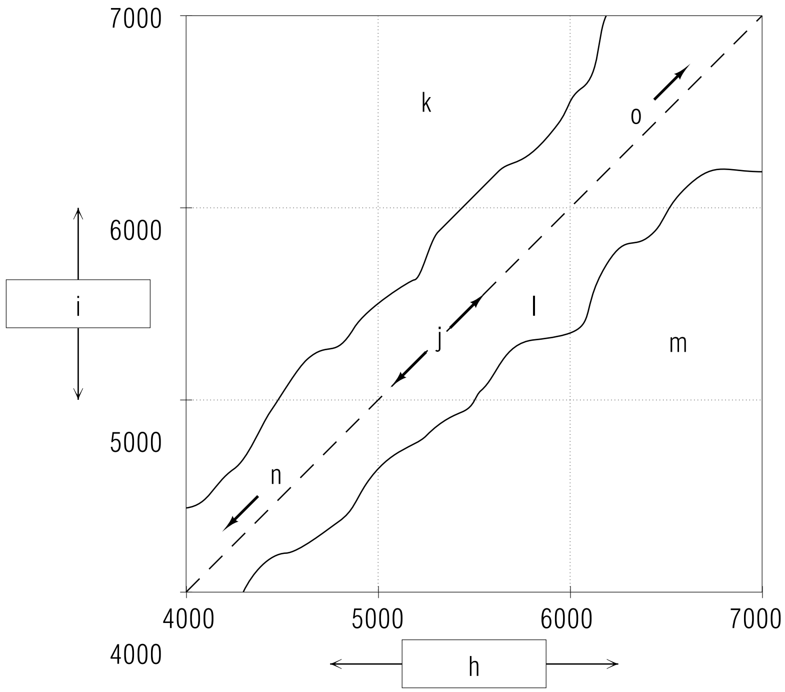
PHYSNET

MISN-0-228

LAND'S OBSERVATIONS ON COLOR PERCEPTION



Project PHYSNET Physics Bldg. Michigan State University East Lansing, MI

LAND'S OBSERVATIONS ON COLOR PERCEPTION

by

K. Franklin, P. Signell, and J. S. Kovacs
Michigan State University

Title: **Land's Observations on Color Perception**

Author: K. Franklin, P. Signell, and J. S. Kovacs, Dept. of Physics, Mich. State Univ.

Version: 2/1/2000 Evaluation: Stage B0

Length: 1 hr; 12 pages

Input Skills:

1. Vocabulary: retinal cones, tristimulus response curves (MISN-0-227).
2. Describe the Young-Helmholtz theory of color perception (MISN-0-227).

Output Skills (Knowledge):

K1. Describe the main points of Land's initial experiments in color perception, including: the nature of the light sources and the slides used, the results predicted by classical color mixing theory, and the results actually observed.

K2. Given an unlabeled version of Land's color range map, state the meaning and units of both axes, and describe the colored scenes produced by combinations of stimuli from various regions demarcated on the map.

K3. Given an unlabeled version of the coordinate graph for predicting the perceived color in an image produced by Land's experimental apparatus, state: the meaning and units of both axes, the meaning of the positively-sloped diagonal, and what colors are found on the three main regions on the map.

External Resources (Required):

1. E. H. Land, "Experiments in Color Vision," *Scientific American*, May 1959, pp. 84-99. For availability, see this module's *Local Guide*.

THIS IS A DEVELOPMENTAL-STAGE PUBLICATION
OF PROJECT PHYSNET

The goal of our project is to assist a network of educators and scientists in transferring physics from one person to another. We support manuscript processing and distribution, along with communication and information systems. We also work with employers to identify basic scientific skills as well as physics topics that are needed in science and technology. A number of our publications are aimed at assisting users in acquiring such skills.

Our publications are designed: (i) to be updated quickly in response to field tests and new scientific developments; (ii) to be used in both classroom and professional settings; (iii) to show the prerequisite dependencies existing among the various chunks of physics knowledge and skill, as a guide both to mental organization and to use of the materials; and (iv) to be adapted quickly to specific user needs ranging from single-skill instruction to complete custom textbooks.

New authors, reviewers and field testers are welcome.

LAND'S OBSERVATIONS ON COLOR PERCEPTION

by

K. Franklin, P. Signell, and J. S. Kovacs
Michigan State University

1. Introduction

The signals that the retinal cones send to the brain are a function of both the intensity distribution and the wavelength distribution of the light entering the eye. According to classical (Young-Helmholtz),color perception theories, the actual color registered in the brain depends only on the wavelength distribution. However, in a series of interesting experiments, Land has found that this is not always the case: the intensity distribution sometimes has an important role in determining perceived color.

2. Assigned Reading

Read "Experiments in Color Vision," by E. H. Land, *Scientific American*, May 1959, pages 84-99. For availability, see this module's *Local Guide*.

3. Comments on Land's Article

3a. The Old Theory. In elementary physics courses there is often some discussion of color mixing. However, these discussions are usually limited to the cases of pigment mixing and shining colored spotlights on a screen. They also usually teach that the hue produced by the mixing of two colors is solely a function of the wavelength distribution present in the two components, and that the brightness of the color is solely a function of the relative intensities of these components.

3b. Natural Images. A "natural" image is one that includes the likenesses of a variety of actual objects found in our world, as opposed to abstract spots and bars of color. This is the kind of image that interested Land. However, a better description of the type of image that will appear colored properly on the screen in Land's apparatus is described on the tenth page of Land's article, about halfway down the third column. According to this definition, an abstract design would appear colored if

it was sufficiently bizarre. Land's experiments have shown that, in "natural" images, the brain's interpretation of a color mixture depends very much (though not totally) on the relative intensity of the components, rather than on the actual wavelengths.

3c. Understand the Two Color Maps. The two graphs on the seventh page of Land's article, and their explanation on the following two pages, are essential to an understanding of Land's findings.

3d. Short-Wave Reversal. "Short-wave reversal" is not very well explained in Land's article. Our interpretation is that, for normal colors to be perceived, the long wavelength must be passed through the short record and vice versa. In other words, the slides in Land's two projectors must be reversed.

Acknowledgments

Preparation of this module was supported in part by the National Science Foundation, Division of Science Education Development and Research, through Grant #SED 74-20088 to Michigan State University.

LOCAL GUIDE

The readings for this unit are on reserve for you in the Physics-Astronomy Library, Room 230 in the Physics-Astronomy Building. Ask for them as "The readings for CBI Unit 228." Do **not** ask for them by book title.

MODEL EXAM

1. Describe Land's initial experiments in color perception, being sure to include:

   a. The nature of the light sources used.

   b. The nature of the slides used.

   c. The results predicted by classical color mixing theory.

   d. The results actually observed. [F]

2. Figure 1 shows a color range map constructed from Land's observations, with letters replacing the labels.

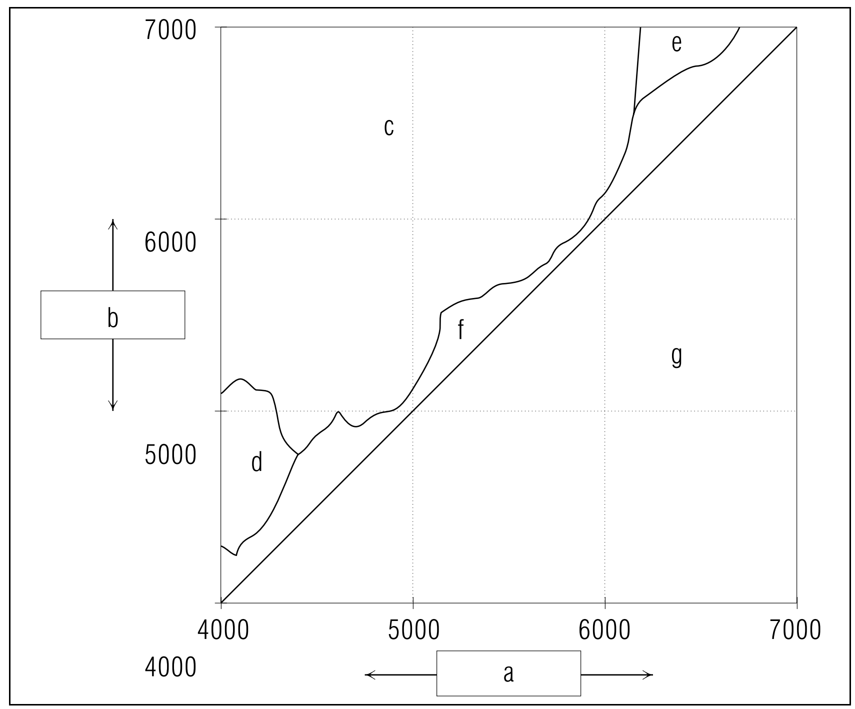


Figure 1. Color Range Map for different combinations of wavelengths (lower figure on page 89 in Land's article).

a. What is the meaning (and units) of the horizontal axis (letter a)? [A]

b. The vertical axis (letter b)? [K]

c. Which region of the graph represents the combinations of the stimuli that produce a colored scene? [H]

d. Are all colors seen in all parts of this region? [B]

e. Which region represents combinations of stimuli that do not produce colored scenes? [L]

f. Which region represents combinations of stimuli that produce red colors only? [N]

g. Which region(s) represent combinations of stimuli that produce normal color only when the two transparencies are reversed? [D]

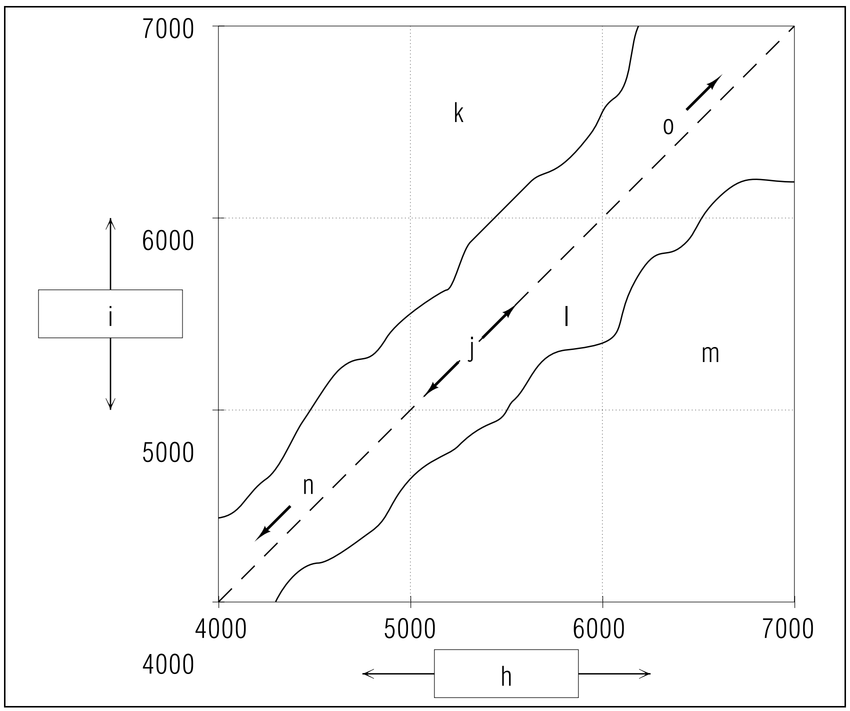


Figure 2. Coordinate graph for predicting perceived color in the image (upper figure on page 89 of Land's article)

3. Figure 2 shows a coordinate graph for predicting perceived color in an image produced by Land's experimental apparatus.

   a. What is the meaning (and units) of the axes of the graph (letters h and i)? [I]

   b. Which axis represents the value for the short-wavelength stimulus? [E]

   c. What is the meaning of the diagonal line j? [M]

   d. What happens to the colors on line j as you go in the direction of the arrow labeled n? [J]

   e. The arrow labeled o? [C]

   f. The graph is approximately divided into three regions of color (k, l, and m). What colors are found in each region? [G]

Brief Answers:

A. Wavelength of the short-record stimulus (Å).

B. No. The region is divided into sub-regions with some colors missing in each.

C. The shades get lighter, approaching white.

D. g.

E. h.

F. See Land's article, especially the first four columns.

G. k - warm colors (red, orange, yellow, etc.). 1 - neutral colors (brown, grey, etc.). m - cool colors (green, blue, purple, etc.).

H. c.

I. The percentage of total light, available from that source, which passed through the transparency (dimensionless).

J. The shades get darker, approaching black.

K. Wavelength of the long-record stimulus (Å).

L. f.

M. The line of gray points . . . all shades of gray from black to white.

N. e.