Effect of Vitamin A<sub>2</sub> on the Red and Blue Threshold of Fully Dark Adapted Vision

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Wald (1) in 1937 found that the retinae of certain fresh water fish were sensitive especially to red light, whereas the visual systems of most other animals are more sensitive to blue light. The substance in fresh water fish reacting to red light was termed visual red or porphyropsin. It is composed of vitamin A<sub>2</sub> and a protein (2, 3). The more common visual purple such as occurs in the human retina is called rhodopsin. It consists of vitamin A and a protein. Schantz et al. (4) showed that vitamin A<sub>2</sub> would replace vitamin A in the visual purple system, blood and liver of the albino rat made previously deficient in vitamin A. The present experiment was based on this work and was undertaken to investigate the physiological activity of vitamin A<sub>2</sub> in the human. The ultimate object was to determine the feasibility of increasing the sensitivity of aviators’ eyes to the red lights used for certain military identification and marker service. Normally the human is much more sensitive to blue than to red light. In our experience with 15 normal subjects, there was a 59 per cent (0.39 log unit) greater sensitivity to blue than to red light.

METHODS AND RESULTS

An adaptometer employing the principles of the Hecht adaptometer for measuring the scotopic vision to red and blue light in the totally dark adapted human being was constructed by members of the Department of Optics of the University of Rochester under the direction of Dr. Brian O’Brien. A system of random testing devised by Selig Hecht was used. The same apparatus and methods were employed by McCann et al. (6) in studying the effect of choline hydrochloride on scotopic vision in chronic non-hemolytic jaundice. The subject was fully adapted to the dark for 30 minutes. Binocular vision was centered on a red cross. Interchangeable red and blue filters were inserted. At 7° below the point of fixation, flashes of red and blue light of varying intensities were exhibited for 0.2 second at 5- to 6-second intervals. The random flashes

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were checked by means of a silent shutter which could shut off illumination although the regular shutter clicked. The threshold was that intensity at which 65 per cent of the flashes of light were perceived with each filter.

The subjects were 15 medical students. Eight subjects received pike liver concentrates containing known amounts of vitamin A₂. This was supplied by Distillation Products, Inc., Rochester, N. Y., under the direction of Dr. Kenneth C. D. Hickman. The vitamin A₂ was assayed by an arbitrary system of units such as that used in measuring vitamin A. Seven subjects took placebo capsules containing corn oil. This contained no vitamin A. (5). After an initial control period all subjects were instructed to follow a diet limited in vitamin A-containing foods. Presumably this restriction was only partial.

At the onset of the experiment, each subject was tested an average of 10 times to familiarize him with the method of testing. Following this, 15 control tests were made in an average of 47 days. Eight treatment subjects then received 13,000 units of vitamin A₂ daily for 72 days; during this period they were tested by the adaptometer an average of 31 times. Since no appreciable change occurred in the thresholds to red and blue light, the dose of Vitamin A₂ was raised to 32,500 U per diem in a second period. This consisted of an average of 39 days with 19 tests per person. During this time the 7 control subjects receiving corn oil underwent a similar number of determinations of dark adaptation. In a final control period all vitamin administration was stopped. This lasted an average of 27 days with 17 tests per person.

Threshold to Red Light. As shown in table I there was a lowering of the threshold to red light among the 8 students taking vitamin A₂ in doses of 32,500 U per diem. This amounted to 0.20 log unit or 30 per cent in the second period when the larger dose of the drug was used. The greatest individual improvements were in 2 students whose average thresholds fell 0.35 and 0.39 log units or 55 and 59 per cent, respectively. The control subjects showed up to 19 per cent deterioration in their ability to see red light. Both groups tended to revert to normal during the short final control period when all vitamin supplementation was stopped, and a normal diet resumed.

Threshold to Blue Light. The control group tended to show some deterioration in sensitivity to blue light during the second treatment period. Otherwise, there was no significant change in either group over the initial control periods in either group.

Ratio of Red to Blue Threshold. This figure was considered of significance because it was less affected by daily variations presumably due to fatigue or inattention. Of even more importance, it should provide a measure of the relative amounts of rhodopsin -2 or porphyropsin to rhodopsin -1 (as derived from vitamin A₂ and A₁ respectively) in the retinae of the subjects independent of the absolute amount of vitamin A₁ available in the diet. As shown in table I and figure 1 the control group showed little change from
the pre-treatment control period. However, in those persons receiving vitamin A₂ the ratio fell by 25 per cent during the period in which 32,500 u of the vitamin were administered. This represents an improvement of red relative to blue vision. The probability of this being a chance occurrence is considerably less than 1 in 100 (Fisher's $t = 3.14$ and 4.53). The greatest individual improvement in this average ratio was 46 per cent. On two occasions this subject was actually more sensitive to red than to blue light.

**Table 1. Changes occurring in the red and red:blue thresholds of scotopic vision in the totally dark adapted human eye**

<table>
<thead>
<tr>
<th></th>
<th>CONTROL PERIOD</th>
<th>VITAMIN A₂ U/DAY</th>
<th>FINAL CONTROL PERIOD</th>
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<tbody>
<tr>
<td></td>
<td>13,300</td>
<td>32,500</td>
<td></td>
</tr>
<tr>
<td><strong>Threshold to red light</strong></td>
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<tr>
<td>Control Group</td>
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<tr>
<td>Threshold</td>
<td>4.072</td>
<td>4.095</td>
<td>4.155</td>
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<tr>
<td>% change from control period</td>
<td>7.5</td>
<td>19.1</td>
<td>8.7</td>
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<tr>
<td>Treatment Group</td>
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<tr>
<td>Threshold</td>
<td>4.271</td>
<td>4.451</td>
<td>3.997</td>
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<tr>
<td>% change from control period</td>
<td>-16.0</td>
<td>-30.1</td>
<td>-21.6</td>
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<tr>
<th></th>
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<th>TREATED GROUP</th>
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<tr>
<td>% change from control group</td>
<td>-8.2</td>
<td>4.9</td>
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<th></th>
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<td>Control Group</td>
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<td>Threshold</td>
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<td>0.377</td>
<td>0.396</td>
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<tr>
<td>% change from control period</td>
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<td>-3.3</td>
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<td>Treatment Group</td>
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<td>0.320</td>
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<td>% change from control group</td>
<td>-12.0</td>
<td>-24.7</td>
<td>-14.4</td>
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1 In log micro micro lamberts.

![Fig. 1. Percentage improvement of red: blue light sensitivity.](http://jap.physiology.org/)

Spectral Sensitivity Curves. These were done under the direction of Dr. Brian O'Brien. There was a slight but apparently significant increased
sensitivity to red light among those persons receiving vitamin A₂. This did not occur in the control subjects.

Toxicity. During the experiment no evidence of toxicity was noted. There were no subjective eye, skin or gastro-intestinal complaints. No anemia or weight loss appeared. Blood vitamin A, calcium, phosphorous, and alkaline phosphatase levels remained normal. A trace of vitamin A₂ was found in the blood of only 1 treated subject. A subject, not included in the experiment, took 90,000 U of vitamin A₂ daily for 2 weeks and exhibited a vitamin A₂ blood level of 1.4 U.

SUMMARY

The average threshold at which the totally dark-adapted human eye could perceive red light fell 0.20 log units or 30 per cent in 8 persons receiving vitamin A₂ while on a diet low in vitamin A. Of perhaps more significance, there was a 25 per cent improvement of red in respect to blue vision as well as an increase of sensitivity to red light shown by spectral sensitivity curves. Vitamin A₂ was not toxic in the dosages used. No changes were noted in blood levels of calcium, phosphorous, phosphatase or vitamin A. These results indicate that vitamin A₂ has some physiological activity in human subjects. It is postulated that in the human being, vitamin A₂ may partly replace the vitamin A of visual purple to form visual red.

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REFERENCES

5. HICKMAN, K. Personal communication.