

Author: Ida Lucy Iacobucci, 2015

License: Unless otherwise noted, this material is made available under the terms of the Creative Commons Attribution-NonCommercial-Share Alike 4.0 License: <http://creativecommons.org/licenses/by-nc-sa/4.0/>

The University of Michigan Open.Michigan initiative has reviewed this material in accordance with U.S. Copyright Law and has tried to maximize your ability to use, share, and adapt it. Copyright holders of content included in this material should contact open.michigan@umich.edu with questions, corrections, or clarifications regarding the use of content.

For more information about how to attribute these materials, please visit:

<http://open.umich.edu/education/about/terms-of-use>.

Chapter 2

FORMS OF RETINAL CORRESPONDENCE

NRC – Normal Retinal Correspondence
(Corresponding Retinal Elements)

ARC – Anomalous Retinal Correspondence
(Noncorresponding Retinal Elements)

I. INTRODUCTION – HOROPTER & TYPES OF ARC

A. Physiological Factors²

Localization is based on physiological factors. *Objective* aspect is the correct geometric localization of an object in space. The objective line of direction (visual axis) is the line drawn from the fixation object through space and the optical system of the eye to the retina. Normally, light from an object located directly ahead stimulates the fovea.

A *retinal element* refers to a rod or cone together with all the chain of cells connecting that sensory cell with the occipital visual cortex.

Subjective aspect (projection) is the place in space where an object *appears* to be situated which depends on the spatial value of the *particular retinal element stimulated*. Each retinal element has its own particular direction in which it localizes objects that stimulate it, which is the visual *direction* of that retinal element. The fovea normally has a zero value visual direction.

The objective line of direction visual axis and the *subjective visual direction* normally coincide.

For every point on the retina of one eye there is a point on the retina of the other eye which is stimulated by the same object. Retinal elements in each eye, which normally are stimulated by the same object, are called *normal retinal corresponding elements*. These are corresponding retinal elements that have the same visual direction. The foveas are corresponding points “par excellence”.

An object stimulating non-corresponding retinal points is seen double because each point has a different visual direction. Slightly disparate retinal elements are fused if the retinal elements are within *Panum's fusional* area and result in stereopsis instead of diplopia. The amount of disparity fused is very small near the fovea but increases in size as the peripheral retinal areas are stimulated.

B. Horopter

Locus of points in a space which at a given distance simultaneously stimulate corresponding retinal elements therefore giving rise to a single image.

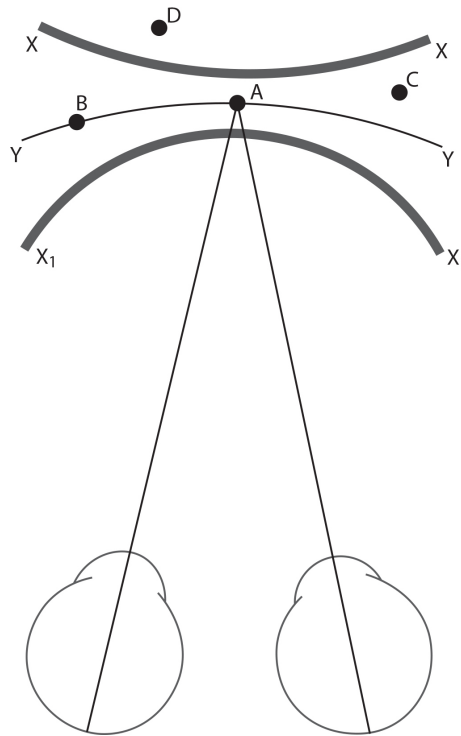
Empiric horopter forms a variable line depending on the distance of fixation object from the eye:

1. Fixation object 2 meters away - horopter is a straight line passing through the fixation point.
2. Fixation object nearer than 2 meters – horopter is curved, concave to the face.
3. Fixation object is beyond 2 meters – horopter is curved, concave to the face.

Images falling on non-corresponding points (each having different visual direction) are seen double. However, slightly disparate retinal points to be stimulated by similar images produce a single image because the retina points fall within Panum's area (stereopsis).

Representative of Panum's fusional space.

Fixation distance 1 METER –
horizontal meridian for the horopter (YY) one meter away.



{Y Y} Horizontal meridian for the Horopter 1 meter away

{XX₁, XX} Limits of Panum's fusional areas in the retina in relation to the horopter

- A- The fixation point.
- B- On the horopter - imaged on corresponding retinal points seen as one.
- C- Is off the horopter but within Panum's fusional areas - imaged on non-corresponding points but is seen with depth effect (stereopsis) and *not double*.
- D- Is off the horopter and outside Panum's fusional area – imaged on non-corresponding points seen double (physiologic diplopia).

Panum found that in the region near the fovea only a *slight degree* of disparity was possible before stereopsis failed and diplopia occurs; nearer to the periphery, more widely disparate retinal points give rise to stereopsis rather than diplopia.

Therefore, imaging areas of disparate points are very small near the fovea and increase in size as they approach the periphery of the retina.

Panum's area – Fusional area around corresponding points *in the retina*.

Panum's space: The space on either side of the horopter containing objects in space, images of which will fall on slightly disparate retinal elements within Panum's fusional areas of the two retinas so that they are found as stereopsis.

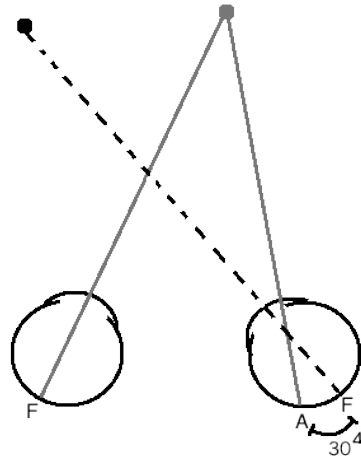
Anomalous retinal correspondence is an attempt of the strabismic patient to obtain some semblance of normal binocular vision. It is a binocular phenomenon though monocularly either eye picks up fixations with the fovea.

In heterotropic patients non-corresponding retinal elements outside of Panum's fusional area are stimulated. Normal localization of the deviated eye results in diplopia rather than fusion. Anomalous localization allows an 'extra foveal' element of the deviating eye to acquire a correspondence with the fovea of the fixing eye. In heterotropia-anomalous, retinal correspondence may develop for the purpose of eliminating diplopia (and confusion) and regaining a semblance of binocularity with some form of stereopsis. It is a binocular phenomenon, though monocularly either eye picks up fixation with the fovea.

C. Two types of ARC

Harmonious ARC

30^Δ Esotropia

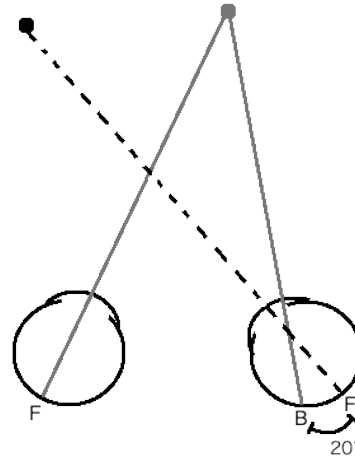


Angle of anomaly is equal to the angle of strabismus

Unharmonious ARC

30^Δ Esotropia – Objective Angle

20^Δ Esotropia – Subjective Angle



Angle of anomaly is not equal to the angle of strabismus

1. Harmonious ARC

Angle of anomaly is equal to the angle of strabismus and therefore the subjective angle is zero. In harmonious ARC a retinal element in the deviated eye which is at the *exact point (A) where the image falls* or the deviating eye *acquires* correspondence with the fovea of the fixing eye.

2. Unharmonious ARC

The subjective angle is not equal to the objective angle of strabismus. The subjective angle is greater than zero but less than the objective angle of strabismus. The fovea of the fixing eye acquires a correspondence with external stimuli of the deviated eye but not at the exact objective angle of deviation (as in harmonious ARC). The pseudo fovea is at a point (B) *less* than the objective angle of deviation. The patient with unharmonious ARC has learned to use their eyes at a less crossed angle in an attempt toward binocularity.

NOTE: Some do not believe unharmonious ARC exists but it is demonstrated on a variety of tests. It has been explained that it could be due to the patient having a change in angle of strabismus and the sensory adjustment hasn't had time to 'catch up' with the change in angle of strabismus. Bagolini has never been able to demonstrate unharmonious ARC with the striated lens following surgical correction and this definitely demonstrates a rapid sensory adjustment. He feels that it exists because of the methods used in testing.

D. Terminology

Clinically, we speak of the *objective angle* as the amount of deviation measured by the examiner and neutralized so that the image of the fixation object falls on the fovea of each eye, such as the alternate cover and prism test or alternate cover test on the amblyoscope.

Subjective angle is the amount of correction in prism diopters in which the patient informs the examiner that he can superimpose and fuse the images of the test object.

Angle of anomaly is the difference of the objective angle minus the subjective angle. In normal retinal correspondence the objective angle and subjective angle are the same, Therefore, the angle of anomaly is zero. In unharmonious ARC, the objective angle does not equal the subjective angle. The subjective angle is less than the objective angle; the angle of anomaly is not zero. In harmonious ARC, the subjective angle is equal to the objective angle.

In summary:

Objective test – depends upon findings of the examiner – independent of patient's response.

Subjective test – depends upon a patient's response.

Subjective angle – The angle on the synoptophore at which the patient can superimpose test object slides is different from the objective angle which shows ARC (at least 8^{Δ} or 4° difference to demonstrate ARC).

Objective angle – The angle to which examiner manipulates the arms of the synoptophore so that the image of test object slides fall on the fovea of each eye.

E. Definitions

Anomalous retinal correspondence can be defined in more than one way.

1. ARC is present when two foveae no longer have a common visual direction.
2. ARC is a binocular condition where the fovea of the fixing eye is used in conjunction with a point other than the fovea of the deviating eye.
3. ARC is a binocular condition where the angles of deviation measured objectively and subjectively are not coincident. The difference between the two angles is known as the angle of anomaly.
4. ARC is a binocular condition where there has been a rearrangement of the normally common visual directions of the retinal elements of the two eyes. Corresponding retinal elements lose their common visual direction while disparate retinal elements acquire a common visual direction.

F. Prognosis for ARC to Develop

Anomalous retinal correspondence is more likely to develop in small to moderate degree manifest deviations with a relatively constant long-standing and stable angle. In large angles of deviation, there is little reward for development of ARC because the peripheral retina has very low visual attention. It is seldom present in accommodative strabismus, intermittent strabismus, and incomitant deviations due to variability of the angle of deviation. It is rare in alternating strabismus.

Cases in which ARC is more likely to develop:

1. Moderate degree of ET (esotropia) and relatively stable angle of deviation.
2. In small angles of deviation under 10 prism diopters the image may fall within Panum's fusional area.

II. SENSORY TESTS FOR ARC

Clinical tests are based on two principles: (1) to assess visual direction of the two foveae, and (2) to compare the subjective localization of images with the objective angle of deviation.

A. Diplopia Test - Method I

1. Red filter over preferred eye. Patient fixes on distant or near light.
2. Place vertical prism (10^{Δ} BU or BD) in front of one eye to help overcome suppression.

Results: If red light is seen above white light in presence of 30^{Δ} ET, this indicates harmonious ARC.

B. Diplopia Test - Method II

1. Objective angle is neutralized with appropriate prisms and checked by cover test.
2. Red filter is placed in front of one eye. Check again if deviation is still neutralized, then ask patient if images are superimposed. If images are not seen superimposed, reduce prisms until the images are seen superimposed or change from crossed to uncrossed or vice versa. If more than 8^{Δ} difference from objective angle, ARC is present.

C. Bagolini Striated Lens

Plano lenses have very fine striations etched in them. They are placed in a trial frame; one is set at 45° and the other at 135° so that the line images are seen obliquely as the patient fixes a light. A person with single binocular vision will see a cross passing through the light. ET with NRC \times (fixation light above), XT with NRC \times (fixation light below).

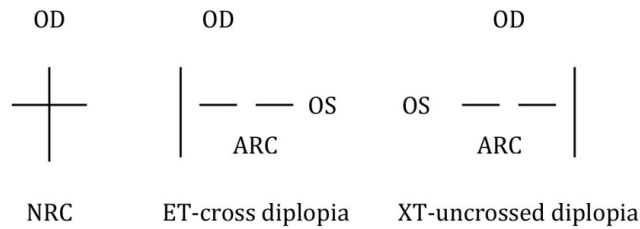
If a person with an ET claims a cross at the light \times then they must have ARC. If only one line is seen passing through the light, suppression of one eye is indicated.

NOTE: The Bagolini lens has the same effect as the Maddox Rod but does not dissociate the eyes by presenting an obstacle to vision and it reduces the artificiality of the testing situation. It represents the most 'normal' seeing conditions.

D. Bielschowsky After Image Test

One eye is occluded and the patient is instructed to fix a dot in the center of a horizontal filament of light for approximately 20 seconds. The light is then extinguished, rotated to 90°, the other eye occluded, and the process is repeated. Present the horizontal light first to the normally dominant eye and then the vertical light to the non-dominant eye.

Results: The patient is instructed to close their eyes and observe the white lines against his eyelids and draw the arrangement of lights seen (the positive after image). Then the patient looks at a blank wall, blinks their eyes, and observes the position of the black lines seen against the wall (negative after image). Each image should have a central gap corresponding to the dot which indicates the visual direction of the fovea. It is the position of this gap or space in the image which is important.



TIP: The distance between the gaps is determined by the angle of anomaly and not the angle of deviation; gaps show directional value of foveas.

IMPORTANT: If ARC is revealed on this test, it is well established. It is possible to show NRC on this test and ARC on other tests because the after image test makes no attempt to produce normal conditions of seeing and is more likely to reveal the original (normal) correspondence.

Disadvantages

- a. Difficult to use with uncooperative patients because of the necessity of accurate observations.
- b. Does not necessarily diagnose what the patient is doing under every day conditions.
- c. Complete suppression of one image may occur.

E. Major Amblyoscope (Synoptophore)

Patient is asked to move the arm of the troposcope before the non-fixing eye until they see the images superimposed or until they see them cross from side to side. The subjective angle at which this occurs is compared to the objective angle of deviation. The angle of anomaly should not be less than 8 prism diopters because it can be confused with:

1. Suppression - Small area of dense central suppression simulating an angle of an anomaly.
2. Accommodation - angle of deviation may vary on dissociation.
3. Small degree of incomitance - apparent angle of anomaly as patient changes fixation from one eye to the other.

IMPORTANT: Degree to which ARC is established can be assessed using different size 1° and 2° slides.

Each eye is covered in turn and the patient is asked to note any movement of the fixation object. The object should move to a degree corresponding to the angle of deviation if NRC is present. If no movement is observed, suspect ARC.

III. OBJECTIVE TESTS

Press-on prisms are a useful tool to assess patient response to surgery.

When patients cannot reliably respond to sensory tests, the prism adaptation test (PAT) may help to prognosticate surgical outcome. Press-on prisms are given in an amount to slightly overcorrect the deviation and are placed completely in front of the preferred eye in children, non-preferred eye in adult, or equally in front of both eyes. If after one to two weeks wearing the prism the patient returns to his original deviation, this informs the surgeon to be more aggressive in the surgical procedure.

IV. TREATMENT OF ARC PATIENTS

A. General Management

Occlusion to eliminate amblyopia or alternate occlusion to prevent reinforcement of ARC which is a binocular phenomenon before surgical management.

B. Cosmetically Acceptable Patients

If patient has a small angle deviation ($10-20^\Delta$), VA is fairly equal, gross fusion and gross stereopsis, no treatment is given in an attempt to break ARC. In fact, some authorities advocate reinforcing and firmly establishing the ARC in order to give a more refined and stable form of binocular vision. The method of treatment used in firmly establishing the ARC is mainly with the amblyoscope. Have the arms set at the patient's subjective angle and increase divergence and convergence amplitudes from the subjective angle.

IMPORTANT: The majority of patients in this group are given no treatment and are just observed at 6 month intervals to check if ARC pattern is firmly maintained.

C. Orthoptic Management

1. Occlusion - to equalize VA and then alternate occlusion continued preoperatively to prevent reinforcement of ARC.
2. If orthoptic treatment is considered, the orthoptic methods performed on the Synoptophore are as follows:
 - a. Bi-retinal kinetic stimulation
The major amblyoscope tubes are locked at the patient's objective angle and the patient is instructed to fix straight ahead into the distance through the pictures. The tubes are then moved back and forth sideways to stimulate retinal corresponding points. The patient must not watch the pictures.
 - b. Massage of the macular area
The major amblyoscope tubes are set at the patient's objective angle and the patient is instructed to fix steadily on the target

before the fixing eye. The other tube is moved from side to side over the objective angle while the patient tries to see that target crossing backwards and forwards over the fixation object.

c. Mayou Technique

A foveal target is presented to the non-dominant eye and boxes of varying size to the fixing eye. Starting with the largest box, the patient is asked to move the tube from side to side over the target. This may cover a large area at first, the area gradually decreasing. When the images can be seen superimposed, smaller boxes are used until foveal targets can be superimposed without movement.

d. Flashing

The major amblyoscope tubes are locked at the objective angle and large, bright targets are used. The illumination is increased to maximum before the non-dominant eye. Alternate flashing is then carried out and the patient attempts to see the images come closer and eventually superimpose.

All exercises are objective and can be dull for the patient. Many patients may eventually give correct answers merely because they are bored.

D. Surgery

Aim is placing the visual axis parallel in order to facilitate constant bifoveal stimulation. Since patients with ARC have an intense motivation to return to their anomalous angle, the surgery considered is usually more aggressive than in patients with NRC.