A Modification of the Bio-Photometer for Alterocular Fixation Control

W. M. LYLE and H. W. HOFSTETTER, Respectively, Research Assistant in Optometry and Professor of Optometry, Division of Optometry, Indiana University, Bloomington

• ONE FACTOR to be controlled in dark adaptation testing is that of fixation so that the region of the retina under investigation is known and constant. This is rather easily controlled during the bleaching phase, but in the test phase the subject is tempted to deviate from the conventional red fixation light to search the area in which the test object is anticipated. This may not be a serious detraction for a trained subject, but it is very disconcerting to both the naive subject and the conscientious test operator.

The present report, preliminary to a more comprehensive study in progress, describes an attempt to modify the Bio-photometer model D-145, an instrument manufactured by the Frober-Faybor Co. of Cleveland, Ohio, (1) to provide for the testing of one eye while its orientation is controlled by the fixation of the other eye. This technique is referred to as alterocular fixation control.

APPARATUS

To control the orientation of the line of sight of the nonfixating eye, which is undergoing the test while the other eye is fixating, it is necessary to hold accommodative convergence constant and to provide a compensatory correction for the relative deviation of the two eyes under dissociation. Both of these conditions are provided for by the combination of a prism and a pair of lenses just inside of the viewing apertures. The instrument, as seen from the subject's side, is shown in Figure 1. The schematic plan of the instrument is shown in Figure 2.

The accommodative convergence is held steady by means of a convex lens (Fig. 2, L_2) mounted in front of the fixating eye (O. S.) to place the image of the fixated red light at a distance of 1 m. Similarly, a convex lens (Fig. 2, L_1) is mounted in front of the test eye (O. D.) to place the image of the test plane at a distance of 1 m. This distance is assumed a suitable accommodative stimulus for all of the subjects in the group, in the sense that an object at this distance can be held in reasonably steady focus.

The compensatory correction for the relative deviation of the two eyes is provided for by the lateral and vertical moveability of the red fixation light (Fig. 2, B) in combination with an 8^{Δ} base-out prism mounted in front of the fixating eye.

Another modification consists of a small opaque annulus (Fig. 2, A), with outside diameter of 15 mm and inside diameter of 6 mm, on the transilluminated bleaching field (Fig. 2, M) to provide a fixation target for the test eye during the bleaching

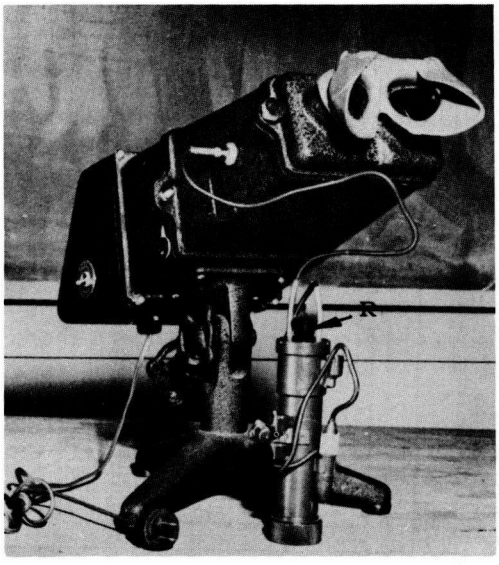

Figure 1. The Model D-145 Bio-photometer with modifications.

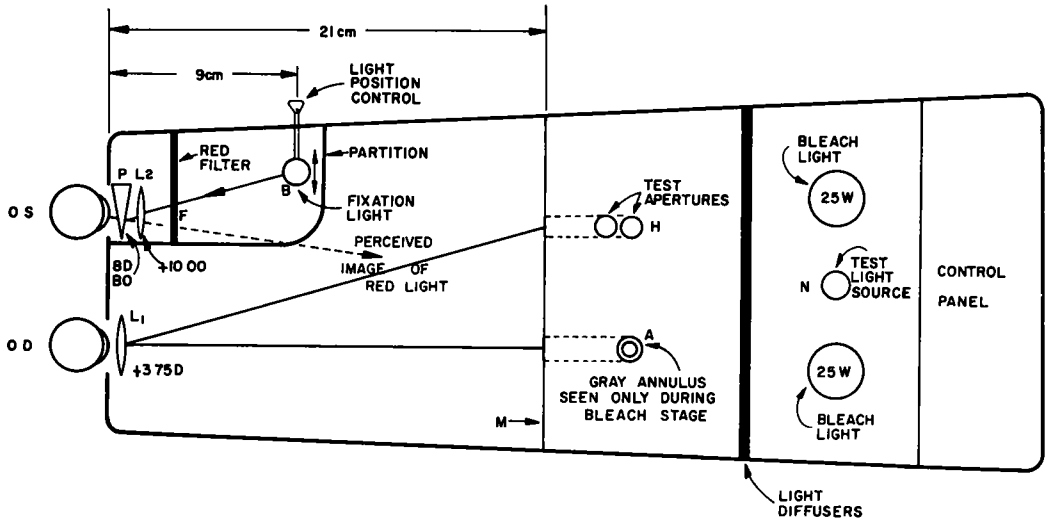

Figure 2. Schematic diagram of the modified Bio-photometer.

phase. This annulus also serves as a fiducial mark for adjusting the position of the red fixation light in front of the other eye until the light appears to lie inside the annulus.

The only other functional modification of the Bio-photometer is that of reducing the luminance of the two brightest spots in the original quincunx target by the overlaying of translucent papers to reduce transmittance. This modification reduces their luminance $7\frac{1}{2}$ times, but they are still brighter than the other three spots. The latter three spots serve no purpose except, rarely, to call attention to negligence on the part of the subject.

Inasmuch as the instrument is to be described in full detail elsewhere (2), only a few functional features need to be pointed out here with reference to Figure 2. The test plane M has two components. One is an opaque rectangular plate with the five quincunx target apertures. Only the two identified as H are employed in the test These apertures, 4 mm in diameter and separated by an edge to edge distance of 28 mm, are located one above the other and are equally luminous. The centers of these two apertures are located 17 mm to the left of center. The other component consists of the translucent bleaching surface that comes into full view when the opaque plate is flipped down, out of position. The opaque, gray-appearing annulus A is located to the right of center so that the total bleaching area centers around a point about 12^0 nasal to the line of sight of the test eye (O. D.). Because the left eye fixation is pre-adjusted to make the red light appear in the annulus, the alterocular fixation of the red light by the left eye is presumed to maintain the line of sight of the right eye in the same position during the subsequent testing. The resulting angle between the line of sight of the right eye and the direction of the test apertures, therefore, approximates 16^0.

PROCEDURE

For the purposes of this preliminary study each subject was kept in a completely dark room for 10 min. Then the bleach lights were turned on and adjusted to give 250 millilamberts, and the subject was instructed to fixate the annulus, which was visible to his right eye. During the bleaching, the position of the red light was adjusted until the subject reported seeing it inside the annulus. The bleaching phase was continued for a total of 3 min. At the same time that the bleach lights were turned off, the quincunx target plate was flipped into position and the faint light, N, was turned on to illuminate the test apertures, H. At the end of the first and each succeeding minute

the subject was instructed to report the first appearance of the two test spots, H, as the intensity of the test light source was gradually increased. As soon as their appearance was reported, the intensity of the test light was noted and immediately reduced to a value well below the threshold. The noted intensity at the moment of visibility was recorded in rheostat scale units. From time to time, the intensity of the red fixation light was reduced to make it comfortably visible to the subject without seeming unncessarily bright.

RESULTS AND OBSERVATIONS

Figure 3 shows a sample of seven successive runs on one subject, numbered in the order in which they were obtained, and successively displaced 20 rheostat units each to separate them on the vertical scale or ordinate.

Altogether 16 pairs of runs on a corresponding number of subjects were made on the modified Bio-photometer. For the purpose of determining the relative reliability of the test at the first, second, and subsequent minutes, the coefficients of correlation of the raw data for each minute and the coefficients of rank correlation of the ranked data for each minute were computed. The trends of these correlation coefficients are shown in Figure 4. The coefficients are positive throughout the range of the 10 min investigated and appear to reach a maximum at about the sixth minute.

What seemed to be a very important incidental observation was that all of the subjects reported the judgments very easy to make. There was virtually complete absence of any temptation to drift away from the fixation light to explore the region in which the test spots were anticipated. The several subjects who had previously submitted to tests on the unmodified Bio-photometer gave substantial testimony to the reduced conflict of attention on the modified instrument.

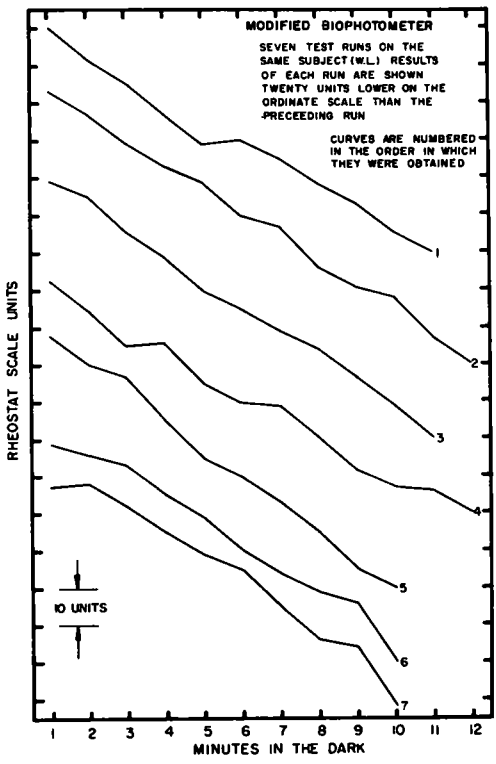

Figure 3. Results of seven test runs on one subject. Each successive run of data is successively displaced 10 rheostat units downward to facilitate complete separation for comparison purposes.

SUMMARY

A Bio-photometer was modified to measure the dark adaptation of one eye while its orientation was controlled by the fixation of the other eye. Preliminary

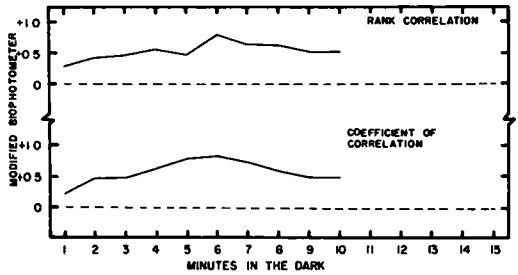

Figure 4. Test-retest correlation coefficients at each of 10 consecutive minutes on 16 pairs of runs on a corresponding number of subjects presumed to be normal. The lower curve represents the standard coefficients of correlation computed from the rheostat scale values. The upper curve represents the rank correlation coefficients computed from the relative ranks of each rheostat scale value at each minute.

testing over a 10-min range on a small sample of subjects suggests that relatively good reliability is attainable, and that the test-retest reliability reaches a maximum at about the sixth minute following the end of the bleach period. Reports of the subjects indicate that the visibility judgments are remarkably easier to make by this technique.

ACKNOWLEDGMENTS

This study was undertaken as a part of the research in night vision for driving, supported by a grant from the American Optometric Foundation.

REFERENCES

1. The instrument manufacturer and address as given in the article were taken from the Bio-photometer nameplate. The accompanying instruction manual was entitled "Vision, Light and Dark Adaptation." Bio-Medical Instrument Company, Newbury, Ohio, no date (circa 1942). In some of the manufacturer's literature the address was given as Chagrin Falls, Ohio.
2. Lyle, W.M., Master's thesis in preparation, Indiana Univ., Bloomington (1962).