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Heterophoria and fixation disparity: A review

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Abstract Heterophoria does not provide a reliable clue for ordering prisms in an asthenopic patient. The same reservation applies to associated phoria, as determined by prism correction of fixation disparity. Subjective tests for fixation disparity, even those with a fusionable fixation target, do not correctly indicate the vergence position of the eyes under natural viewing conditions. Attempts to measure fixation disparity on the basis of stereo disparity, using the "Measuring and Correction Methods of H.-J. Haase", have failed.

Key words Heterophoria; fixation disparity; asthenopia; prism therapy

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Introduction A considerable proportion of patients consulting eye clinics complain of asthenopia. A classical description of asthenopia was given by von Noorden:[1] "The complaints range from redness and a feeling of heaviness, dryness and soreness of the eyes, to pain in and around the eyes, frontal and occipital headaches, and even gastric symptoms and nervous exhaustion. The eyes are easily fatigued, and such patients often have an aversion to reading and studying. Typically, these complaints tend to be less severe or to disappear altogether when patients do not use their eyes in close work."

The impetus for the present article is derived from two sources: On the one hand, heterophoria and fixation disparity have been considered typical candidates for causing asthenopia; on the other hand, it seemed necessary to dispute treating heterophoria and fixation disparity with prisms uncritically.

Heterophoria (dissociated phoria) Heterophoria is defined as a deviation from orthoposition that occurs when binocular fusion is made impossible as, for instance, by covering one eye. Because of the dissociation of the two eyes, the term "dissociated" phoria is also used. Heterophoria is not necessarily pathological.[1,2] Even a large heterophoria can be found in subjects who do not have symptoms, demonstrating that the phoric angle cannot be regarded as a ”vergence position of rest”. This commonly used term is biased since it implies comfort and thus an indisputable goal for therapy. Moreover, the term ”vergence position of rest” is misleading with respect to the innervation of the eye muscles: If an eye deviates from orthoposition into, e.g., a divergent position under cover 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). Rather, the phoric angle is a reaction to an artificial interference with binocular vision.

Fixation disparity and associated phoria To obtain a more reliable sign for asthenopia, it has been suggested to search, under natural viewing conditions, for a “residual vergence error”,[3] commonly called “fixation disparity”.[4] 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. The vergence angle obtained after prismatic correction of fixation disparity is called associated phoria,[5] 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[1] because the direction of fixation disparity can be opposite to heterophoria.[6,7] Nevertheless, several authors have accepted fixation disparity as a sign of stress on the vergence system (for review, see Schor[8]).

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.[9] 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.

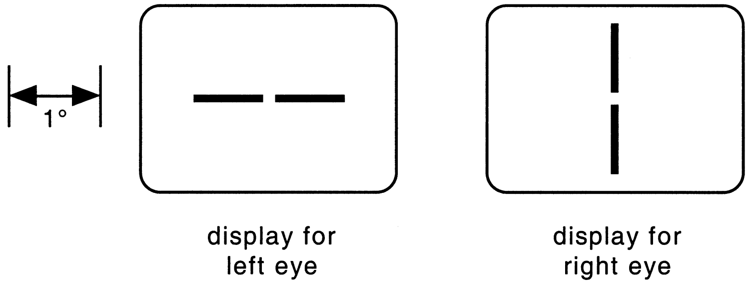

Fig. 1. H.-J. Haase's Cross test.

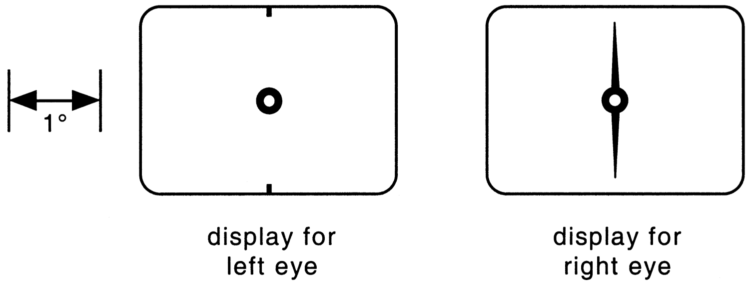

Fig. 2. H.-J. Haase's "clock hand test" for fixation disparity.

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.

In 1995, H.-J. Haase[10] developed a variant of Ogle's test, the cross test (Fig. 1). The advantage of H.-J. 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,[11-16] 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. For instance, the retinal correspondence can be shifted during fusion of a stereogram[11] and during convergence stress.[12,13]

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.[17] 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,[18] have not been fully successful since the monocular nonius lines compete with the binocular background, causing a suppression in their surroundings.[19]

Tests for fixation disparity with a fusionable fixation target To come close to natural viewing conditions, tests for fixation disparity have been designed that contain a fusionable fixation target. An example is the "clock hand test" (Fig. 2) developed by H.-J. Haase.[10] The central "axis" of the clock hands is presented to both eyes, serving as a fusional stimulus. As an indicator for relative eye position, the right eye is presented with "clock hands" and the left eye with peripheral marks. Given normal retinal correspondence, any deviation of the clock hands from the marks should indicate fixation disparity.

At first glance, this test appears convincing. However, we were concerned that the fusional stimulus created by the central "axis" might be impaired by the dissimilarities that surround it, causing binocular rivalry and suppression. Taken as a whole, the displays for the right and left eyes are different, and this difference might considerably degrade the fusional stimulus. To test this possibility, we compared the vergence position of the eyes under two conditions.[20] First, when the subject was looking at a target that was identical for both eyes, and second, when the subject was looking at the original clock hand test (Fig. 2).

To measure fixation disparity objectively we used the search coil technique.[21] Nine paid subjects were selected who saw a deviation both in the cross test (Fig. 1) and in the clock hand test (Fig. 2). They wore metal coils embedded in silicone rings sucked to the conjunctiva just outside the limbus of both eyes. Polarizing filters were used to separate the visual objects for the right and left eyes. Targets were presented at a distance of 4.5 m on a liquid crystal display (Polatest® E, Zeiss).

In a first experiment, we performed the unilateral cover test under natural viewing conditions, using the fixation target that was identical for both eyes. A refixation movement did not occur in any of the nine subjects, proving that they did not have a fixation disparity.

In a second experiment, we compared the eye position under two conditions, the natural viewing condition and the artificial condition of the clock hand test (Fig. 2): Under the artificial condition a fixation disparity gradually developed.

The subjectively perceived separation between the clock hands and the marks was similar to the objectively measured fixation disparity in all nine subjects, demonstrating that the clock hand test reliably indicates fixation disparity under its artificial viewing condition. It has to be realized, however, that the fixation disparity that arises when looking at the clock hand test does not indicate a fixation disparity under normal viewing conditions.

Attempts to test for fixation disparity on the basis of stereo disparity H.-J. Haase[10,22] suggested two tests for fixation disparity that avoid any deviation from natural viewing conditions. Both of these tests are based on a stereo display.

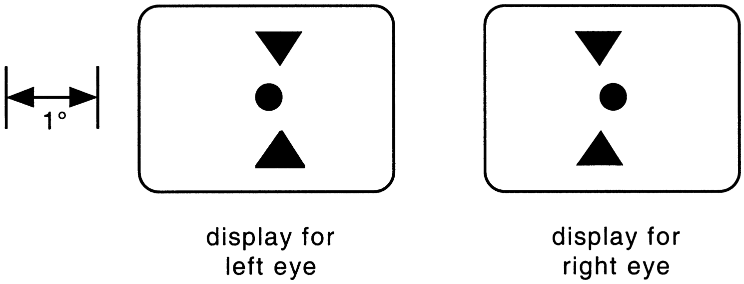

Fig. 3. H.-J. Haase's Stereo reversal test. The display of the triangles is switched between crossed (depicted) and uncrossed stereo disparity. The subject has to report whether or not the stereo percept arises with equal promptness and clarity in the two variants.

THE STEREO REVERSAL TEST[10,22] The subject looks at a fixation point. Two triangles, one above and the other below the fixation point, are displayed with crossed and uncrossed disparity in alternating succession (Fig. 3). H.-J. Haase suggests that a difference between crossed and uncrossed disparity in the promptness and clarity of the stereo percept indicates fixation disparity. If the triangles are seen faster and clearer in front of the fixation point (crossed stereo disparity) than behind it (uncrossed stereo disparity), he infers that the subject has an eso fixation disparity. The reasoning behind this suggestion is the following: Given an eso fixation disparity, triangles with crossed stereo disparity will be imaged closer to the foveal center of the deviating eye. In exo fixation disparity, triangles with uncrossed stereo disparity will be imaged closer to the foveal center of the deviating eye.

THE STEREO BALANCE TEST[10,22] The subject looks at a fixation point. Two triangles, one above and the other below the fixation point, are displayed either with crossed or uncrossed stereo disparity (Fig. 4). If the contribution of the two eyes to the percept is balanced, the triangles appear in the midline above and below the fixation target. A dominance of one eye against the other is recognized by the subject as a lateral offset of the triangles. The subject is asked to report the magnitude of the offset with reference to two scales of six vertical lines displayed without stereo disparity between the fixation point and the triangles. The magnitude of the offset is taken as a measure of the imbalance. After having excluded an organic cause, H.-J. Haase assumes that an inferiority of one eye indicates that the triangles are imaged further away from the foveal center in that eye. In other words, H.-J. Haase takes an imbalance of the percept as a sign of fixation disparity. The direction of the fixation disparity is inferred from the imbalance of the percepts evoked by crossed and uncrossed stereo disparities. For instance, an eso fixation disparity of the left eye is diagnosed by an offset of the triangles to the right when they are displayed with uncrossed stereo disparity, and no offset when they are displayed with crossed stereo disparity (Fig. 4).

We tested the validity of the stereo reversal and balance tests by recording the unilateral cover test with search coils.[23] Nine subjects were selected who reported an asymmetrical percept in both the stereo reversal and balance tests. In none of the subjects was a fixation disparity found.

Since our results did not support H.-J. Haase's interpretation of the stereo reversal and balance tests, we consider that binocular rivalry

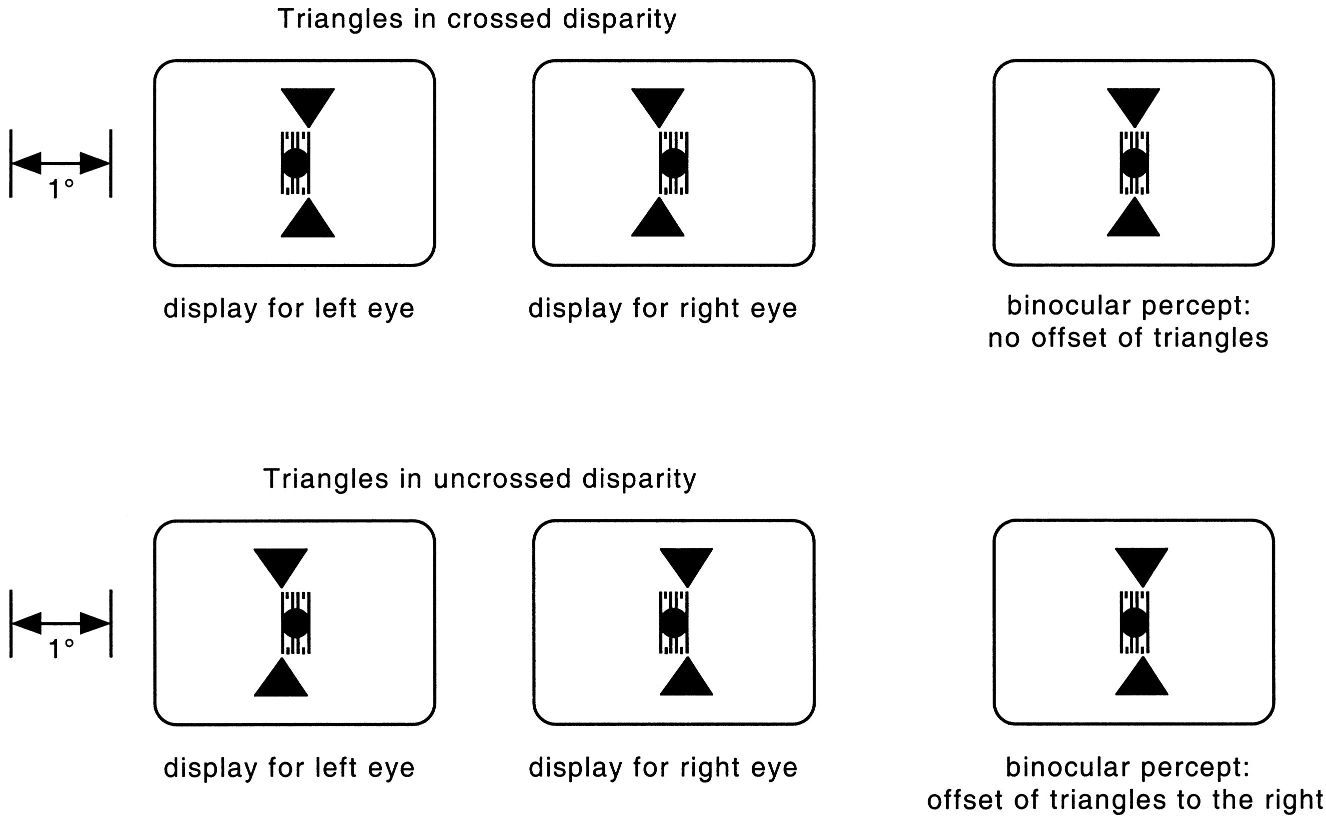

Fig. 4. H.-J. Haase's Stereo balance test. The triangles can be presented with crossed or uncrossed stereo disparity. The subject has to report any lateral offset of the triangles. The offset can be quantified with respect to the scales above and below the fixation point.
Example: If the triangles are displayed with crossed stereo disparity the subject perceives no lateral offset (upper diagram): Both eyes contribute equally to the binocular percept. If displayed with uncrossed stereo disparity (lower diagram) the subject perceives an offset of the triangles to the right. This demonstrates a dominance of the right eye, i.e., an inferiority of the left eye.
Interpretation according to H.-J. Haase: Eso fixation disparity of the left eye.

between the stereo disparate objects, rather than fixation disparity, may explain the imbalance between the percepts provided by the two eyes. The rivalry may be elicited by the large stereo disparity contained in the stereo reversal and balance tests. A similar interpretation was suggested by Lang.[24] His experimental design was, however, not suitable to prove binocular rivalry. By adding monocular markers he created an unnatural viewing condition which, by itself, can produce binocular rivalry and suppression. (The same criticism applies to Haase's clock hand test, see above). Nevertheless, we think that Lang's suggestion is tenable.

H.-J. Haase proposes that the stereo reversal test and the stereo balance test can indicate fixation disparity even in subjects who perceive the cross test (Fig. 1) in zero position (with or without prisms). In such cases, he ascribes the percept of zero position in the cross test to a shift in retinal correspondence. Although this concept is consistent in itself (and would apply for microstrabismus), it did not stand the test of our objective eye position recordings.

H.-J. Haase[10,22] uses an intricate sequence of his tests to determine prisms for the treatment of asthenopic patients. For instance, if his tests suggest an eso fixation disparity he applies base-out prisms, trying to reach a neutral point for the cross test (Fig. 1), the clock hand test (Fig. 2), the stereo reversal test (Fig. 3), the stereo balance test (Fig. 4) and three other tests, mainly for correction of vertical deviations. He reports that these prisms can improve stereo acuity and can relieve asthenopia in many patients. Several other authors have confirmed H.-J.

Haase's findings.[25-28] Moreover, H.-J. Haase's therapeutic approach has gained wide acceptance among the members of the International Association for Binocular Full-correction (IABF). Although H.-J. Haase's theoretical considerations, based on the diagnosis of fixation disparity, have not been supported by our experiments,[20,23] these therapeutic observations deserve further attention.

Conclusions

(1) Subjective tests for fixation disparity, even those with a fusionable fixation target, do not correctly indicate the vergence position of the eyes under natural viewing conditions.

(2) Attempts to test for fixation disparity on the basis of stereo disparity must be questioned.

(1) Both dissociated and associated phorias constitute reactions to artificial viewing conditions.

(4) Both dissociated and associated phoria provide only weak clues for ordering prisms in an asthenopic patient. There is no evidence for concluding which of the two, dissociated or associated phoria, provide the better clue.[29] Hence, neither of them can serve as a "gold standard" to judge the value of the other.

Recommendations Given these conclusions, what can be inferred for the therapy of asthenopic patients?

(1) Notwithstanding the need for history taking and medical examination, the decision for prescribing prisms in an asthenopic patient should depend on prism trials in natural surroundings. In this way, the therapeutic "end-point" is tested, as opposed to dissociated or associated phorial which are only "surrogate markers".

(2) To avoid being misguided by a placebo effect, prism trials should include controls, as for instance applying so-called yoked prisms with the base in the same position in both eyes, not in mirror position.

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