IES Transaction

The Movement of People Toward Lights

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AS A PART of another lighting experiment, 107 right-handed and four left-handed subjects slowly entered a doorway through a curtain and read a printed message which was placed immediately in front of them. This message made each subject stop for a few seconds and had vertical lettering to destroy any left-to-right movement tendencies associated with normal reading patterns. After reading the message the subject could only move to his left or right along an eight feet long, two feet wide passageway. The end of each passageway had a side opening into the remainder of the room. The illumination at one foot from drapes at the end of one passageway was held constant at 1, 3, 10, 30, or 100 footcandles while the illumination on the other side was held constant at one footcandle. Thus the ratio, R, of the illumination levels was 1, 3, 10, 30, or 100. The brighter side was evenly balanced between the left and right side and the direction chosen by the subject was measured as a function of the illumination ratio and the location of the brighter side. The subject was present for another experiment and was unaware of this movement measurement. After completion of the other experiment (about ten minutes later), the subject left the room via the passageways and the direction chosen was again noted as a function of illumination ratio. However, the leaving situation differed from the entering situation in that the subject was no longer naive about the space, an experimenter was present, and the direction of travel was chosen before the passageways were entered. These differences add complications to the interpretation of the leaving results.

Under equal illumination ($R = 1$), 67 per cent entered and 59 per cent left to their right (the difference between these values is not statistically significant). For illumination ratios greater than one, 70 per cent of the subjects entered toward the brighter side and 58 per cent left toward the brighter side. There was evidence that the higher the illumination ratio the higher the percentage of subjects entering to the brighter side, *e.g.* 100 per cent of the subjects entered to the right when the right side was 100 times brighter than the left side. Furthermore, for the same brightness ratio, a higher percentage of subjects would always enter to the right when it was the brighter side, than would enter to the left when it was the brighter side. These trends were not duplicated in the leaving results. These showed that subjects left more to the brighter side as the ratio increased from one to ten but left less and less to the brighter side as the ratio increased to 100. Moreover, the changes were not as large, *e.g.* at a ratio of 100, 73 per cent exited to the right when it was the brighter side but only 22 per cent exited to the left when it was the brighter side. These trend differences are probably caused by the Ss becoming consciously aware of the lights whenever $R > 10$.

It is frequently of interest to know in which direction people will move when they are presented a choice of directions in their normal movements. For example, well defined traffic flow patterns are desirable in theaters, museums, stores, streets, etc. The traffic flow pattern is obviously influenced by many factors such as people's habits, light, sound, architectural designs, etc. Although physical barriers are very frequently used to establish traffic patterns, light is seldom used except in the most primitive manner of lighting desired paths while not lighting undesired paths. It would be desirable to more definitively study the effect of light brightness.

Melton (1933) observed that 75 per cent of museum visitors turn right when the environmental factors favoring a right or left turn are equivalent. Dalkvist, *et al.* (1970) studied the relationships of perceived space enclosure and light brightness. They concluded that light cannot simply be substituted for physical barriers (screens) to decrease an apparent closed space, although light brightness does influence closed space. This latter relationship indicates that light brightness would probably affect the movement of people (either toward or away from the perceived closed space). Flynn (1970) noted that lighting enables a person to readily identify and relate to various activity needs, and recommended a study of the effect of lighting on entry-egress and circulation (or movement) behavior.

These studies and a little thought lead to the formulation

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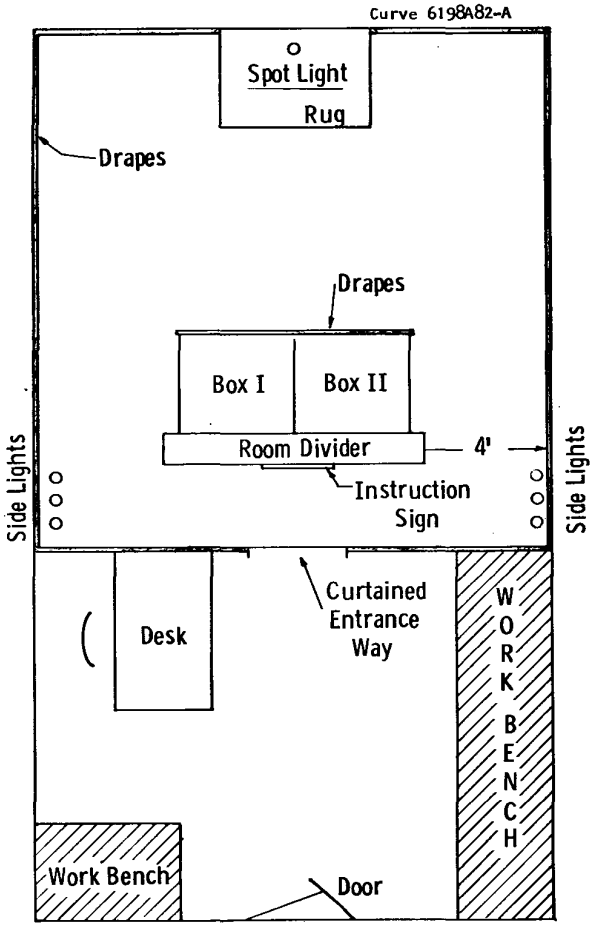

Figure 1. Experimental room floor plan.

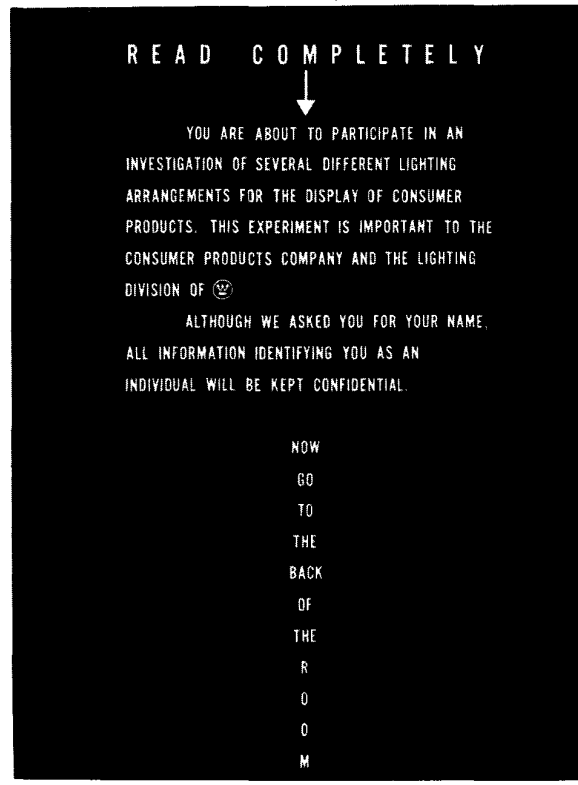

Figure 2. Instruction sign.

of four hypotheses for the behavior of individuals encountering a left-right path decision point for the first time:

H1. When equivalent left-right paths are presented to individuals, approximately 75 per cent will choose the right path.

H2. When one of the paths is more brightly lighted, individuals will tend to choose the brighter path.

H3. The higher the illumination ratio between the left-right paths, the more people will choose the brighter path.

H4. An illumination ratio threshold exists below which hypotheses 2 and 3 will not significantly affect hypothesis 1.

These hypotheses contain the implication that none of the paths are so brightly lighted that they cause visual discomfort which would lead to path avoidance behavior. The satisfaction of the third hypothesis automatically assures satisfaction of the second hypothesis but the converse is not true. The purpose of this study is to test these hypotheses.

Procedure

Subjects: The 111 subjects were volunteers recruited from the Laboratories who were permitted to take the required time off from their normal duties. Of these volunteers about one-third had college degrees, 46 per cent wore glasses, 52 per cent were female, 23 per cent were between 18 and 25 years of age, 35 per cent between 26 and 35; 28 per cent between 36 and 50, and 14 per cent were over 50 years old. Only four subjects were left handed.

Method: This experiment was contained within another experiment about which the subjects had been told, Taylor, *et al.* (1973), and for which the subjects had volunteered. At no time were they told about this experiment.

The experimental room floor plan is diagrammed in Fig. 1. The subjects entered the door and were greeted by an experimenter at the desk. The subject completed a very brief questionnaire and was then instructed to step slowly through the curtain, read the printed message he would see immediately in front of him, and to proceed as indicated in the message. The printed message was hung at eye level on the room divider (see Fig. 1) and is shown in Fig. 2. These instructions had only one purpose: to stop the subject long enough to destroy any tendency to walk to his right which may originate from the desk location on the left side of the doorway. The vertical wording at the bottom of the instructions was intended to destroy any left-to-right behavior generated by normal reading.

After reading the instructions, the subject could go to his left or to his right to get around the room divider which was constructed of plywood and extended from the floor to the ceiling. In each direction three floodlights called side lights were suspended from the ceiling and splashed the beige-draped side walls with a controlled intensity of light.

Table I—The Number of People Going Toward the Bright Side or Dim Side as a Function of the Ratio of the Side Lights Illumination Levels. The Brighter Path Location is Specified as Being to the Left or to the Right of a Person Entering the Room.

Illumination Ratio	Brighter Path Direction	No. of S Entering Toward Bright Side	No. of S Entering Toward Dim Side	No. of S Leaving Toward Bright Side	No. of S Leaving Toward Dim Side
1	Right*	14	7	9	13
3	Right	8	5	8	5
	Left	7	5	6	6
10	Right	11	3	9	5
	Left	8	2	7	3
30	Right	6	4	4	6
	Left	5	5	8	2
100	Right	9	0	2	7
	Left	8	3	8	3

* By Definition.

An experimenter waiting on the rug in the back of the room noted the direction in which the subject walked around the room divider.

The lighting preference experiment for which the subject had volunteered was then conducted, utilizing the two display boxes. For that experiment, which lasted about ten minutes, the side lights were turned off. At the conclusion of the preference experiment, the side lights were turned on and the experimenter would stand in the middle of the back wall directly under the spotlight and thank the subject for his cooperation. The subject would then turn and walk out of the room—while the experimenter again noted the direction in which the subject walked around the room divider.

Side Wall Illumination: The illumination at one foot from the beige drapes on one side was held constant at 1, 3, 11, 30, or 100 footcandles (fc) while the illumination on the other side was held constant at one fc. The illumination levels of both sides were changed after every five subjects. Thus the ratio, R, of the side walls illumination levels was 1, 3, 10, 30, or 100. The experiment was balanced in that as many subjects had the brighter path on their right as on their left when they entered the room.

Results

Raw Data: The numerical results are tabulated in Table I. Note that the brighter path is specified as being to the right or left of the subject as he enters the room. Thus if the brighter path is on his right as he enters the room, it is on his left as he leaves the room. For $R = 1$, the brighter path is defined as being to the subject's right as he enters the room. Thus, the table shows that when $R = 1$, the majority of subjects enter and leave to their right.

Before these data are analyzed it is important to note the differences between the experimental conditions existing when the subject enters the room and when he leaves the room. As the subject enters the room, he believes he is alone and has plenty of time to choose his route to his left or right—both choices leading to unfamiliar space. As the subject leaves the room he has just stopped talking to the experimenter, must physically turn around to face the two exits and has little time to choose his exit. Furthermore, only one exit now leads to familiar space—the other exit leads to the passageway portion which was not taken when the subject entered the room. These differences make difficult the direct comparisons of the entering and leaving results. Since the entering situation has few interactions, the entering results are considered to be the true results of this experiment and the leaving results are only used for validation insofar as possible.

Hypothesis 1: When equivalent left-right paths were presented ($R = 1$), Table I shows that 67 per cent of the subjects entering and 59 per cent of the subjects leaving the room chose the right path. The difference between these results is not statistically significant and a fairly good validation is achieved. The difference between 67 per cent and 75 per cent is also not significant and is good evidence that hypothesis 1 is valid with the true value being around two-thirds or three-quarters.

The experimental room floor plan (Fig. 1) may influence these results in that when the subjects finish the questionnaire at the front of the desk, they may have a tendency to walk toward the right when entering the passageway. The instruction sign (Fig. 2) was designed to stop this tendency but may have introduced a right-hand bias caused by normal reading habits, although the vertical lettering was designed to minimize this tendency. Post-experimental interviews with several subjects gave unanimous evidence that the sign did destroy all conscious movement tendencies, although a couple of subjects (whose data were not used) thought "back of the room" was synonymous with the dark side of the room. The 67 per cent result being slightly below rather than above the previous 75 percent result suggests that the sign was effective and thereby adds to the credibility of the present results.

Hypothesis 2: This hypothesis is tested by grouping together all of the data in Table I, excluding the $R = 1$ results. Of these 89 subjects, 70 per cent entered and 58 per cent exited via the brighter path. The experimental design provided for a right-left balance of the brighter path. If the lights have no effect on the path choice, we would expect a 50–50 split in those choices. Thus hypothesis 2 is validated by the entering results ($p < 0.0004$) and marginally validated by the leaving results ($p < 0.20$).

Data Plotting: The testing of the remaining two hypotheses is facilitated by plotting the data in Table I. Let N_r be the percentage of subjects moving to the right (relative to themselves) when the brighter lights are on the subject's right, and let N_l be the percentage of subjects moving to the left when the brighter lights are on the left. These variables are plotted in Figs. 3 and 4. The confidence limits are calculated in the usual manner (Brownlee, 1965).

The average difference between all of N_r and N_l for entering the room can be estimated in the following manner. Let N_r be the total number of subjects which followed the right path and let N_l be the total number which followed the left path. The average difference, δ, can then be

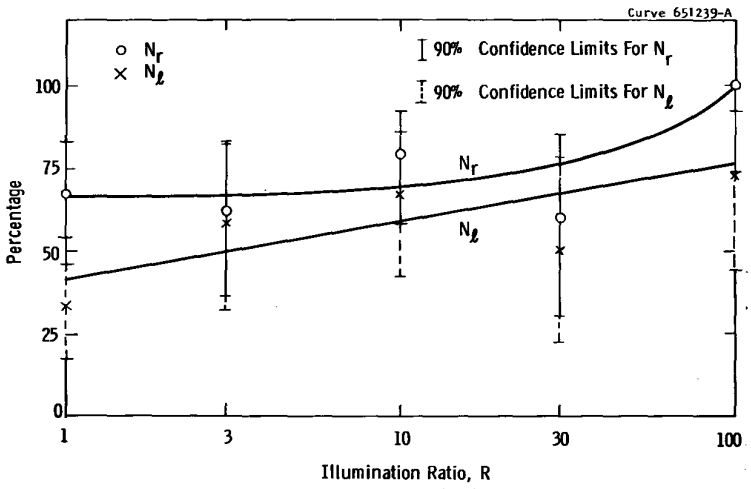

Figure 3. The percentage of subjects moving to the same side as the brighter lights as they enter the room. The curves are the results of a trend analysis.

defined as

$$\delta = (N_r - N_z)/N \quad (1)$$

The data in Table I gives the result that $\delta = 14$ per cent for entering and 15 per cent for leaving. Since the N_r and N_l points differ by 33 per cent at $R = 1$ this result shows that the N_r and N_l curves converge as the illumination ratio increases. Furthermore, an examination of Fig. 3 shows that at the same illumination ratio, more people will follow the brighter path if it is on their right than if it is on their left.

Hypothesis 3: An examination of Fig. 3 shows that an increase in the illumination ratio does not always mean an increase in N_r or N_l. However, the general trend is better visualized by doing a least-squares trend analysis on the data. The results for the entering data are

$$N_r = 66 + 0.34\,R \quad (2)$$

$$N_l = 41 + 17 \log R \quad (3)$$

where the equations are expressed in percentages and the quadratic terms are not included because they are not statistically significant. These two curves are shown in Fig. 3, but are not purported to actually represent the true curves that would be determined by further experimentation but are only used to better visualize the trends in the present data. The trends shown by these curves do indeed support the third hypothesis. However, the data points do not consistently support the hypothesis. The values for $R = 30$ are particularly troublesome. The net conclusion is that this experiment has given some evidence in support of the third hypothesis but the evidence is insufficient to consider the hypothesis proven. Further experimentation is clearly needed.

A trend analysis of the leaving data (Fig. 4) shows that the trend of N_r is either slightly increasing with increasing R values or slightly quadratic in the convex direction. The results are simply not adequate to discern the N_r trend. However, the N_l trend is definitely convex:

$$N_l = 42 + 50 \log R - 31 (\log R)^2 \quad (4)$$

This result appears to be evidence against the validation of hypothesis 3, but the convex trend is probably due to a threshold-dependent behavior. Consequently the leaving data cannot be applied to the third hypothesis.

Hypothesis 4: The trend curves in Fig. 3 do indeed exhibit thresholds. If a significant threshold is defined as an absolute change of 10 per cent in the N values from the value at $R = 1$, the N_l threshold is seen to be much lower ($R \approx 3$) than the N_r threshold ($R \approx 30$). In other words, hypothesis 4 is validated with the additional result that the

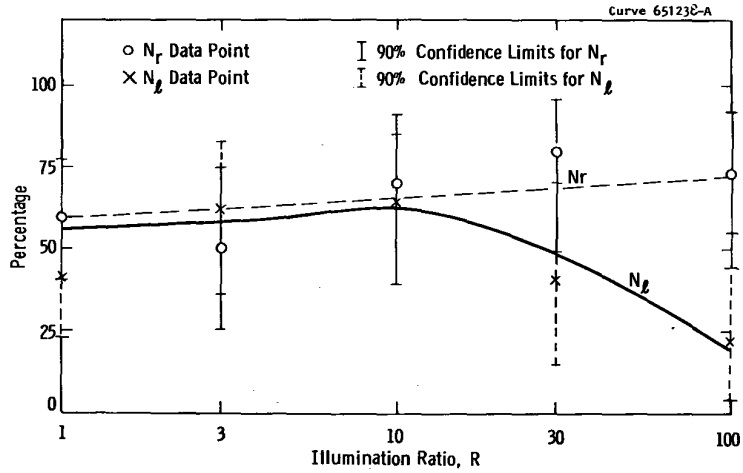

Figure 4. The percentage of subjects moving to the same side as the brighter lights as they leave the room.

thresholds for left and right path selecting are not the same.

A comparison of the entering and leaving splits in Table I shows an unexpected threshold behavior. If the lights are the only dominant factor involved in the subjects behavior, these splits should be nearly identical. For $R \leq 10$ the splits are very close to each other but become dissimilar for $R > 10$. The subject's entering *vs* leaving behavior appears to change for $R > 10$. This behavioral change is best shown by the trend curve in Fig. 4. For $R < 10$ the N_l trend is to increase with increasing R, in support of hypothesis 3, but as R increases beyond 10 the subjects actually prefer to leave via the dimmer path although they entered via the brighter path. A behavioral change threshold appears to exist around $R = 10$ which leads to very significant effects for $R \geq 30$.

Other Factors: No significant dependencies were found on sex or age. The wearing of glasses seemed to be slightly significant but not enough to examine here. The four left-handed subjects exhibited average behavior and subsequently had no appreciable effect on any of the results.

Discussion

The major findings in this study for an individual encountering a left-right decision point for the first time are as follows:

(1) When equivalent left-right paths are presented, two-thirds of the people will take the right path. This result is a good check on Melton's 1933 finding that three-quarters of the people will take the right path. Particularly since Melton's data concerned non-isolated, moving people and was recorded forty years ago.

(2) When one of the paths is more brightly lighted, people will tend to choose the brighter path.

(3) There is evidence that the higher the illumination ratio between the left-right paths, the more people will choose the brighter path. However, this relationship will have to be determined by further experimentation.

(4) At the same illumination ratio, more people will follow the brighter path if it is on their right than if it is on their left. On the average this difference is about 14 per cent.

It would be interesting to know if people who normally turn left when the paths are equivalent are also more likely to follow the brighter path than those people who normally turn right when the paths are equivalent. This study sheds no light on this hypothesis.

(5) There is an illumination ratio threshold below which the brighter path has little effect. This threshold is lower when the brighter path is on the person's left than when it is on his right.

The difference in the thresholds is not surprising because at $R = 1$ there are twice as many right-turning individuals as there are left-turning individuals. Thus, if the same percentage select the brighter path at any $R > 1$, irrespective of their behavior at $R = 1$, there are twice as many available to switch to the brighter path on the left than there are to switch to the brighter path on the right. However, a closer examination of the data indicates that this cannot be the complete explanation because the percentage affected by the brighter path is not a simple function of the illumination ratio.

(6) A behavioral change threshold exists between illumination ratios of 10 and 30. Below the threshold the leaving results closely duplicate the entering results but above this threshold the entering and leaving results exhibit large deviations.

This result indicates that above an illumination ratio of 10 the subjects became consciously aware of the different illumination of the two paths. This awareness might have affected their entering behavior if they guessed the nature of the experiment. However, only two subjects at $R = 100$ asked the experimenter about the lights (their data were not used).

On the other hand, just before the subjects leave the room the side lights are switched on with a loud click. The combination of this loud click and strong illumination level is quite likely to draw the subject's attention to the side lights. If he then recalled that he entered via the brighter path he may choose to depart by the dimmer path since he may have guessed the experimenter's intent or he may simply want to explore the passageway portion which he had not traversed. Of course, these explanations are speculative and can only be accepted or rejected by further experimentation.

(7) There are no significant dependencies on age, sex, or glasses-wearing. However, the absence of many left-handed subjects restricts these results to right-handed people in a right-handed culture such as found in the United States. It would be interesting to repeat this experiment in another culture which does not have such a large right-hand bias.

The application of these results is straightforward. When a traffic pattern skewed to the right is desired, it is better to illuminate the right path at least 30 times more than the left path. Traffic patterns skewed to the left should be avoided, but if they are necessary the illumination ratio should be higher than at points where the pattern is deliberately right-skewed. These simple rules should increase the traffic to displays such as often encountered in museums and retail stores, and should also be an aid on controlling exiting traffic on highways.

References

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