DARK ADAPTATION IN NEUROTIC PATIENTS

By

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1. Introduction

Several studies have been undertaken in which the "dark vision" of normal and neurotic groups has been compared (see (5) for references). As a result of these researches it appears that neurotic patients tend to have inferior performances to normal subjects on tests of "dark vision". The term "dark vision" is, however, a very general one, covering all aspects of visual functioning at brightness levels below about 0·01 candle per square foot (13). Clearly we need to know more precisely *which* aspects of dark vision are impaired in neurotics, the *extent* of the impairment, the *conditions* under which it occurs, etc., if we are to go beyond fairly crude descriptive statements about differences between normal and neurotic groups to an understanding of the processes involved.

Of the many questions that need to be answered, a fairly basic one concerns the relative importance of the light and form senses in producing the observed differences. While work on the Livingston Rotating Hexagon test (10, 11) suggests an impairment of form perception in neurotics under conditions of low illumination, other research (6, 7) suggests that the light thresholds themselves may be impaired. Moreover, the writer's work (6) leads one to suppose that this impairment may extend over a large part, if not the whole range, of the rod portion of the adaptation curve.

However, owing to certain unsatisfactory features of the instrument used for measuring dark vision and the test procedure, information on this point is indefinite. In the first place, the instrument lacked a suitable scale of brightness for the plotting of threshold values throughout the dark adaptation period; secondly, it did not incorporate a unit for light-adapting the subject prior to the test; and, thirdly, viewing conditions were such that the angle subtended at the eye by the test field was rather too small in relation to the type of test object to provide information on the light sense as such.

In an attempt to obtain more precise information on the possible impairment of light thresholds in neurotics, the present study has been undertaken using a Crookes Adaptometer* and a somewhat different test procedure.

2. Description of Apparatus

The apparatus consists essentially of two parts, a "bleaching" or light adapting unit, and a dark adaptation test-light unit; these will be described in turn.

(a) *Light-adaptation Unit*

This consists of a cylinder with an arrangement of lamps and diffusing media arranged so as to give a uniform illumination of the surface of a sand-blasted "bleaching" bowl (see Fig. 1). The brightness of this bowl is 750 ml.

* The writer is greatly indebted to The Crookes Laboratories, Ltd., for the loan of the adaptometer and for permission to reproduce Fig. 1; and to Dr. J. I. M. Jones of their Research Laboratory for helpful discussion.

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and the colour temperature approximately 2,750°K. This particular brightness value viewed for five minutes was selected as being sufficiently high to ensure that subsequent dark adaptation should not be too rapid to keep track of and also to make evident the cusp in the dark adaptation curve denoting the transition from cone to rod vision.

A further advantage of this particular level of brightness is that it tends not to give rise to complications due to after-images (1).

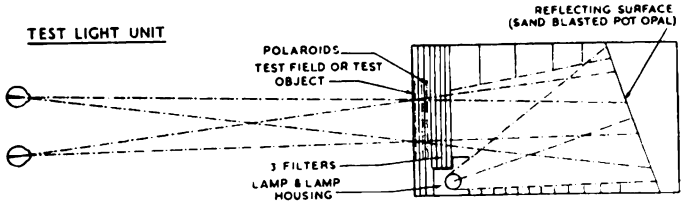


FIG. 1.—The Test-light Unit.

(b) *Dark-adaptation Test-light*

The test object consists of an arrow-head cut out of a metal diaphragm and appears against a background of sand-blasted pot opal illuminated by a lamp placed normal to its centre. The shape of the arrow was designed in such a way that no part can be seen as such before its shape as a whole is perceived. Its position can be varied (up, down, left or right) by means of a rod at the side of the instrument, thus providing some check on the subject's responses.

Owing to the fact that various points on the pot opal screen are at different distances from the lamp the brightness of the surface of the screen is not perfectly uniform. However, under conditions of binocular viewing and with summation operating the lack of uniformity is to some extent compensated for by the fact that a point of lower brightness for one eye corresponds to one of higher brightness for the other. Brightness of the test field can be varied by means of a combination of three neutral density filters and two polaroid discs* over a range of a million to one in steps of ·05 log units.

The reflecting screen is viewed by the subject through the neutral density filters and polaroid discs at about 12° from the normal but with diffuse light this does not affect the brightness of the projected field. A facepiece and chin rest are mounted on a telescopic unit. When this is fully extended the facepiece is at a distance of two feet from the test-object, and at this distance the arrow subtends a visual angle of 7 degrees.

While the Crookes Adaptometer represents an improvement upon the instrument used in previous studies, it is not of course claimed that it is entirely free from criticism. Thus, there is no control over the retinal area stimulated, the natural pupil and not an artificial one is used, so that differences in adaptation due to differences in pupillary size are included in the results, and finally, a test *object* rather than a light-flash is used. These "limitations" are not, however, as serious as might at first appear, as Godding (4) has shown, but they should be borne in mind when evaluating results.

3. TEST PROCEDURE

The subject was seated before the facepiece of the instrument and it was explained to him that he would first be asked to lean forward and look into the

* Two neutral density filters have a transmission of 1/10 (Density 1) and one a transmission of 1/100 (Density 2). One of the polaroid discs is fixed and the other rotatable to give a continuous reduction in brightness to 1/10.

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bleaching bowl for five minutes. The light would then be switched off and he would be asked to look through the eyepiece and tell the experimenter immediately he saw the position of the arrow. The arrow would be in any one of four possible positions which he should report as "top", "bottom", "right" or "left".

With the subject in the correct position for light adaptation, eyes close to the bleaching bowl, the bleaching and test-lights were switched on (this ensures stabilization of the test-light before the dark adaptation test starts) and the subject instructed to look *in and around* the bleaching bowl so that all parts of the retina were light-adapted.

During the light-adaptation period the voltage of the test-light was adjusted to the standard voltage for the instrument, the first neutral density filter (1/100th) brought into position and the polaroid scale put at 2. This gives a brightness of $10^{6 \cdot 4}$ micromicrolamberts (6·4 log units).

At the end of five minutes the bleaching light was switched off, a stopwatch was started and the subject asked to sit back and tell the experimenter which way the arrow was pointing. A final check was made on the voltage and the subject was told that it would take a little time for his eyes to become accustomed to the darkness. The time (to the nearest second) was noted when the arrow's position was seen. The brightness was immediately reduced by two units on the polaroid scale (i.e. 0·10 log units), the arrow rotated into a different position and the subject instructed once again to report as soon as he could see the arrow. The time was again recorded and this procedure was repeated throughout a thirty-minute period, various combinations of neutral density filters being used in conjunction with the polaroids to obtain the required range of brightness.

With regard to time of testing, practical considerations, especially in the case of the neurotic group, necessitated testing subjects at different times of the day. As far as possible these times were randomized over both neurotic and normal groups so as to reduce effects due to differences in pre-test illumination.

4. Subjects

Twenty neurotic patients* and twenty normal controls were tested with the adaptometer. The neurotics ranged in age from 17 to 45 while the age range of the controls was 18–49, with means of 32 and 30, respectively. With only a small correlation between age and dark adaptation over the age range 17–50 (8, 12) it was not considered necessary to attempt any precise matching of the two groups.

With regard to other variables that were taken into account when selecting groups, an attempt was made to have groups roughly comparable in intelligence and socio-economic status. Small correlations between intelligence and dark vision tests have been reported from time to time (e.g. (6)) although owing to the use of many different experimental conditions and varying degrees of heterogeneity in the experimental populations their significance is difficult to assess in a general way. It is probable that the effect of intelligence, particularly with the simpler type of dark vision test, may be an indirect one reflecting differences in nutritional state (e.g. vitamin A) between different socio-economic groups.

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Subjects with any history of diseases known to effect dark adaptation (such as gastritis, gastric or duodenal ulcer and cirrhosis of the liver) were excluded from the experiment, as were those with any history of vitamin A deficiency.

Finally, no subject was tested who had an uncorrected visual acuity of less than 6/9. Of the total number of subjects tested only two wore glasses; the estimated effect due to loss of light by reflection and absorption of lenses on threshold values is relatively small (4), probably not more than ·05 log unit.

5. Results and Discussion

A dark adaptation curve was plotted for each subject in the two groups. The distribution of threshold measures on which these curves were based is shown in Figures 2 and 3. Inspection of these distributions reveals several

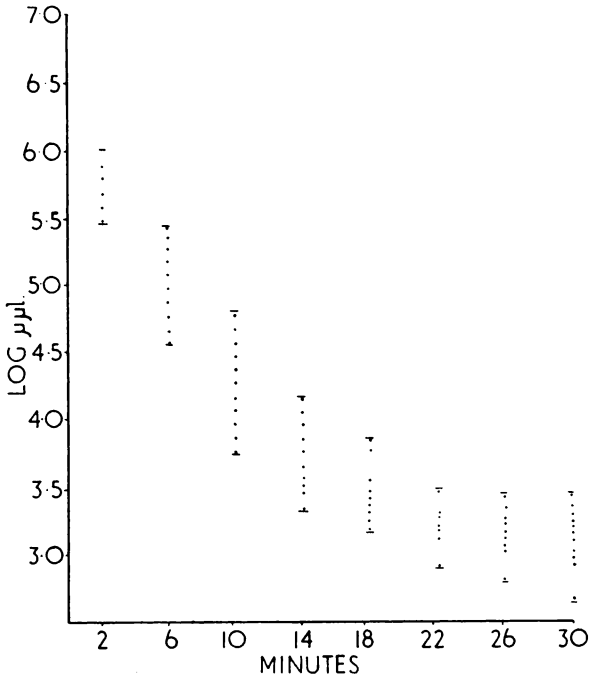


Fig. 2.—Distribution of Threshold Measures—Normal Group.

interesting features. In the first place, both distributions follow the same general pattern as regards shape. In the second place, the neurotic group is characterized by greater variability than the normal. Thirdly, in regard to level of sensitivity, there is some tendency for the neurotic group to be displaced upwards along the intensity axis.

The nature of these distributions makes it fairly clear that comparison of the normal and neurotic groups on the basis of means *alone* would be very inadequate. This does not of course imply that such a comparison would be invalid. In fact, the frequency distributions for both groups are sufficiently symmetrical for the means to represent their central tendencies fairly well.

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Figure 4 shows the mean thresholds for the two groups over the 30-minute adaptation period and it will be seen that the neurotics have higher thresholds than the normals during the first few minutes after light adaptation. Particularly interesting is the fact that it is not until between six and eight minutes that the difference between groups becomes at all striking. This is about the transition-time for cone to rod vision and should this finding be confirmed it would be worthwhile pursuing in terms of the well-known duplicity theory of retinal functioning. However, our main interest in the present experiment is in the behaviour of the two groups over the rod portion of the curve, so we will consider the extent of the difference between them in terms of units of brightness.

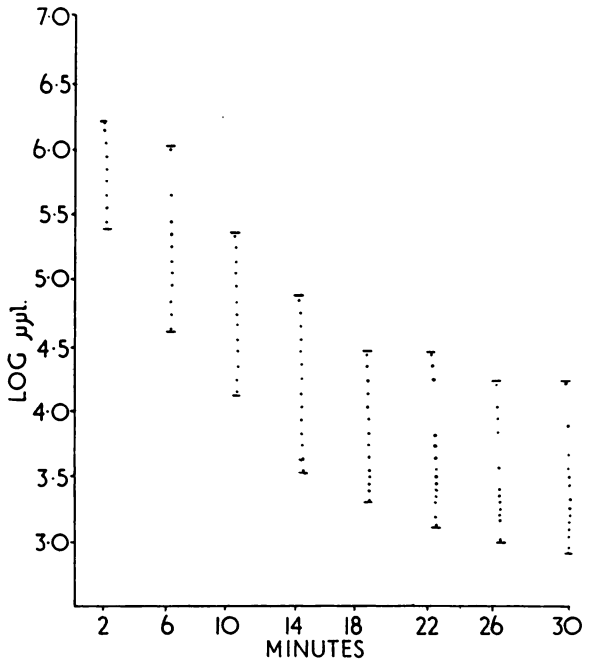


FIG. 3.—Distribution of Threshold Measures—Neurotic Group.

Starting at eight minutes, the difference between the means of the two groups amounts to as much as 0·3 log units (in other words, the neurotics require on the average about three times as much light as the normals to see the test-object); by ten minutes the difference has increased to about 0·4 log units and by twelve minutes to 0·5 log units. Thereafter the difference decreases to 0·3 log units at 16 minutes and decreases still further until at 18 minutes it is about 0·2 log units. For the final ten minutes or so of the adaptation period, the difference remains at about this level.

While these differences are of significant size from the psychophysical point of view, it must be remembered that there is considerable scatter about the means, particularly in the neurotic group. The standard deviation of threshold measures for the normal group is about 0·20 between 8 and 30 minutes (with a range of ·26 to ·16), while the neurotic group have a standard deviation of about ·35 (range ·40 to ·31). Applying the usual significance tests to the differences in means at various periods of dark adaptation, we find that the differences reach significance at the ·05 level between 8 and 22 minutes but fail

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to reach significance thereafter. However, more important than tests of "significance" at a given point, is the general trend of the data. This is sufficiently obvious for the conclusion to be drawn that the neurotic group have higher mean thresholds over the rod portion of the adaptation curve. The extent of this difference varies somewhat from about 0·3 to 0·2 units with the difference decreasing as the final rod threshold is approached. Whether the result will generalize to other groups remains to be seen. Certainly it is in accordance with what previous research (6) had led us to expect.

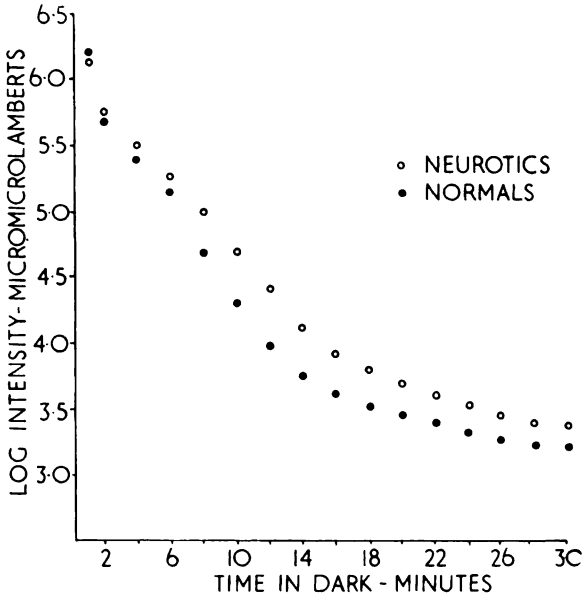


FIG. 4.—Mean Dark Adaptation Curves.

Although we may conclude that there is an overall difference in means between the two groups, the large scatter of threshold values about the mean in the neurotic group makes it necessary to examine individual curves more closely. When we do this, several interesting features appear; in fact, the incidental findings in this study are in certain respects of more interest than those directly related to the hypothesis under test.

In the first place, examination of the shape of individual curves shows a tendency for "steps" or "plateaux" to occur in certain cases, periods during which there is little or no increase in sensitivity. Taking as a rough quantitative criterion a period of two minutes or more during which the improvement in sensitivity is ·05 log units or less, not including of course the cone-rod transition period and the final rod portion of the curve where flattening normally occurs, the interesting fact emerges that in 12 cases in the neurotic group, there is definite evidence of a plateau effect. Of these 12 cases, eight curves are those of anxiety cases, one is that of a patient suffering from hysteria with anxiety symptoms, one is the curve of a psychopath, one that of an obsessional neurotic and one the curve of a neurotic with very mixed symptoms who could not be classified into any specific category. Of the eight patients not showing the effect, three were hysterics,* two were psychopaths, one was an anxiety depressive,

* Two were very severe cases.

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and two were anxiety states. Examples of curves showing the "plateau" effect are presented in Figure 5.

Now it is fairly obvious from the composition of our neurotic group that we cannot reach any definite conclusion as to the relationship between plateau effect and anxiety. But it is worth noting that among the eight anxiety states showing the effect, the mean "retardation time" in their sensitivity curves amounted to about six minutes compared with a mean of two minutes in those patients not diagnosed as anxiety states who showed the effect. In other words, the anxiety states did appear to show the effect to a greater extent. It is also of

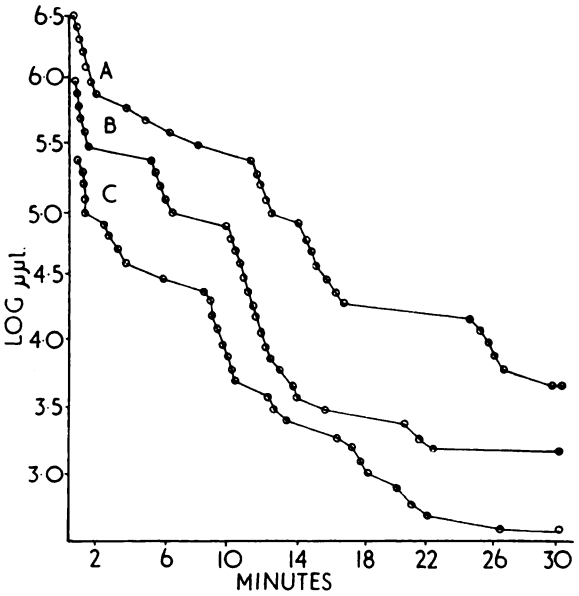


FIG. 5.—Examples of Adaptation Curves showing Plateau Effects (Curves B and C have been Displaced 0·5 and 1·0 Log Unit respectively along the Intensity Axis).

some interest to note that if psychopaths and hysterics are grouped together in accordance with the findings of some previous work at the Institute of Psychiatry (9), and the anxiety depressive and the obsessional are grouped with the anxiety states under the category of "dysthymic" neurotics, then out of six "hysterics" only one shows the "plateau" effect, whereas it is shown by nine out of twelve "dysthymic" patients.

Here again we cannot reach any definite conclusions owing to the fact that our neurotic group was not selected for the purpose of investigating differences between psychiatric sub-categories. However, in the author's view such evidence as we have suggests that further research into differences within the neurotic group would be profitable. It is also worth noting that the plateau effect occurs within the normal group, although to a lesser extent, and it is the writer's *opinion* that "plateau" effects occur more frequently in the curves of subjects who showed signs of anxiety in the test situation than in subjects who appeared more relaxed. But at the moment too much rests on opinion and we must clearly undertake further experiments to obtain more precise information. Before leaving the subject of "plateau" effects, the writer would point out that, having observed the apparent connection with anxiety states, he asked three other psychologists to examine the adaptation curves to confirm the finding.

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As to the "explanation" of the plateaux, hypothesis-formation is best left until we have confirmed and quantified the effect. However, it does make a certain amount of sense in terms of previous research and tentative suggestions as to its nature will be put forward in a critical review now being prepared on "Dark vision as a measure of personality". In this paper the writer attempts to organize what little knowledge we have into some sort of coherent framework which can serve as a basis for further studies.

Turning next to other aspects of the dark adaptation curves of the neurotic group, it is interesting to note that of the three hysterics, two have very abnormal curves indeed in so far as level is concerned. It will be noted from Figure 6, where the curves are plotted, that both are shallow when compared with a typical normal curve, both have delayed cone-rod transition times and both have very high final thresholds. In fact, such curves may be regarded as falling within the "pathological" category; had they been obtained in a survey of dark adaptation in the normal population (8) they would probably have been regarded as possible cases of vitamin A deficiency. It is hoped to make a more detailed study of these two cases at a later date.

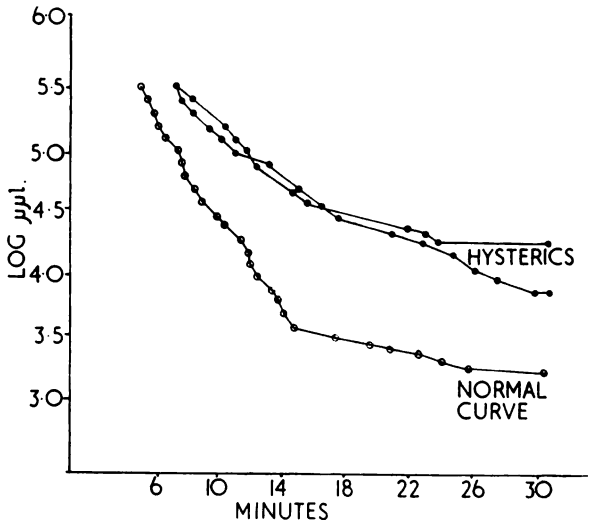


FIG. 6.—Comparison of Hysteric and Normal Adaptation Curves.

Four other curves within the neurotic group had high final thresholds but they all fell between 3·5 and 3·75 log units, well below the thresholds of the two hysterics. Furthermore, these four curves showed a much steeper slope over their rod portions than did those of the hysterics.

While there are several other interesting features of the adaptation curves, one is sufficiently striking to be mentioned here, namely, that the three psychopaths had very low final rod thresholds (3·15, 3·0 and 2·95 log units). All three thresholds fall within the upper range of the normal group. A threshold of 2·95 is equalled or exceeded by only two subjects in the normal group, one of 3·0 by three subjects and a threshold of 3·15 by six normal subjects.

It seems fair to conclude that further research involving a detailed examination of individual dark adaptation curves with regard to level, rate, fluctuations etc., will prove very rewarding indeed. In fact it would appear that different

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aspects of personality may be reflected in different features of the adaptation curve and that the adaptation curves of psychiatric patients may serve to "highlight" some of these factors by displaying them in an exaggerated form.

While we have reason to be fairly enthusiastic about the possibility of tapping personality characteristics we must remember that an individual's dark adaptation curve is the resultant of many interacting forces, physical, physiological and psychological, some of which are due to fairly fortuitous and temporary circumstances. For instance, it is known that exposure to fairly intense illumination prior to the test can affect the adaptation process. We must also remember that there is considerable individual variation from day to day. While the actual amount is partly dependent upon the type of test used, experimental conditions, etc., day-to-day variation of as much as 0·3 log unit is commonly reported. One cannot, however, make any broad generalizations and much further work needs to be done before we shall be in a position to say how much is due to error of measurement, environmental variables, etc., and how much is due to variability in the organism itself.

Summary

1. The object of this experiment was to determine if neurotic patients showed an impairment in their absolute light thresholds over the rod portion of the dark adaptation curve.

2. Twenty normal subjects and twenty neurotic patients were tested using the Crookes Adaptometer and mean dark adaptation curves plotted for the two groups.

3. Differences ranging from 0·2 to 0·5 log units ($\mu\mu l$) at different periods of adaptation were found, the neurotics having higher thresholds than the normals at all points of the rod adaptation curve.

4. Scatter about the means, however, was considerable, particularly in the neurotic group whose average standard deviation was about 0·3 log units, and an examination of individual curves was therefore undertaken.

5. This analysis revealed differences within the neurotic group that appeared to be related to diagnostic category. Plateau effects in the adaptation curve seemed to be associated with anxiety states rather than with hysterics or psychopaths; high final thresholds with hysterics, and low thresholds with psychopaths.

6. As a result of these observations it was considered that further research should be undertaken with another group of neurotic patients in which each of the various sub-categories was more adequately represented.

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