The Effect of Induced Prisms in Haploscopic Measurement of Fusional Limits

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Abstract

When the haploscope is used to measure fusional limits at near, a - 2.50 D lens is placed in a lens holder in front of each eye of the subject. It is assumed that the lines of sight will rotate equal amounts to the movement of the haploscope tubes such that the foveal fixation is maintained. This assumption is investigated. It was found that the lines of sight of 60% of the subjects studied lagged behind the movement of the arms of the haploscope. The implication of this is discussed and it is recommended that the haploscope be used as an instrument to train fusional vergences rather than to measure them.

Abrégé

Si le haploscope est utilisé pour déterminer l'amplitude de la fusion de près, on doit interposer une lentille de -2.50 D devant chaque oeil. On s'attendrait que les axes visuels suivraient les angles de rotation des tubes de l'haploscope afin de maintenir la fixation sur la fovéa. Cette hypothèse est l'objet de ce travail. Il a été révélé que dans 60% des cas étudiés leurs axes visuels étaient en retard sur la rotation des bras du haploscope. On discute des effets possibles de ce retard. Les auteurs concluent que le haploscope est un instrument de réhabilitation et non pas un instrument diagnostique.

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Introduction

In binocular vision, the fusional limits of a subject are determined by means of prisms or haploscope. The Risley prisms are employed mostly in routine clinical practice, and the haploscope is occasionally used. When the prisms are used, the phoropter field stop is sometimes displaced, and the subject experiences an early break in fusion. This was studied by Remole and Sheni,[1] and they recommended that the phoropter P.D. be decentered for higher base-out prisms in order to avert this limitation. When a haploscope is employed in measuring the fusional limits, a similar but different situation occurs.

At a distance, the arms of the haploscope are rotated to create retinal disparity, and the lines of sight are assumed to rotate equal amounts behind the tubes such that foveal fixation is maintained. The negative and positive blur and break limits are then measured.

At near, however, the situation is slightly altered. To simulate 40 cm working distance the - 2.50 Diopter lens is placed in a lens holder in front of each eye, and it is expected that the eye would accommodate 2.50 Diopters and converge appropriately due to accommodative convergence. To compensate for the convergence, the arms of the haploscope are set 15 prism diopters convergent. The findings of the limits of single binocular vision are measured from this reference point, subtracting 15^{Δ} in convergence and adding 15 prism diopters for divergence. During the measurement of fusional limits, the eyes are expected to move equal amounts to the movements of the arms of the haploscope. Usually, the lines of sight then intersect at or near the optical centres of the lenses, and no oblique aberrations occur. However, in some cases, one or the other of the following happens; (a) the eyes lag behind the movement of the arms of the haploscope, (b) the eyes move faster than the arms of the haploscope and (c) the eyes alternate between fast and slow movements. Usually the conjugate movements of the eyes are less than the movements of the arms of the haploscope (refer to figure 1). When this occurs, base-out prisms are induced. This results in a lower-scale reading of the arms of the haploscope than ideal. The other thing that happens when the eyes look through the periphery of the lens rather than the center is the influence of aberrations on the retinal image. Oblique rays become more prominent and oblique aberration influences the retinal image by decreasing the sharpness of the image. The result is that the subject perceives blur earlier than he or she should. If, on the other hand, the lines of sight move faster than the arms of the haploscope, a base-in effect is induced. The effect is that a higher than ideal base-out finding is recorded. Oblique aberrations would still play a similar role by influencing the perception of blur. This is only an occasional occurrence. The situation where the same subject alternates between base-out and base-in induced prisms during the same measuring period is very rare. One of the problems that occurs when a subject has high vergence limits is that a break is not experienced before the arms of the haploscope lock together.

It is the aim of this paper to investigate the influences of the above-mentioned factors on the fusional limits of subjects.

Methods

Ten (10) subjects, ranging in age from 20 to 32 with an average age of 23.3 years, participated in the study. Their refractive states are as shown in Table 1. All subjects had visual acuities of 20/20 or better in each eye with their best correction on. A Curpax 5000 Synoptiscope was used in this study and the findings were taken for an optical distance of 40 cm. The arms of the haploscope were adjusted for the near interpupillary distance of the subject and set 15 Prism Diopters convergent. The synoptiscope was set up such that the minus 2.50 Diopter lenses were suspended on a horizontal bar supported by two vertical rods. This arrangement made it easier for the lenses to be decentered with the rotation of the arms of the haploscope. In this way the lines of sight always passed through the optical center of the lenses. The findings were first taken conventionally, and then by decentration of the lenses. During the conventional measurements of the fusional limits, the subject sat comfortably, looking through the tubes as disparity was introduced. The subject reported a blur that could not be cleared and a break that did not permit fusion temporarily. Each haploscope field was supplied with a vertical row of 20/30 Snellen acuity letters which had been photographed and printed on transparent plastic sandwiched between two pieces of glass.

The positive limits of single, clear binocular vision were determined and then those of single binocular vision. For the most of the subjects, the findings were determined conventionally and then by decentration of the lenses. To control training effect, the procedure was reversed for subject C.T. When the subject wore a prescription at the spectacle plane, this was combined with the - 2.50 D lens. For example, subject C.K. needed about - 6.00 Diopters in both eyes; this was combined with the - 2.50 Diopter lens and a - 8.50 D lens was placed in the lens holder.

Table 1 Subjects' Refractive Status

Subject	Spectacle Correction (Diopters)	Subject's I.P.D. Far/Near (mm)	Base-out Findings Blur Break (Prism Diopters)
D.W.	2Δ Exophoria @ 40 cm OD PL-0.50 x 137 OS - 0.75 (Glasses)	65/61 Age = 21 yrs.	7/14.8 9.4 / 19.4
C.P.	1.5Δ Esophoria @ 40 cm OD - 3.75 OS - 4.00 (Gl)	59/55 Age = 21 yrs.	14.8 / 21.4 24.8 / 32.4
C.T.	6Δ Exophoria @ 40 cm OD - 1.75 - 1.50 X 176 OS - 1.25 - 1.00 X 161 (Glasses)	62/59 Age = 23 yrs.	X / 27 X / 29.4
S.T.	Orthophoria Emmetrope	61/58 Age = 20 yrs.	X / 27 X / 32.2
C.K.	2Δ Exophoria OD - 6.00 - 0.75 X 010 OS - 5.50 - 1.25 X 165 (Glasses)	59/57 Age = 21 yrs.	X / 39.2 X / 49.0
M.C.	5.5Δ Exophoria @ 40 cm Emmetrope	61/58 Age = 22 yrs.	X / 10.8 X / 10.7
K.M.	5Δ Exophoria OD - 6 - 0.75 X 080 OS - 5.50 - 1.0 X 050 (Glasses)	59/57 Age = 21 yrs.	X / 7 X / 5.6
B.G.	Orthophoria Emmetrope	64/59 Age = 25 yrs.	X / 20.2 10.2 / 22
D.D.	2Δ Exophoria Emmetrope	69/66 Age = 27 yrs.	32.33 / 78.33 32.33 / 72.83
J.M.	Emmetrope	67/64 Age = 32 yrs.	28.6 / 89.6 21/4 / 73.6

Results

Table 1 shows the results for the 10 subjects that participated in the study. Column 4 of the table shows the base-out to blur and break findings. Each datum is an average of three or more findings. The upper findings represent data taken conventionally, and the lower ones were taken when the lenses were decentered and set perpendicular to the lines of sight. The "X" stands for "no blur reported." This might result from the subject changing his or her criterion for blur. In most of the reported cases of base-out-to-blur findings, the data with the lenses decentered were larger than those taken conventionally, except subject J.M. Most of the subjects demonstrated this for the limits of single binocular vision, except subjects K.M., D.D., J.M., and M.C. Subject M.C. showed no difference in the findings, whereas subjects K.M., D.D., and J.M. demonstrated a decrease. Most of the subjects had a low phoria and enough fusional reserves to satisfy Sheard criterion. Subjects M.C. and K.M., who either marginally satisfy or fail to satisfy Sheard criteria, had no binocular complaints or symptoms.

Discussion

When a subject looks into the tubes of the haploscope for the purpose of measuring fusional limits, it is assumed that the eyes look through the optical center of the lenses all the time. As seen from Table 1, there are times when the eyes lag behind the rotation of the arms of the haploscope (refer to Figure 1). Column 4 of Table 1 clearly shows that, in most cases, the findings of the blur and break limits were larger when the lenses were decentered than when taken conventionally. The negative fusional vergence limits are usually low and the effect of induced prisms might not be significant enough. It was decided to concentrate on the positive rather than the negative limits. When the eyes look obliquely through the negative lenses, base-out prismatic effects are induced and a lower than ideal scale reading is recorded. Apart from this effect, oblique aberration brings on an earlier perception of blur. This may also influence the break finding. As shown in Figure 1, if the lines of sight lag behind by 4 mm, in an emmetropic subject, the induced prismatic effect is given by Prentice's rule $D = CF$; $D = 0.4 \times 2.50 = 1.00\Delta$, at least one prism diopter base-out induced in each eye. The effect becomes more dramatic if the subject is a medium or high myope like subject C.K. The subject's prescription is OD: - 6.00 - 0.75 x 010 and OS: - 5.50 - 1.25 x 165. If it is assumed that each eye has a spherical equivalent of - 6.25 Diopters, so that when this is combined with - 2.50, a - 8.75 Diopters lens would be placed in the lens holder. The induced prism is $0.4 \times 8.75 = 3.500$ prism diopters: a total of 7Δ in front of both eyes. The possibility of a greater or lesser lag than 4 mm cannot be neglected. On the other hand, when the eyes move faster than the haploscope arm, a base-in-prismatic effect is induced. This has an influence of making the findings higher than the ideal. Subjects K.M., D.D. and J.M. are three representatives of this effect. There is a third group whose lines of sight move at the same rate as the arms of the haploscope. This group demonstrates no significant change in the positive fusional limits. For example, subject M.C. showed no change in the fusional limits between the conventional and decentration techniques. Subject D.D. demonstrated an increase in the blur findings and a decrease in the break findings when the lenses were decentered. This demonstrates clearly how interchangeably the factors could operate in a single individual.

In the case of a hyperope, a base-in prismatic effect is induced when the eyes lag behind the movement of the arms of the haploscope. As a result, a higher than ideal base-out finding is recorded. The opposite effect happens when the eyes move faster than the arms of the haploscope.

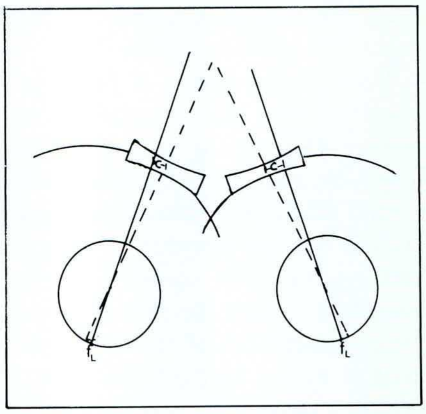

Fig. 1 Diagramatic representation of the lines of sight as they lag behind the movement of the arms of the haploscope during force convergence. C is the displacement of the lines of sight from the optical center of the lens. The induced prismatic effect is given by $\Delta = CF$.

Conclusion

The haploscope, like the Risley prism, is usually employed in measuring and training vergence limits. The above study has clearly indicated the need for using the haploscope mainly as a training instrument rather than as an instrument for accurate measurement of fusional limits. When it is employed in measuring these limits, it should be used with caution. Of the 10 subjects studied, only 10% demonstrated the classical theoretical expectations. 20% showed the base-in induced effect and 60% the base-out induced prism effect. 10% demonstrated a combination of both the base-out and base-in effects. There is, therefore, a need to have a rule for decentration of the lenses. This is more important if the subject is a high myope. For example, in a medium myope like the case above, there was a difference of 10 prism diopters increased when the lenses were decentered 8 mm in front of both eyes. A total of 7 prism diopters were induced when the lenses were not decentered. By simple arithmetic, about 1.0Δ induced prism diopter was eliminated by decentering 1 mm. This corresponds to a 10Δ prism diopter scale reading. This implies that the lenses should be decentered 1 mm for every 10 prism diopters of the haploscopic arms scale reading.

It is therefore suggested that the lenses be decentered 1 mm inwards for every 10 prism diopters of convergence.

Reference

Remole A., and Sheni, D.D., Prismatic displacement of field stop. *Optometric Monthly*, 1981; 72(5): 23-6.