28. Illumination Suited for a Picture Gallery.

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To arrive at the numerical value of illumination best suited for pictures exhibited in a gallery, we availed ourselves of the eleventh exhibition (1930) of The Imperial Academy of Arts in the Art Gallery of Tokyo Municipality. We measured the illuminations of a number of selected pictures at their centers by a calibrated Macbeth photometer, and at the same time opinions were invited of a number of persons on the suitability or otherwise of the actual illumination. The tests were performed under various weather conditions, at various hours of the day, and on different types of pictures, namely, oil pictures on canvas and those of the Japanese school, both on paper and on silk. Forty-three Japanese pictures and twenty-five oil paintings were used in the tests that extended over a period of seven days. Opinions on the illumination were procured from forty-seven persons including connoisseurs, amateurs, and university students. These pictures were hung on walls of the exhibition rooms illuminated mostly by natural light from the ceiling through matted glass panes.

Every person whose opinion was asked, received a card on which he was requested to note down his impressions by prearranged numerical marks. When the light at the moment of inspection just suited the observation of a picture, it received the full mark of 10, with diminished gradings of 9, 8, 7 etc. together with signs plus or minus according as it departed in excess or defect of the best illumination. Every person was particularly requested to note down his individual impressions only and not opinions formed after consultation with others. And it was moreover found necessary, at the outset of the tests, to remind those whose opinions were sought, that the marks were symbols to indicate suitability of illumination, irrespective of the intrinsic merits of the picture as a picture, because without this precaution, observers are apt to be swayed in their decisions by the pictorial merits according to their personal tastes of the picture, regardless of the main objective of the quest, illumination.

We tried at first to find the illumination best suited for the inspection of a picture, or "normal illumination" for each individual

picture, or at least for a group of similar pictures, but without success owing to paucity of material for the purpose. We were therefore obliged to content ourselves by grouping indiscriminately all pictures of the Japanese school to one side, and all pictures in oil to the other.

The adopted system of marks to indicate suitability of illumination as above stated is however ill-adapted to statistical reduction. For example, to a picture illuminated with a normal value, one observer considering it a little over-illuminated might accord it the mark +9, while another considering it a little under-illuminated might call it -9. In this case of normal illumination, we expect that the mean value of the opinions of these two persons ought come out to a result to indicate the normal illumination, whereas the mean of +9 and -9 equals zero, which does not help us in the least. This difficulty was overcome by transforming the marks into another variable x as in the subjoined table.

Illumination	in defect				normal	in excess			
Mark	-6	-7	-8	-9	10	+9	+8	+7	+6
Variable X	-4	-3	-2	-1	0	+1	+2	+3	+4

Now the variable x is a quantity expressing the *sensation* of the observer, while the illumination L measured by the photometer is a quantity expressing the optical *stimulus*, so that by following Fechner's well known law, it befits this case to seek the correlation between x and $y = \log_{10} L$. Plotting the corresponding values of x and y , the points were found to be distributed over a fairly wide area, still the general arrangement of the points was such that a straight line through them represented well the correlation between x and y . We put therefore

$$y = \log_{10} L = A + Bx,$$

and determined the values of A and B by the method of least squares with the following result.

For Japanese pictures from 1335 pairs of x and y ,

$$y = 2.029 + 0.230. x$$

and for oil paintings from 900 pairs of x and y ,

$$y = 1.728 + 0.259. x,$$

where L is expressed in meter-candles or Lux. It is rather surprising

that the inclinations of these lines are nearly equal, which may mean that the judgements of observers of illumination were fairly trustworthy, and also that Fechner's law held good in the present study.

The value of the normal illumination L_0 is the value corresponding to $x=0$, or $\log_{10} L_0 = A$. From the above results, we deduced

$L_0 = 106.9$ Lux for Japanese pictures,

53.5 Lux for oil paintings.

If we put $x = C + Dy$ as the correlation between x and y , we get for Japanese pictures

$$x = -6.610 + 3.170 \cdot y,$$

and for oil paintings

$$x = -4.565 + 2.475 \cdot y,$$

from which we deduced

$L_0 = 121.6$ Lux for Japanese pictures

69.8 Lux for oil paintings.

Thus it appears that oil paintings on canvas require half as much light as the Japanese pictures, owing perhaps to differences in the nature of the finished surfaces.

It is noteworthy that in these tests, there were about twice as many illuminations falling below the normal value as those that exceeded it, from which we may conclude that the areas admitting light into the exhibition rooms in the Art Gallery of Tokyo Municipality are inadequate for the purpose of a picture gallery.