BINOCULAR VISON AND SPACE PECEPTION

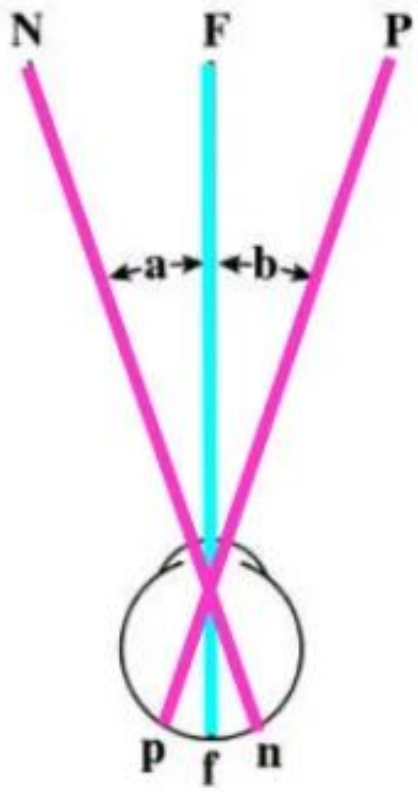
Terms

- Location:
  - Position of an object in physical (objective) space
- Localisation:
  - Position of the object in visual (subjective) space
- Retinal elements / points/ Areas:
  - The retinocerebral apparatus engaged in elaborating a sensation in response to excitation of a unit area of retinal surface

Relative subjective visual direction

- Whenever retina is stimulated by the light- the stimulus is perceived in terms of certain brightness, colour, form and localization in a certain direction in visual space.
- Each retinal element localizes the stimulus as a visual percept in a specific visual direction relative to *visual direction* of fovea.

  - Fovea is the carrier of principal visual direction (F)
  - All other retinal elements – Secondary visual direction (N&P



Retinomotor values

- The appearance of an object in the periphery of the visual field attracts attention and the eye is turned towards the object so that it may be imaged on the fovea.
- It is degree of movement of the eye to get fixation at fovea.
- Appearance of an object in periphery → Signal from retinal periphery to brain → corresponding impulse to the EOM → Necessary ocular rotation (Saccade)

Retinomotor values

- The Retinomotor value of fovea = Zero (once an image is on fovea, there is no incentive for ocular rotation)

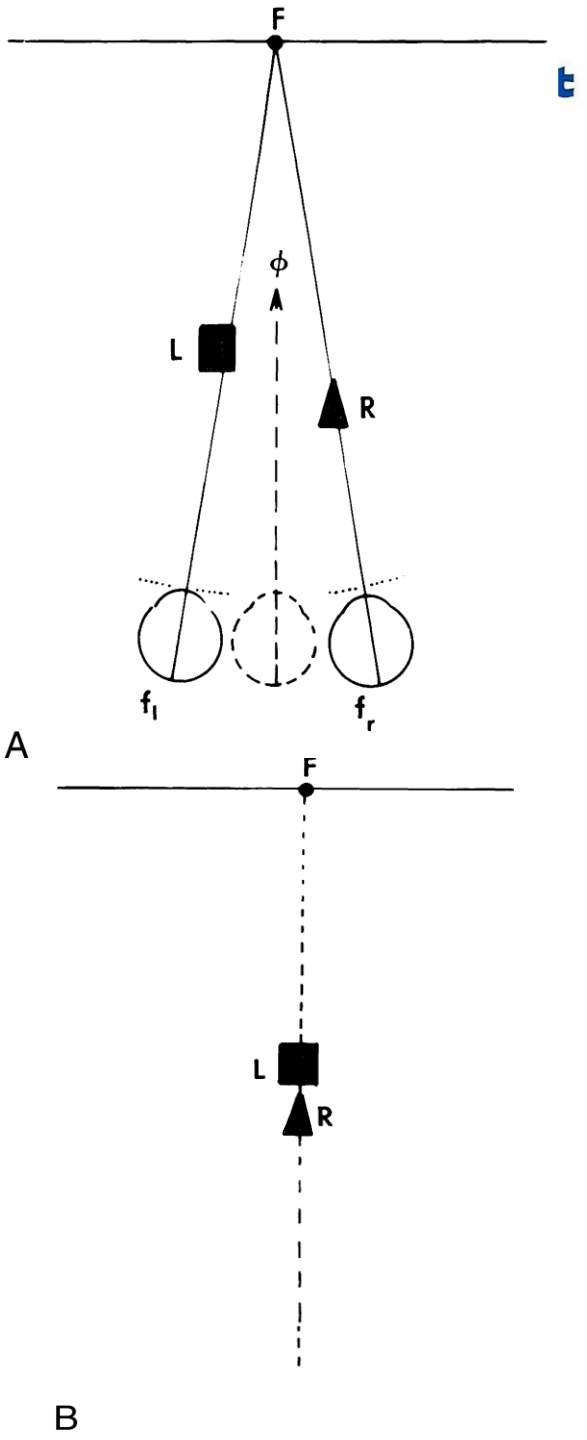
- *Clinical application*: Measure of ocular deviation by prism bar cover test (PBCT)

Common relative subjective visual direction

- In geometric construction a line that connects an object point with its image on the retina is called line of direction/ principal lines of direction or visual axes
- If two principal lines of direction intersect at the fixation point, it is said that there is binocular fixation, If only one principal line of direction goes through the fixation point fixation is monocular

Common relative subjective visual direction

- All object points that simultaneously stimulate the two fovea's appear in one and the same subjective visual direction i.e not in the direction of the principal line of direction of either eye but in a direction coinciding with the medial plane of the head
- Every retinal point or area has a partner in the fellow retina with which it shares a common relative subjective visual direction.
- F, L, and R therefore are in the common relative subjective visual direction of the two foveae, f, as shown in B. The imaginary ‘‘third’’ eye, *the cyclopean eye*, is indicated by dashed lines in A.



Retinal correspondence

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- Corresponding retinal elements are those elements of the two retinas that give rise in binocular vision to the localization of object in one and the same subjective visual direction.
- Normal retinal correspondence:
  - Normal retinal correspondence is the normal state in which the visual direction of each fovea is the same.
  - The fovea and areas on the nasal and temporal side of one retina correspond to and have, respectively, common visual directional sensitivity with the fovea and temporal and nasal areas of the retina of the other eye.

Retinal correspondence

Abnormal retinal correspondence:

- This is a binocular condition in which there is a change in visual directional sensitivity such that the fovea of the fixing eye has a common visual directional sensitivity with an area other than the fovea of the deviating eye. The pairing of all retinal areas is similarly changed.

a) Harmonious ARC:

- the angle of anomaly is equal to the objective angle, and the subjective angle is zero.
- This indicates the ARC fully corresponds to the strabismus
- Provide compensation for the angle of squint
- Eliminate the awareness of diplopia and confusion

Retinal correspondence

Abnormal retinal correspondence: (cont…

b) Unharmonious ARC:

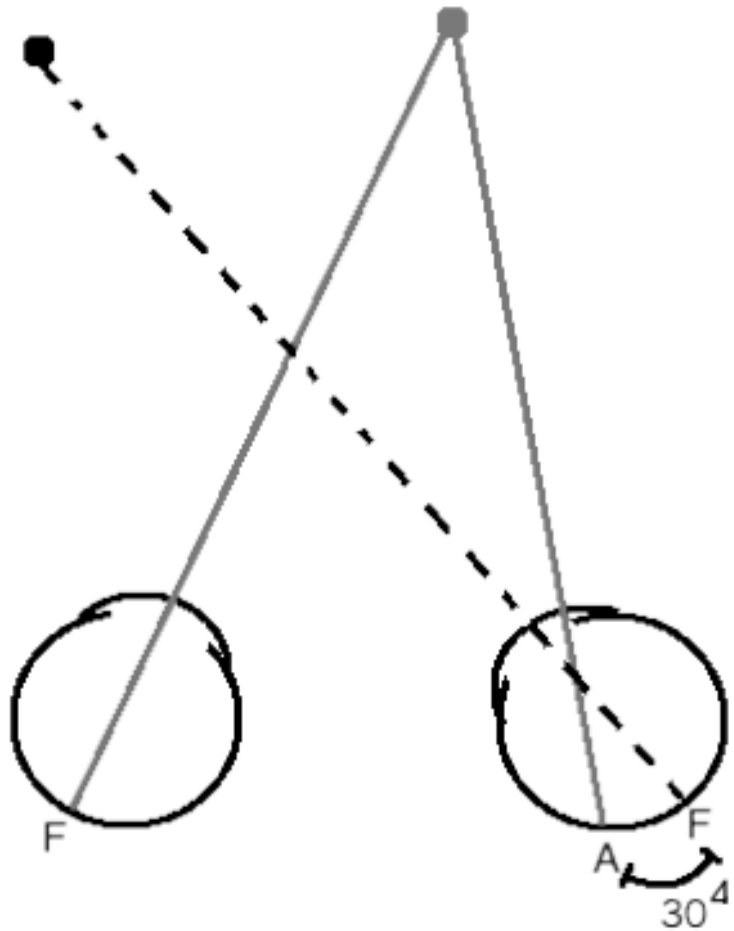
- the angle of anomaly is different from the objective angle.
- Subjective angle is not zero

c) Paradoxical:

- When angle of anomaly is greater than the objective angle of deviation
- It occurs mainly after overcorrection of the squint surgery

Harmonious ARC

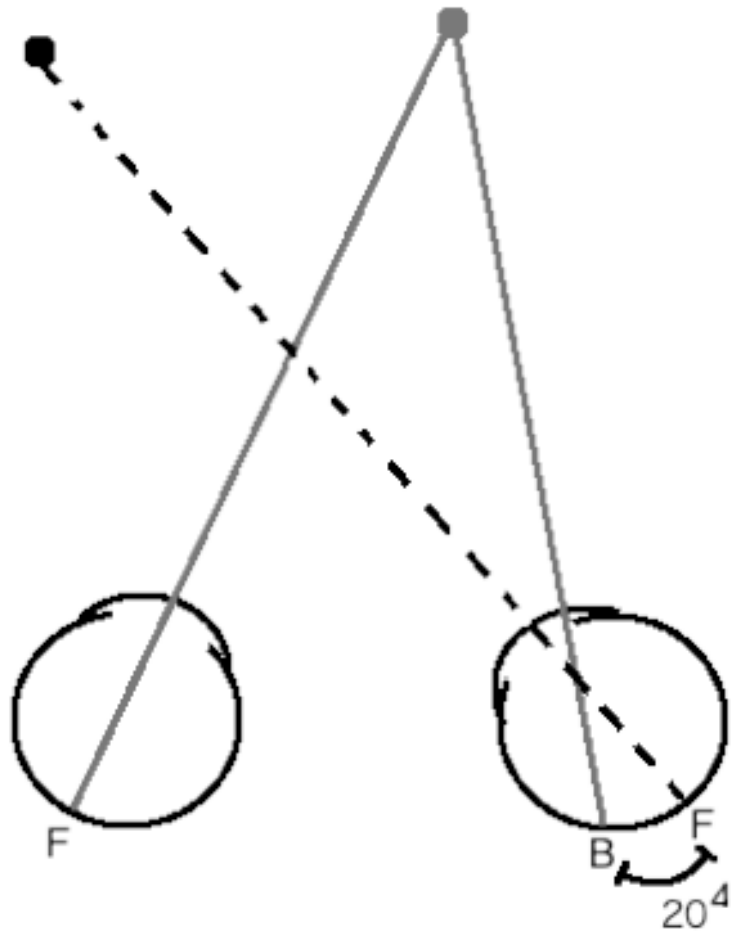
30 Δ Esotropia



Unharmonious ARC

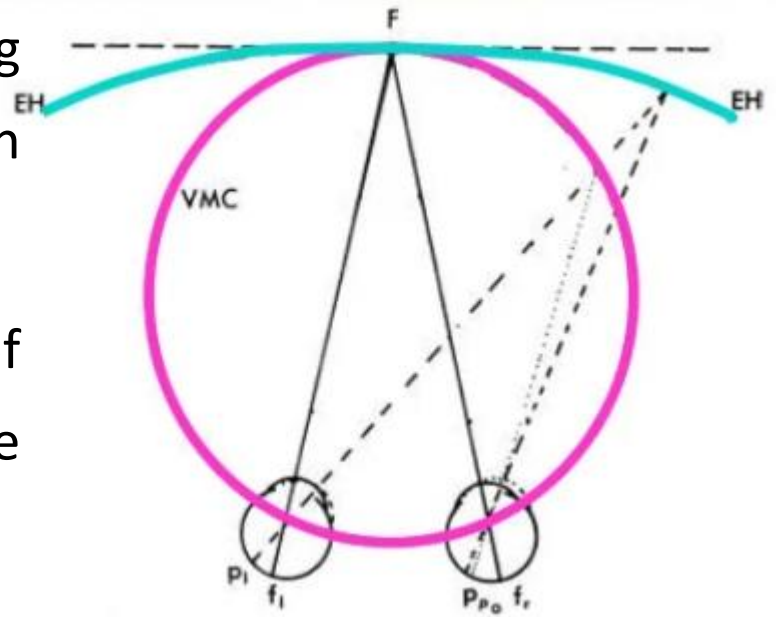
30 Δ Esotropia – Objective Angle

20 Δ Esotropia – Subjective Angle



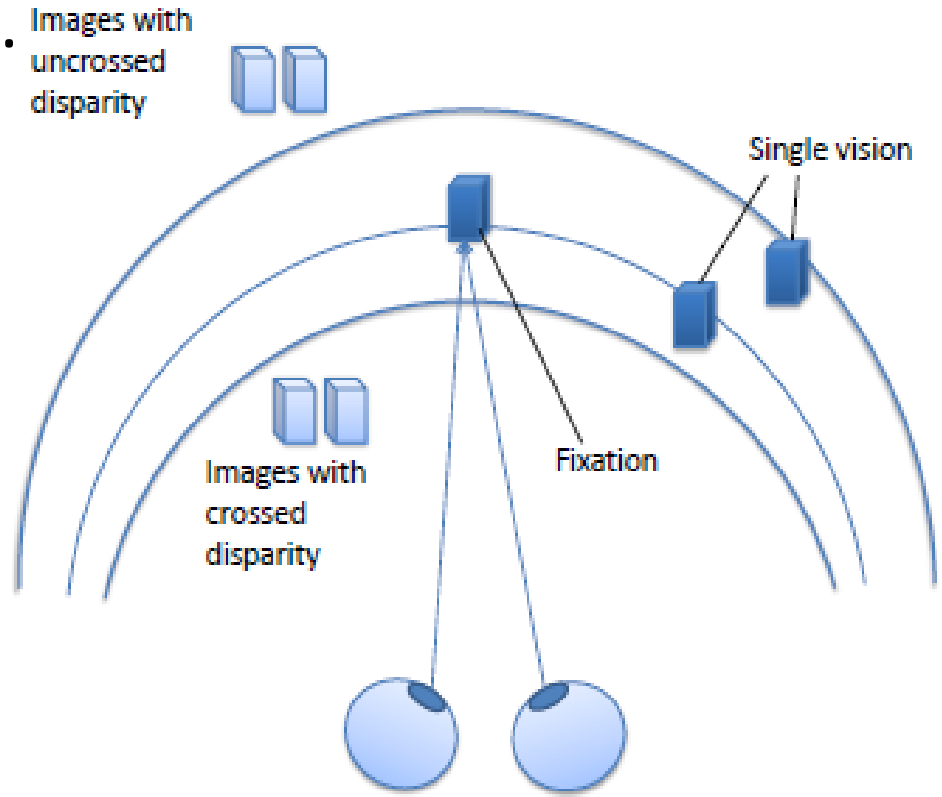
Horopter

- It is defined as the locus of all object points that are imaged on corresponding retinal elements at a given fixation distance.
- The horopter is an infinitely thin curved plane drawn through all object points in visual space that are imaged on corresponding retinal points
  - ***Veith-Muller circle:*** Horopter curve would be a circle passing through the center of rotation of the two eyes and the fixation point
  - ***Emperical Horopter curve***: flatter than the VMC. The distribution of the elements that correspond to each other is not the same in the nasal and temporal parts of the two retinas



Panum's fusional space/ area

- It is the region around the horopter where objects are seen as single even though the object points stimulate slightly disparate retinal elements.
- the region in front and back of the horopter in which single vision is present is known as Panum's area of single binocular vision.
- Not only is single vision possible in Panum's area but visual objects are seen stereoscopically, that is, in depth.



Fixation disparity

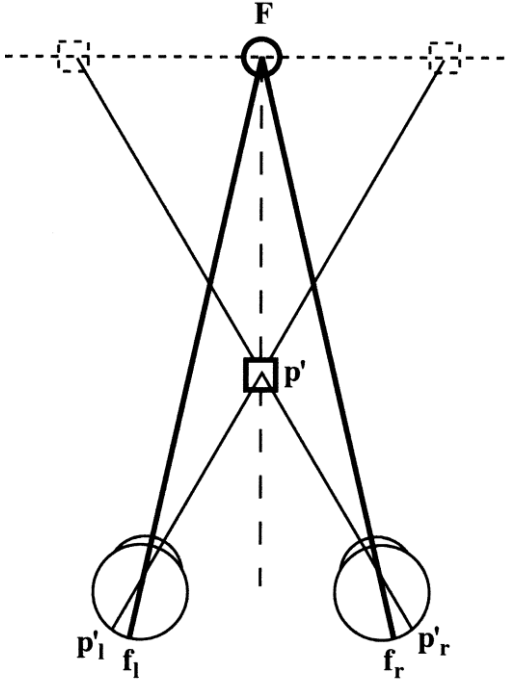
- During binocular fixation, point fixation is rarely ever imaged exactly on corresponding points of two fovea. Primary line of sight of one eye misses the fixation point very slightly, being under converged or over converged
- At central fixation the horizontal extent of panum's fusional space is upto 20 min of arc.
- Disparity is less than size of panum's area- no diplopia.

Diplopia

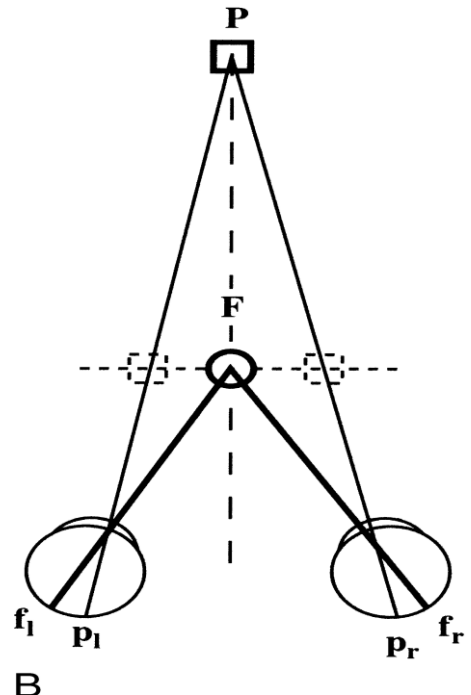
- Occurs due to retinal disparity

Physiological Diplopia:

- As an individual fixes the object of interest, all the objects outside the panum's fusional space are seen double this is known as *physiological diplopia.*
- *When fixating a distant object, near object is seen in cross(heteronymous) diplopia. Cross diplopia is explained by the fact that near object is seen in crossed disparity.*
- *When fixating a near object, a distance object is seen in uncrossed (homonymous) diplopia. Uncrossed diplopia is explained by the fact that distant object is seen in uncrossed disparity*



A



B

Diplopia

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Physiological Diplopia: (cont…)

- Significance: Physiological diplopia is important for

I. Its presence indicates that patient is capable of using both eyes and is not unconsciously suppressing vision in one eye

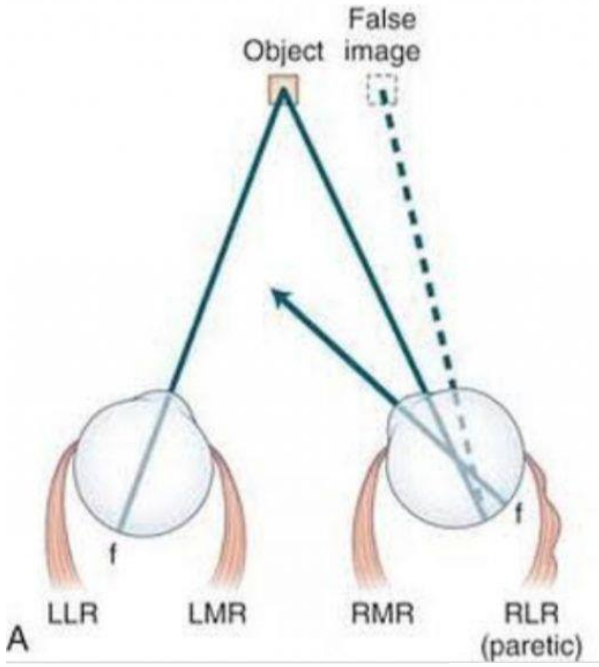
II. The patient who is unconsciously suppressing can be trained as a form of antisupression exercise, to appreciate physiologic diplopia for increasingly longer period

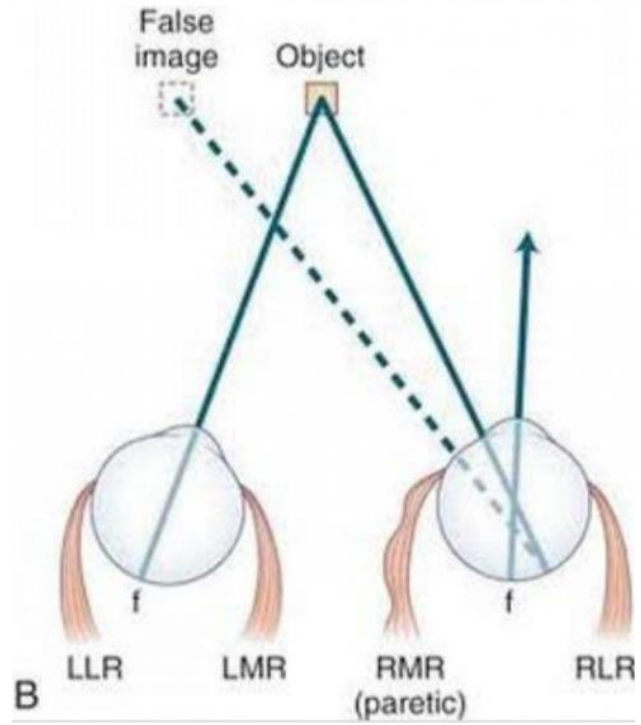
III. Occasional patients with normal vision will notice physiologic and present to the ophthalmologist believing something is wrong with their eyes or their brain

Diplopia

Pathological Diplopia: (cont…)

- Due to pathological disorder of eye like squint.
- *Homonymous Diplopia (uncrossed): Usually is eso-type of squint cause binasal disparity*
- *Heteronymous Diplopia (crossed): Usually occur in exo-type squint, cause bitemporal disparity*

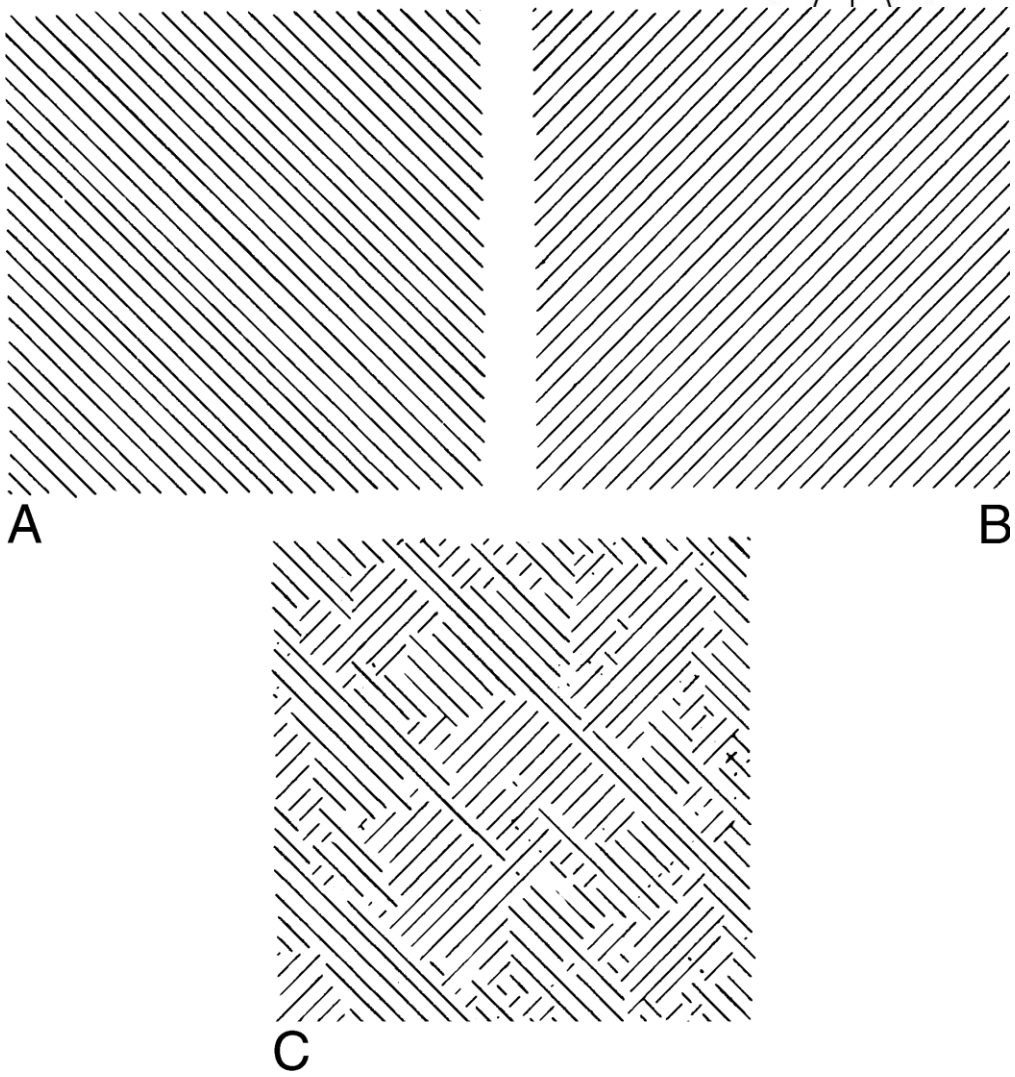




Retinal rivalry

- When dissimilar contours are presented to corresponding retinal areas, fusion becomes impossible Instead, retinal rivalry may be observed. This phenomenon, also termed binocular rivalry

- The phenomenon of retinal rivalry may be explained as: Simultaneous excitation of corresponding retinal areas by *dissimilar stimuli but localized in the same visual direction* which give rise to *conflict and confusion, one or the other is temporarily suppressed*. Which of the two is suppressed more *depends on the eye and not the stimulus* that competes for dominance.



Suppression

- Suppression is the mental inhibition of visual sensations of one eye in favour of those of the other eye when both eyes are open. This may occur in binocular single vision and commonly in manifest strabismus.
- Physiological suppression is present in binocular single vision. Blurred images are suppressed when concentrating on one particular object.
- Pathological suppression is present in manifest strabismus and may alternate with alternating deviations
- Suppression may occur with intraocular blur, suspension, binocular retinal rivalry or permanent suppression

Monocular vision (oculocentric visual direction)

- Monocular vision is oculocentric because the eyes visual direction are always located relative to the principle visual direction
- The law of oculocentric visual direction states that any two points in the same relative visual direction will stimulate the same retinal point.
- Objects with superimposed retinal images will be seen in the same visual direction although at differing distance from the eye

Binocular vision (egocentric visual direction)

- In binocular vision the principle visual direction of 2 fovea's are identical.
- An image falling on either foveola will appear to be localized in the same direction- common principle visual direction
- Consequently when both eye are used visual space appears to be seen from an imaginary eye situated in the head midway. Helmholtz called this cyclopean eye
- The head, the egocentre is used as a reference rather than the eye, the oculocenter so binocular vision is egocentric rather than oculocentric

Binocular single vision

- When a normal individual fixes his visual attention on an object or regards, the image is formed on the fovea of both the eye separately but the individual perceives single image. This state is called binocular single vision.
- BSV may be defined as the state of simultaneous vision, which is achieved by the coordinated use of both eye, so that separate and slightly dissimilar images arising in each eye are appreciated as a single image by the process of fusion.

Binocular single vision (cont…)

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Pre-requisites of BSV:

- Straight eyes starting from the neonatal period, with precise co-ordination for all direction of gaze (**motor mechanism**)
- Reasonable clear vision in both eyes so that similar images are presented to each retina. (**sensory mechanism**)
- Ability of visual cortex to promote BSV (**mental process**)

Grades of Binocular single vision

There are 3 grades of BSV:

I. Grade I : simultaneous macular perception (SMP)

II. Grade II: Fusion

III. Grade III: Stereopsis

Grades of Binocular single vision (cont…)

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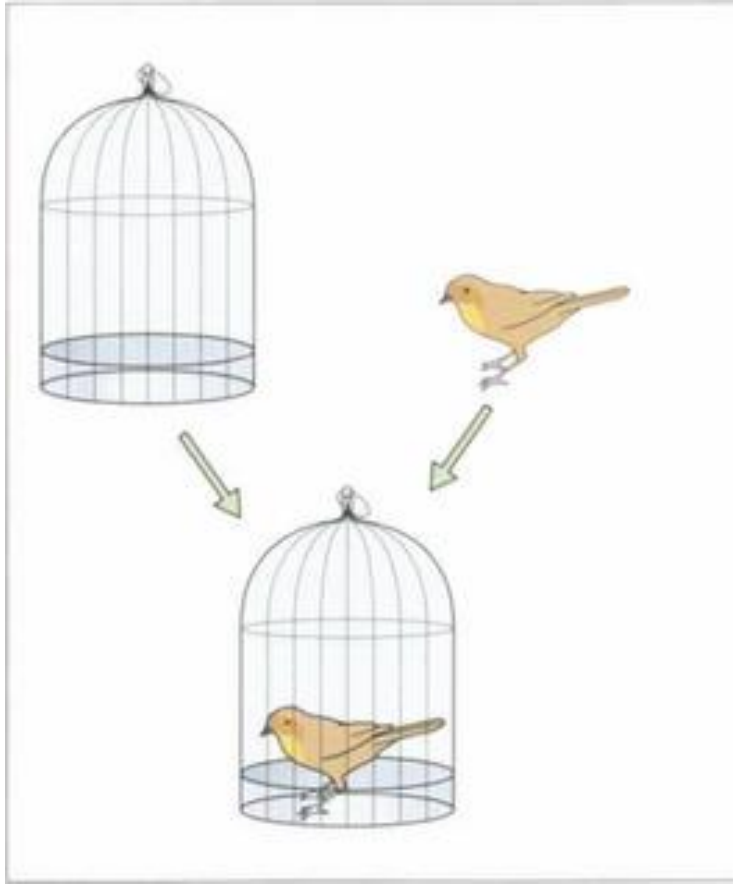
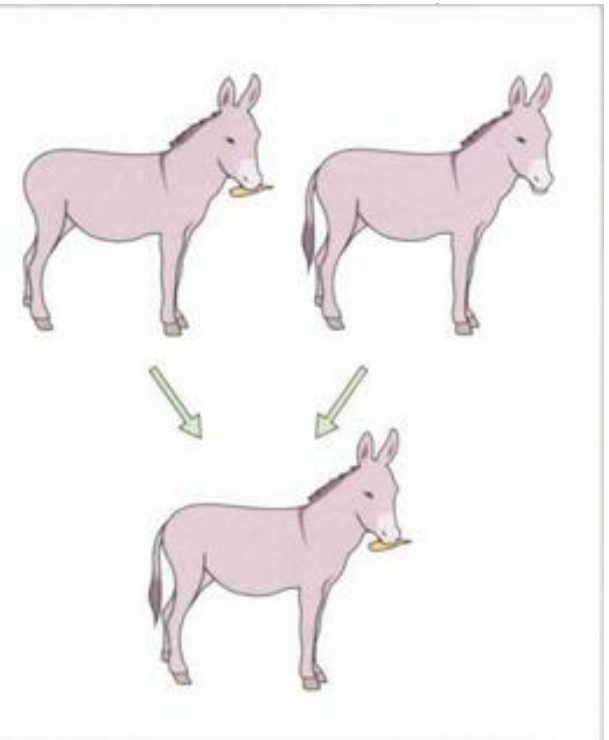
I. Grade I : simultaneous macular perception (SMP)

- Simultaneous perception is the ability to perceive simultaneously two images, one formed on each retina.
- SMP exists when signals transmitted from the two eyes to the visual cortex are perceived at the same time. It doesn't imply that both eye see the same object and transmit identical information to the visual center nor does it imply that 2 pictures can be seen superimposed
- It is the ability to see 2 dissimilar objects simultaneously

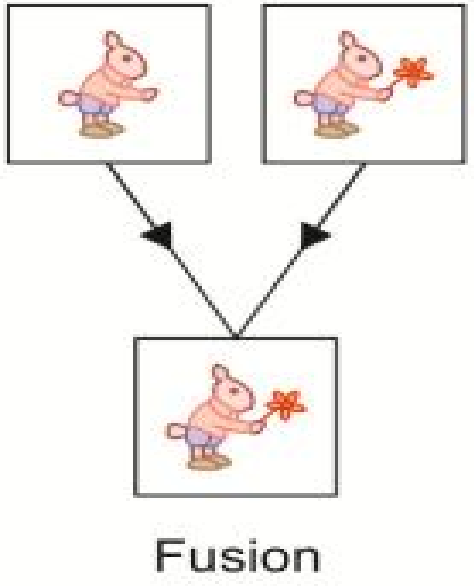


Grades of Binocular single vision (cont…)



II. Grade II: Fusion

- It implies the ability of the two eyes to produce a composite picture from two similar picture each of which is incomplete in one small detail.
- Fusion may be sensory or motor. Sensory fusion is the ability to perceive two similar images, one formed on each retina, and interpret them as one. Motor fusion is the ability to maintain sensory fusion through a range of vergence
- Eg:



Grades of Binocular single vision (cont…)

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III. Grade III: Stereopsis

- Stereopsis implies the ability to obtain an impression of depth by the super imposition of 2 picture of the same object which have been taken from slightly different angles, such as bucket that is appreciated in 3 dimensions.
- Stereopsis refers to the visual appreciation of 3D during binocular vision
- As object moved out of horopter position but lie in panum's space they appear in front or in back of the fixation object, they are seen stereoscopically.
- Stereopsis arises when horizontally disparate retinal elements are stimulated simultaneously. Vertical disparity produce no stereoscopic effect. This is the physiologic basic of binocular depth perception.

Grades of Binocular single vision (cont…)

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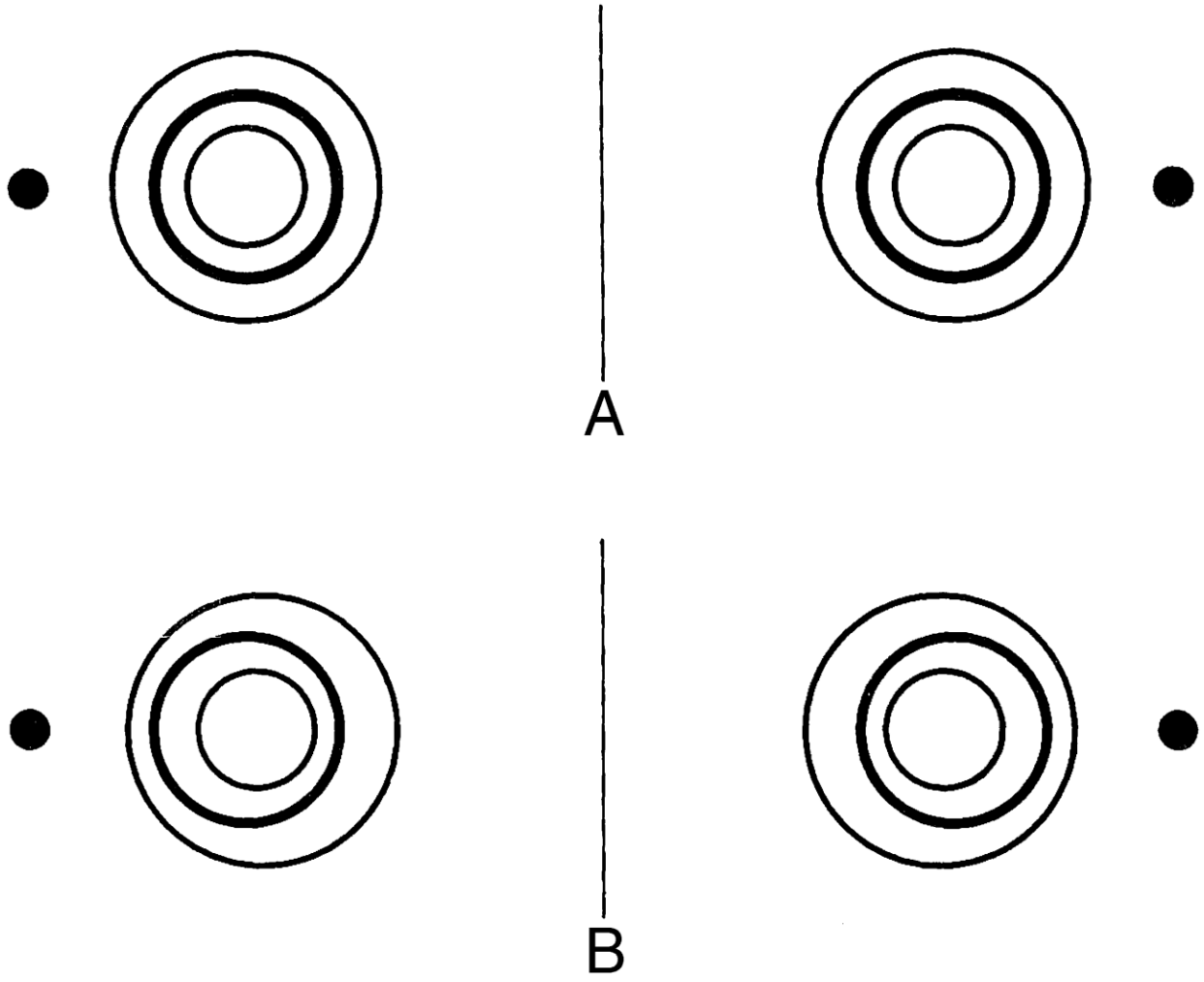
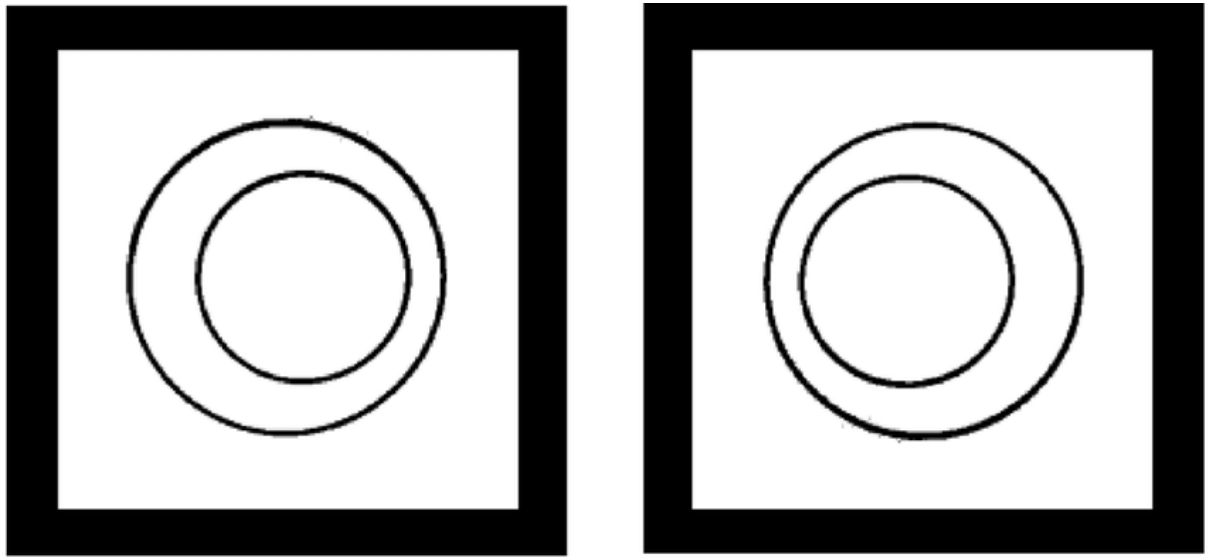
III. Grade III: Stereopsis



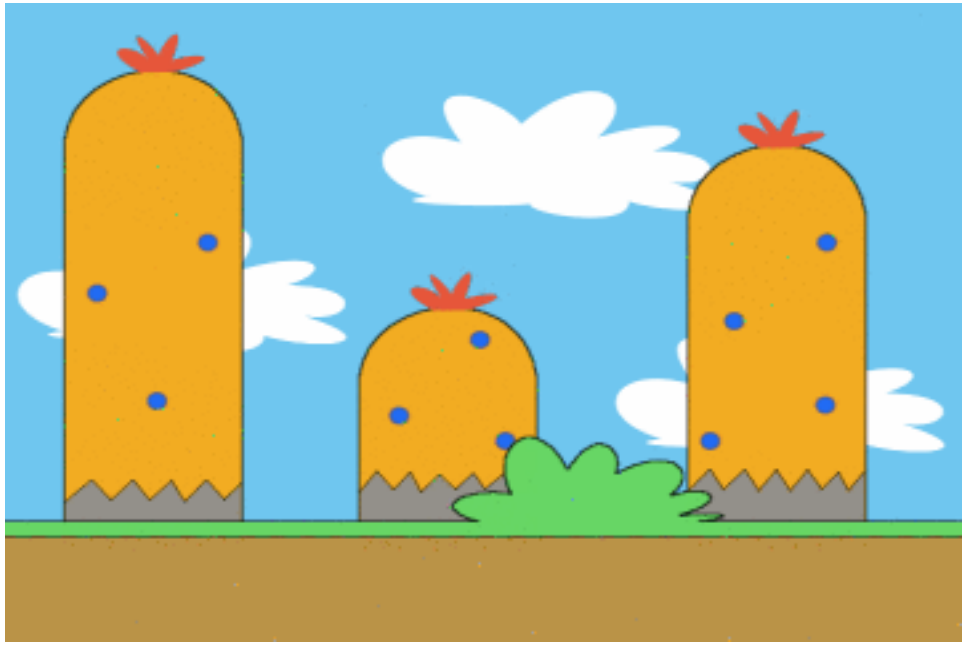


Monocular (Nonstereoscopic) Clues to Spatial Orientation

- Stereopsis is restricted to relatively short visual distances and is not the only means we have for spatial orientation.
- A second set of clues, the *monocular or experiential clues*, are important in our estimation of the relative distance of visual objects and are active in monocular as well as binocular vision.
- Such clues are :
    a) Motion parallax
    b) Linear perspective
    c) Overlay of contours
    d) Distribution of headlights and shadows
    e) Size of known objects
    f) Aerial perspective

a) Motion parallax:

- When one looks at two objects, one of which is closer than the other, and moves either the eyes or the head in a plane parallel to the plane of one of these objects, movement of the objects becomes apparent.
- Object will appear to move a greater amount if they are closer to an observer than they would if they were at a greater distance

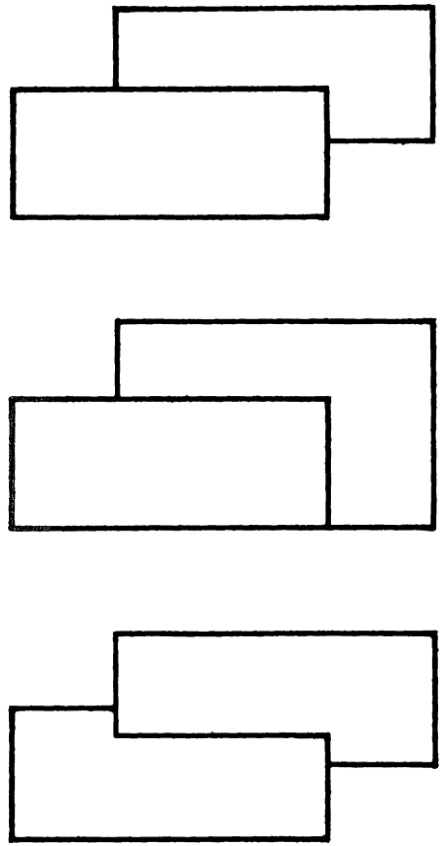


b) Linear perspective:

- Object points having a constant size appear to subtend smaller and smaller angles as they recede from the subject.
- Eg: Railroad tracks, which are in fact parallel, seem to approach each other in the distance.

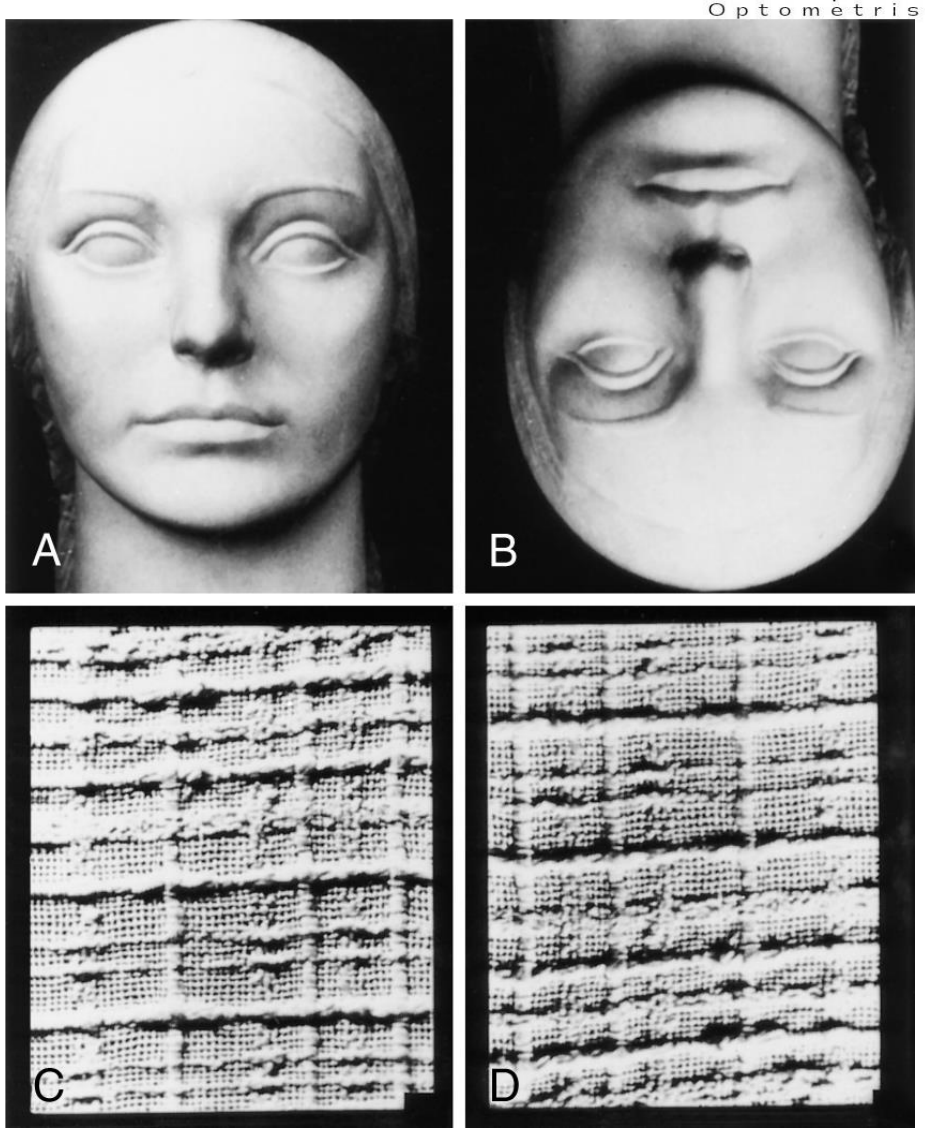
c) Overlay of contours:

- An object that interrupts the contours of another object is generally seen as being in front of the object with incomplete contours



d) Distribution of headlights and shadows:

- Highlights and shadows are among the most potent monocular clues. Since sunlight comes from above, the position of shadows is helpful in determining elevations and depressions, that is, the relative depth, of objects.

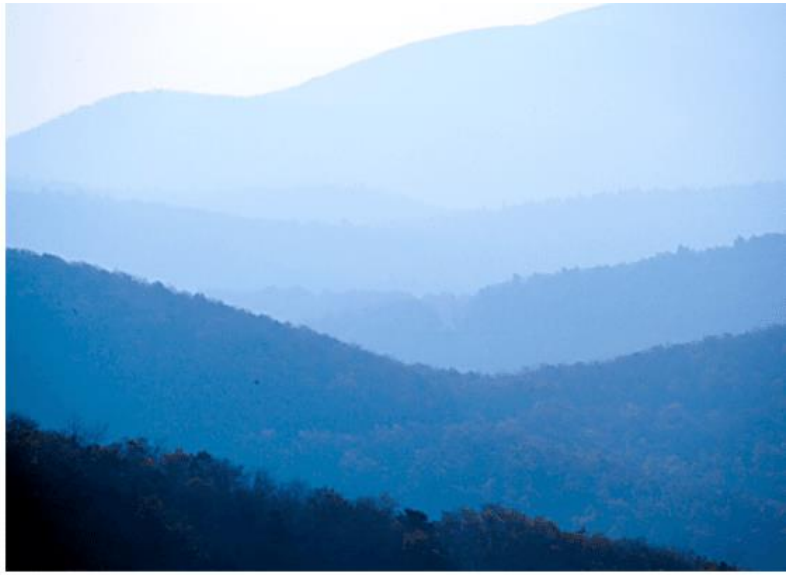


e) Size of known objects:

- If the size of two objects is known, one can judge the relative distance of these objects by their apparent size.
- If an object known to be smaller appears to be larger than the other, we judge it to be nearer.

f) Aerial perspective:

- Aerial perspective is the term used for the influence of the atmosphere on contrast conditions and colors of more distant objects.
- objects that are further away to look blurry and have a bluish tint.



Theories of Binocular vision

1. Correspondence and Disparity:

- A given retinal element in one retina shares a common subjective visual direction with an element in the other retina. These corresponding elements form the framework or zero system of binocular vision.
- When stimulated simultaneously by one object point, they transmit single visual impressions that have no depth quality.
- When stimulated simultaneously by two object points that differ in character, binocular rivalry results.
- When disparate elements are stimulated by one object point, diplopia is experienced.
- However, if the horizontal disparity remains within the limits of Panum's area, a single visual impression is elicited that has the quality of relative depth or stereopsis.

Theories of Binocular vision

2. Neurophysiologic Theory of Binocular Vision and Stereopsis:

- A reasonable assumption is that neuron in the striated cortex responding well to successive stimulation and especially those is which the response can be maximized with simultaneous stimulation are somehow involved with binocular visual processing

Theories of Binocular vision

3. ALTERNATION THEORY OF BINOCULAR VISION.:

- In replacement theory of binocular vision, assumed that corresponding retinal units were represented separately in the brain but that each one of every pair was represented in consciousness by the same single unit. This conscious unit would receive the stimulus from only one retinal unit at a time the other was excluded.

Theories of Binocular vision

4. PROJECTION THEORY OF BINOCULAR VISION:

- theory that has now been largely abandoned is the projection theory, which contends that visual stimuli are exteriorized along the lines of direction.
- If a person fixates binocularly, a ‘‘bicentric’’ projection is supposed to occur that places the impression of each eye at the point of intersection of the lines of projection.