Summary A person walking through a building will experience a sequence of lighting installations and the adaptive mechanisms of his visual system will respond to each in succession. The delay in the photochemical response of the retinal cones is appreciable in relation to this movement from room to room. Equations have been derived to model this photochemical response, and both a field study and a scale model study have been carried out in order to calibrate this mathematical model. The effects of three alternative approaches have been compared: (1) the time course of photochemical changes was taken into account, (2) adaptation was determined by the illuminance of the area just vacated, and (3) adaptation effects were ignored. In many cases the simplest assumption was adequate. The more complex mathematical model was, however, found to be more accurate.

A study of the sequential experience of different lighting

G. T. McKENNAN, DipArch, PhD

1 Introduction

Architecture is experienced through motion. To experience a work of architecture we have to walk around it, moving from room to room—at least moving from the exterior to the interior. Thus our experience of interior spaces and their lighting is often an unfolding impression gained on moving from one space to the other.

In our daily routines we have to enter and very often pass through entrance foyers, lobbies, receptions and offices, along corridors and up and down by stairs and lifts. Even sedentary occupations involve movement from room to room, especially where resources are shared, for example in educational buildings. Such buildings as galleries may be experienced totally as a sequence of spaces.

This sequential aspect of the experience of building interiors has long since been recognised by architects and examples of where it has been used to generate architectural form can be found scattered throughout architectural history. Today, the lighting engineer too plays an important part in forming this experience, because, more often than not, each room or space contains a lighting installation. A person walking through a building will experience therefore a sequence of lighting systems.

However, current practice in lighting design is to consider installations on a room by room basis with little or no regard for the sequential experience.

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This paper describes a small study of the sequential experience of interior lighting which hopefully will stimulate interest and further discussion about this aspect of lighting design.

2 Changes in lighting level

The human visual system has evolved to cope with situations ranging from shadows on a starlit night to snow in full sunlight, levels of luminance varying in the order of 1 to 10^{12}. The visual system can adapt over a period of time so that vision is possible under both extremes.

This range is not likely to be met within a building although the often quoted experience of walking into a cinema from a bright street provides us with a close example.

The interior of a building provides the visual system with a different problem to that of the natural range of illumination. Whilst the range within the building will be not nearly so great, the changes may occur more rapidly. However, the same mechanisms are at work in an attempt to produce optimum vision under the given conditions.

If we are adapted to a very bright scene and then view a dark one, it will initially appear darker than it will become. Conversely, if we adapt to a dark scene and then view a very bright one, it will initially appear lighter. If the luminance of the second scene remains constant, the change in brightness reflects a change in the visual system.

Photochemical and neural actions of the visual system have been two major areas of investigation for vision researchers concerned with this temporal change. But studies of the initial stages of adaptation show that fluctuations in threshold level due to neural mechanisms are confined to a time period of about one second after a change of luminance[1,2].

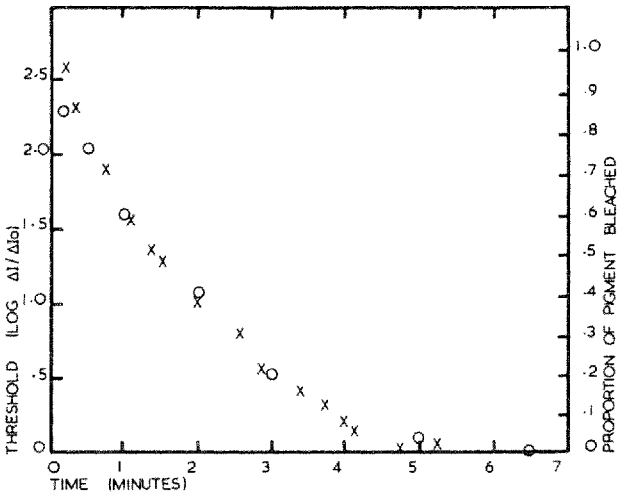

Fig. 1. The relationship between the proportion of bleached cone pigment (circles) and cone dark adaptation thresholds (crosses).

When one is walking through a building, significant changes in lighting level may occur at time intervals of a few seconds or minutes. Therefore, photochemical changes in the retina are examined. Furthermore, in most cases photopic conditions will prevail (the eye will be light adapted rather than dark adapted) and the photochemistry may be confined to a description of cone pigments.

Fig. 1 illustrates the early part of the classical dark adaptation curve, and it shows the close correspondence between the threshold and the proportion of bleached pigment in the cones.

Fig. 1 suggests a relationship between pigment concentration and sensitivity of the visual system (measured at threshold level)[3], and to use this relationship as a model of the visual system to predict whether people would find a sequence of rooms either bright or dim excludes such important effects as constancy and simultaneous contrast, but the simplification is necessary at this initial stage of study.

3 Cone photochemistry

Cone pigments act under two main influences, bleaching due to light and regeneration due to chemical processes. Rushton[4] proposes that:

(1) Pigment is bleached at a rate proportional to quantum catch;

(2) Regeneration proceeds at a rate proportional to the fraction of pigment in the bleached state; and

(3) Processes 1 and 2 are independent and therefore additive.

From Rushton's theory, Cornsweet[5] derives the following equation:

$$\frac{dX}{dt} = K(1 - X) - AQX \qquad (1)$$

where X=proportion of regenerated pigment in a receptor,
K=probability that an unregenerated molecule will be regenerated in time dt,
A=probability that a quantum incident on a region containing a regenerated molecule will bleach that molecule,
and Q=number of quanta incident during time dt.

Equation 2 is Cornsweet's solution to Equation 1.

$$X = \frac{K}{K + AQ} + \frac{AQ}{K + AQ} e^{-t(K+AQ)} \qquad (2)$$

Cornsweet gives:

$A = 64 \times 10^{-8}$
$K = 0.0077$

and redefines

Q = adapting intensity in trolands.

This solution is valid if X = 1 when t = 0. In other words, the model is always adapting from the completely dark adapted state to a state Q.

For the case where the model is adapting from any initial state, Q1, to any other state, Q2, the following solution to Equation 1 is valid:

$$X = \frac{K}{K + AQ2} - \frac{KA(Q1 - Q2)}{(K + AQ1)(K + AQ2)} e^{-t(K+AQ2)t} \qquad (3)$$

Where a step change of stimulus occurs at some value of t, Q2 takes the value of the new stimulus (This is the prevailing stimulus to which the system will adapt). However, the level to which pigment is bleached must be at some level in between the steady state levels determined by either Q1 or Q2 (unless t = 0 or t approaches infinity).

Fig. 2 illustrates this schematically, where in Fig. 2a a light stimulus occurs (change from Q1 to Q2) and pigment bleaches as in Fig. 2b. When the stimulus changes again (change from Q2 to Q3) pigment already bleached is at a level P1. It can be seen that this value can be less than the final steady state level of bleaching, P2.

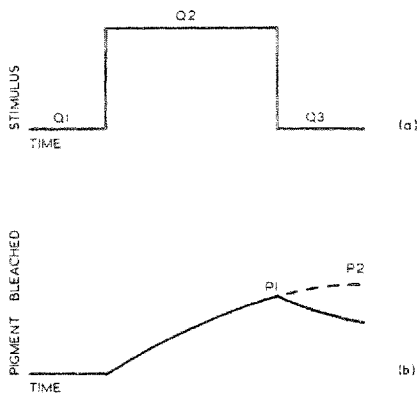

Fig. 2. Bleaching action of cone pigment due to a step change of stimulus.

Many values of the prevailing stimulus will cause bleaching or regeneration of pigment to the level P1. However, for each one there is a unique value of t. For example a strong stimulus may bleach to level P1 in a short time whilst a weaker stimulus will take longer. In Equation 3 when t = 0 the model is at an equilibrium determined by Q1. Therefore, when a step change of stimulus occurs (t = 0) the new value of Q1 is defined as the stimulus value which would bleach or regenerate to the steady state value P1. This can be derived from Equation 3 and is as follows:

$$Q1 = \frac{K(1 - X)}{XA} \tag{4}$$

The stimulus Q (and therefore Q1 and Q2) is defined by Cornsweet as retinal illuminance in trolands. For our purpose this may be more usefully stated in units of luminance (cd/m^2). The following equations convert luminance to retinal illuminance[6]:

Retinal illuminance = L × Se (effective trolands)

and

$$Se = \frac{d^2}{4}\left\{1 - 0.085\,\frac{(d^2)}{8} + 0.002\,\frac{(d^4)}{48}\right\} \tag{5}$$

Where Se=effective pupil area
d=pupil diameter (mm)
L=luminance (cd/m^2)

It is necessary now to establish values for the pupil diameter. The diameter of the pupil changes with a change of luminance and the following equation gives approximate values for pupil diameter as a function of luminance, based on a hyperbolic tangent law suggested by Crawford:

$$d = 5 - 3 \tanh (0.4 \log L) \tag{6}$$

For simplicity, these changes are assumed to be instantaneous with a change of luminance.

What now remains is to establish values for L, the field luminance.

4 Field luminance

Undoubtedly, as one walks about a building, one's field of view changes. Often, the walls will form a major element in the field while at other times one may look at the floor, ceiling or a particular feature such as a picture, or one may move one's view about the whole room to get a general impression. Even when the direction of one's view is kept parallel to the direction of movement, the field will change.

Therefore, and for reasons of much greater simplicity, no attempt at restricting the model to viewing only a part of a room has been made. Instead, the average luminance of the room is proposed as the luminance of the field. This assumes that all directions of view have equal weight.

Where the surfaces of the room are assumed to be matt, the luminance averaged over all surfaces, in cd/m^2, is given by the following expression:

$$L = \frac{E\rho}{\pi} \tag{7}$$

Where L=the average luminance of all surfaces (cd/m^2)
E=the average illuminance on all surfaces (lux)
and ρ=the area-weighted average reflectance

The average luminance of a room or part room is proposed as the stimulus. Therefore, Q2 takes the value of the average luminance of the room or part room in which the model is situated. Q1 initially takes this value also (or the luminance of the room to which presumed adapted).

5 Estimating field luminance

The average luminance of each room or part room is estimated in two stages.

Firstly, the area-weighted average reflectance of each space is calculated from known surface reflectances and areas (or if the building already exists, it may be estimated by subjectively matching the colours of the major surfaces to colour samples of known reflectance and then measuring the surface areas).

Secondly, the average illuminance of the surfaces of each room is calculated using the method described by Sumpner[7].

In the steady state condition, the average illuminance on all surfaces is given by:

$$E = \frac{\phi L \times LOR}{\Sigma A(1 - \rho)} \tag{8}$$

Where E=average illuminance (lux)
LOR=light output ratio of the luminaires
ϕL=total light output of the lamps (lumens)
A=area of each surface (m^2)
and ρ=respective surface reflectance

In estimating the illuminance of rooms (particularly in existing buildings) two complications may arise.

Firstly, rooms will seldom be empty. Here, a simple solution can be adopted. Major items, such as filing cabinets and desks, can be regarded as an extension of the room surface and accounted for in the calculation. Minor items may be ignored.

Secondly, the rooms may not be separate enclosures, and rooms therefore 'borrow' light from each other. Some rooms may be of irregular shape, with a clearly irregular lighting distribution. Both these cases may be treated in the same manner. The average illuminance for each separate enclosure (room or part room) is calculated using Equation 8. The amount of borrowed light is then estimated and added.

The question now worth asking is, can the model make predictions consistent with people's subjective responses in real interiors?—and a small field study was conducted to provide data to answer this question.

6 Field survey

A field survey was conducted in which ten people participated. The aim of the survey was to elicit their verbal responses to the level of lighting at set points along a prescribed route, within a building. The route was described to each subject and each subject was told that each point along the route, at which he was to make his statement, was marked by a red triangle placed on the floor. It was stated that these were at approximately five second intervals along the route. The observer walked along the route with each subject, for a distance of three markers, to indicate the desired speed (approximately 0.9 m/s).

Fig. 3 shows a plan of the building in which the survey took place and the points along the route at which a statement of the brightness of the room was made. Subjects started at point 0 and walked along the route indicated by the numbers 0, 1, 2, 3, etc. to point 16, then, turning around, retraced the route back to point 0. This was performed without stopping at any point.

Ratings of the brightness of each room were made using the seven point scale shown in Fig. 4 which was chosen for its simplicity in recording subjects' impressions of the lighting level independant of a task. Subjects carried a copy of this scale with them along the route as a reminder.

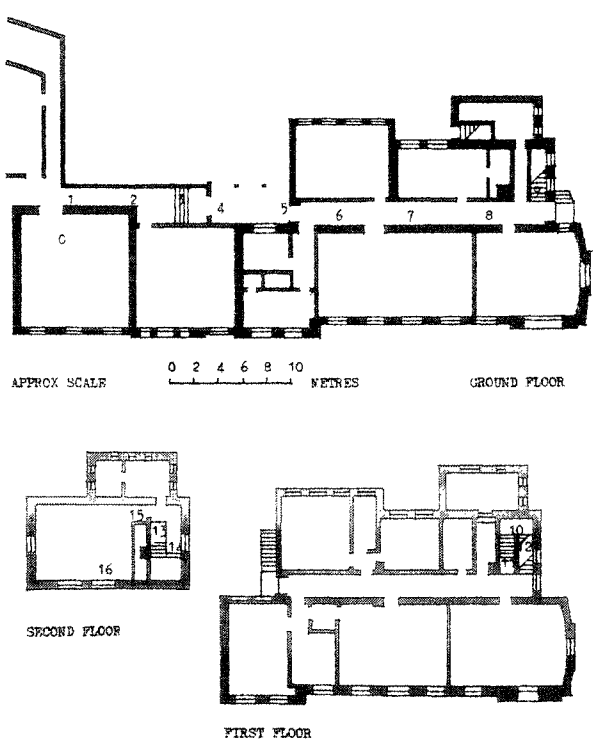

Fig. 3. Plans of the building used in the field study. Numbers 0 to 16 show the positions of markers at which impressions of brightness were stated.

VERY DARK	DARK	DIM	SATISFACTORY	LIGHT	BRIGHT	VERY BRIGHT
1	2	3	4	5	6	7

Fig. 4. Seven point scale of brightness.

DATE _____ NAME _____

VERY BRIGHT
BRIGHT
LIGHT
SATISFACTORY
DIM
DARK
VERY DARK

TIME TAKEN _____

Fig. 5. Standard form used by the observer for recording subjects' verbal responses to changes in lighting level.

The survey was conducted on two separate days at approximately 22.00 h and lighting was due to artificial light only. The subjects spent some time in the building before the start of the survey and about 5 minutes in room 0, the starting point. It was therefore assumed that subjects were light adapted, furthermore, that they were adapted to the luminance of room 0. While in room 0, each person was handed a written introduction to the survey (Appendix A) and was asked to rate this room before walking along the route.

Each verbal statement was recorded on a standard form (Fig. 5) by the observer who walked along the route just behind each subject, and the numerical values associated with each verbal category, in Fig. 4 formed the basis of a simple statistical analysis.

Fig. 6 shows the medians of estimates made along the route, and Fig. 7 shows the frequency of estimates at each point.

7 How the model was compared with the field survey data

One of the aims of the present study was to make a first stab at developing a computer program which would enable designers to investigate the effects of alternative architectural forms on the sequential experience of interiors, at the design stage.

It was thought useful therefore to compare predictions by the whole program with results from the survey. A short description of the relevant parts of the program follows therefore.

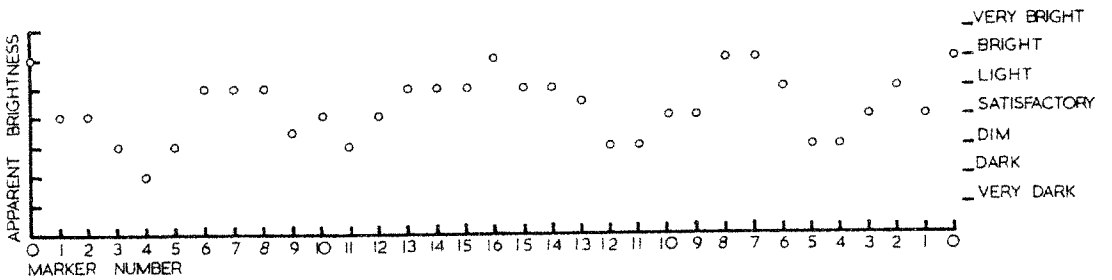

Fig. 6. Median responses given at each point along the route.

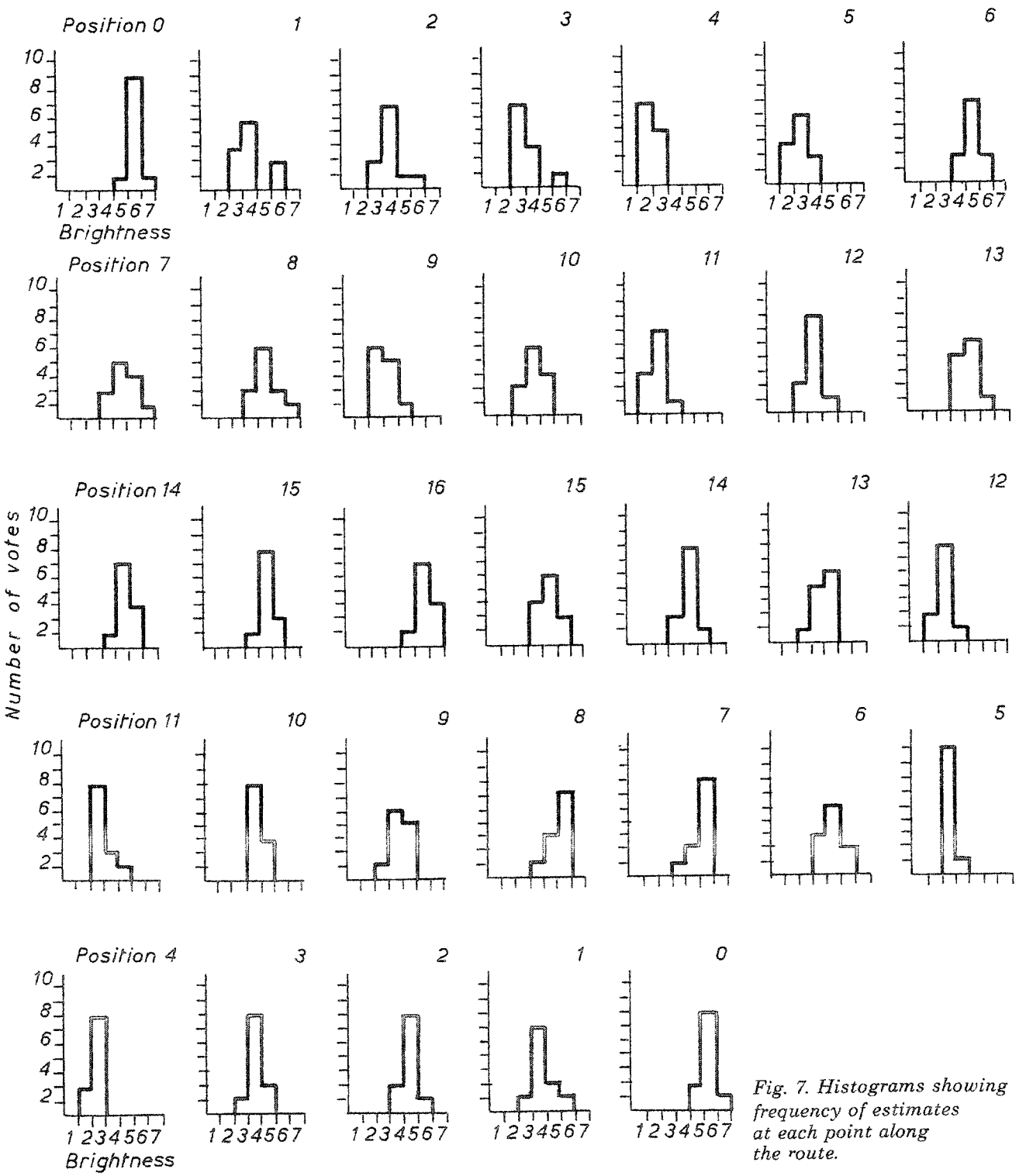

Fig. 7. Histograms showing frequency of estimates at each point along the route.

Essentially, the program allowed one to describe a series of rooms and a route through these rooms, and to obtain output, in the form of verbal categories on a seven point scale of brightness (Fig. 4) at desired time intervals.

The description of movement was confined to firstly specifying the geometry of the route through the rooms by a series of points defined by their 3-D co-ordinates, and secondly, specifying the modes of progression along the route. These were sitting or standing at any point (This distinction was necessary for part of the program dealing with thermal sensations) and between any two points, walking slow or fast. Slow walking was assumed to be at a speed of 3.2 km/h and fast walking at a speed of 6.4 km/h.

The average luminance of each space was estimated as described above and together with a description of the route and rooms formed input to the computer program.

Fig. 8 is an example of the graphical output from the computer program of the rooms and route geometry. This representation is a simplification of the geometry of route and rooms shown in Fig. 3.

In Fig. 8, each rectangle represents a room (numbered 1-18) and rooms on different floor levels are drawn separately. The single continuous line indicates the route and only those rooms through which the route passes are necessarily described.

The program determines in which room the model is situated at any given moment (based on route geometry and speed of movement) and selects the luminance of that room as data at that moment.

Table 1 shows the estimated values of average luminance in each space along the route together with the marker number (see Fig. 3) in that space.

8 What the model predicts

From Table 1 we can see that room 0 has the highest estimated value of luminance and, as

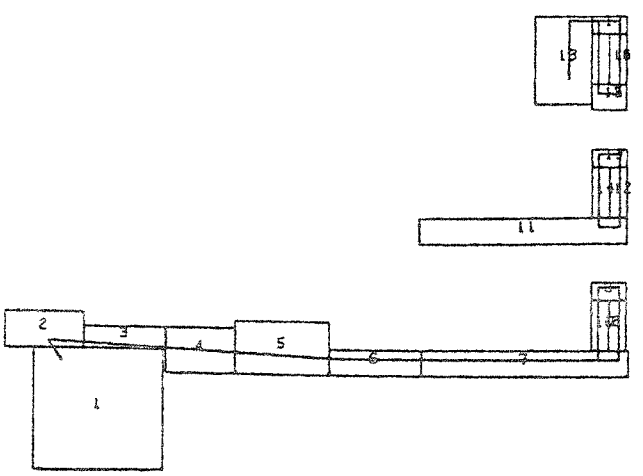

Fig. 8. Output from computer program showing simplified description of building and route geometry used in predictions. Note: this is a reproduction of the actual computer output, and the lettering is necessarily small.

subjects spent about 5 to ten minutes in this room before commencing the walk, it was assumed that pigment in the cones was bleached to a level determined by this value. Therefore, we would expect that in general on moving to other rooms, with a lower luminance, regeneration of pigment would occur and as a consequence sensitivity of the visual system would increase.

Predictions by the model of pigment concentration at points along the route are illustrated in Fig. 9 showing the gradual regeneration which takes place along the whole length of the route, only interrupted temporarily at points of relatively high luminance.

If pigment regeneration increases the sensitivity of the visual system, we should expect a gradual increase in values of estimated brightness along the length of the route, corresponding to the regeneration of pigment.

As points along the route illustrated in Fig. 3 were symmetrical about point 16, assessments of brightness were made twice at each point (except at point 16) once on the outward journey and once on the return journey. If brightness estimates were made consistently by subjects and there was no gradual increase (or decrease) then the two estimates at each point would be numerically the same. Inspection of Fig. 6 shows eight pairs of estimates to be the same, six pairs to show an increase and two pairs to show a decrease. It is obvious that there was a greater tendency for estimates to increase rather than decrease, but a non-parametric sign test applied to test whether this upward trend was significant or whether it could be accounted for by scatter of votes, shows any upward trend to be not significant at the 5 per cent level ($p = 0.145$).

Fig. 10 shows values of the rate of pigment bleaching computed for each point along the route. These are shown plotted where the abscissa is log luminance and the ordinate is the rate of bleaching (where values are negative this is the rate of regeneration).

Experience tells us that as we move from the bottom left of the figure to the top right, the values of the subjective estimates should increase. This is because to the left of the figure are values of low luminance and to the right are values of high luminance. Therefore we should expect an increase in the value of estimates from left to right. Also, the bottom of the figure corresponds to values of rapid regeneration, associated with a relatively large drop in luminance level. The top of the figure corresponds to values of rapid pigment bleaching, associated with a relatively large increase in luminance level. We should therefore expect an increase in the value of votes from the bottom to the top of the figure. This general trend can be seen in the figure.

By definition, loci of equal perceived brightness should run across this general trend. This is seen to be so from Fig. 10 where regression lines have been drawn by eye for each group of estimates.

Table 1. Average luminance of each space and marker number.

Marker Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Luminance (cd/m^2)	90	41	41	15	6	6	72	72	72	17	16	5	3	40	40	58	58

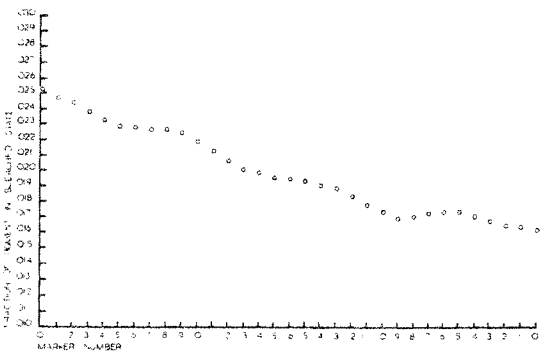

Fig. 9. Predicted regeneration of pigment along the route.

The disposition of the regression lines accords with our experience. A line approaching the horizontal at values of low luminance and rapid pigment regeneration, that is a situation where one is plunged into darkness, suggests that differences in luminance are relatively unimportant in the estimate of apparent brightness. When plunged into a dark room, details are indistinguishable. It is only later, as the room appears lighter, that differences may be noticed.

Two points (numbers 1 and 12) at which 'satisfactory' votes (value 4) were given cause the regression line for this group to be inconsistent if included. Examination of these two points shows them to be on the threshold of spaces with a large difference in luminance. It is possible that while the luminance of one space may be relevant on the outward journey, the luminance of the adjacent space is relevant on the return journey. If we plot these two points with the luminance of the adjacent space and the computed rates of bleaching, the two plotted points fall more consistent with the regression line fitted to the 'satisfactory' estimates. These two points are shown marked X in Fig. 10. A sign test performed on the data excluding these two points showed any upward trend in estimates still to be not significant but to approach significance at the 5 per cent level ($\rho = 0.062$).

This suggests that while the model makes predictions consistent with experience, for the conditions experienced in the study, the gradual regeneration of pigment may be ignored and predictions of the subjective estimates may be based on luminance.

To establish a relationship between the values of luminance and the values of subjective estimate, the mean value of log luminance was established for each group of subjective estimates (column 1, Table 2). These means were then expressed as ratios between means of contiguous pairs of estimates. These are shown in column 2, Table 2. The mean of these ratios is 1.4. An increment of one vote on the verbal scale therefore corresponds to a mean ratio of 1.4 between two values of log luminance.

This is based on data collected in the dynamic situation, where subjects walked into different rooms and had no control over the lighting level. Values were also determined where subjects viewed one room and controlled the setting of the level of lighting and these may be compared.

9 Scale model study

A model office with furniture to 1/12 scale was used in the study. Fig. 11 shows the model and the

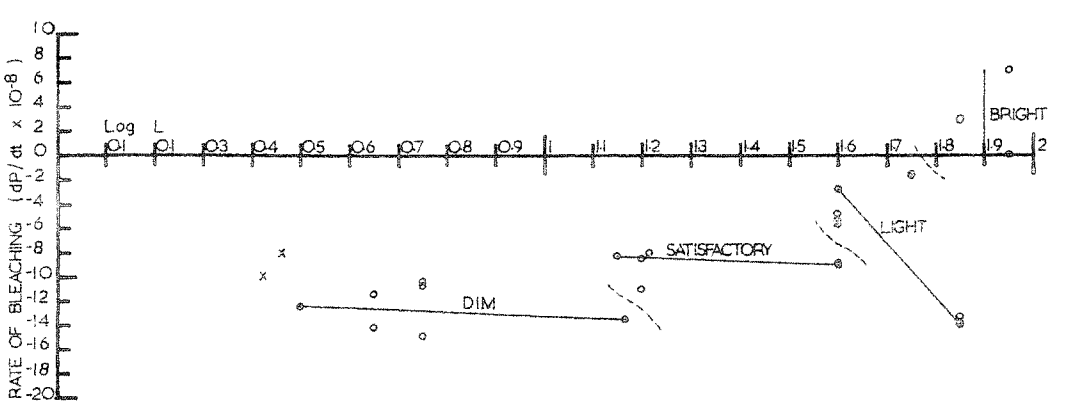

Fig. 10. Plot of log luminance against rate of bleaching for votes cast along the route. The dashed lines separate groups of equal apparent brightness votes.

Table 2. Log luminance ratios for field study and model study.

Log L Field study	Ratios	Log L Model study	Ratios	Subjective Estimates
0.77	1.74	0.96	1.95	3
1.34	1.30	1.88	1.15	4
1.74	1.10	2.16	1.17	5
1.88		2.54		6
Mean	1.4		1.4	

viewing position and Fig. 12 shows the interior of the model which contained a translucent plastic ceiling illuminated from above, by a number of incandescent sources, as evenly as possible. The lamps were connected to a dimmer over which subjects had control. A total of seven subjects participated.

The verbal categories shown in Fig. 4 were used by subjects to rate the lighting level of the office. Each subject was asked to set the level of lighting in the office so that it appeared 'dim', 'satisfactory', 'light', etc., but the top category on the scale in Fig. 4 was omitted to avoid artificially limiting the top of the scale by the maximum output of the lamps, and the bottom category of the scale was omitted to keep the scale symmetrical.

To eliminate order effects, each subject made settings for the whole five point scale twice, setting the level for 'dark', then moving up the scale to 'bright' and then back down to 'dark', or first setting for 'bright', then moving down the scale to 'dark' and back up to 'bright'. These two procedures were alternated between subjects.

At each setting made by a subject, an observer recorded the illuminance in the vertical plane, at the viewing end of the model. The estimated average illuminance on all surfaces in the office was found to be in the ratio 1:1.14 to measurements taken at this point.

The raw data consisted of five pairs (one value determined moving up the scale and one determined moving down for each of the five verbal categories) of values of illuminance for each subject.

The geometrical mean of each pair was taken, producing one value of illuminance for each category per subject. The means of illuminance values for each category were taken, producing one value of illuminance for each category for the whole group. These means of measured illuminance were adjusted ($\times$ 1.14) to indicate the values of illuminance averaged over all surfaces of the office.

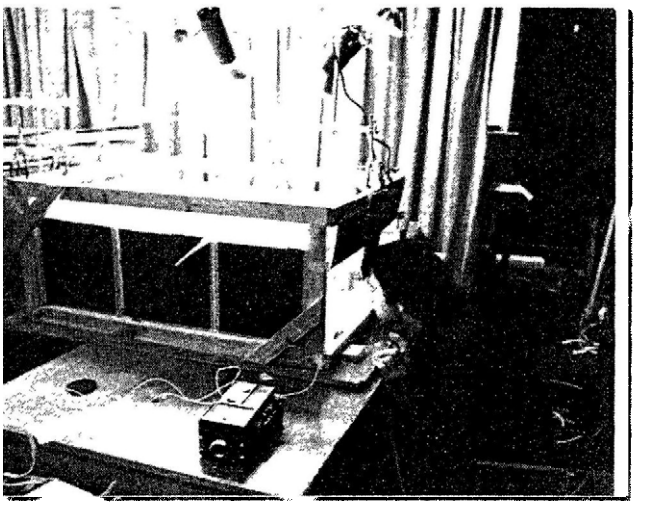

Fig. 11. Viewing conditions of the scale model used in the study.

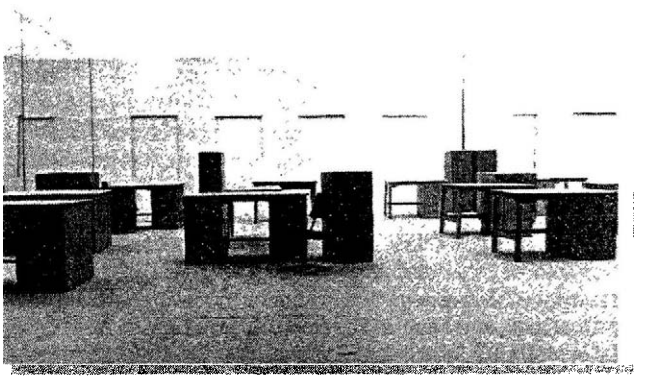

Fig. 12. Interior view of the model.

The area-weighted average reflectance of the office was estimated at 0.63 and using Equation 7 values of luminance were determined.

These values were converted to log units and the ratios between these values calculated for comparison with those determined under dynamic conditions. These are shown in column 4 of Table 2. The two sets of ratios are in reasonable agreement, the mean of the ratios being 1.4 when calculated for both the dynamic conditions and the model study, providing a simple expression for approximating subjective estimates made in the two studies:

$$\text{increase in subjective estimate} = \frac{r}{1.4}$$

Where r=estimated log luminance ratio of two successive lighting levels.

10 Predictions compared with data

Table 1 shows the estimated values of average luminance in each space along the route together with the marker number in that space. The value of the luminance at point 12 on the outward journey was estimated at 27 cd/m^2 and the value at point 1 on the return journey 4 cd/m^2.

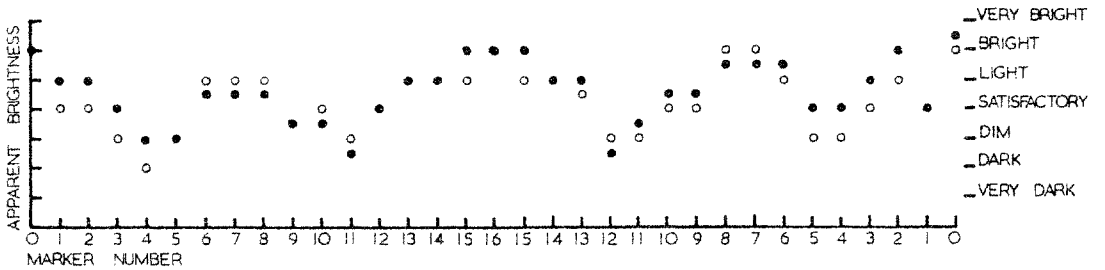

Fig. 13. Comparison of verbal responses of subjects (open circles) with predictions by model accounting for previous conditions (solid circles). The correlation coefficient, r, between the two sets of ratings is 0.71.

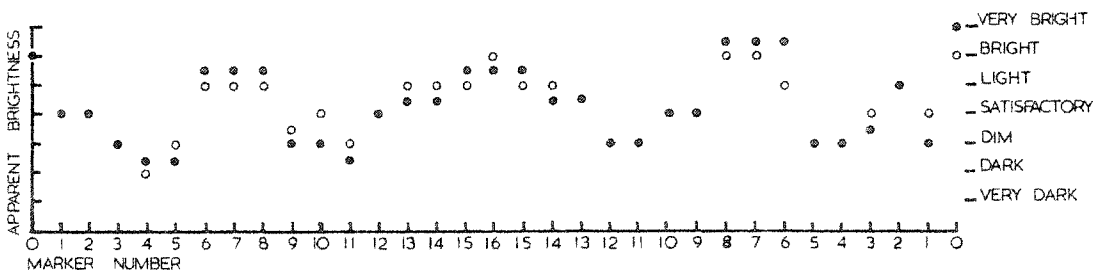

Fig. 14. Comparison of verbal responses of subjects (open circles) with predictions by model accounting for photochemical changes (solid circles). The correlation coefficient, r, between the two sets of ratings is 0.78.

Using the simple relationship established above and the estimates of luminance, predictions of brightness were made and compared with the survey data. Fig. 13 shows reasonably close agreement between the survey data and these predictions, where the initial estimate was given the same value (6 = bright) and where values are rounded to the nearest half vote. This suggests that we may make acceptable predictions of the general trend of estimates without consideration of the photochemical changes in the eye.

Fig. 14 shows the more accurate predictions that can be made if the photochemical changes are included. A simple equation of the type below was used, expressing a change of brightness as a function of a change of luminance and pigment concentration, with the constants derived from the data.

$$Z' = Z + a(X' - X) + b(Y' - Y)$$

where Z' = prevailing apparent brightness
Z = previous apparent brightness
X' = prevailing luminance
X = previous luminance
Y' = prevailing fraction of bleached pigment
Y = previous fraction of bleached pigment
and a and b are constants.

The methods of prediction used to produce values for Fig. 13 and 14 both assume implicitly that it is necessary to take account of previous conditions as well as prevailing conditions, and it is worthwhile making some attempt at a prediction using prevailing conditions only, for comparison.

Data from the survey are shown replotted in Fig. 15. The regression line was fitted by eye and an equation of the type below was used to predict the values shown in Fig. 16.

$$x = ay + b$$

where x = brightness estimate
y = log luminance
and a and b are constants

With the constants a and b derived from Fig. 15, Fig. 16 shows that predictions at least as accurate as those shown in Fig. 13 may be made by considering prevailing conditions alone.

11 Discussion

The slow improvement in vision that we experience on walking into a dark room such as a cinema from a brightly lit place closely follows the regeneration of pigment in the retina. This suggests that the increase in vision may be due to the increase in the fraction of unbleached pigment.

The above study examined the possibility of using this theory to predict people's general impressions of brightness whilst moving through a series of rooms in an artificially lit building, and Fig. 14

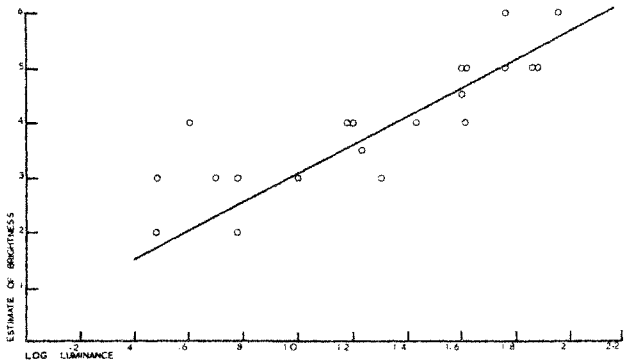

Fig. 15. Replot of data showing brightness estimates against log luminance.

shows that a model based on this photochemical theory can produce predictions reasonably consistent with subjective assessments.

The limited amount of data does however indicate that within the range of lighting levels encountered (approximately 600 lux to 20 lux average illuminance) the part played in determining people's impressions of brightness, by photochemical changes, if any, is so small as to be insignificant and that predictions may be made based on luminance alone.

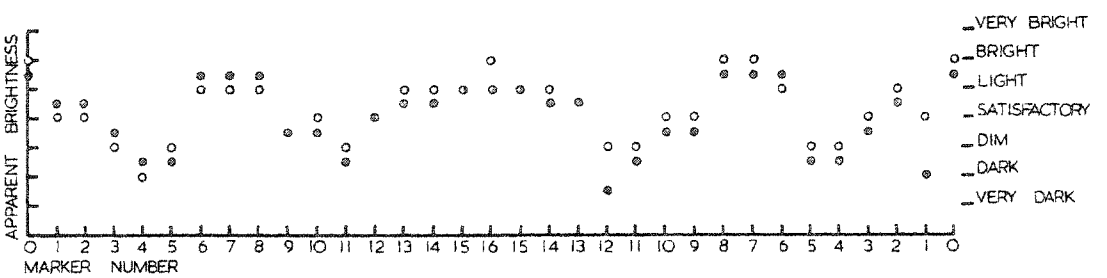

Fig. 16. Comparison of verbal responses of subjects (open circles) with predictions based on prevailing conditions only (solid circles). The correlation coefficient, r, between the two sets of ratings is 0.74.

Furthermore, Fig. 16 shows that for the data collected, reasonable predictions may be made by considering the luminance of the space in question, regardless of previous conditions.

There are a number of possible reasons for this. It may be that any adaptation taking place occurs much faster than the discreet intervals chosen in the above study, and that combined with the graduation of lighting levels that naturally occur in spaces, this changes the relevant previous conditions from those of say a previously experienced room to some level much closer to prevailing conditions.

Constancy may also play some part in determining the estimates of brightness, as all subjects were familiar with the building. Also, the route was symmetrical and subjects retraced their steps through the series of spaces (therefore each level of lighting was associated with one room only, even though experienced twice).

Both these factors are likely to reduce any increase or decrease in estimates of brightness and further work is needed before conclusions of a generalised nature can be made.

Appendix A
Introduction to survey handed to each subject

You are asked to walk along a prescribed route through the building at a constant speed and to state your impressions of brightness, using a prescribed scale, at five second intervals.

You will be shown the route, and the speed at which to walk will be indicated. The intervals along the route at which you are to state your impressions are marked on the floor. You are *not* to stop at any of these points but proceed along the whole length of the route without stopping.

The scale by which you will state your impressions is given below. You will also be given a copy to carry with you, but it will help if you memorise the scale before walking through the building.

VERY DARK DIM SATISFACTORY LIGHT BRIGHT VERY BRIGHT
DARK

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