Stereopsis

- Edge detection is improved in binocular vision because binocular contrast sensitivity has been shown to be some 40% better than monocular contrast sensitivity.

- Stereopsis works by detecting geometrical disparities between the images of both eyes (much like edge detection works by detecting luminance differences).

- **stereopsis is the ability to perceive depth and 3- d structure obtained on the basis of visual information deriving from two eyes by individual with normally developed binocular vision**

- Stereopsis occurs in two basic stages:

    a. ***First, both monocular images are matched so that fusion is possible***. Here, individual points on the OS image are matched (or correspond) with individual points on the OD image. Independent edge detection by each eye is a pre-condition sine qua non for this stage.

    b. **Second, the fused image is analyzed to judge depth information**

- The lateral separation of the two eyes means that horizontal disparities are more important than vertical disparities in Stereopsis. Vertical disparities are sometimes present, although they are of a much smaller magnitude.

- We said earlier that points in the monocular image of OS correspond with points in the image of OD. This is not exactly the case. What happens is that one image point on the OS image corresponds with a particular area of the monocular OD image. This area is referred to as ***Panum's fusional area***.

- The assumption made in describing binocular fusion and Stereopsis is that Panum's fusional area is fixed for any one point. In actuality, the size and shape of Panum's fusional area, vary with the spatial and temporal parameters of the object/s being fused.

Common methods used to assess Stereo-acuity

1- contour stereopsis (Stereo Fly test)

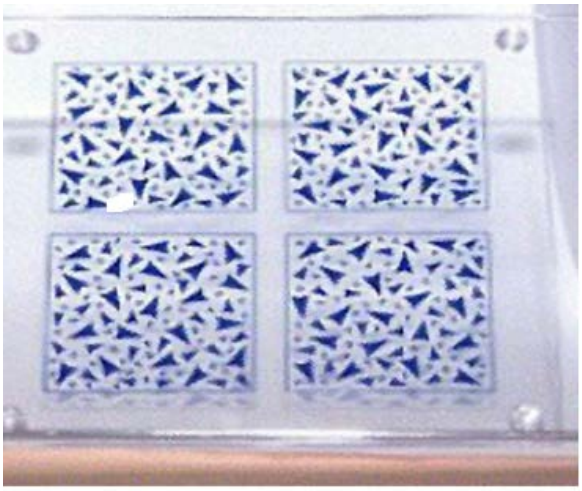
- The patient uses 3-D glasses and asked to look at a picture and determine whether the 3-D figure can be seen.
- The amount of disparity in images vary such as 400-100 sec of arc and 800-40 sec of arc.
- This test also known as The Titmus stereotest.

2- Random dot stereopsis (<u>The Random dot E test</u>) :

- The ran dot stereotest is a vector graph random dot stereotest .It is frequently used for detecting amblyopia ,strabismus.
- random dot test can measure stereoacuity to 20 seconds of arc
- A patient who has stereopsis will see a raised letter E in the random dot pattern of one of the test plates ,where the other plate is blank.

3-Frisby test:

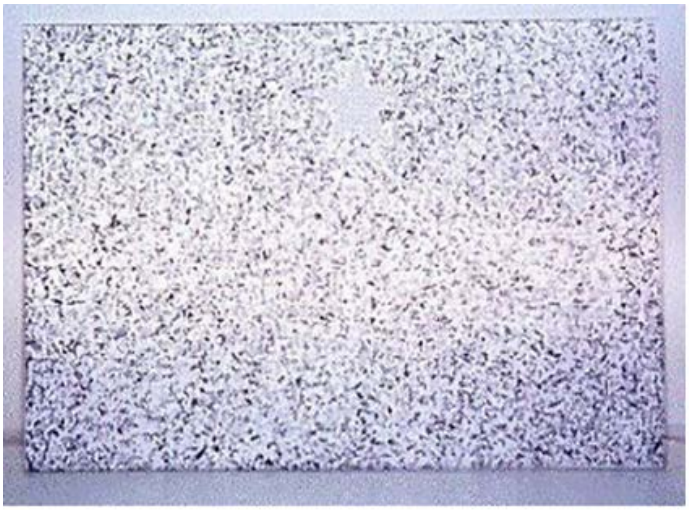
- The Frisby test consists of three transparent plastic plates of varying thickness.
- On the surface of each plate are printed four squares of a small randomly distributed shapes
- One of the squares contains a hidden circle.
- The test doesn't require special spectacles because the disparity is created by thickness of plate.
- The disparity measured is 600to 15 seconds of arc.



The Frisby Stereotest.

4- lang test :

- The Lang test can be used to asses stereopsis in very young children and babies who may reach out to touch the pictures
- It doesn't require special spectacles.
- The targets are seen by alternately by each eye through build in cylindrical lens element.
- Displacement of dot creates disparity and the patient is asked to name or point to a simple shape such as star ,on the card.
- The degree of disparity is quite gross ranging 1200 to 600 seconds of arc at 40cms.



The Lang II.

COLOR VISION

Color Production

Light is an electromagnetic radiation. What we see as light (the visible spectrum) is the range of wavelengths between 380 and 780 nanometers (nm). One nanometer is 10^{-9} meters.

Within this visible spectrum, a person with normal color vision can see about 150 colors.

In the visible spectrum, the following color names are associated with the following wavelengths:

- Below 380 nm ---- Ultraviolet
- 380 - 450 nm ---- Violet
- 450 - 490 nm ---- Blue
- 490 - 560 nm ---- Green
- 560 - 590 nm ---- Yellow
- 590 - 630 nm ---- Orange
- 630 - 780 nm ---- Red
- Above 780 nm ---- Infrared

It is of some importance to note that in the ultraviolet region of the electromagnetic spectrum, we have x-rays, and in the infrared region, we have TV waves, radio waves, and terahertz waves.

Terahertz waves promise to revolutionize our lives in the future. They can be used to 'see' through walls, clothing, and our body tissue. They can also be used to detect tumors and cancerous cells in the body. Therefore, the potential application of these waves in airport screening facilities, and in preventative and diagnostic medicine (to name just a couple of areas), is enormous.

As we know, there are two receptor types in the retina – Rods and Cones. Color vision is a characteristic of cone-vision only. This means we can only appreciate different colors only when our cone photoreceptors are functioning. Therefore, in the fully dark-adapted eye, we only see in black and white, using contrast to differentiate between different objects.

There are about 7 million cones, and 120 million rods in the normal human retina, but neither rods nor cones are uniformly distributed on the retinal surface.

Cones have their highest density immediately around the fovea centralis, in a zone that is essentially rod-free.

While the cones have there maximum concentration 2^0 from central fixation, the rods have their maximum concentration 5^0 from central fixation.

Both receptor types reduce in density toward the periphery.

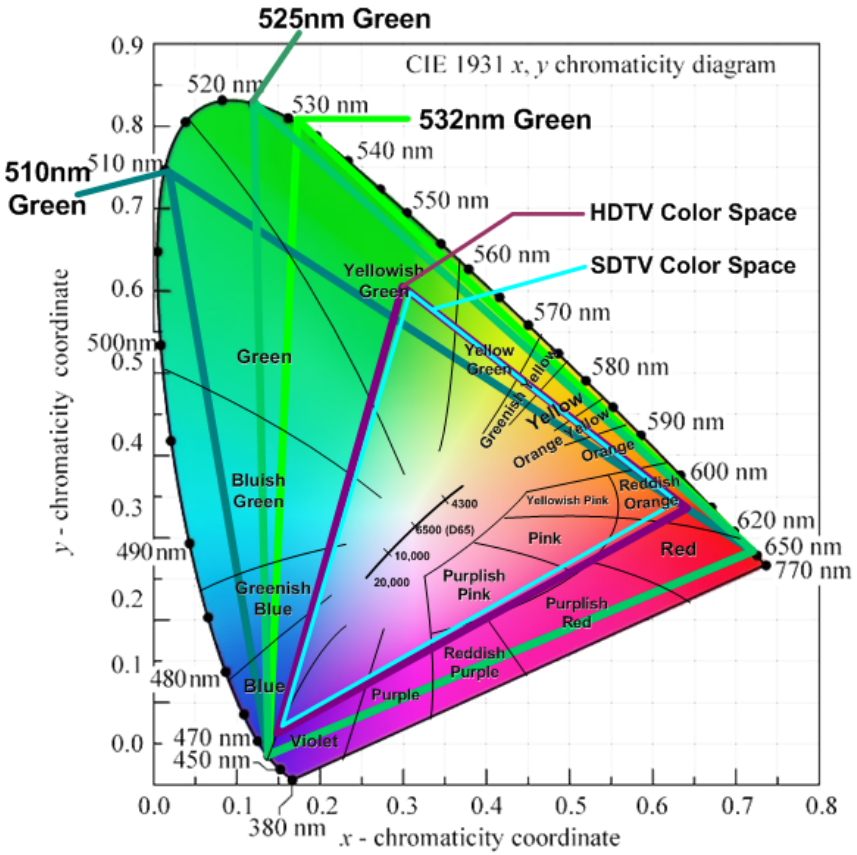
Whereas rods are not directionally-sensitive to light, cones display a marked directional sensitivity. For rays which pass into the eye through the periphery of the pupil and are incident on the retina at oblique angles, the cone response to them is weak or absent. In such cases, monochromatic light (light that has just the one color) appears to change in both hue and saturation.

Trichromatic Color Vision

Normal color vision is Trichromatic. Any secondary color can be derived by an appropriate mixture of the three primary colors (which Red, Green, and Blue). The exception to this rule is that above 520 nm, all wavelength hues are matched (by the eye) by an appropriate mixture of red and green. The blue-sensitive cones do not contribute to deriving colors in this category.

The L-sensitive, M-Sensitive, and S-Sensitive cones have maximum sensitivities in the long (560 nm), medium (530 nm), and short (420 nm) parts of the visible spectrum.

In the central of the retina the majority of photoreceptors are M-Sensitive photoreceptors. The scarcity of S cones in the central retina renders the normal retina blue-blind if an object field subtends less than 0.5^0 at the nodal point of the eye. This phenomenon is known as 'Small-field tritanopia'.



Congenital Color Deficiency

The first recorded case of congenital color deficiency was the case of Harris the shoemaker in 1777. From that time onward, different hypotheses have been postulated to explain the classes of color vision defects and their mechanism of inheritance. What we know today, about color vision defects, can be summarized as follows:

Congenital color deficiency is caused by inherited photopigment abnormalities. One, two, or all three photopigments may be present or absent. When they are all present, they may exist in normal proportions (resulting in normal color vision), or they may exist in abnormal proportions (resulting in anomalous trichromatic color vision). This information is summarized in the table below.

Table1: Classification of Congenital Color Deficiency

No. of Photopigs.	Type	Denomination	Hue Discrimination
None	Monochromat	Typical (Rod) Monochromat	Absent
One	Monochromat	Typical (cone) Monochromat	Absent
Two	Dichromat	Protanope Deuteranope **or** Tritanope	Severely impaired
Three	Anomalous Trichromat	Protanomalous Deuteranomalous **or** Tritanomalous	Continuous range of severity from mildly to severely impaired
Three	Normal trichromat	Normal Trichromat	Optimum

The anomalous trichromat also uses three colors to match all spectral hues, but the ratio of mixing of these colors is different from that of a normal.

The classification of protan (red-defective), deutan (green defective), and tritan (blue defective) - meaning first, second, and third) in Greek, also hold for ***dichromatism***. Except that while in anomalous trichromatism, the protan defective is ***Protanomalous***, in dichromatism, the protan defective is a ***Protanope***.
In dichromatism, all spectral hues are matched using only two color variables.
Very severe dichromats confuse even colors which are very bright. For example, severe red-green dichromats confuse bright reds with bright greens, whereas mild red-green dichromats only confuse dark (desaturated) colors.

Monochromats are able to match all spectral hues with just one color. Differentiation of different hues is by shades of brightness only. There are two types of monochromatism:

Rod Monochromatism

Rod monochromats have no functioning cone receptors and typically have very poor visual acuity, in the range between 6/36 and 6/60. Photophobia and nystagmus are usually present.

Cone Monochromatism

This type of monochromatism is very rare. Cone monochromats have only one type of cone receptor, usually the blue-sensitive cones. Visual acuity is in the range between 6/9 and 6/24, but only in those cases where the V.A. is less than 6/18 would one find photophobia and nystagmus.

Tests for Defective Color Vision

Test Designs

Color vision tests are used clinically to identify and differentiate congenital and acquired color deficiencies, and to select personnel for occupations which require good color vision.

Different tests are used for different functions. The two basic functions are ***Screening*** and ***Grading***. Screening tests diagnose the type of color deficiency and Grading tests assess the severity of the deficiency.

There are four test designs in use today:

Pseudoisochromatic (PIC) Plates These exploit colors that lie on or close to pseudoisochromatic lines of particular color defects. Colors on these lines a regularly confused by an observer who has a particular color defect.

The tests plates use a random arrangement of dots as a background, and within this background, and using a pseudoisochromatic color (i.e. pseudoisochromatic with the background color) a figure is presented. Such a figure is seen by a normal but not by a color defective. There are other designs based on the same principle

Hue Discrimination Tests Basically, after showing the patient an example, he is expected to arrange the colors provided for him in the appropriate sequence. These tests requires more complex color discrimination than with the PIC plates.

Color Matching Tests: These require matching of test colors with 'standard' colors provided.

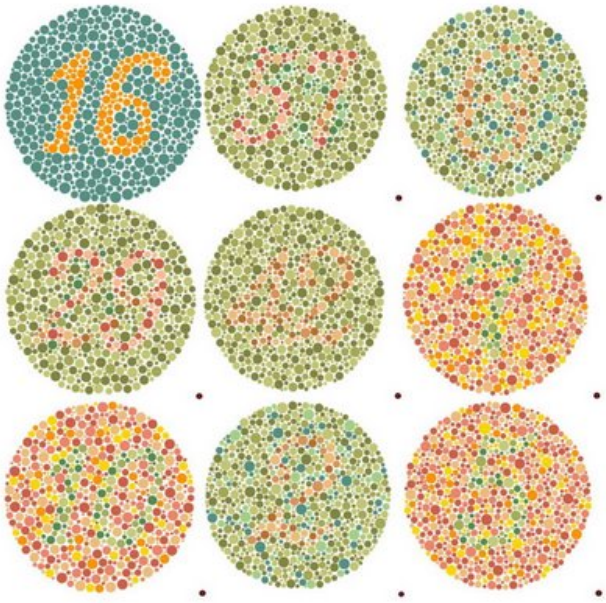
Lantern Tests:
These involve naming of colors presented to the subject.

Pseudoisochromatic (PIC) Plates

These plates use the principle of color camouflage. The background is made up of random dots, and then the figure – printed in an isochromatic color – is printed within the background.

Administration of Ishihara Plates

- ✓ Tests plates are held by the examiner at two-thirds of a meter (arm's length) away from the subject.
- ✓ An introductory plate is usually included with PIC tests. A correct response to this plate indicates that the subject possesses sufficient acuity for the test, and is not malingering (pretending).
- ✓ Maximum allowed viewing time is 4 seconds. The examiner should change the figure after that period.
- ✓ Some PIC tests do not use figures or numbers, but ***pathways*** which can be traced by children or none verbal patients
- ✓ PIC patterns have been used in computer displays to test for color deficiency. These tests are good at isolating isochromatic zones but they cannot distinguish between dichromats, and anomalous trichromats.



HUE DISCRIMINATION TESTS

These are grading tests which identify moderate and severe color deficiency and classify protan, deutan, and tritan defects.

These tests are unsuitable for young children and educationally disadvantaged groups.

These tests are particularly useful for acquired defects which can easily be monitored.

The most widely used tests in this category are the dichotomous (D15) test, and the Farnsworth-Munsell 100 hue test. Both these tests contain colors selected from the complete hue circle.

Individual colors in both tests, are contained in a circular cap subtending 1.5^0 at a test distance of 50 cm.

Administration of Hue Discrimination Tests

To start, all the colors are brought out of the box and arranged randomly on the table. For the 100-Hue test, one box is emptied at a time, in rank order, starting from box 1, or from box 4.

The patient is then asked to replace the caps in what he perceives to be the natural other using the fixed cap/s in the box, as start (and end, in the case where there are two fixed caps) points. In the F-M 100 Hue test, the error score for each cap is calculated and plot on a polar diagram. Some color vision clinics use computer programs to assist this process.