of the second dog is covered.

So, now, relative size I already spoke about the relative size, the convergence. Now if lines are converging further away. So, this must be a distance now even if you look at this image of the deck, here the lines are more close to each other and they are you know here the objects seem a little smaller.

So, definitely this is further away again you see occlusion is used here. Here there is a bench which is partially covered by the small table coffee table and the chair. So, these must be before the bench ok. So, these are cues that we use to understand what is nearer to us and what is further away.

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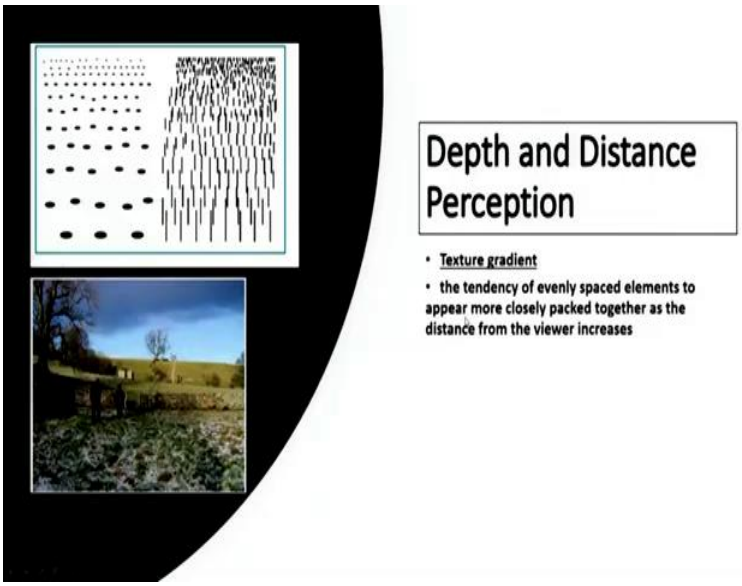


One more very important information property that helps us to understand depth and distance is texture gradient. So, the if there are the texture in front of us if you look at this image is more detailed, but if it is further away, it seems more you know closely packed together and smooth. Now this is if you look at this image you can understand. So, people who draw who paint use these cues to show that this is a tree that is nearer. So, the details are viewed more clearly, but if it is further away that is more smoothened and the details are not very clear.

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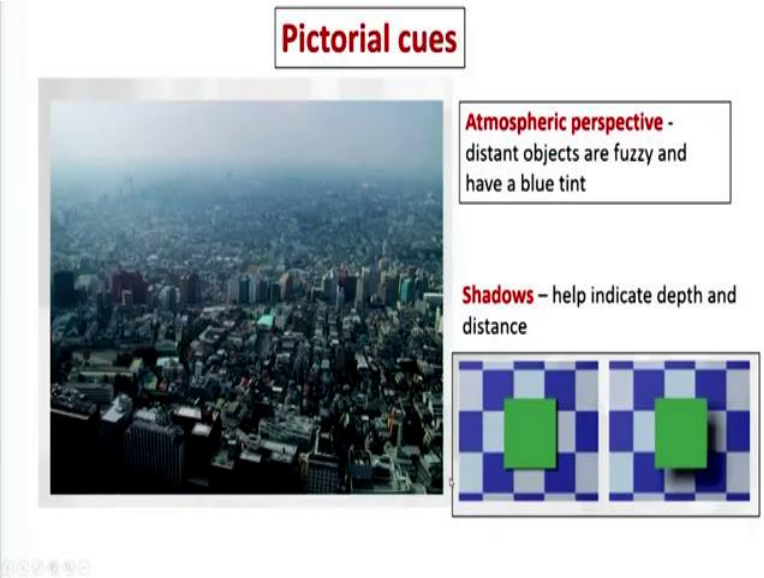


Another pictorial cue is atmospheric perspective. So, distance distant objects are generally fuzzy and have a bluish pink ok, but some things you if you look at these the textures are detailed and these do not have a bluish pink as compared to further away.

Shadows also helps indicate depth and distance. So, look at this 2- D image just by addition of this shadow it seems to be jutting out. So, it seems to be raised from the background plane, here it seems to be on the background plane.

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Now, another cue is a motion parallax. So, close objects in the direction of movement glide rapidly past, but objects in the distance appear to move slowly. This is one cue which you will often see when you are traveling by train.

And in a train the lamppost nearby seem to pass away very fast because the field of vision in the nearer space is much lesser than the angle that opens up widely ok if you are looking at a distance. So, if there is a lamp post further away to go from your field of vision it will have to travel this whole distance, but for a lamp post near or near you if it is here it will soon pass by.

So, you know that input is also used by us to understand that this is further away this is closer to us. Deletion and accretion objects are covered or uncovered as we move relative to them and we also. So, that is also you know occlusion in motion as I said it passes away very quickly.

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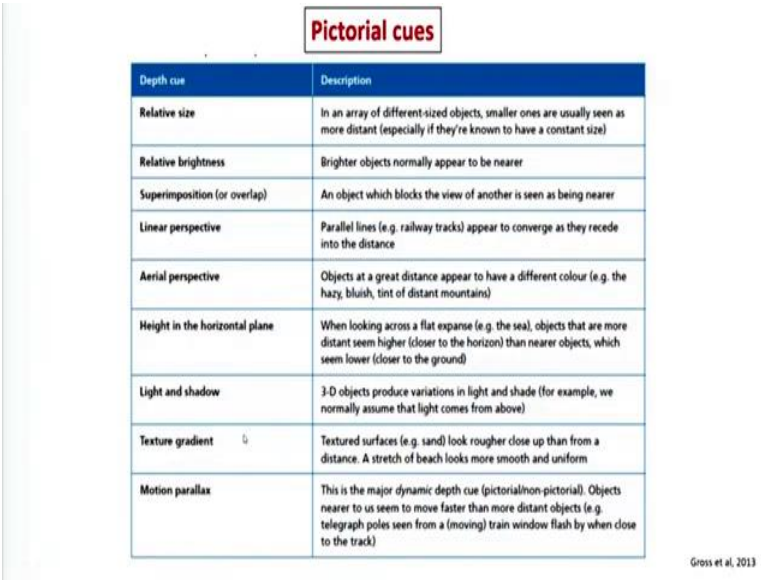


So, these are the pictorial cues you can take a look at this in details later on in the slides that are provided I spoke of almost all of this ok.

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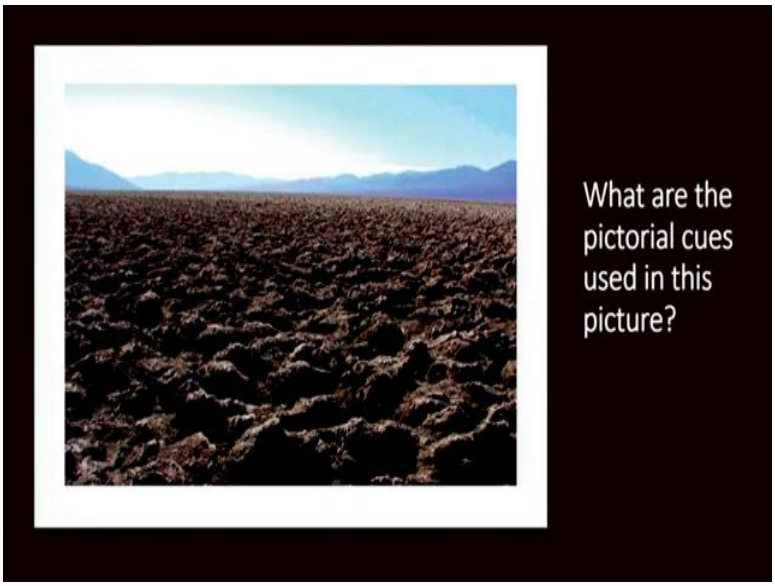


And to ask yourself that what are the pictorial cues that are used in this picture.

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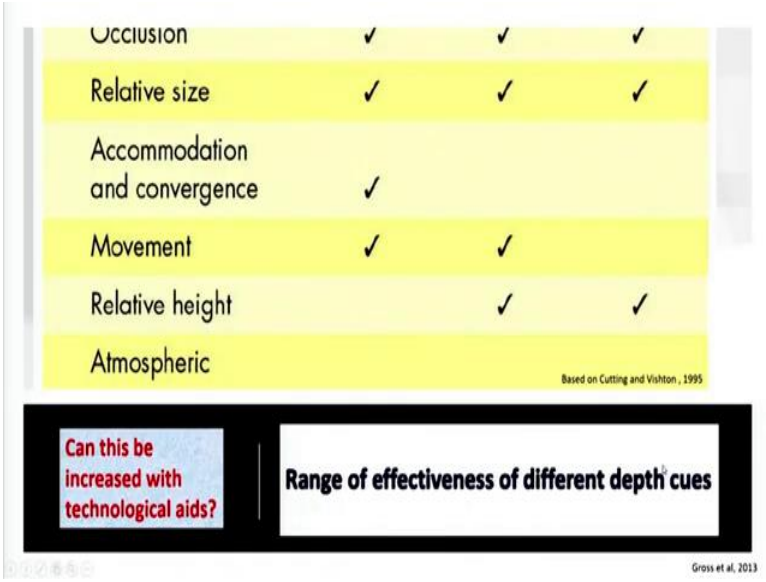

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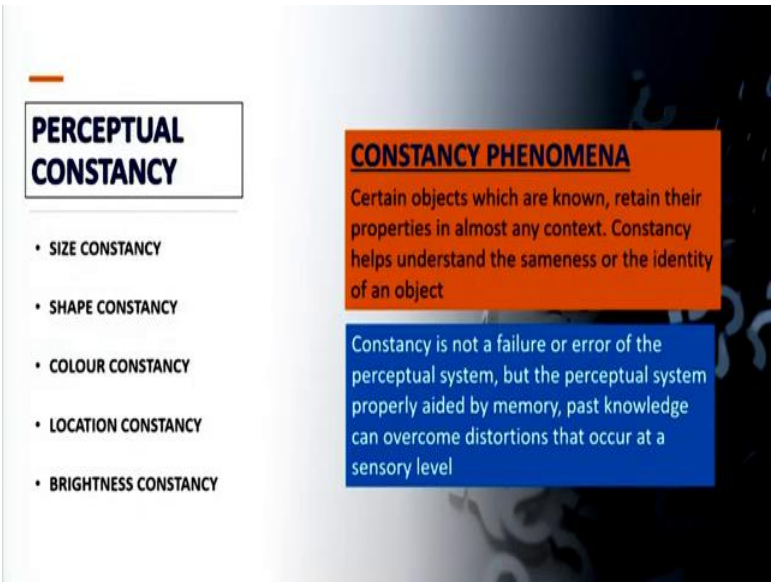


So, this brings us to our next lectures topic that many a times these cues that we use and our earlier understanding of you know of cues of our past experiences with the visual world help us to have perceptual constancies. So, like you know these constancies these ideas about depth and distance that we have been trained to over time which we have learnt through the years is also a reason for illusions.

So, in our next class we will in today's class we discussed about form perception depth and distance perception. I would there are many more things in perception that could be talked upon, but in the next class we will try to talk more about the perceptual constancies and move on with how constancies and constancies cause illusions. So, that would cover our 6th week of attention and perception.

Thank you.