Vision
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Depth Perception

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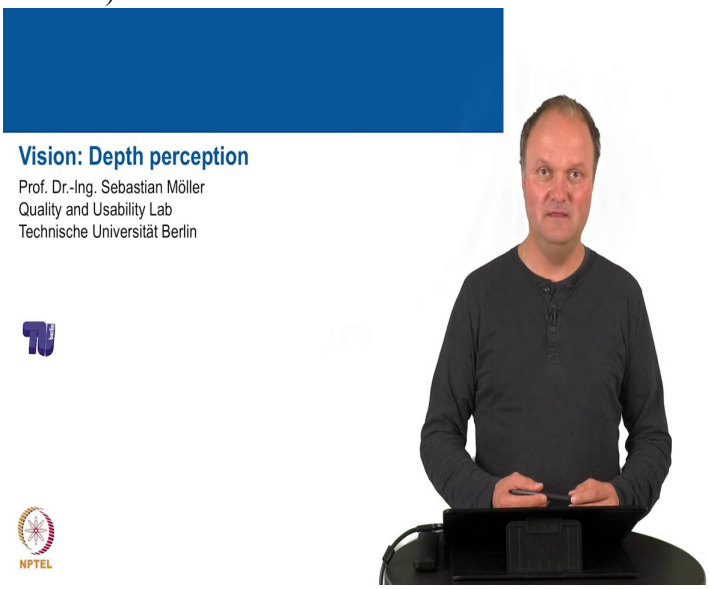

In this video we will explain some principles of perceiving depth that is the distance between the observer and an object.

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Actually in order to analyze the depth of a scene, we have different so-called cues; that is sources of information of the retinal image which are used in order to identify certain depth of an object in the scene.

And we learn the connection between these cues and the depth by repeated exposure so that this association becomes automatic through our experience. There are two types of cues which can be distinguished, the first ones

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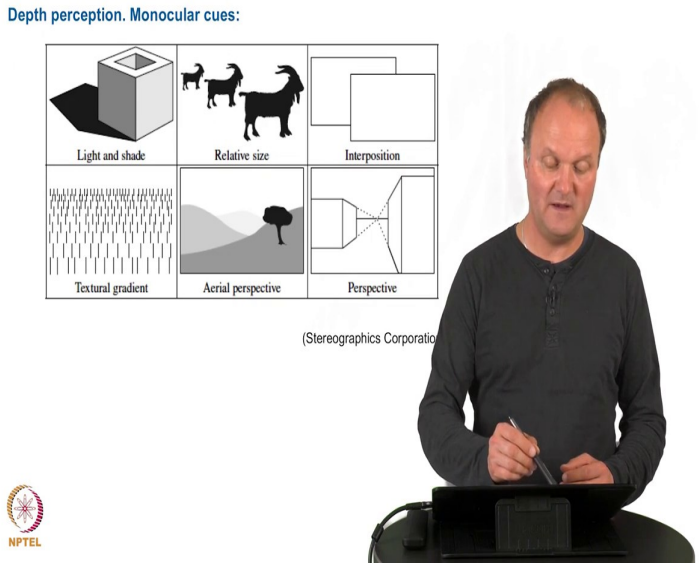

are the ones which result from viewing with only one eye, so-called monocular cues. And you see examples of these monocular cues in the picture behind me.

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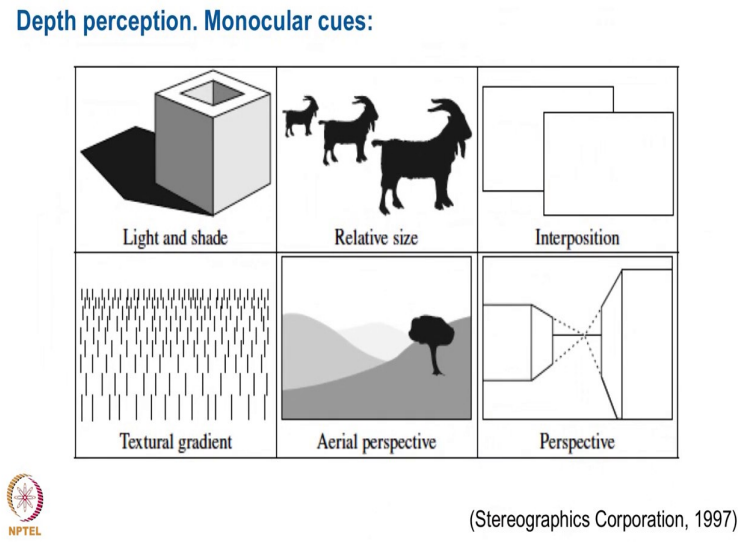

There is for example, the principle of Light and Shade that is an object produces a shadow when it is illuminated from one side and the shadow usually goes to the back of this object. There is the Principle of Relative Size; that are objects which are more distant from the observer are small in size.

There is the Principle of Interposition; that is two objects may overlay each other and the one which is overlaying is actually the one closer to the observer.

There is the Principle of Textural Gradient; that is repeated objects seem to be more fine-grained in the distance, there is the Principle of Aerial Perspective that is objects which are further away in the air, they are lighter and they have more grayish color.

And there is well-known Principle of Perspective which is sometimes used in pictures in order to produce artificially depth.

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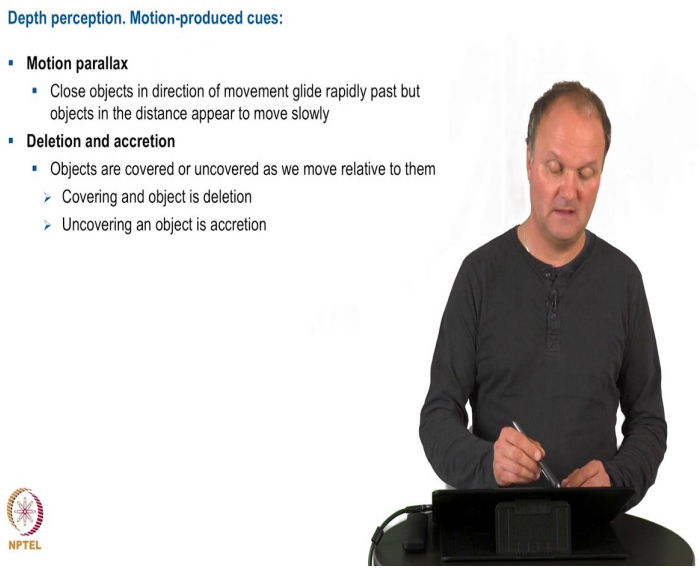

These cues come together with cues of dynamic nature which happen when we move. It is the so-called Motion parallax which is that close objects in the direction of movement glide more rapidly past than objects which are at a distance.

And then objects may be covered and uncovered as we move relative to them, the covering is then called the deletion and the uncovering is called an accretion.

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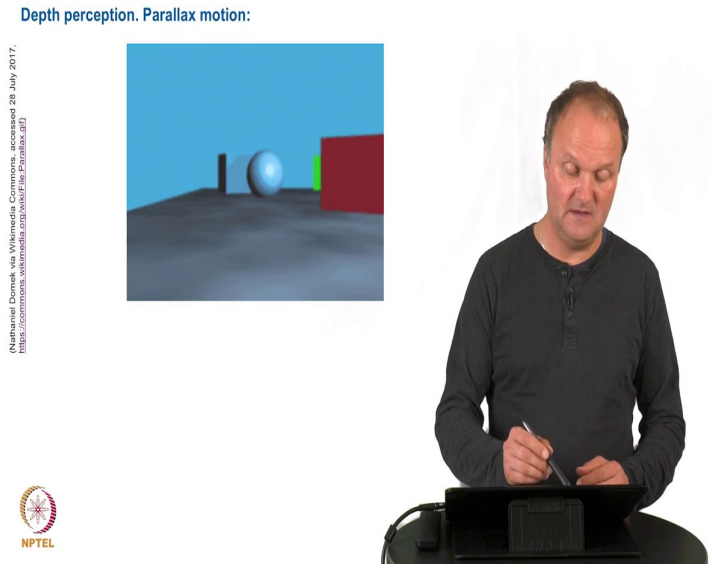

And you see examples of those objects, with slow movement of objects which are further away and also covering and uncovering of objects as we move around.

These static and dynamic monocular cues

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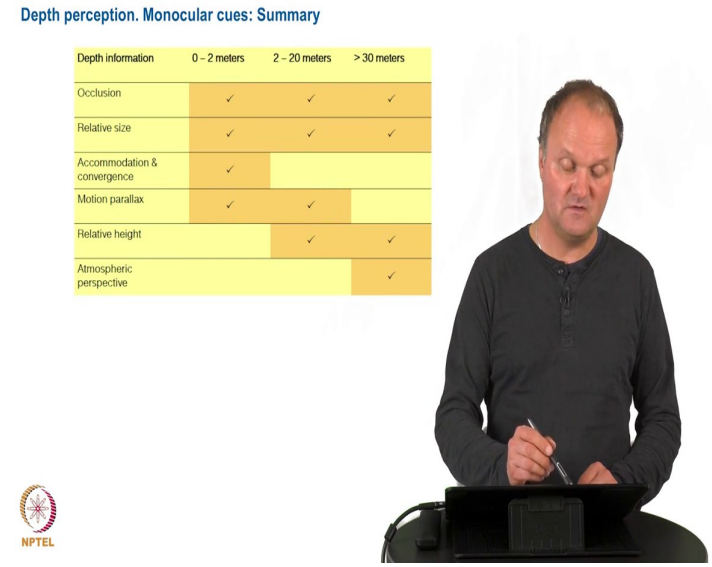

are effective at different distances and you see an overview here.

In the table behind me there is, for example, the Principle of Atmospheric perspective and Relative height which is more effective at distant objects and there are principles like Occlusion, Relative Size, Accommodation and Parallax, Motion parallax which are more effective at closer distances to the observer.

In addition to these monocular cues, there are also so-called

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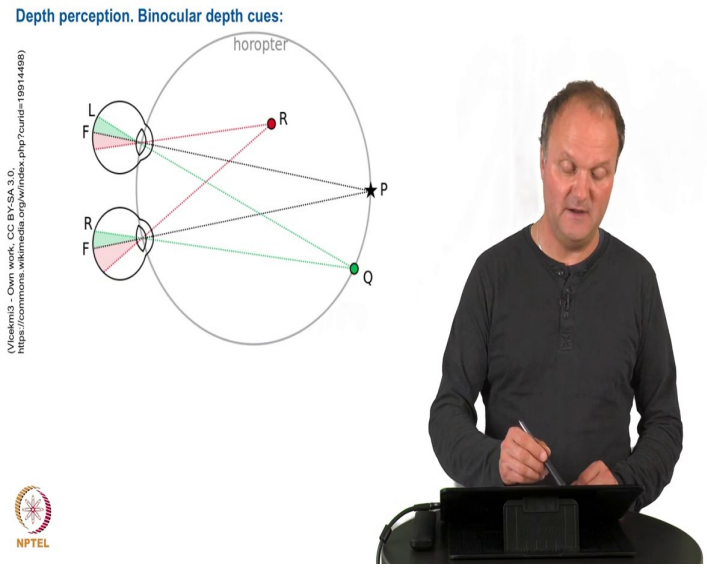

binocular cues which only happen because we have two eyes. And two eyes means that we can actually analyze the difference in the retinal images from the two eyes. This difference is called the binocular disparity and the analysis of this helps us to identify depth.

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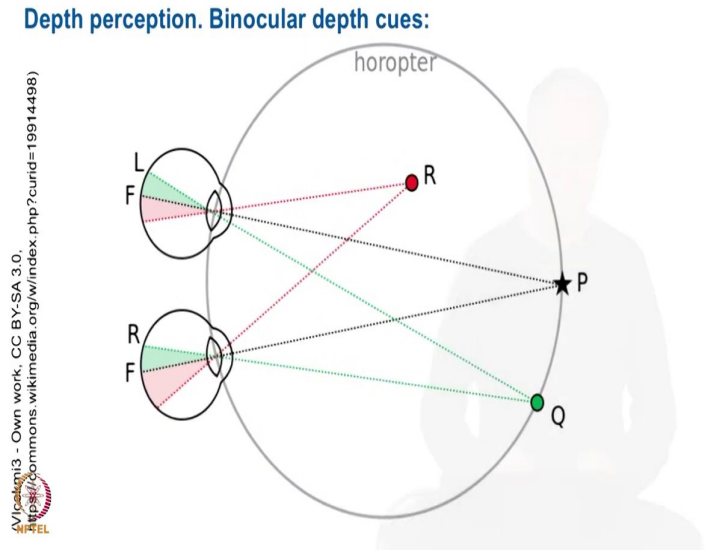

In order to do so, it is important to understand the concept of the horopter. The horopter is an imaginary sphere that passes through points of focus F

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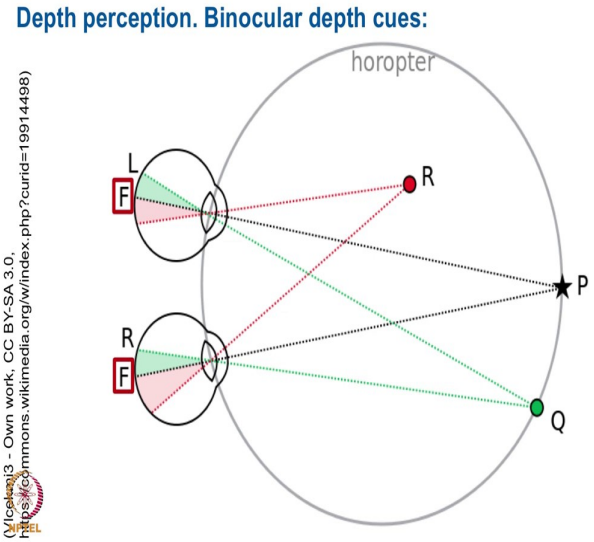

which you see on the left hand side of this picture.

And these points which are on the horopter produce the same distances from the retinal images to the focus points of that respective eye. That is we have the same difference between R and F and L and F if the object is on the horopter.

Objects which are not on the horopter fall on non-corresponding points that is we have disparate images, that is we have a non-zero value of the disparity R minus L. This disparity L is thus zero for points on the horopter and non-zero for points which are not on the horopter. And this helps us to perceive distance.

Actually we have to sense the positioning of our eyes and there are

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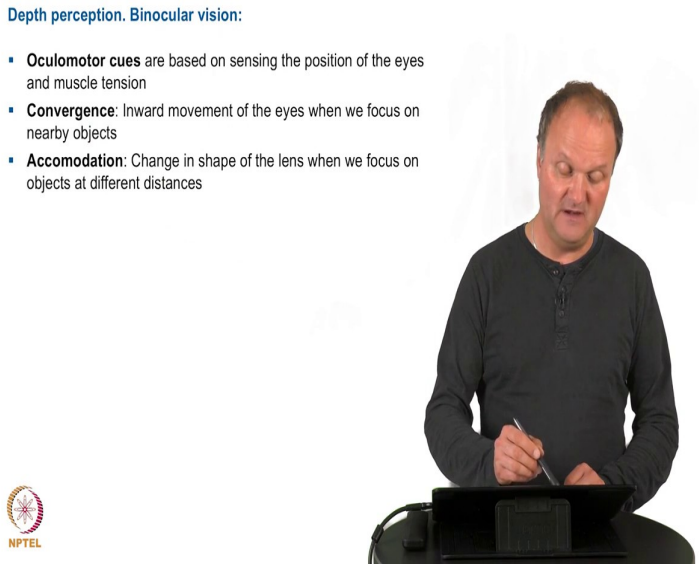

3 principles which are used for this, the so-called oculomotor cues which are based on sensing the information of the eyes and muscle tensions.

Then the so-called convergence which is the inward movement of the eyes when we focus objects which are closer to ourselves.

And then the one on accommodation which I have explained to you in earlier video which is shape, change of the shape of the lens when we focus on object at different distances. All these muscle information can be analyzed in order to derive depth with the help of binocular cues.

There are some technical means where these cues are fooled

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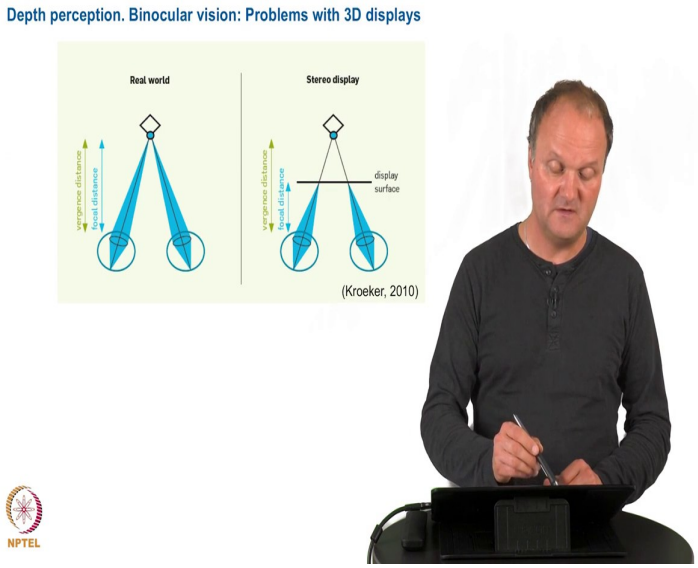

specially when we come to modern equipment like 3D displays.

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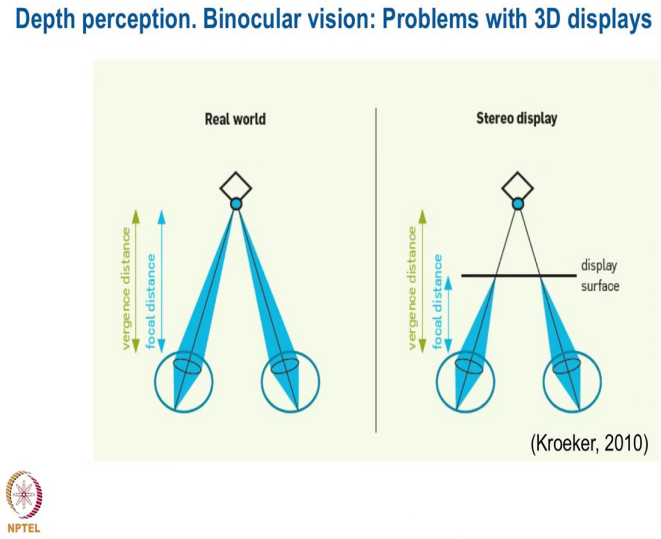

In 3D displays we actually try to produce an object at a certain distance but we are actually producing it on a relatively closeby display surface. So in order to see that object clearly the human observer has to focus on the depth of the display.

But the object he or she actually want to see is further away. So there is the difference between where the eye actually has to focus on and where the object seems to be. And this difference may lead to feeling unwell of an observer especially when he is long exposed to pictures from 3D displays. This does not happen with all observers but it happens with many observers.