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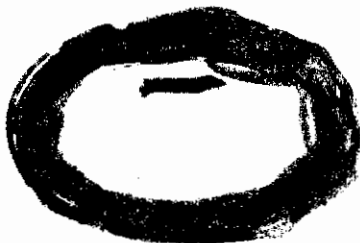
WADC TECHNICAL NOTE 59-426



# STANDARDIZATION OF AN ENDPOINT TO POSITIVE ACCELERATION ON THE HUMAN CENTRIFUGE

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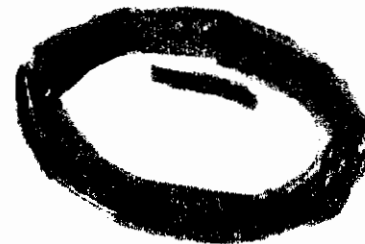
*Aerospace Medical Laboratory*



*DECEMBER 1959*

Project No. 7222

Task No. 71746



WRIGHT AIR DEVELOPMENT CENTER  
AIR RESEARCH AND DEVELOPMENT COMMAND  
UNITED STATES AIR FORCE  
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

700 - July 1960 - 41-1184

This study was conducted under Project 7222 "Biophysics of Flight," and Task 71746 "Acceleration of Flight," by the Acceleration Section, Biophysics Branch, Aerospace Medical Laboratory.

The author wishes to acknowledge the aid of Captain Neville P. Clarke, Mr. John Frazier, and the members of the Acceleration—Deceleration Panel.

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## ABSTRACT

The experimental variables in acceleration research should be standardized among all of the different centrifuges. This would make similar data comparable from one laboratory to another. The purpose of this study is to establish an objective and standardized endpoint for positive acceleration experiments.

A comparison was made of blackout thresholds to a red filtered light of 760 m $\mu$ , raised 0.5 log units above visual threshold in dark adapted subjects and to a white light in the same subjects. A significant difference was found for each subject ( $p < .02$ ). Differences between white and red light varied from 1.1 to 2.8 g for this group. The differences observed would vary from one centrifuge to another depending on the intensity and transmission spectrum of the white light used.

Physiological implications, advantages, and possible sources for error are discussed.

## PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:



WALTER F. GRETHER  
Director of Operations  
Aerospace Medical Laboratory

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## INTRODUCTION

An objective and standardized endpoint for positive acceleration experiments is not presently available. Different criteria are used to describe the endpoint on all the centrifuges. They include central white light blackout, central "grey-out," peripheral light loss, peripheral "grey-out," red central peripheral light loss, and low intensity red light "blackout" in a dark adapted subject. Different intensity lights are used.

In addition, there are no standardized rates of onset of the acceleration. This introduces still another variable in physiological and performance testing from one centrifuge to another.

Body positioning produces marked variation in tolerance due to changes in the hydrostatic column of blood. The subjective milieu, motivation, apprehension, frequency of exposure, and experience, as well as time relation to intake of food are some of the many possible variables in tolerance. British authors list other physical variables (2). Recent pleas have been made to standardize as many as possible of these factors (2, 5). As a beginning it was suggested at a meeting of representatives from several groups interested in acceleration research that a comparison be made between the British red light "black-out" and a white light black-out.

White light blackout is an endpoint which can be reproduced with reasonable exactness. However, there are two major disadvantages. One is the proximity with which unconsciousness and severe cerebral ischemia may supervene following blackout. The other is the fatigue experienced by the subject with each experiment making prohibitive the performance of multiple tests on the same day.

## METHODS AND MATERIALS

The cab of the WADC Human Centrifuge was enclosed and made dark. A black curtain divided the compartment one meter from the eye of the subject. In the center of the visual field was a three-sixteenth-inch-ground-glass aperture. A white light source of variable intensity provided illumination. Red and neutral density filters could be interposed between lamp and screen.

Each subject was first dark adapted with X-ray goggles for 15-20 minutes, then allowed to remain in total darkness for an additional 15 minutes. This time was sufficient to approach complete adaptation. Threshold was determined for a Wratten Type 87 infrared filter having a transmission spectrum of 760 m $\mu$ , raised 0.5 log units by an appropriate neutral density filter. When the neutral density filter was removed, the test light was then 0.5 log units above visual threshold. The white light was about 40 foot candles above threshold, but was not standardized for each subject's threshold.

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The subject was seated, relaxed, in a standard aircraft seat with a backward angle of 13°. The legs were semiflexed. Contact was maintained with the subject by the central observer flashing the test light at intervals. When the subject failed to respond by extinguishing the light, the centrifuge was brought to rest.

A manually operated rate of onset of 0.1 g/sec  $\pm$  0.01 g/sec was used. The accelerometer curve was recorded on a Sanborn Polyviso Recorder, as was the pattern produced by the flashing of the light (Figure 1). The endpoint was taken to be the point at which the unanswered light was first presented to the subject.

Two consecutive red light "blackout," and one white light blackout were performed in each series. Multiple exposures were made over a 3-month period.

## RESULTS

Table I shows the data obtained in 6 subjects on the centrifuge panel. There is a consistent significant difference in the same subject between red light and white light blackouts ( $p < .02$ ). The variability of the differences between red and white for the same subject are not significant ( $p > .5$ ). It is noted that there is daily variation in blackout tolerance to either light pattern. Physiological variation of the daily absolute threshold to color has also been previously demonstrated (7).

As a safety precaution, the experiment was halted at 7.0 g if blackout had not occurred to white light. As a result much data were obtained that could not be used in this report. Red "blackout" was always considerably lower than this 7.0 g value.

Two of our subjects were found to have aberrations of color perception so that the data obtained from them could not be used. One subject was not aware of this prior to entering service, at which time standard Air Force color testing charts revealed a partial color blindness to red wave lengths. The other subject was considered to have normal color vision until it was found that his white light, and red light results were the same. Color threshold perception tests revealed a 30% defect for blue and green wave lengths.

## DISCUSSION

The mechanisms for peripheral light loss, and blackout have been previously described (3). The arterial system of the retina is composed of end arteries, and a pressure gradient thus exists from center to periphery. A gradual reduction in central arterial pressure will result in mechanical collapse first in the periphery, and then more centrally. There is resultant ischemia and subsequent light loss in each area, progressing from periphery to center.

SANBORN Recording Permapaper

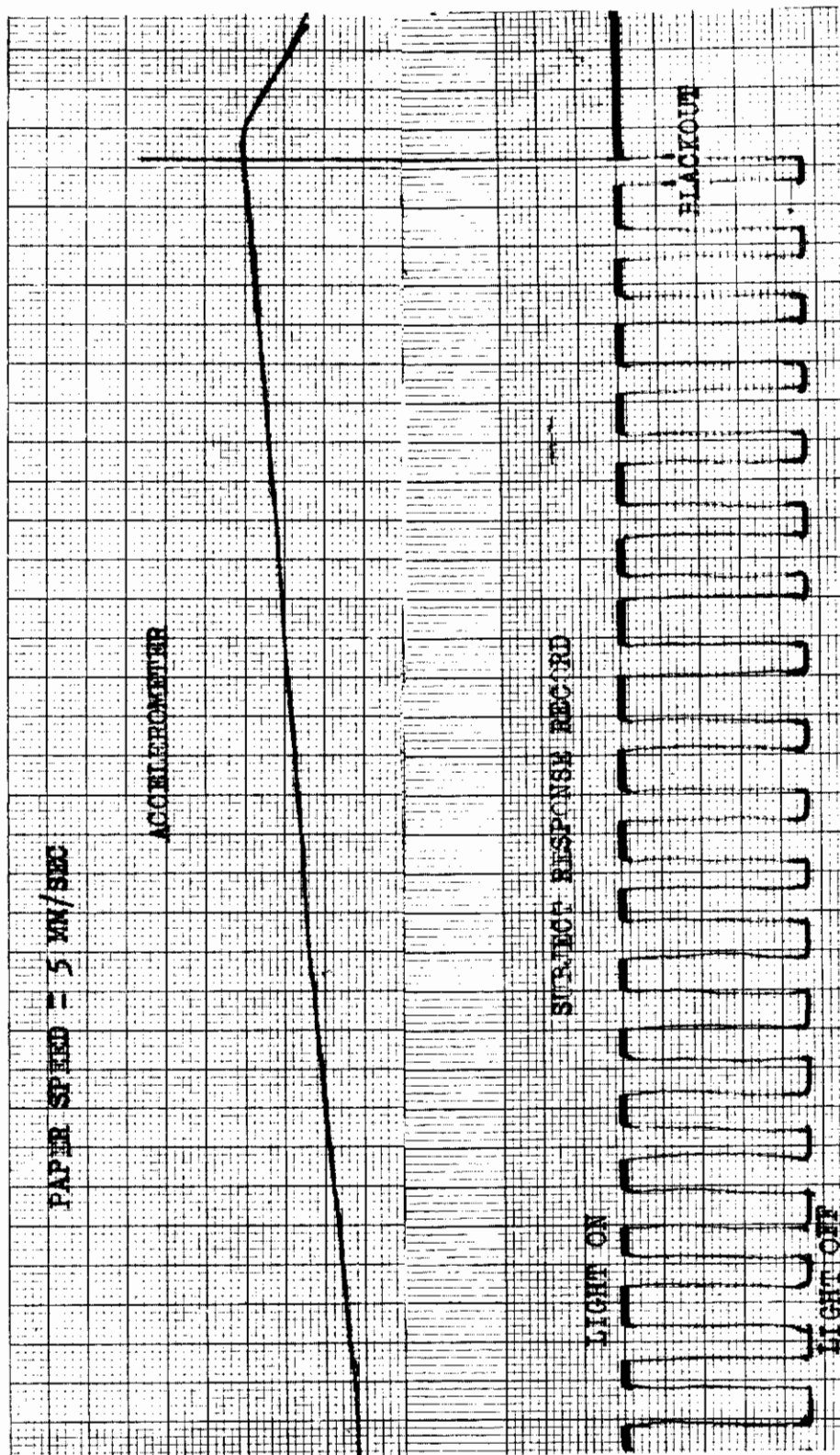


FIGURE 1 A REPRESENTATIVE ACCELEROMETER RECORDING DEMONSTRATING THE BLACKOUT THRESHOLD

TABLE I - COMPARISON OF CENTRAL WHITE AND RED LIGHT BLACKOUTS

Experimental Exposure

Subj.	1		2		3		4		5		Mean	P Values R Com - Vari pared - ability to W of W - R		
	Red White W - R	W - R	Red White W - R	W - R	Red White W - R	W - R	Red White W - R	W - R	Red White W - R	W - R				
J.R.	5.0 5.1 6.4	1.4	4.4 4.5 5.8	1.4	5.0 5.3 6.2	1.1	4.2 4.1 6.0	1.8	4.5 4.5 5.8	1.3	4.6 6.1	1.4	<.001	>.9
J.F.	5.2 5.1 7.0	1.9	4.6 4.9 6.6	1.8	4.7 4.6 6.2	1.6	4.3 4.4 6.5	2.1	4.5 4.4 6.4	1.9	4.7 6.5	1.9	<.001	>.9
N.C.	4.2 4.2 7.0	2.8	4.2 4.2 7.0	2.8	4.3 4.4 7.0	2.7	4.1 4.3 7.0	2.8	4.0 3.9 7.3	3.3	4.2 7.1	2.9	<.001	>.8
L.B.	4.8 4.5 5.9	1.3	5.0 5.4 6.8	1.6	4.2 4.4 6.0	1.7	4.8 4.6 6.2	1.5	4.0 4.3 5.8	1.6	4.6 6.1	1.5	<.02	7.5
W.J.	5.4 5.1 6.4	1.2	5.5 5.5 6.6	1.1	3.8 3.6 5.0	1.3	4.5 4.3 5.7	1.3	4.0 4.2 5.4	1.3	4.6 5.8	1.2	<.02	7.5
L.E.	4.3 4.3 5.2	1.1	4.8 4.5 5.8	1.2	4.7 4.8 5.8	1.0	4.3 4.3 5.3	1.0	4.5 4.7 5.8	1.2	4.5 5.6	1.1	<.01	>.9



The subjects noted no intervening "grey-out" threshold to the red light, as is seen with normal white light blackout. The reason for this is easily observed by comparing a scopic luminosity curve for color, and colorless vision, as seen in Figure 2 (1). There is no achromatic range for these wave lengths, and the energy is perceived only as color. The size of the test light maintained stimulation almost exclusively to the fovea.

Howard (4) and White (6) have shown that positive acceleration gradually decreases the sensitivity of the retina. They have demonstrated increments in threshold throughout the range of positive acceleration. Red light "blackout" tolerance varies depending on the strength of the neutral density filter. White had demonstrated that the threshold for perception of white light is increased as the g is incremented as shown in Figure 3 (6). White light tolerance varies then as the intensity of the bulb used, and its spectral characteristics. The current load on the filament, age of the filament, and manufacturer of the filament would each make standardization of white light difficult from one installation to another. It would be interesting to observe the g level at which "blackout" occurred for each wave length, if they were compared at the same level of photic energy.

A plausible explanation for the central "grey-out" phenomenon follows. All regions of the retina do not undergo change simultaneously. There is a gradual reduction in brilliance of the white light. "White" light, made up of a mixture of different energy levels of the chromatic spectrum, changes its characteristics as the threshold for each wave length is changed or exceeded by the decreasing retinal sensitivity. This occurs in the periphery first. Some colors may be eventually dropped out prior to total blackout. Thus the decrease in brilliance and the change in characteristics gives the light its greyish appearance. We can speculate that the variability between "grey-out" and blackout would depend on the energy level, and the characteristic transmission spectrum of the filament used.

## CONCLUSIONS

The use of the red "blackout" method for determining an endpoint to positive acceleration is somewhat awkward, requiring dark adaptation, and threshold determinations. It is very useful when a few subjects must undergo many frequent exposures. Subjects, however, should be screened for defects in color vision.

We feel that red "blackout" cannot be used as an endpoint in every case for the study of positive acceleration. We do not know that all physiological defenses are brought into play, i. e., some of the physiological decrements may not be linearly related to the magnitude of the acceleration and would not appear at these lower accelerations.

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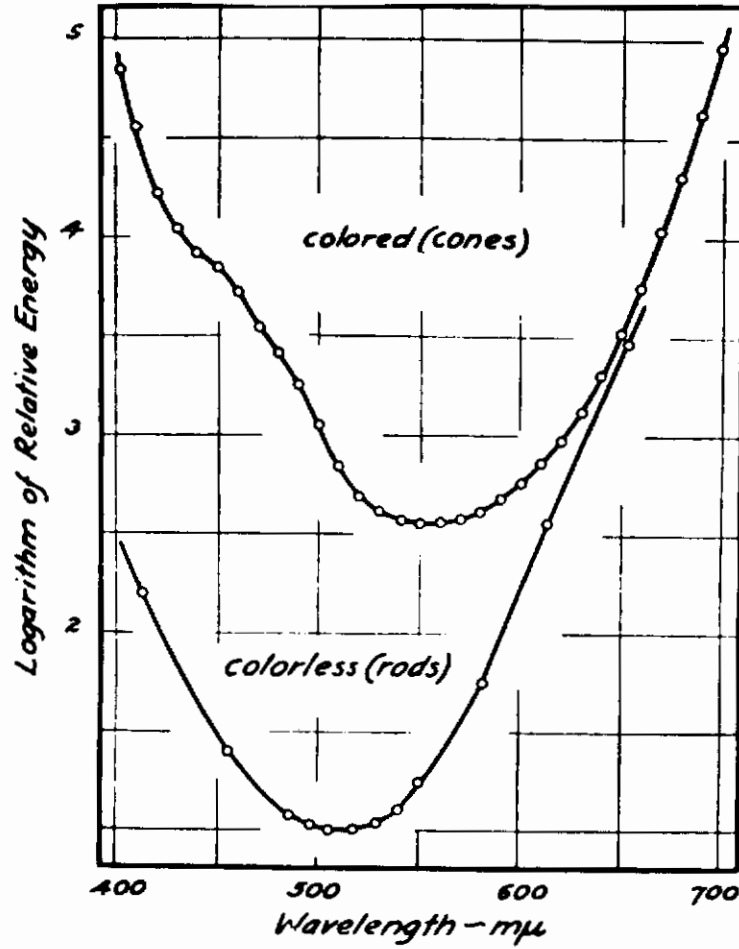


FIGURE 2

Spectrum sensibility curves for rod and cone vision  
on a real energy basis

Taken from "PHYSIOLOGY OF THE EYE" ADLER, F. H.  
C. V. MOSBY CO. 1953

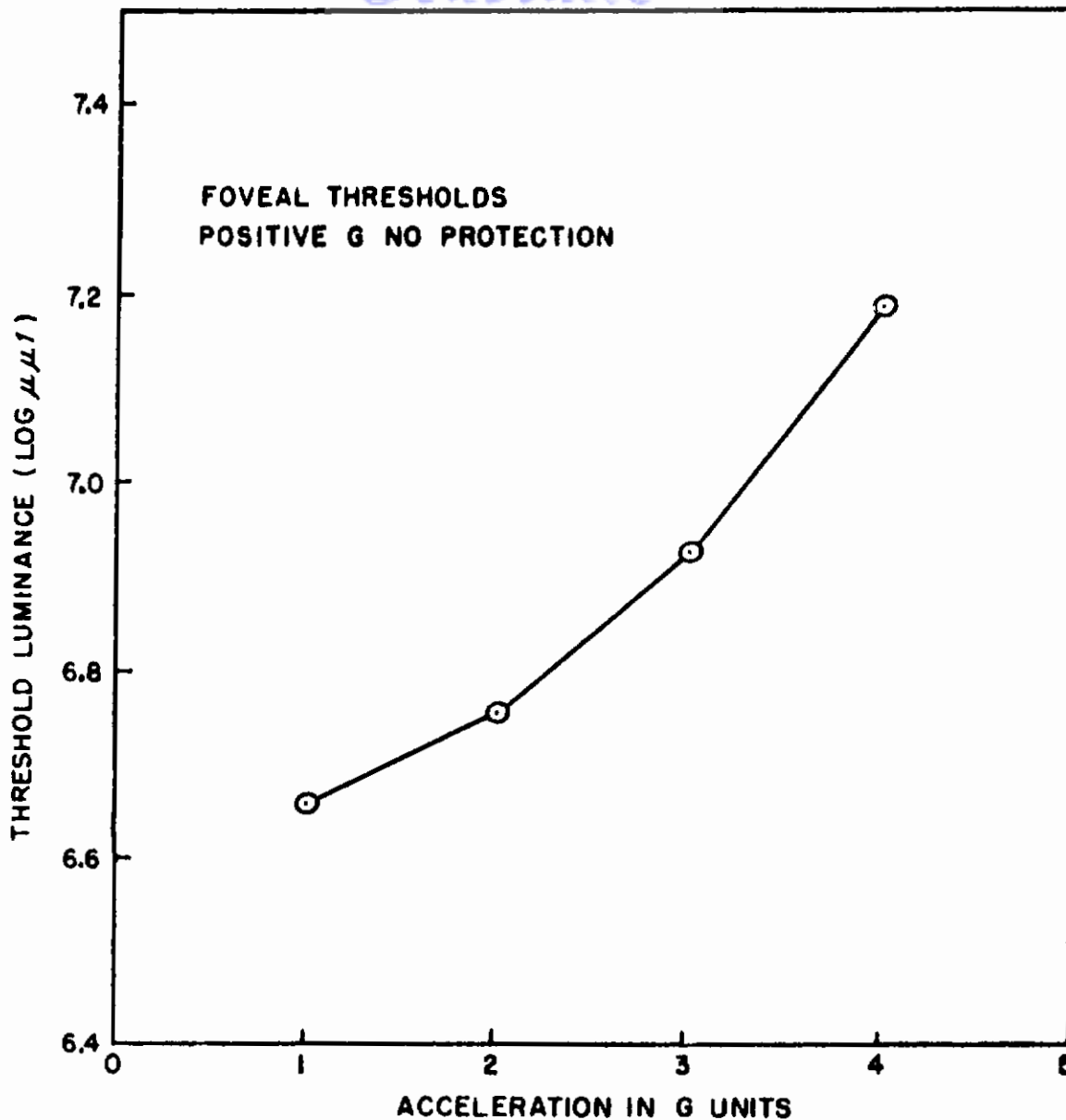


Figure 3. MEAN THRESHOLD LUMINANCE AS A FUNCTION OF ACCELERATION. ONE CAN SEE THAT ACCELERATION OF 2G PRODUCES MEASURABLE IMPAIRMENT OF THE DARK ADAPTED FOVEAL THRESHOLD. A RISE IN THRESHOLD INDICATES A DECREASE IN VISUAL SENSITIVITY.

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BIBLIOGRAPHY

1. Adler, F. H., Physiology of the Eye-Clinical Application, The C. V. Mosby Co., 1953.
2. Browne, M. K., Method of Threshold Determination in the Human Centrifuge, RAF Institute of Aviation Medicine, Farnborough, England. FPRC Report 1029, September, 1957.
3. Duane, T. C., Preliminary Investigation into the Study of the Fundus Oculi of Human Subjects Under Positive Acceleration, Aviation Medical Acceleration Laboratory Report No. NADC MA 5303, July, 1953.
4. Howard, P., and Byford, G. H., Threshold Determination Techniques on the Human Centrifuge, RAF Institute of Aviation Medicine, Farnborough, England, FPRC Memo 75, September, 1956.
5. Leverette, S. D., and Zuidema, G. D., Standardization of Human Centrifuge Techniques, Meddelanden Fran-Flyg-Och Navalmedecenska Namnden 6:33-39, 1957.
6. White, W. J., Acceleration and Vision, Wright Air Development Center, Wright-Patterson AFB, Ohio. WADC Technical Report 58-333, November, 1958.
7. Willmer, E. N., Further Observations on the Properties of the Central Fovea in Colour Blind and Normal Subjects, Journal of Physiology, 110: 422-446, December, 1949.