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Biomedical Investigation of Heterophoria; Identification, Classification and Detection

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Abstract **Review Article**

Heterophoria is a clinical condition where the tendency for the eyes to deviate is kept latent by fusional reflex. It is an ocular defect in which the visual axes are directed towards the fixation but deviate in dissociation. It is also called 'latent strabismus'. The tendency for the two visual axes of the eyes not to be directed towards the point of fixation in the absence of an inadequate stimulus. It is the relative deviation of the eyes in absence of fusional vergence or the deviation from Ortho position that occurs when binocular fusion is made impossible. Heterophoria can be classified based on the direction of deviation or the manifestation of symptoms. Fusional vergence can be deprived by occluding one eye while the other fixates a visual target. The occluded eye will presumably deviate from its initial position by an amount of light that corresponds to the heterophoria. The cross-cover test, or alternating cover test is usually employed to detect heterophoria. One eye is covered, and then the cover is moved immediately over to the other eye. With heterophoria, when the cover is moved to the other eye, the eye that has just been uncovered can be seen to move from a deviated point.

Keywords: Hetrophoria; asthenopsia; fixation disparity; fusional vergence; Strabismus.

INTRODUCTION

The term heterophoria is derived from a Greek word, 'heteros' meaning 'other', or 'different from'; and 'phoria' meaning 'bringing' or 'comparing' [1]. Heterophoria is defined as a deviation from orthoposition that occurs when binocular fusion is made impossible (Manuel, Victor, [1,2]. Because of the dissociation of the two eyes, the term "dissociated" phoria is also used [2,3]. Heterophoria is not necessarily pathological, therefore, it may sometimes be physiological. Even a large heterophoria can be found in subjects who do not have exhibit symptoms that are typical, demonstrating that the phoric angle cannot be regarded as a" vergence position of rest" [4,5]. This commonly used term is biased since it implies comfort and thus an indisputable goal for therapy [6]. Moreover, the term" vergence position of rest" is misleading with respect to the innervation of the eye muscles [7]: If any of both eyes deviate from orthoposition into, e.g., a divergent position under covers the net pull of the eye muscles is not relaxed. If this were so, the eye would come forward. Rather, a relaxation of the medial rectus is compensated for by a tightening of the lateral rectus. Further, one has to realize that dissociated phoria is not a primary physical property independent of the method of examination (as opposed to, e.g., myopia or a manifest strabismus) [8]. Rather, the phoric angle is a reaction to an artificial interference with binocular vision.

Classification of heterophoria

Hetrophoria can be classified based on;

1. The basis of direction of deviation
2. On the basis of symptoms

On the basis of direction of deviation

1. **Esophoria**; In which visual axes are convergent when the eyes are dissociated.
2. **Exophoria**; In which visual axes are divergent when the eyes are dissociated.
3. **Hyperphoria or Hyophoria**; In which visual axes are vertically misaligned when the eyes are dissociated.

4. **Cyclophoria**; In which the eyes rotate about the visual axes when the eyes are dissociated. It can further be classified as;

(a) **Incyclophoria**; if the top of the primary vertical meridian rotates nasally and (b) **Excyclophoria**; if the top of the primary vertical meridian rotates temporally.

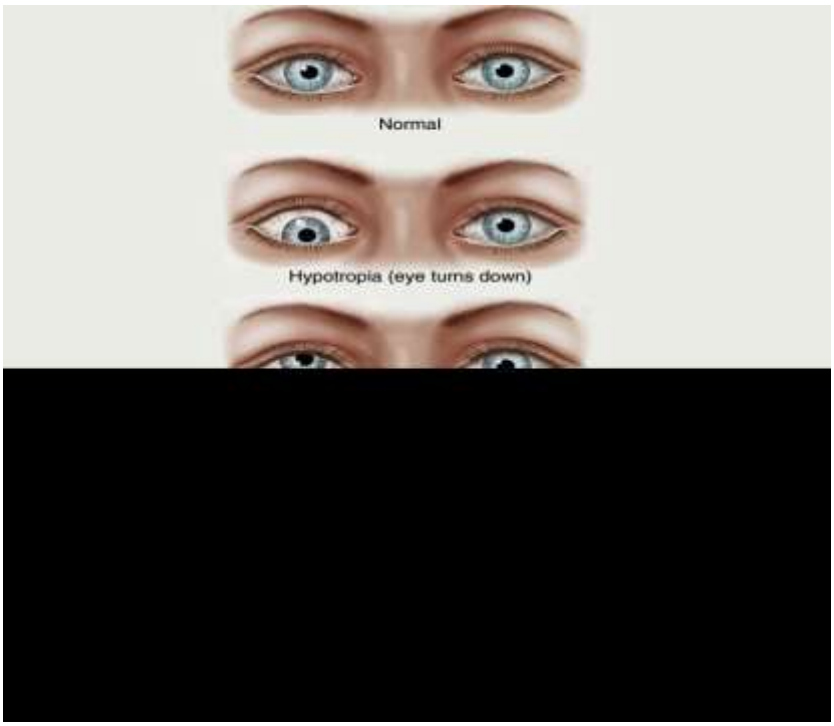

Fig. 1: Classification of heterophoria on the basis of direction of deviation [4]

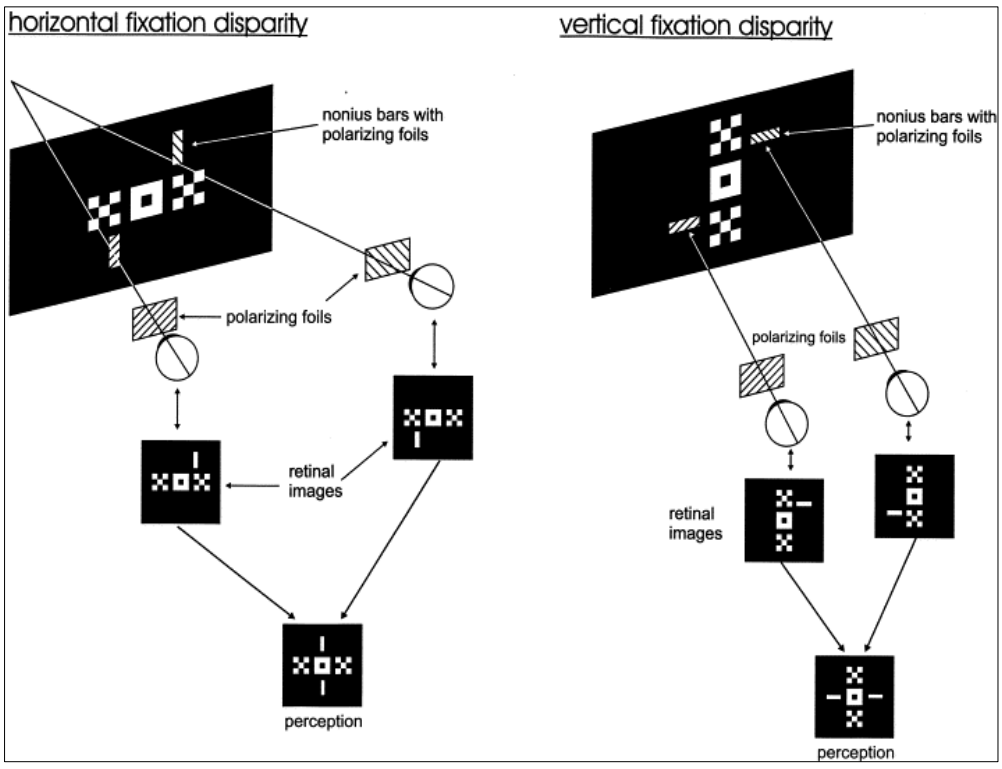

Fig. 2: Illustration of the psychophysical method for measuring fixation disparity with two nonius lines that are presented dichoptically, i.e. one to each eye, by means of polarizing filters in front of the nonius lines and the eyes. A fixation disparity is indicated by the physical offset between the nonius lines when they are perceived in line. The central fusion stimulus, the text characters XOX, are visible to both eyes. The test is shown in the horizontal (left) and vertical (right) meridian [1,8]

On the basis of symptoms

1. **Compensated Heterophoria**; This is a controlled heterophoria with no symptoms. Accounts for majority of population. Compensation depends upon the reserve neuromuscular power to overcome the muscular imbalance.
2. **Decompensated Heterophoria**; Occurs with inability to control the angle of deviation through inadequate fusional amplitudes and it is symptomatic. Even debilitating illness may precipitate symptoms in a previously asymptomatic patient [9] [10]. It is associated with symptoms associated the muscular fatigue like Headache, Asthenopia (eyestrain), Photophobia (increased sensitivity to light), difficulty in changing focus from near to distance and vice versa [11] and symptoms due to failure in maintaining binocular single vision (BSV) like blurring of vision, crowding of words while reading, difficulty with stereopsis, Intermittent diplopia and Intermittent squint without diplopia as well as Symptoms due to defective postural sensations which causes problems in judging distances and positions, especially of objects in motion [12].

Detection of heterophoria

The cross-cover test, or alternating cover test is usually employed to detect heterophoria [13,14]. One eye is covered, and then the cover is moved immediately over to the other eye. With heterophoria, when the cover is moved to the other eye, the eye that has just been uncovered can be seen to move from a deviated point. The difference between heterotropia and heterophoria can be easily understood as follows. With heterotropia, a correcting movement of the eye can be detected already by the simple cover test; with heterophoria, such correcting movement only takes place in the cross-cover test. People with heterophoria are able to create and maintain binocular fusion through vergence, and the cross-cover test purposely breaks this fusion, making the latent misalignment visible [15,16]. The alternate cover test induces dissociation to reveal total deviation when fusion is disrupted [16]. It is performed after cover-uncover test [17,18]. The occluder is shifted quickly back and forth from one eye to other, several times. After the cover is removed, the speed and smoothness of recovery is noted as the eyes return to their pre- dissociated state. A patient with well compensated heterophoria will have straight eyes before and after the test has been performed, whereas a patient with poor control may decompensate to manifest deviation [19].

Whereas the cross-cover test allows a qualitative assessment to be done, a quantitative assessment of latent eye position disorders can be done using the Lancaster red-green test [20].

In the fields of optometry and ophthalmology, the Lancaster red-green test is a binocular, dissociative, subjective cover test that measures strabismus in the nine diagnostic positions of gaze [13,21]. The test is named after Walter Brackett Lancaster, who introduced it in 1939.

The patient wears red-green glasses, and two lights (one red, one green) are used, so that the patient thus sees each light with a different eye. One light is held by the clinician, the other by the patient. The clinician points the light to a screen, requesting the patient to bring the second light to align on top of it. The patient's eye positions are measured while the patient performs the test.

Advantageously, monocular occlusion is applied before the test for at least 30 minutes [17,20]. This largely eliminates the neurologically learned fusional vergence tone ("vergence adaptation") that is present in patients who are able to achieve fusion in a limited area of gaze, as is often the case for patients with incomitant strabismus [14,15]

The Lancaster red-green test quantifies comitant and incomitant misalignments. It accurately assesses horizontal and vertical misalignments (heterotropia, heterophoria) as well as torsional misalignments (cyclotropia, cyclophoria) in all nine diagnostic gaze positions.

Other methods of detection include;

Maddox rod test: The Maddox rod is composed of a series of fused cylindrical red glass rods that convert the appearance of a white spot of light in to a red streak. The optical property of rod causes the streak of light to be at an angle of 90˚ with the long axis of the rods. The Maddox rod is placed in front of one eye and patient fixates with both eyes on a spot of light. The patient is asked whether the streak produced by Maddox rod passes through the fixation light seen by the other eye. When rod is placed horizontally, a vertical streak is produced and it gives an idea about exophoria or esophoria. A rod placed vertically produces horizontal streak, and it delineates hyperphoria or hypophoria. Prisms may be inserted in front of one eye to make the streak pass through the point of fixation, which estimates the degree of error. Maddox tangent scale placed at one meter or five meters may be used to measure degree of heterophoria directly from the scale [16,17]

Maddox wing test: This is used to measure the level or intensity of heterophoria at near fixation. The instrument is constructed or fabricated in such a way that the right eye sees only a white vertical arrow and a red horizontal arrow, whereas the left eye sees only horizontal and vertical rows of numbers. Patient rests the front piece of Maddox wing on nose and looks through the slit in eyepieces. Right eye of patient sees white scale and the left eye sees arrow. The number on scale through which white arrow passes, gives the measurement of horizontal

heterophoria [16,17]. Similarly, reading on vertical scale measures vertical phorias. Cyclophoria may be found by adjusting shaft of red arrow parallel to the horizontal scale.

Near point of convergence: The near point of convergence is the nearest point on which the eyes can maintain binocular fixation [15,17]. It may be measured with royal air force (RAF) rule, which rests on cheeks of patient. A target is slowly moved along the rule towards the eyes of patient until one eye loses fixation and drifts laterally. The subjective near point of convergence is the point at which the patient reports diplopia. Normally, the near point of convergence should be nearer than 10cm without undue effort.

Near point of accommodation: The near point of accommodation is the nearest point on which the eyes can maintain clear focus. It may also be measured with the RAF rule. The patient fixates a line of print, which is then slowly moved towards the patient until it becomes blurred. The distance at which blurring is reported first is read off the rule and it denotes the near point of accommodation. The near point of accommodation recedes with age [22]. When near point of accommodation recedes sufficiently far away to render reading difficult without optical correction, presbyopia is present.

Measurement of fusion reserves: Fusion amplitudes measure the efficacy of vergence movements [7,10]. These may be tested with prisms bars or the synoptophore. An increasingly strong prism is placed in front of one eye, which then abduct or adduct (depending on whether the prism is base-in or base-out), in order to maintain bi-foveal fixation. When a prism of greater than fusion amplitude is reached, diplopia occurs or one eye drifts in the opposite direction, indicating the limit of vergence ability.

Fixation disparity and associated phoria

Fixation disparity is a condition of binocular vision in which a fused fixation point is not projected onto the centre of the fovea in each eye [11,17]. This means, the principle visual directions that are associated with the centres of the foveae do not intersect at the fixation point, but do intersect either in front (eso) or behind (exo) in the case of horizontal fixation disparity. Large fixation disparities are likely to be associated with asthenopic complaints [5,11]. Such vergence errors may occur in subjects with normal binocular vision and typically amount to a few minutes of arc, thus are smaller than the Panum's areas and therefore do not lead to double vision to obtain a more reliable sign for asthenopia, it has been suggested to search, under natural viewing conditions, for a "residual vergence error", commonly called "fixation disparity". A fixation disparity might indicate that it is too strenuous for the asthenopic patient to overcome an abnormal phoric angle by motor fusion. According to this concept, a prismatic correction eliminating fixation disparity would allow asthenopic patients to relax into their phoric angle [22]. The vergence angle obtained after prismatic correction of fixation disparity is called associated phoria, as opposed to dissociated phoria, because associated phoria is determined without (or with only partial) dissociation of the two eyes. Similar to dissociated phoria, associated phoria is a reaction to an artificial interference with binocular vision, not a primary physical property independent of the method of examination. The value of fixation disparity as an indicator for an abnormal phoric angle has been challenged because the direction of fixation disparity can be opposite to heterophoria. Nevertheless, several authors have accepted fixation disparity as a sign of stress on the vergence system.

A therapy of asthenopia based on prismatic correction of fixation disparity and associated phoria, respectively, has to face two problems:

1. Search coil recordings have shown that fixation disparity regularly occurs when normal subjects are not in a laboratory situation with a fixed head, but move their head freely. There is no evidence that head movements (within limits) impair vision.
2. Conventional subjective tests for fixation disparity require markers that allow the subject to differentiate between the image of the right and left eye. These markers entail a deviation from natural viewing conditions, which may limit the validity of the results.

Conventional tests for fixation disparity

It would be desirable to detect and measure fixation disparity objectively with the unilateral cover test, analogous to the well-established test for strabismus. However, the refixation movement of the deviating eye is in the order of minutes of arc, too small to be seen with the naked eye. Performing the unilateral cover test for fixation disparity requires sophisticated instrumentation. As a way out, fixation disparity is often diagnosed subjectively, using Ogle's test, for example. A frame displayed to both eyes serves as a "fusional lock". The left eye sees a line in the upper half, the right eye in the lower half of the field (nonius lines). In the absence of fixation disparity, the two lines appear in alignment with each other. Any separation of the two lines is conventionally interpreted as fixation disparity [12,19].

In 1995, Haase developed a variant of Ogle's test, the cross test. The advantage of Haase's test over Ogle's is that a vertical deviation can be measured simultaneously with a horizontal deviation.

There are two questionable points in Ogle's approach:

1. The reliability of the test depends on the retinal correspondence, which should be normal and

invariant within the test area, including the "fusional lock" and the nonius lines.

2. The eye position assumed while looking at the artificial configuration of the test should be similar to that obtained under natural viewing conditions.

The first point has been examined by several authors, who compared the subjective percept with objective eye position data in normal subjects. It has been found that the two parameters do not always match [14,17].

For instance, the retinal correspondence can be shifted during fusion of a stereogram and during convergence stress. With respect to the second point, it has been recognized that restricting the binocular contours to the periphery loosens the "fusional lock" and allows the eyes to deviate from orthoposition. This observation is explained by Panum's areas of binocular single vision, which are larger in the periphery than in the center. Attempts to fill the central gap by fine fusionable objects, still using Ogle's nonius lines as indicators for the vergence position of the eyes, have not been fully successful since the monocular nonius lines compete with the binocular background, causing a suppression in their surroundings.

Clinical implication of hetrophoria

heterophoria only requires treatment if it is causing symptoms or impaired performance, if the binocular status is likely to deteriorate if it is not treated, or if the condition might in the future need treatment and would be more effectively treated now. A heterophoria that is causing symptoms or impaired performance or is breaking down to a strabismus is called a decompensated heterophoria [13,21]. If it is decompensated, the evaluation should identify which factors have provoked it to become so. In general, it is a heterophoria that has been fully compensated but becomes decompensated that gives rise to symptoms. After identifying the factors that cause the heterophoria to decompensate, the management consists of removing or relieving as many of them as possible [20].

Some heterophoria can be related to an active disease, pathological process, or recent injury. This type will be called 'pathological' heterophoria [15]. It is usually incomitant. In some directions of gaze, it may even lead to strabismus and double vision may occur. some parts of the routine occular screening are clinically relevant in the investigation of pathological deviations, and these assume more importance in the overall evaluation when pathology is suspected.

CONCLUSION

Heterophoria can be described as an ocular condition in which the eyes in the primary position or in their movement are maintained on the fixation point under stress only, with the aid of corrective fusion automatic responses. When the influence of fusion is removed, the visual axis of one eye deviates. It can be classified based on the direction of deviation of the eyes and also based on the manifestation of symptoms. Several methods can be used in its detection with the most common being the cross-cover or alternating cover test.

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