

EFFECT OF DIRECTION OF ILLUMINATION
ON
THE PLEASANTNESS AND INTELLIGIBILITY

by

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INTRODUCTION

The form of an object is determined (visually) by the direction of lighting. When the direction of light is nearly from the front of the object, shadows are less perceptible and the image appears uniform. As the angle of direction of light increases, the shadow component becomes more emphatic and there is a greater contrast. The appearance of form depends upon the contrasting values of light.

Subjective Reactions

It is commonly believed that objects and people have a fixed appearance and that illumination is necessary only to dispel the darkness and to cause this appearance to be seen. This is not true. Woll (1964) stated that lighting has been utilized to create "atmosphere" or mood on the stage, in the movies, in the home and elsewhere, so also it can be used to enhance the "working atmosphere" by directing proper lighting in the working area. This also tends to keep people's attention on the subject at hand.

Research and work is concerned with this in stage lighting where it is desired to express feelings and communicate without speaking but by changing the facial impressions. Sellman (1972) in his work on stage lighting pointed out that the direction of light can also change emotional and psychological impressions of the viewer. This in turn affects the aesthetic pleasantness to the viewer. Bellman (1974) stated that one of the powerful

things which the direction of lighting can do is to control the focus of attention of viewers.

In discussing the techniques of stage lighting, Williams (1958) said that visually people are conscious only of an image of light formed by light rays reflected from the surface in question. When a change in direction of lighting alters the reflection of light rays in the direction of viewer, there is a change in the appearance of the person, which is an important matter. While discussing the importance of direction of light, Williams said that with the light derived from a single source, if its direction is from the front, the illumination looks even. But as the angle widens, as it moves away from the front position, contrast increases and the effect becomes more dramatic. When light falls on an object at an angle of 45° from above, a fairly normal appearance is usually achieved. But as the angle increases, the shadow component becomes more conspicuous, and as it approaches 90° the contrast effect becomes very marked.

Williams said that the appearance of an object depends upon just how light is located in both horizontal and vertical planes. When the light comes from a point below and the horizontal angle of light exceeds 45° , dramatic rather than normal effects on the face are provided. A very good angle of light from a single source is from the front and with light coming down at an angle of 45° to the horizontal. This is a pleasing arrangement on most of the people. An angle of 45° in the horizontal plane may give quite a different effect to that

given by the same angle in vertical plane. Bentham (1968) indicated that the most pleasing effect for an overhead lighting position is from 45° angle. Williams finally pointed out that with lighting of people, it is useful to consider the direction of lighting in the form of zones. On both the horizontal and vertical planes, a simple rule to follow with a single light source is as follows:

Angle of 0° - 30°	Even shadowless lighting
Angle of 30° - 60°	Normal lighting
Angle of 60° - 90°	Contrast lighting of great dramatic value.

Speech

Words and word communication are the primary devices for transmitting meaning from one person to another. These words may be received orally as in the speech or visually as in reading. Lewis and Nichols (1965) indicated that roughly 75 percent of our communication time deals with transmitting or receiving these verbal symbols. In the face to face situation, however, meaning is ordinarily carried through both sound and sight and sometimes through the other senses. Visual reinforcement as stated by Lewis and Nichols, enters the speaking situation in two ways:

- a) through the use of graphic or visual aids, such as using pictures and slides for communication, and
- b) through signals indicated by the speaker through bodily action, such as waving of hand to say Hello!

Leavitt and Mueller (1951) studied effects of visual feedback on communication. Materials to be communicated were a number of geometric patterns. Communication described these complex drawings to subjects under four conditions of feedback: 1) zero feedback in which an instructor sat behind a movable blackboard to describe the patterns. No questions or noise were permitted from the listeners; 2) the visible audience condition in which listeners and instructor could see each other but no speaking by listeners was allowed; 3) a yes-no condition in which the visible audience was permitted to say only yes or no in response to questions from the instructor; and 4) a free feedback situation in which students were permitted to ask questions, interrupt, etc. It was found that more feedback condition helped in communication in the order 4, 3, 2 and 1.

Strodtbeck and Hook (1961) stated that generally the host in the party sits at the head of the table to make sure that he could view all others and vice versa. For the same very reasons meetings and conferences are sometimes held on oval and round tables so that everyone can look at each other.

Sumby and Pollack (1954) and Neely (1956) in their research on oral speech intelligibility found some contribution of vision to speech intelligibility.

As stated by Lewis and Nichols the most efficient communication demands the use of both sight and hearing. Lewis and Nichols pointed out that listeners comprehend and retain a significantly greater quantity of information when they can see

as well as hear the speaker. The listener is able to recognize the visible movements associated with some of the vowels and constants. As indicated by Paul (1947) there are sounds (those which possess the least sound power) which are the most difficult to hear but are easiest to identify visually, for example, "f", "s", "ch" and "th". On the other hand sound which are the least difficult to hear are most difficult to catch visually. "P", "t" and "k" are some of them.

Background Studies

Subjective reactions. Distortion of faces by direction of light can have a disturbing effect on patients in mental hospitals, according to a study by Barton, Spivack and Powell (1972). Their paper reports a study in which photographs of faces were used as a standardized tool for analyzing the effects of lighting angles. Subjects were asked to recognize each photograph, and recognition time was fastest for the light positions at center (0°) and 45° to the right and left of the center; women took more time than men in recognition. Regarding preference for lighting, light from the sides (45°) was preferred over head on (0°) or extreme angle (90° , 135°) positions. Preference for illumination in order was below eye level, above eye level and eye level. This study also showed that males preferred lighting at 45° to the right, while females preferred it to the left. However, no statistical analysis was run to support this statement. Interviews with the subjects indicated that heavy and sharp shadows frequently elicit subjective tones characterized by descriptions such as "threatening", "hostile", "inhuman", while better lighted and

less harshly shadowed photographs elicit responses characterized by such terms as "friendly", "determined", "human". No relationship was found between the speed of recognition and preference for those photographs.

Fischer (1970) discussed the directional effects of lighting on both human faces and still objects (flower, tennis balls). The test object was situated at the center of a cube and received a vectorless illumination from twelve 65 W fluorescent lamps installed at the edges of the cube. Directional lighting was added by additional fluorescent lamps mounted in such a way that illumination vectors from the following three directions could be produced:

horizontal angle = 0° , vertical angle = 45° (front lighting)

horizontal angle = 90° , vertical angle = 45° (side lighting)

overhead (vertical angle = 90°) (top lighting)

Subjects rated their views on an eleven point scale with extremes, unpleasant (0) and pleasant (10). The human face was judged pleasant when the light was coming from front (0° horizontal and 45° vertical angle) and was judged unpleasant for side lighting (90° horizontal and 45° vertical angle). Lighting from the top (exactly over head) was judged in between these two. For still objects the most pleasing effect was from side lighting (90° horizontal and 45° vertical angle) while lighting from the front (0° horizontal and 45° vertical angle) was judged as giving displeasing effects. Lighting coming

top (exactly over head) again was ranked between the other two judgments. This study shows some contradictions with the results of study done by Barton, Spivock and Powell, where lighting from the sides (45° horizontal angle) was preferred and judged pleasant over lighting from front (0° horizontal angle) when judging the photographs. However, the contradiction might be because Fischer used both vertical and horizontal illumination angles at the same time where as Barton, Spivock and Powell had only horizontal illumination angles.

A pilot study was done by Kumar (1976) on the effect of illumination angles and level on pleasantness and on speech intelligibility. It was found that the most preferred lighting angles were those which throw a slight amount of shadow on the face. Lighting from sides (45° horizontal angle) was judged to give most pleasing effects. Lighting from straight in front (0° horizontal angle) or extreme sides (90° horizontal angle) were judged to give unpleasant effects. There was relatively very little differences between males and females in their preferences for the angles.

Einhorn (1970) also emphasized, in his study the importance of direction of illumination. He concluded that light from straight in front of a person was undesirable. This would give both glare and unpleasing effects.

Fischer's conclusion was that light from front (0° horizontal and 45° vertical angle) gave pleasing effects on human face viewing. While Kumar, Einhorn and Barton, Spivack and

Powell's conclusions were somewhat the same. They all concluded that light from straight in front (0° horizontal angle) at eye level would give unpleasant effects and light from sides (45° horizontal angle) would give pleasing effects.

Speech intelligibility

One study in the field of speech intelligibility was done by Sumby and Pollack (1954). Speech intelligibility tests were conducted with and without supplementary visual observation of the speakers' facial and lip movements. The difference between these two conditions was examined as a function of the speech-to-noise ratio and of the size of the vocabulary under test. The experimental variables manipulated were: the absence or presence of supplementary visual observation of a speaker's lips and facial movements; the speech to noise ratio; and; the size of the vocabulary. Sumby and Pollack found that speech intelligibility decreased as the speech-to-noise ratio was decreased and as the size of the vocabulary was increased. Under the condition of low speech to noise ratio, the visual contribution was increased with an increase of vocabulary size. They finally concluded that supplementary visual observations of the speaker appreciably improved speech intelligibility.

In a study by Neely (1956) attempts were made to quantify further the visual contribution to speech intelligibility in a high intensity noise environments in terms of the angle and distance from the listener to the speaker. This study indicated that there was a significant difference in intelligibility

scores ($\alpha = 0.10$) between those subjects who saw the speaker as they heard the speech stimuli and those who did not. The distances between the listener and the speaker in their study were three, six, and nine feet. There were no differences in the correctness of response of the observers within three to nine feet distances. However, analysis of data did indicate a significant difference, statistically, in intelligibility scores relative to the angles at which the observers sat with regards to the speaker. The face-to-face position was judged as best. The other two sitting position angles in order were 45° and 90° .

Both Sumby and Pollack's study and Neely's research showed that speech intelligibility was increased by vision.

In a speech intelligibility test, Kumar found that only sex of the subjects was significant ($\alpha = 0.05$). Women were found to do better than men. Percent error scores for speech intelligibility at all three levels of luminances (10 FL, 40 FL and 70 FL) were consistant at 43-44%. Statistically, there was no significant difference found on the basis of luminances.

Kumar concluded that as all the subjects were friendly to the speaker, and knew him well before the test, that women subjects tried to do their best because of some psychological reasons. Pleasantness and intelligibility was found independent of luminances used during the study (70 FL, 40 FL and 10 FL).

PROBLEM

More research is needed to get a full understanding between illumination angles, pleasantness and intelligibility.

The basic purpose of this research is to study how people react subjectively when they view a person under different horizontal and vertical illumination angles and to study the effect of different horizontal and vertical illumination angles on the speaker's intelligibility during communication. This research will help the designer in designing more satisfactory illumination environments.

Specific Hypotheses

Considering the techniques of stage lighting and previous research work in the field of direction of light, the following hypotheses are set for the present research work:

1. Illumination from a 45° horizontal angle would always be judged as most pleasant as compared with 0° or 90° horizontal angles.
2. The level of illumination favored in order would be above eye level, eye level and below eye level.
3. Intelligibility error scores would be minimum for the illumination from side (45°) and above eye level illumination position.

METHOD

This study was divided into two parts, one in which subjects gave their subjective reactions to photographs taken under various horizontal and vertical angles. The other part consisted of a speech intelligibility test under various horizontal and vertical angles with a constant background noise level.

Subjective Reaction

In this part, subjects were asked to evaluate the photographs of faces of four models (two males and two females) on four seven point scales. The photographs were taken by a professional photographer under various horizontal and vertical illumination angles.

Independent variables in the experiment were nine combinations of three vertical and three horizontal illumination angles and the sex of both the model and subject. The dependent variables were the ratings given by the subjects in evaluation of the photographs. X

The four models were whites with face reflectances in the range of 0.33 to 0.35. They were friends of the researcher. A 60 watt incandescent lamp with a cylindrical shade of fifteen centimeters diameter and fifteen centimeters length with an aluminium foil lining was used as a light source on the model's face. In the background of the model was a screen covered with a sheet of paper of light reflectance of 0.50. The background was also illuminated by an incandescent lamp source. Background

luminance and model's facial luminance were both ten foot lamberts.

Figures 1 and 2 show the layout for taking the photographs. In Figure 1, L_1 , L_2 and L_3 are the light source positions for illuminating the model's face. They show the horizontal angles for illumination (0° , 45° , and 90°), on right hand side of the model. "M" is the position for the model and "C" for the camera. The background screen was 30 inches behind the model, illuminated by an incandescent lamp source kept just behind the model. The illumination source for the model's face enclosed in an area "B" in the Figure 1 and is shown in detail in Figure 2. This shows the vertical position and the angles for the source of illumination (-45° , 0° , $+45^\circ$). The two spot lights with -45° and $+45^\circ$ angle are at 24 inches distance from eye level spot light with 0° angle as shown in Figure 2. The models wore the same shirt during the photographs to give some consistency to the photographs. In all there were 36 photographs for the four models, nine for each (three horizontal and three vertical angles of illumination). These are shown in Figure 3.

Photographs A, B, C, and D show the four models used in the study. Photographs E, F, and G give an example of change in the model's face because of change in angle of illumination. Photograph E shows illumination from extreme side (90°) with quite a bit shadow on the face. Photograph F and G respectively show illumination from side (45°) and straight in front (0°). Photographs H, I, and J show the effect of change in levels for the same angle of illumination. Photographs H, I, and J are

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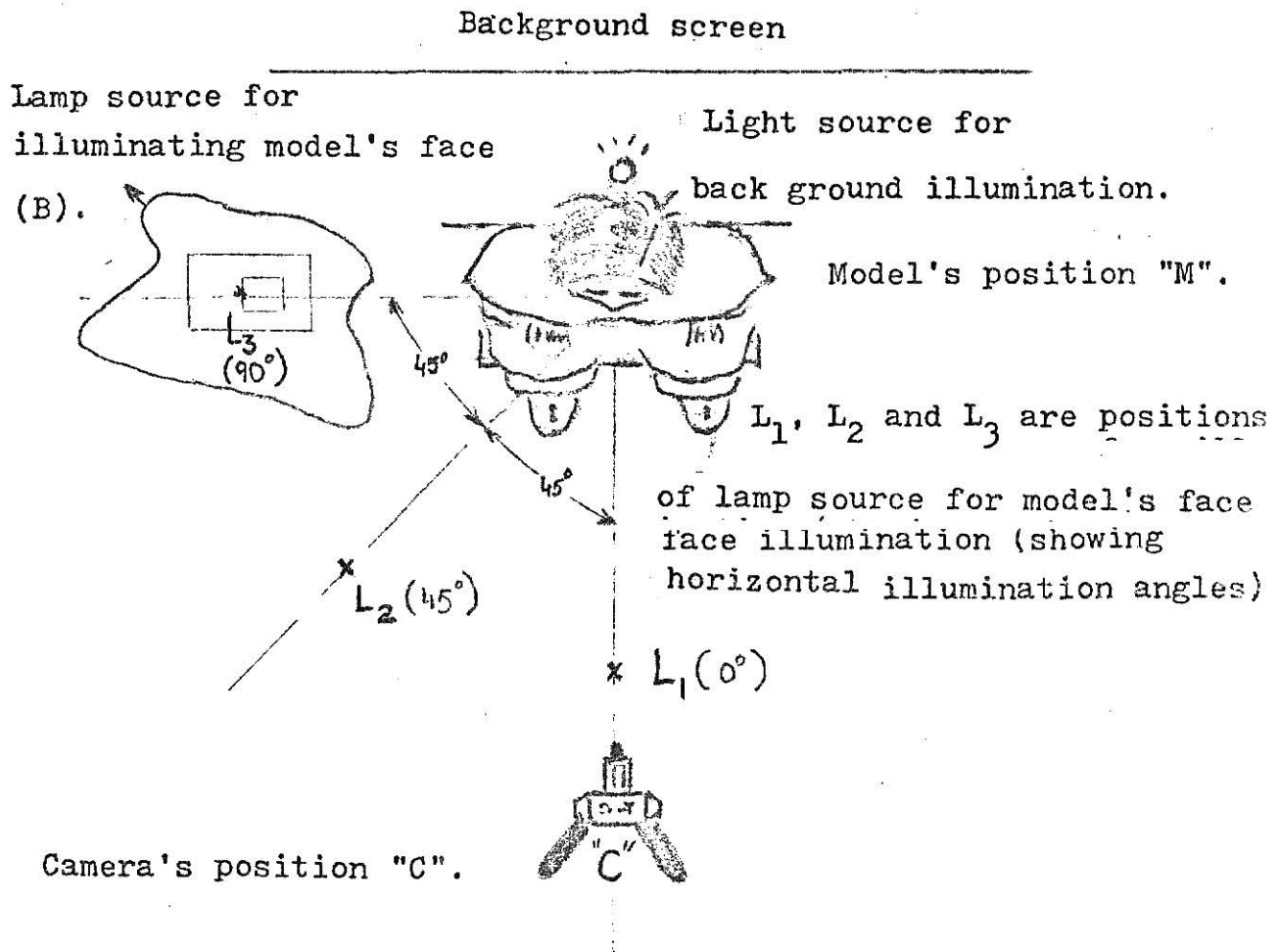


Figure 1. Layout for taking photographs (Top View),
for subjective evaluation part.

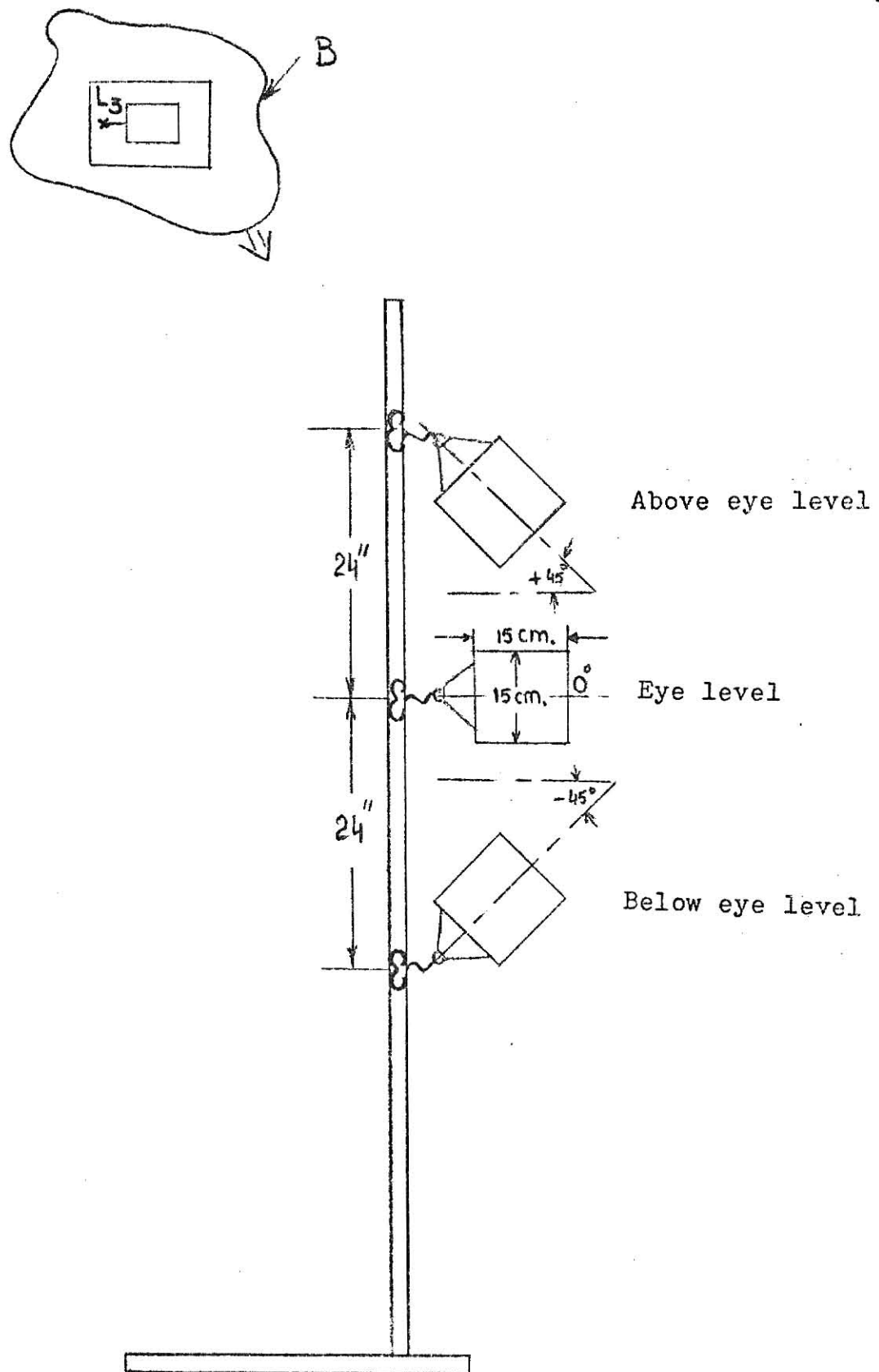


Figure 2. Positions of the three spot lights used in the experiment.



A



B



C



D

Figure 3. Photographs showing models and different angle and level conditions.



E



F



G

Figure 3. (cont.)



H



I



J

Figure 3. (cont.)

for above eye level, eye level and below eye level illumination respectively when the illumination is from extreme side (90°).

Speech Intelligibility

In this study, subjects were given an intelligibility test at each of the nine test position with a constant background noise level of 85 dB(A). This noise level was enough to ensure that subjects did have difficulty in hearing the speaker's speech which otherwise without this noise would not have been.

Independent variables were the same as in the subjective evaluation part of this research except that only one model, a male, was used. The dependent variable was the intelligibility test score.

Figure 4 shows the layout for the experiment. The speaker and subject sat at a distance of six feet facing each other. The speaker's face reflectance was 0.27 and his face was illuminated from the same light source and same positions as were used for illuminating model's face in the subjective evaluation part of this research. The only addition is of a noise source, which was a white noise generator (Lafayette Instrument Co., Model #15012, Indiana) placed at a distance of four feet behind the subject's position.

Tasks

In subjective evaluation part of this research, each subject was given the 36 photographs. He was asked to rate each photograph on four seven point scales using these terms on the

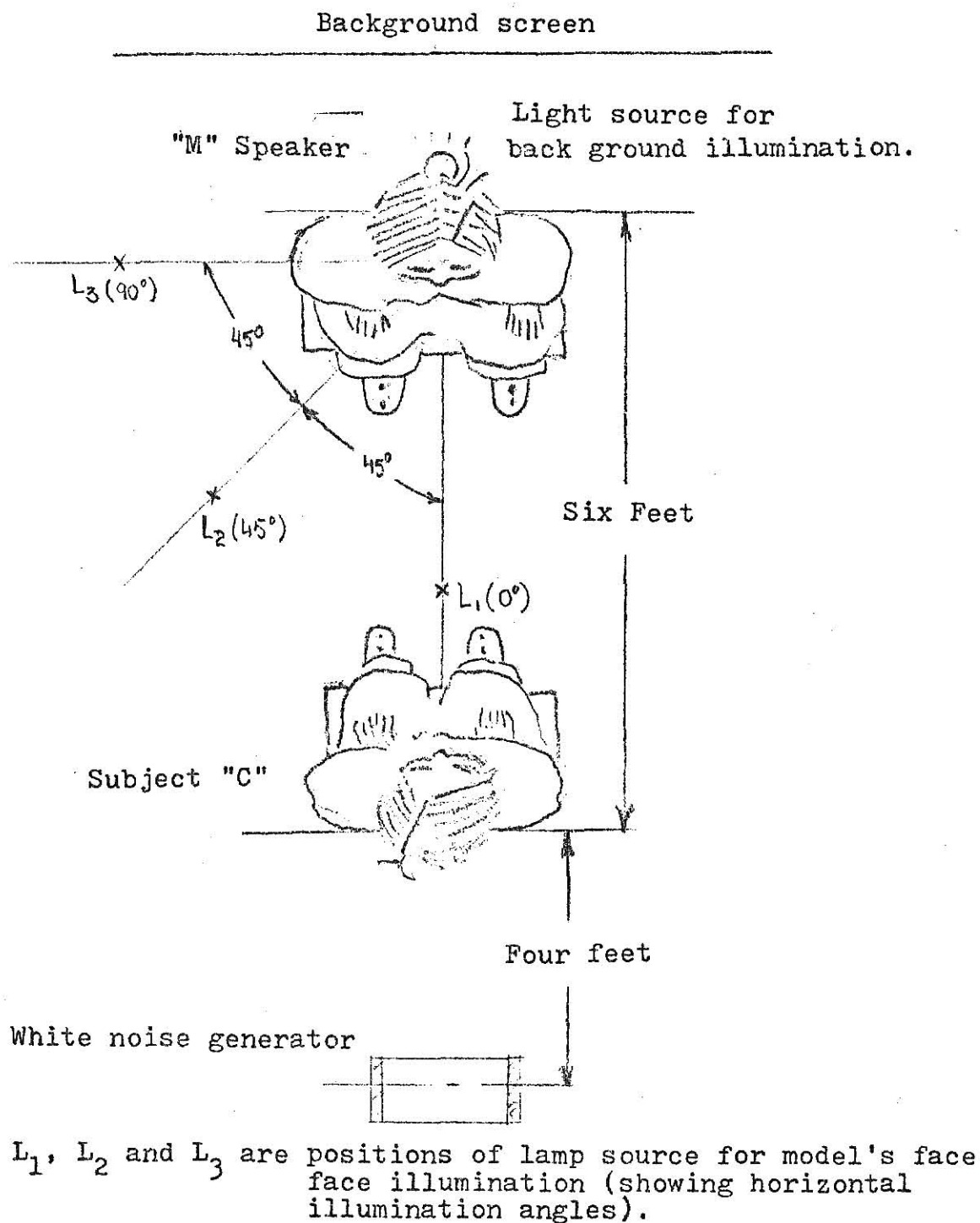


Figure 4. Layout of the experiment (Top View) for intelligibilit
part.

extremes: friendly vs. hostile; happy vs. sad; preferred vs. nonpreferred; and honest vs. dishonest.

The 36 photographs enclosed in transparent folders, were spread on the table. A strip was placed on the table showing seven points. Different cards were printed with the words to be used on the extremes of the scale. Each time two opposite words, such as, friendly-hostile were kept on the extreme points and subjects were asked to arrange the photographs into columns below these seven points. Point one in the scale always corresponded to the pleasant word; Happy, Friendly, Honest, or Preferred. While point seven always corresponded to the unpleasant words; Sad, Hostile, Nonpreferred or Dishonest. After subjects finished arranging those 36 photographs, the rating of each photograph was noted. The photographs were then mixed again and spread at random to start again for judging on the next scale. This way the experiment was repeated for all the scales for each subject, with the order of scales randomized for each subject.

In the speech intelligibility test, subjects were given the test for listeners intelligibility at each of the nine test positions. The noise level which was kept at 85 dB(A) throughout this experiment was checked with a noise level meter, both before and after the experiment. The intelligibility tests (Multiple-Choice Tests) are available in standard form. The test used for this research was from Black (1953).

Instruction sheets with an informed consent form were given to the subjects. They were made as simple and easy to understand

as possible. Subjects were also instructed to ask questions when in doubt at any time. Figure 5 shows the instructions and informed consent sheets given to the subjects before starting the experimentation.

Experimental Design

The independent variables in the experiment were the horizontal and vertical illumination angles and the sex of both, the models and the subjects.

The dependent variables in the subjective evaluation part were the four sets of ratings given during evaluation of the photographs and in speech intelligibility part it was the listeners intelligibility test error scores. Random number tables were used for randomization of sequences of illumination angles, levels and intelligibility tests lists in the speech intelligibility test.

Subjects

In the subjective evaluation, 22 K.S.U. students participated. Data of 20 students were used for analysis as the researcher observed two of the participants seemed disinterested during experimentation. Out of 20 subjects, ten subjects of each sex were run.

In the speech intelligibility part, 20 K.S.U. students, ten of each sex, participated. Some students participated in both, the subjective evaluation part as well as in intelligibility part of this research.

Please Read Carefully and take your own time :

This experiment is designed to study the effect of different lighting conditions on the pleasantness and intelligibility of the viewer.

You as subject (viewer) will be taking part in this experiment which is divided into two different parts.

Figure 5. Instructions

Instructions for Subjective Evaluation Test

1. You will be given a set of 36 photographs.
2. I want you to rate each photograph separately on all the following scales separately.
 - a) Happy Vs Sad
 - b) Preferred Vs NonPreferred
 - c) Friendly Vs Hostile
 - d) Honest Vs Dishonest
3. I will place one seven point scale on the table.
4. You will spread all of these 36 photographs on the side of this scale facing you.
5. Arrange each of the photograph under one of the seven columns, you feel is most appropriate.
6. You can rearrange the photographs any time, as you proceed to arrange all 36.
7. Take you own time.
8. When you are finished on one scale, I will note down your evaluation for each photograph.
9. I will reshuffle the photographs and you will be asked to proceed to evaluate on the second scale.
10. This way you will be evaluating them on all of the scales.

Instructions for Intelligibility Test

1. You will be sitting face to face with the speaker (me) at a distance of six feet.
2. I will speak two groups of four words each for each of the nine test positions.
3. You are supposed to look and concentrate on my face while I am speaking the words and do not lean forward or to the side. This is important.
4. There will be a constant noise level in the background during the experimentation.
5. You will be provided with a set of nine answer forms. One sheet of answer form for each test position.
6. The figure A, shows an example of an answer form. For each of the four words, I speak in one group, there will be four choices column-wise in the answer form.
7. All the four words in same column have similar sounds. The first word will be in first column on left, the second word in the second column and so on.

The following example will make this clear:

Example:

You will hear speaker saying

"Number One Flesh Size Wait Pass"

Now you look into your answer form in the figure A. The first word after one is "Flesh" and this appears in the first left

Figure 5. (Cont.)

Number One				Number Two			
Flush	Size	Wake	Cast	Thus	Hit	Girl	Hollow
Pledge	Sigh	Waste	Pass	Dust	Fit	Pearl	Mellow
Fresh	Side	Wait	Cats	Buss	Lit	Earl	Felow
Flesh	Site	Haste	Past	Duck	Sit	Knurl	Shalow

Figure A. Example of an Answer Form

hand column of four words. The second word "Size" will be in second column of four words and so on. Encircle one word in each column you have heard or you think you have heard. The second group of four words will only start after you finish the first four words. So take your own time in recollecting or thinking of the words.

After you have finished answering the first group of words, you will hear

"Number Two Thus Sit Earl Hollow"

You can proceed to answer as you did in the first group.

Note: You can look into each answer sheet before the starting of each test. The speaker will speak with a normal speed and he will not repeat the words at any time, so please be attentive throughout the experiment.

Please see figure B, and do not hesitate to ask any question you have now or at any time during the experiment.

WHEN YOU HEAR

"Number One Flesh Size Waitful Past"

MAKE YOUR ANSWER SHEET LIKE THIS

Number One

Flush Size Waitful Cast
 Pledge Sigh Wake Past
 Erase High Wasteful Pass
Flesh Side Wakeful Path

WHEN YOU HEAR

"Number Two Thus Lesson Kiss Pearl"

MARK YOUR ANSWER SHEET LIKE THIS

Number One

Flush Size Waitful Cast
 Pledge Sigh Wake Past
 Erase High Wasteful Pass
Flesh Side Wakeful Path

Number Two

Thus Legend Hit Girl
 Bust Ledger Fist Pearl
 Duck Leaden This Curled
 Dust Lesson Kiss Curl



Figure B. Intelligibility Test Example

Informed Consent Form

There are no dangers and risks involved in these experiments.

However, you can stop participating at any time you wish.

I hope that you will continue and complete the experiment so that I can collect all the needed data and complete my research.

Now, if you are ready for the experiment, please sign the informed consent form given by the experimenter.

If you have any comments about the procedure and experiment please feel free to write them at the end of the experiment in the space provided on the answer form or data sheet.

Thanks for your Cooperation.

As the subjects were unpaid the main criterion in their selection was their willingness to participate in the study, provided they had normal vision and hearing. This was confirmed by asking them before performing the experiment.

In the subjective evaluation part, the average age of female subjects was 24.2 years. This included six Americans, two Indians and two Philipinos. The average age of male subjects in this part was 30.8 years. This included eight Americans and two Indians.

In the intelligibility part, the average age of female subjects was 25.6 years including eight Americans and two Indians. The average age of male subjects in this study was 28.7 years, including eight Americans and two Indians.

Each subject on the average took 45 minutes to finish the subjective evaluation part and took 25 minutes to finish the intelligibility part of this research.

RESULTS

The subjective reactions of the subjects to the photographs are given in the Appendix, in Tables A1 to D4.

Tables A1, A2, A3 and A4 show the raw scores on the seven point scale with extremes Friendly (1) and Hostile (7) for the four models. Similarly the evaluations of four models on other three seven point scales "Happy (1) vs. Sad (7)", "Preferred (1) vs. Nonpreferred (7)" and "Honest (1) vs. Dishonest (7)" are shown in Tables B, C, and D respectively. Subjects error scores in speech intelligibility test are shown in Appendix, Table E.

Tables 1, 2, 3 and 4 show the mean ratings given by subjects on the seven-point scales with extremes "Friendly (1) - Hostile (7)", "Happy (1) - Sad (7)", "Preferred (1) - Nonpreferred (7)" and "Honest (1) - Dishonest (7)", respectively. Table 5 gives the means of listeners intelligibility test error scores out of a maximum possible of eight errors. Table 6 gives intercorrelations among the four subjective reactions. As may be seen, these variables are highly intercorrelated. A principal components factor analysis was carried out on this matrix intercorrelations using the BMD03M factor analysis computer program (1965). Table 7 shows the factor loadings. While the rotated factor loadings show one interpretation which is that there are two different but related factors, a simpler explanation may be seen from the unrotated factor loadings and from Figure 6. There is a single dimension (unrotated factor number one which accounts for most of the variance in these four

TABLE 1. Mean ratings given by subjects when evaluating on scale "Friendly (1) vs. Hostile (7)".

		MODEL					
ANGLE	LEVEL	MALE		FEMALE		MEAN	
		1	2	1	2		
90°	High	5.35	4.45	4.10	2.90	4.20	
	Eye	5.00	5.00	4.05	3.25	4.32	4.31
	Low	5.15	5.05	4.60	2.85	4.41	
45°	High	4.80	3.30	2.60	2.20	3.22	
	Eye	4.55	2.65	3.10	2.00	3.07	3.54
	Low	5.60	4.65	4.05	3.25	4.38	
0°	High	3.35	3.35	1.85	2.55	2.77	
	Eye	5.00	4.65	3.95	3.15	4.18	3.52
	Low	5.80	3.40	2.20	3.15	3.63	
	Mean	4.95	4.05	3.38	2.83		

TABLE 2. Mean ratings given by subjects when evaluating on scale "Happy (1) vs. Sad (7)".

		MODEL					
ANGLE	LEVEL	MALE		FEMALE		MEAN	
		1	2	1	2		
90°	High	6.05	5.00	4.00	3.40	4.61	
	Eye	6.05	5.25	4.25	3.65	4.80	4.72
	Low	6.40	4.85	4.35	3.40	6.75	
45°	High	4.70	4.05	2.70	2.90	3.58	
	Eye	4.70	3.50	2.95	2.05	3.30	3.80
	Low	5.90	4.95	4.30	2.95	4.52	
0°	High	3.30	6.00	2.95	3.20	3.36	
	Eye	5.10	4.75	4.05	3.95	4.46	3.98
	Low	5.70	4.65	2.45	3.75	4.13	
	Mean	5.32	4.55	3.55	3.25		

TABLE 3. Mean ratings given by the subjects when evaluating on scale "Preferred (1) vs. Nonpreferred (7)".

ANGLE	LEVEL	MODEL				MEAN	
		MALE		FEMALE			
		1	2	1	2		
90°	High	6.05	5.75	4.95	5.35	5.52	5.68
	Eye	6.45	6.30	5.35	5.00	5.77	
	Low	6.50	5.25	6.20	5.10	5.76	
45°	High	4.60	3.50	2.50	3.35	3.48	4.02
	Eye	4.10	3.25	2.80	2.85	3.25	
	Low	6.05	5.25	5.30	4.75	5.33	
0°	High	2.25	2.00	1.55	1.85	1.91	2.80
	Eye	3.15	3.70	4.25	2.30	3.35	
	Low	4.45	3.00	2.00	3.15	3.15	
	Mean	4.84	4.22	3.87	3.74		

TABLE 4. Mean ratings given by the subjects when evaluating on scale "Honest (1) vs. Dishonest (7)".

ANGLE	LEVEL	MODEL				MEAN	
		MALE		FEMALE			
		1	2	1	2		
90°	High	5.90	5.25	3.95	4.00	4.77	4.79
	Eye	6.00	5.20	4.15	4.10	4.86	
	Low	5.95	4.50	4.90	3.60	4.73	
45°	High	4.40	2.65	2.30	2.65	3.00	3.34
	Eye	3.65	2.65	2.60	2.00	2.72	
	Low	5.30	4.10	4.56	3.35	4.32	
0°	High	2.70	2.85	2.30	2.00	2.46	3.38
	Eye	4.00	3.90	4.20	2.80	3.72	
	Low	5.75	2.75	3.95	3.40	3.96	
	Mean	4.85	3.76	3.60	3.10		

TABLE 5. Mean listeners intelligibility test error scores out of a maximum of eight errors.

ANGLE	LEVEL	SUBJECT		MEAN	
		MALE	FEMALE		
90°	High	3.6	3.4	3.5	
	Eye	3.9	2.9	3.4	3.53
	Low	4.1	3.3	3.7	
45°	High	3.3	2.7	3.0	
	Eye	3.2	2.3	2.75	2.96
	Low	3.4	2.7	3.15	
0°	High	3.6	3.4	3.50	
	Eye	3.5	3.6	3.55	3.61
	Low	3.3	3.7	3.80	
	Mean	3.54	3.13		

TABLE 6. Intercorrelations among variables (subjective reactions)

		Friendly vs. Hostile 1	Happy vs. Sad 2	Preferred vs. Nonpreferred 3	Honest vs. Dishonest 4
Friendly vs. Hostile	1	1.00			
Happy vs. Sad	2	0.92	1.00		
Preferred vs. Nonpreferred	3	0.70	0.67	1.00	
Honest vs. Dishonest	4	0.84	0.82	0.84	1.00

TABLE 7. Comparison between two factor loadings.

Variable	Unrotated		Rotated	
	1	Factor 2	1	Factor 2
1) Friendly vs. Hostile	0.93	-0.19	0.81	0.49
2) Happy vs. Sad	0.91	-0.22	0.82	0.45
3) Preferred vs. Nonpre- ferred	0.81	0.28	0.40	0.76
4) Honest vs. Dishonest	0.93	0.16	0.57	0.75

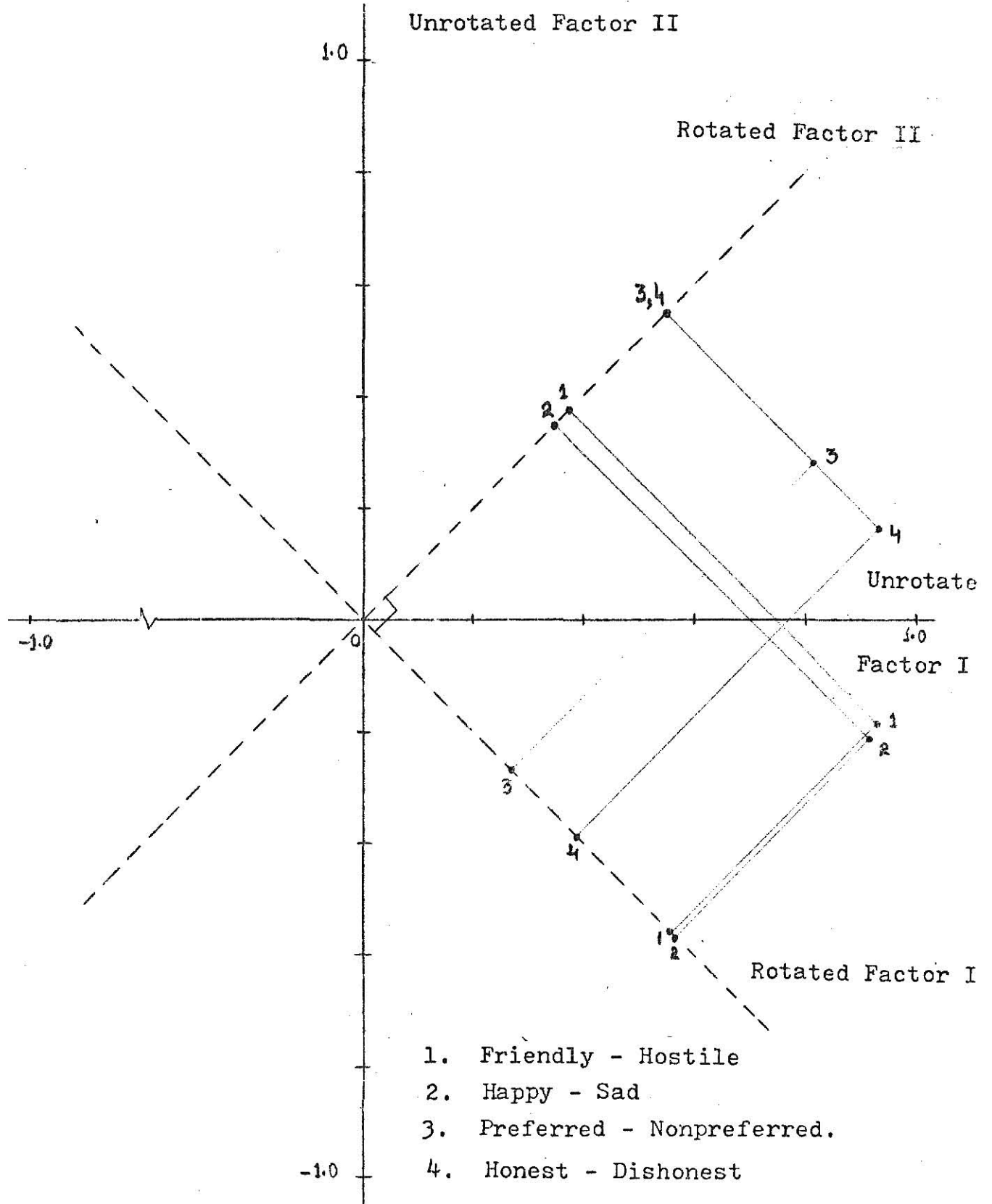


Figure 6. Orthogonal factor rotation

subjective scales, with a little differentiation of the pair "friendly" and "happy" from the pair "preferred" and "honest"). For all practical purposes subjects reacted to these four scales in the same way. The results of the analysis of the effects of the independent variables, to be considered next, will support this view that there was essentially one subjective reaction.

An analysis of variance, using the Aardvark (1969) program, was performed on the ratings given by subjects for each scale. It was assumed that subjects represented a random variable, and that the angle, level and sex were fixed variables. The 0.05 level of significance was chosen. The results of analysis are shown in Tables 8, 9, 10 and 11 for the four scales; "Friendly - Hostile", "Happy - Sad", "Preferred - Nonpreferred", "Honest - Dishonest", respectively. The results indicate significant difference among angle, level, both sex of models and subjects and interaction of angle and level, on all the four scales. Further analysis by Tukey's (HSD) test at $\alpha = 0.05$, indicates which means are significantly different. Tukey's results are shown in Tables 12, 13, 14 and 15 for the above four scales. Figures 7 to 14 show the variation among the variables which show significant differences.

Analysis of variance of the intelligibility test error scores are shown in Table 16. Results indicate that none of the variables is significantly different at $\alpha = 0.05$.

TABLE 8. Analysis of variance of "Friendly vs. Hostile".

<u>Source of Variance</u>	<u>Sum of Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F</u>
Angle (A)	99.16	2	49.58	6.52*
Level (L)	69.05	2	34.52	4.54*
Sex of Model (S)	359.01	1	357.01	46.97*
Sex of Subject (G)	88.90	1	88.90	11.69*
Model (M)/Sex (S)	13.11	2	6.55	0.86
A x L	99.48	4	24.87	3.27*
A x S	0.00	2	0.00	0.00
A x G	24.83	2	12.41	1.63
A x M	0.71	4	0.17	0.02
L x S	7.80	2	3.90	0.51
L x G	5.63	2	2.81	0.37
L x M	28.06	4	7.01	0.92
S x G	3.06	1	3.00	0.40
G x M	3.06	2	1.53	0.20
A x L x S	6.48	4	1.62	0.21
A x L x G	15.43	4	3.85	0.51
A x L x M	17.13	8	2.14	0.28
L x S x G	9.60	2	4.80	0.63
A x L x S x G	39.85	4	9.96	1.31
Subject (P)	136.89	18	7.60	
Error	1267.24	648	1.95	
Total	2292.59	719		

*Significant difference at $\alpha = 0.05$.

TABLE 9. Analysis of variance of "Happy vs. Sad".

<u>Source of Variance</u>	<u>Sum of Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F</u>
Angle (A)	105.07	2	52.53	13.30*
Level (L)	49.54	2	24.77	6.27*
Sex of Model (S)	412.53	1	412.53	104.43*
Sex of Subject (G)	51.73	1	51.73	13.09*
Model (M)/Sex (S)	17.78	2	8.89	2.25
A x L	66.53	4	16.63	4.21*
A x S	10.54	2	5.27	1.33
A x G	23.91	2	11.95	3.02
A x M	3.24	4	0.81	0.20
L x S	9.87	2	4.93	1.25
L x G	12.41	2	6.20	1.57
L x M	14.94	4	3.73	0.94
S x G	8.66	1	8.66	2.19
G x M	1.73	2	0.86	0.22
A x L x S	11.00	4	2.75	0.69
A x L x G	5.60	4	1.40	0.35
A x L x M	14.95	8	1.86	0.47
L x S x G	2.67	2	1.33	0.34
A x L x S x G	18.83	4	4.70	1.19
Subject (P)	71.11	18	3.95	
Error	1301.85	648	2.00	
Total	2224.59	719		

*Significant difference at $\alpha = 0.05$.

TABLE 10. Analysis of variance of "Preferred vs. Nonpreferred".

<u>Source of Variance</u>	<u>Sum of Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F</u>
Angle (A)	866.55	2	433.27	124.50*
Level (L)	127.67	2	63.83	18.34*
Sex of Model (S)	124.16	1	124.16	35.67*
Sex of Subject (G)	26.83	1	26.83	7.70*
Model (M)/ Sex (S)	25.36	2	12.68	3.64
A x L	172.06	4	43.01	12.35*
A x S	1.51	2	0.75	0.21
A x G	0.58	2	0.29	0.08
A x M	25.68	4	6.42	1.84
L x S	0.46	2	0.23	0.06
L x G	18.10	2	9.05	2.60
L x M	6.75	4	1.68	0.48
S x G	13.06	1	13.06	3.75
G x M	3.46	2	1.73	0.49
A x L x S	23.25	4	5.81	1.66
A x L x G	8.93	4	2.23	0.64
A x L x M	8.91	8	1.11	0.31
L x S x G	23.58	2	11.79	3.38
A x L x S x G	70.70	4	17.67	5.07*
Subject (P)	62.80	18	3.48	
Error	1302.85	648	2.01	
Total	2913.38	719		

*Significant difference at $\alpha = 0.05$.

TABLE 11. Analysis of variance of "Honest vs. Dishonest".

<u>Source of Variance</u>	<u>Sum of Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F</u>
Angle (A)	378.05	2	189.02	30.78*
Level (L)	70.54	2	35.27	5.74*
Sex of Model (S)	177.01	1	177.01	28.82*
Sex of Subject (G)	100.50	1	100.50	16.36*
Model (M)/ Sex (S)	3.33	2	1.66	0.27
A x L	115.25	4	28.81	4.69*
A x S	7.25	2	3.62	0.59
A x G	2.20	2	1.10	0.18
A x M	3.05	4	0.76	0.12
L x S	2.03	2	1.01	0.16
L x G	20.01	2	10.00	1.62
L x M	8.75	4	2.18	0.35
S x G	23.11	1	23.11	3.76
G x M	14.23	2	7.11	1.15
A x L x S	17.73	4	4.43	0.72
A x L x G	3.63	4	0.90	0.09
A x L x M	4.77	8	0.59	0.09
L x S x G	23.63	2	11.81	1.92
A x L x S x G	91.23	4	22.80	3.71*
Subject (P)	110.63	18	6.14	
Error	1175.15	648	1.81	
Total	2352.16	719		

*Significant difference at $\alpha = 0.05$.

TABLE 12. Tukey's test at $\alpha = 0.05$ for variables and interactions having significant difference in Analysis of Variance of "Friendly vs. Hostile".

Angle	90°	45°	0°						
Mean	4.32	3.57	3.50						
Level	Low	Eye	High						
Mean	4.17	3.81	3.41						
Sex of Model	Male	Female							
Mean	4.50	3.09							
Sex of Subject	Female	Male							
Mean	4.15	3.44							
Angle x Level	45°/Low	90°/Low	90°/Eye	90°/High	0°/Eye	0°/Low	45°/High	45°/Eye	0°/High
Mean	4.74	4.41	4.31	4.24	4.08	3.63	3.19	3.03	2.79

Underlines connect means that are not significantly different.

TABLE 13. Tukey's test at $\alpha = 0.05$ for variables and interactions having significant difference in Analysis of Variance of "Happy vs. Sad".

Angle	90°	0°	45°						
Mean	4.70	4.01	3.81						
Level	Low	Eye	High						
Mean	4.48	4.19	3.84						
Sex of Model	Male	Female							
Mean	4.93	3.41							
Sex of Subject	Female	Male							
Mean	4.44	3.90							
Angle x Level	90°/Eye	90°/Low	90°/High	45°/Low	0°/Eye	0°/Low	45°/High	0°/High	45°/Eye
Mean	4.79	4.74	4.56	4.52	4.46	4.18	3.58	3.38	3.32

Underlines connect means that are not significantly different.

TABLE 14. Tukey's test at $\alpha = 0.05$ for variables and interactions having significant difference in Analysis of Variance of "Preferred vs. Nonpreferred".

Angle	90°	45°	0°						
Mean	5.69	4.07	3.02						
Level	Low	Eye	High						
Mean	4.80	4.19	3.78						
Sex of Model	Male	Female							
Mean	4.67	3.84							
Sex of Subject	Female	Male							
Mean	4.45	4.06							
Angle x Level	90°/Eye	90°/Low	90°/High	45°/Low	0°/Eye	45°/High	45°/Eye	0°/Low	0°/High
Mean	5.77	5.77	5.52	5.46	3.54	3.48	3.26	3.18	2.33

Underlines connect means that are not significantly different.

TABLE 15. Tukey's test at $\alpha = 0.05$ for variables and interactions having significant difference in Analysis of Variance of "Honest vs. Dishonest".

Angle	90°	45°	0°						
Mean	4.82	3.35	3.23						
Level	Low	Eye	High						
Mean	4.18	3.81	3.42						
Sex of Model	Male	Female							
Mean	4.30	3.31							
Sex of Subject	Female	Male							
Mean	4.18	3.43							
Angle x Level	90°/Eye	90°/Low	90°/High	45°/Low	0°/Eye	0°/Low	45°/High	45°/Eye	0°/High
Mean	4.98	4.76	4.73	4.32	3.72	3.47	3.02	2.72	2.49
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Underlines connect means that are not significantly different.

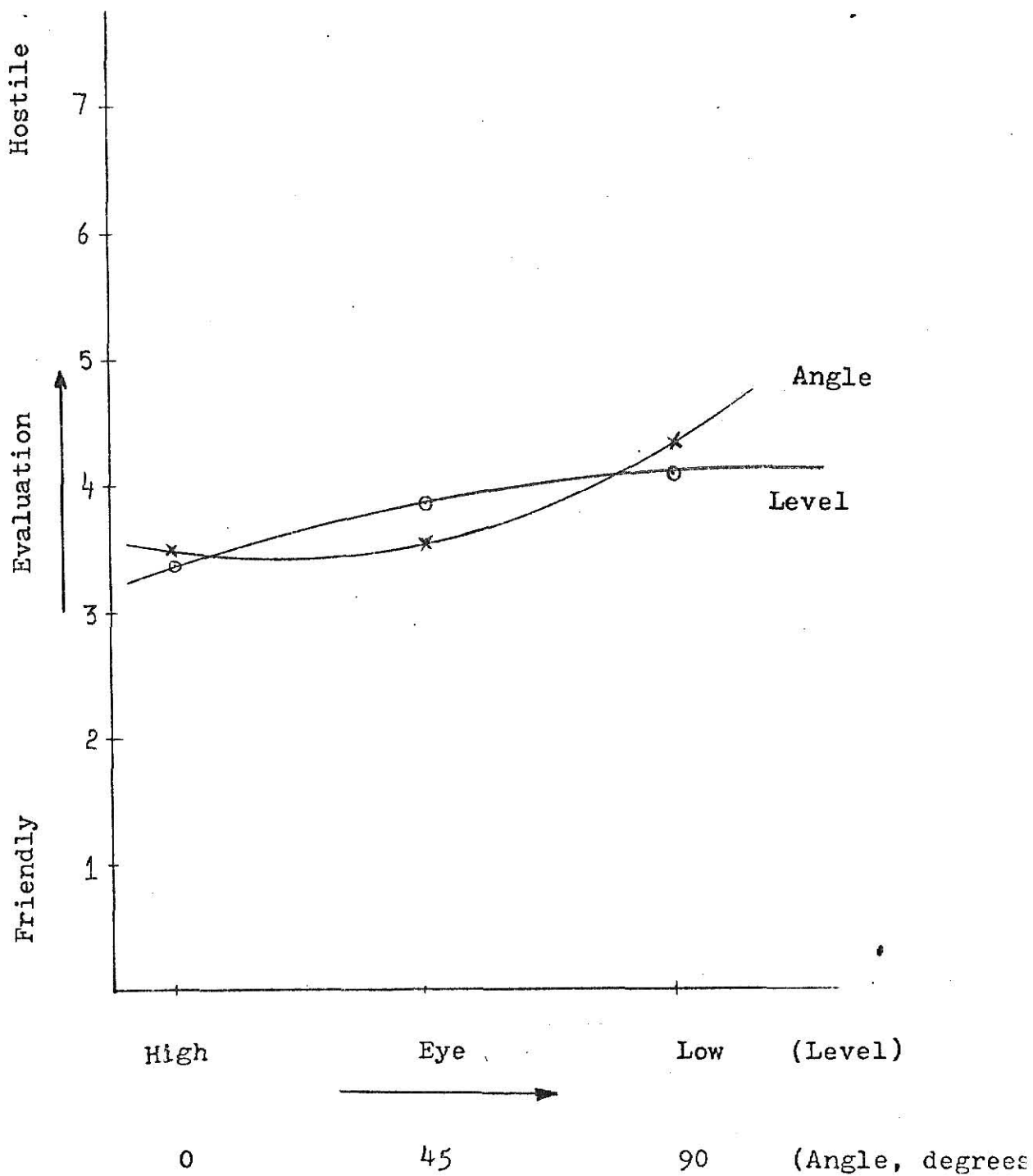


Figure 7. Mean evaluation vs. angle and level of illumination.

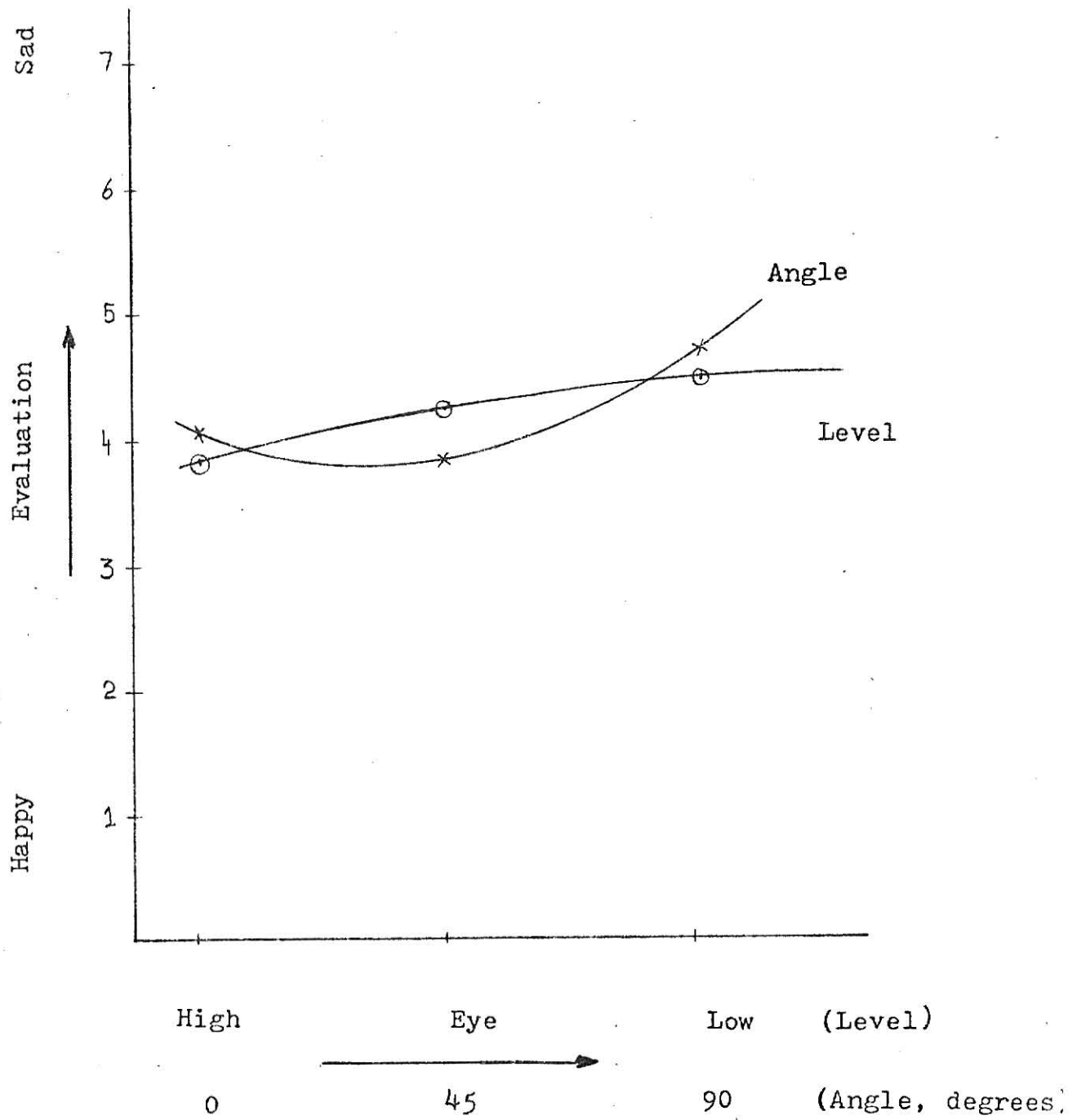


Figure 8. Mean evaluation vs. angle and level of illumination.

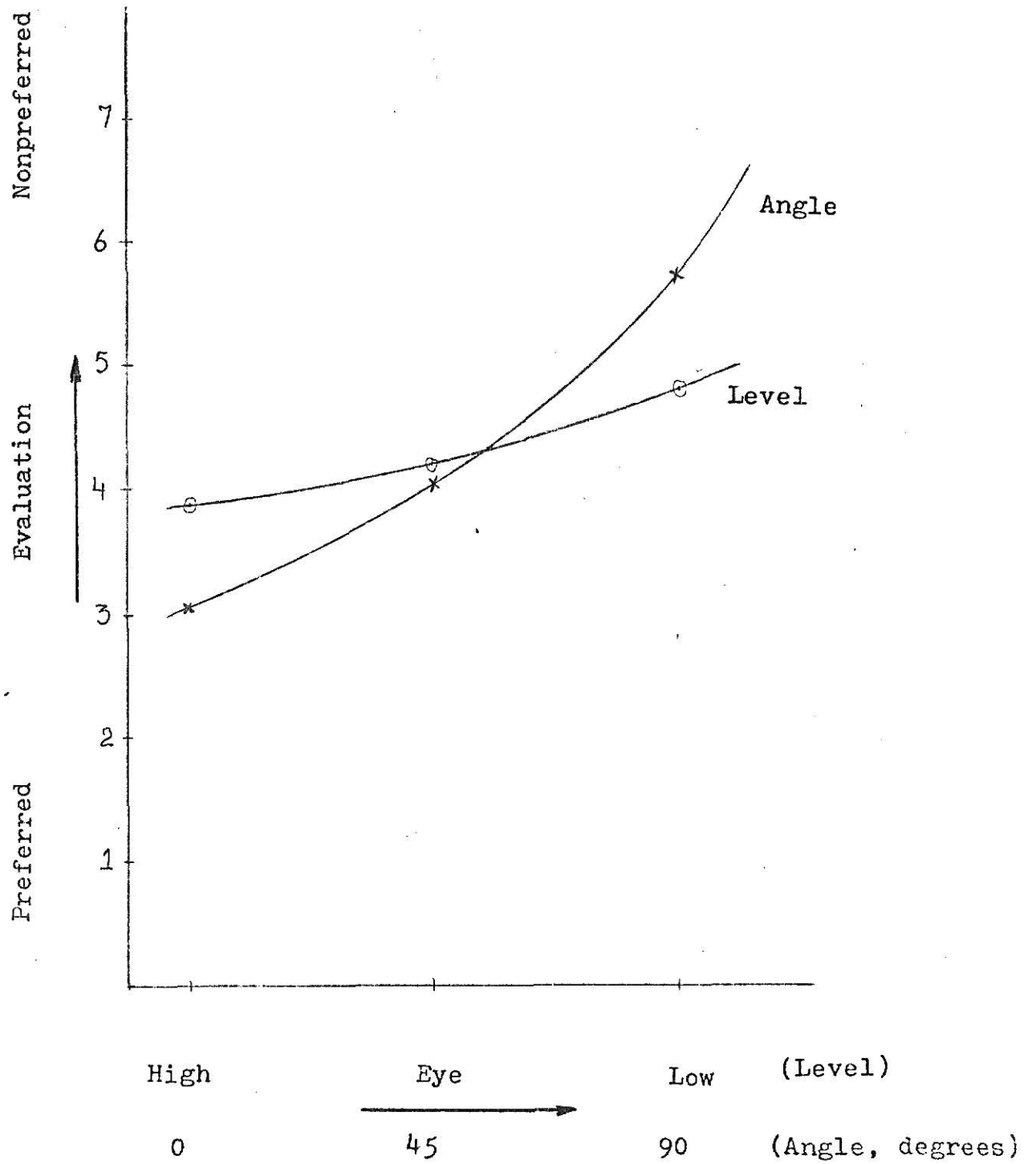


Figure 9. Mean evaluation vs. angle and level of illumination

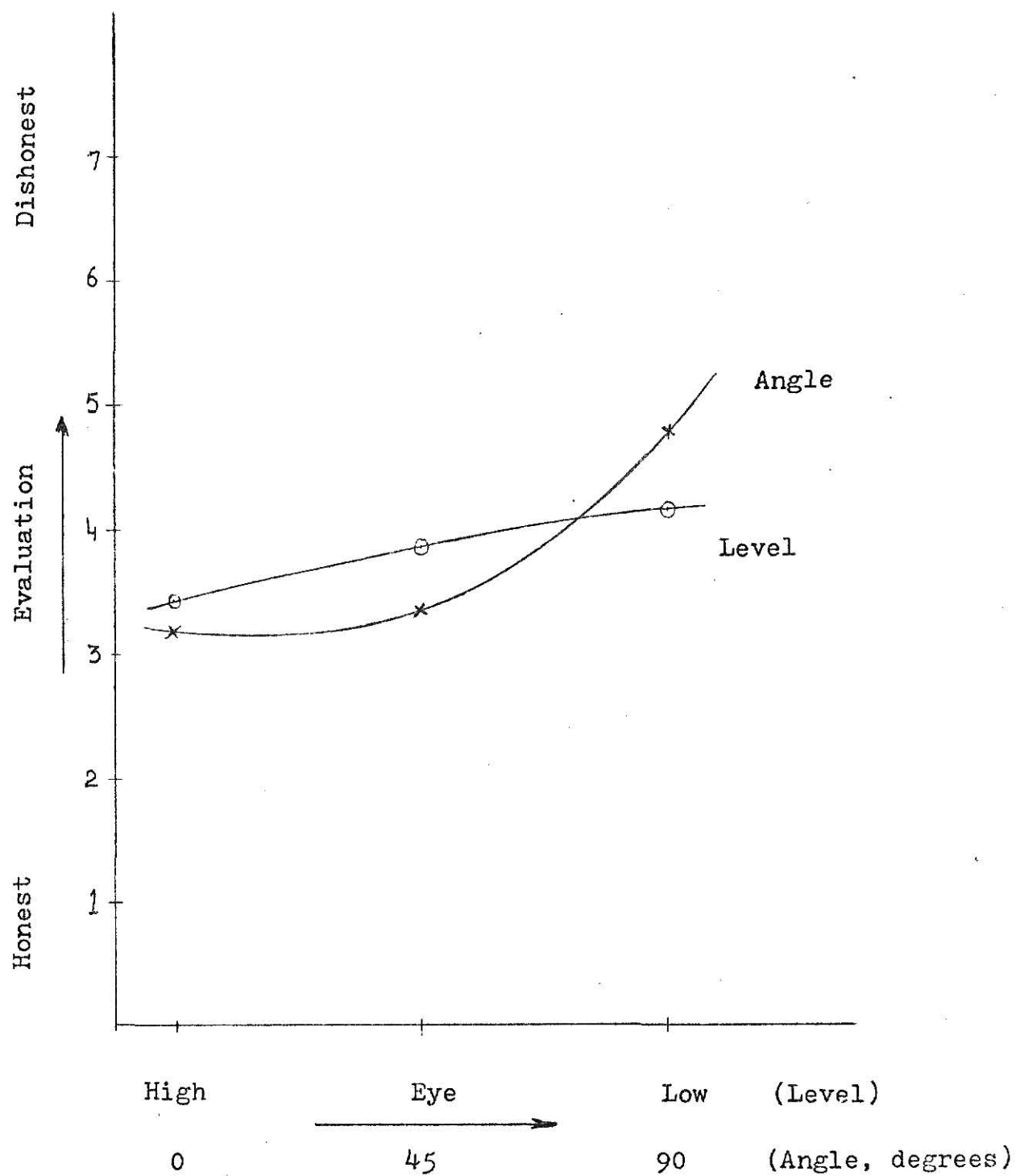


Figure 10. Mean evaluation vs. angle and level of illumination.

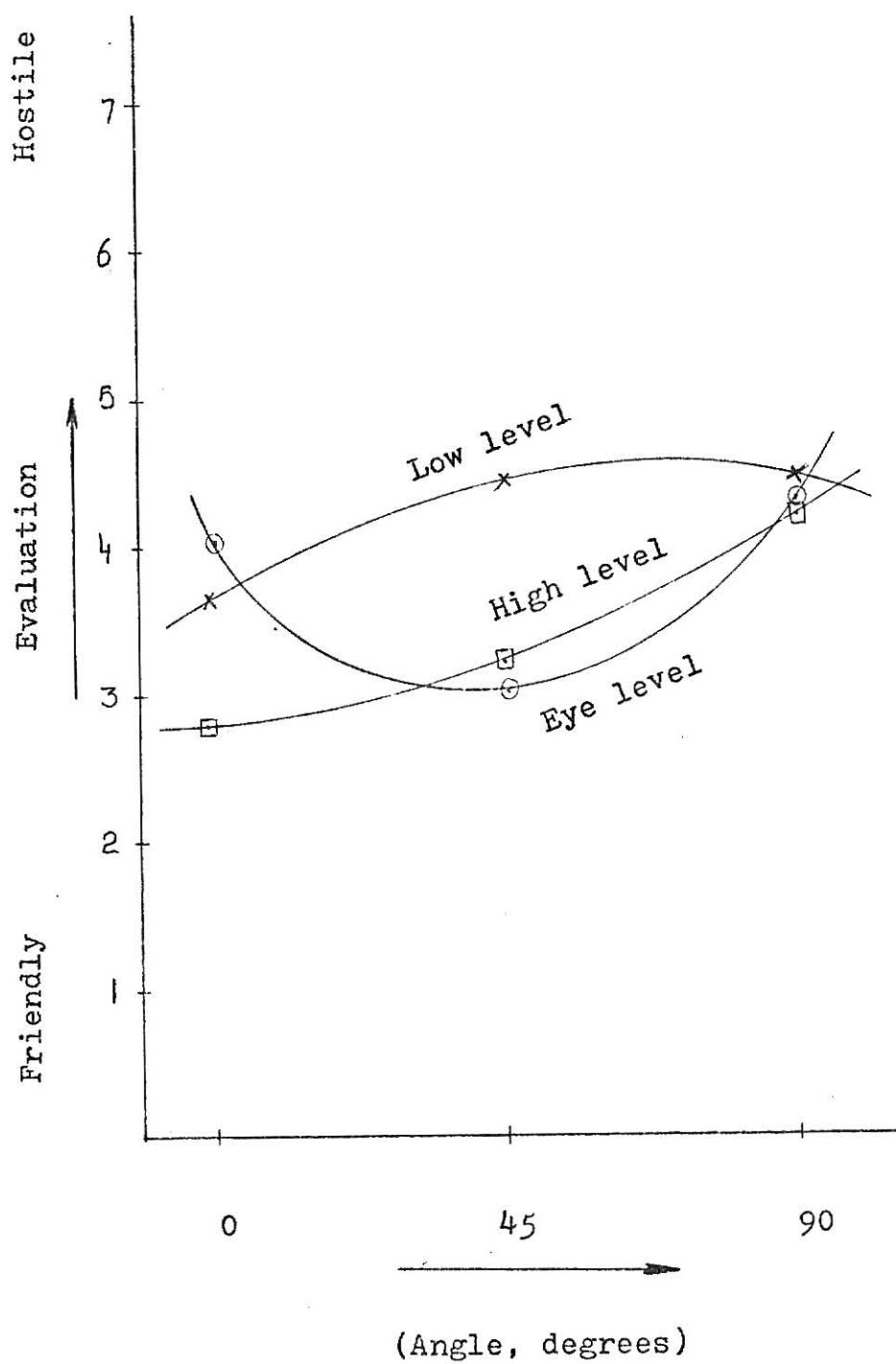


Figure 11. Mean evaluation vs. angle at the three levels of illumination.

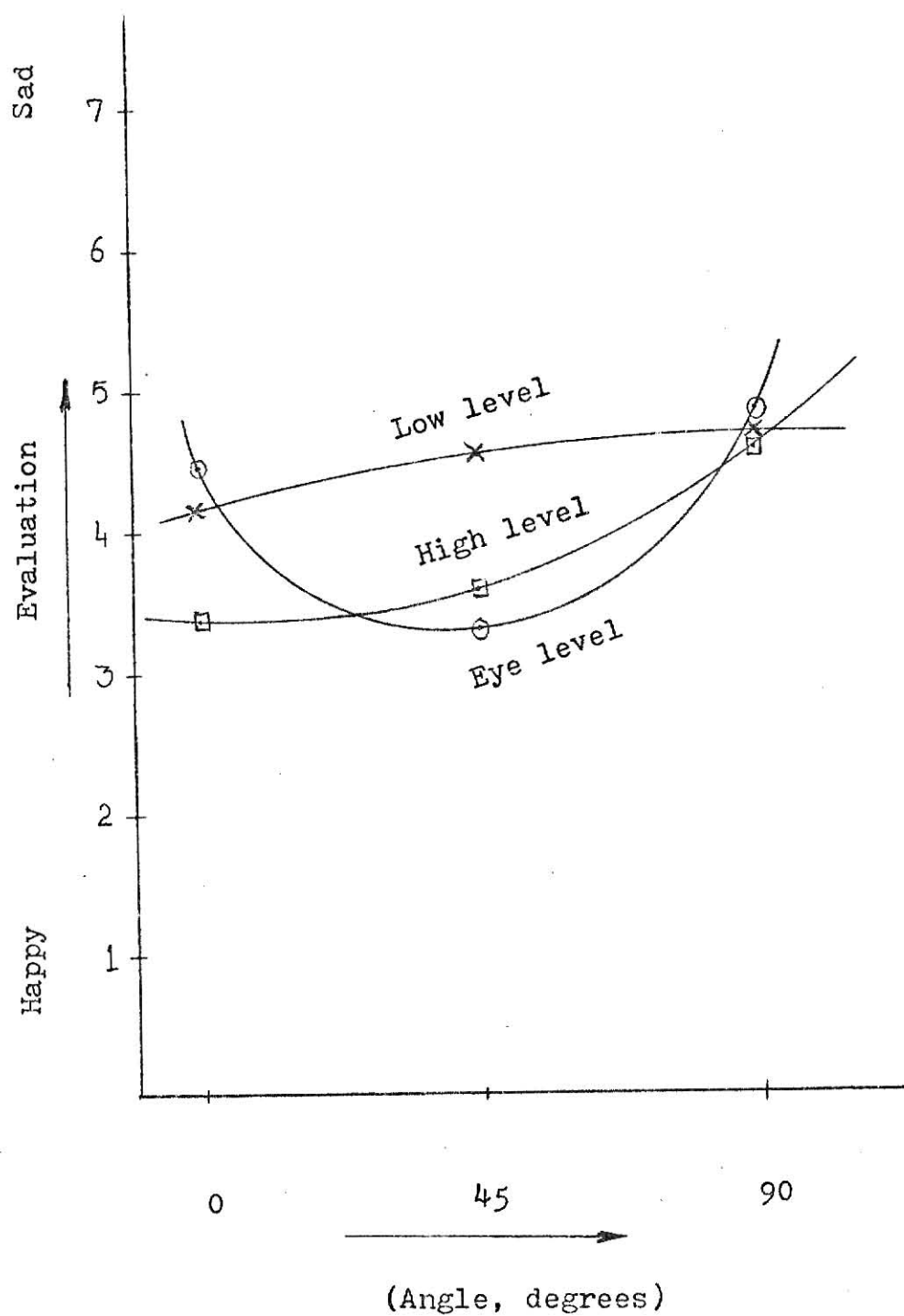


Figure 12. Mean evaluation vs. angle at the three levels of illumination.

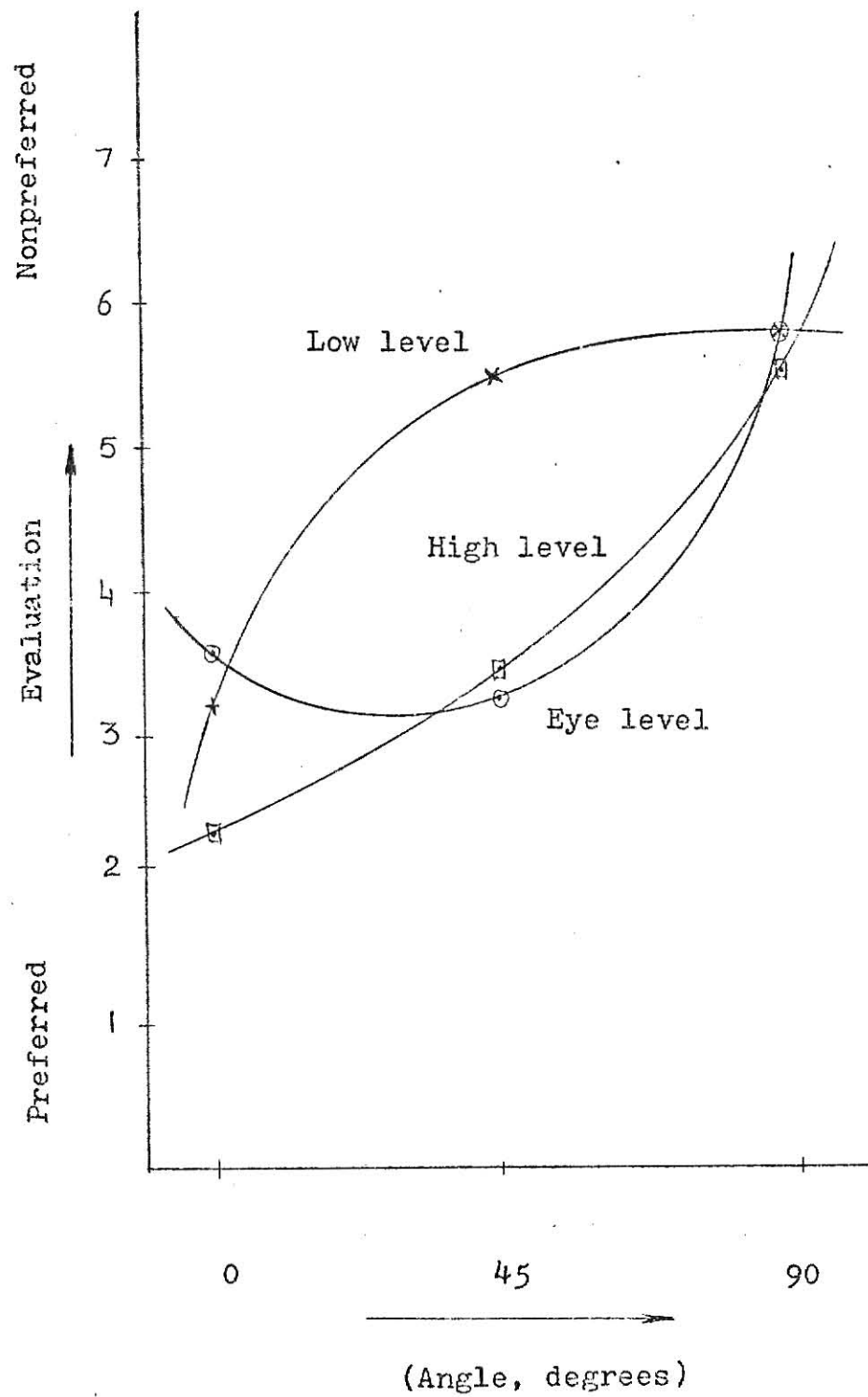


Figure 13. Mean evaluation vs. angle at the three levels of illumination.

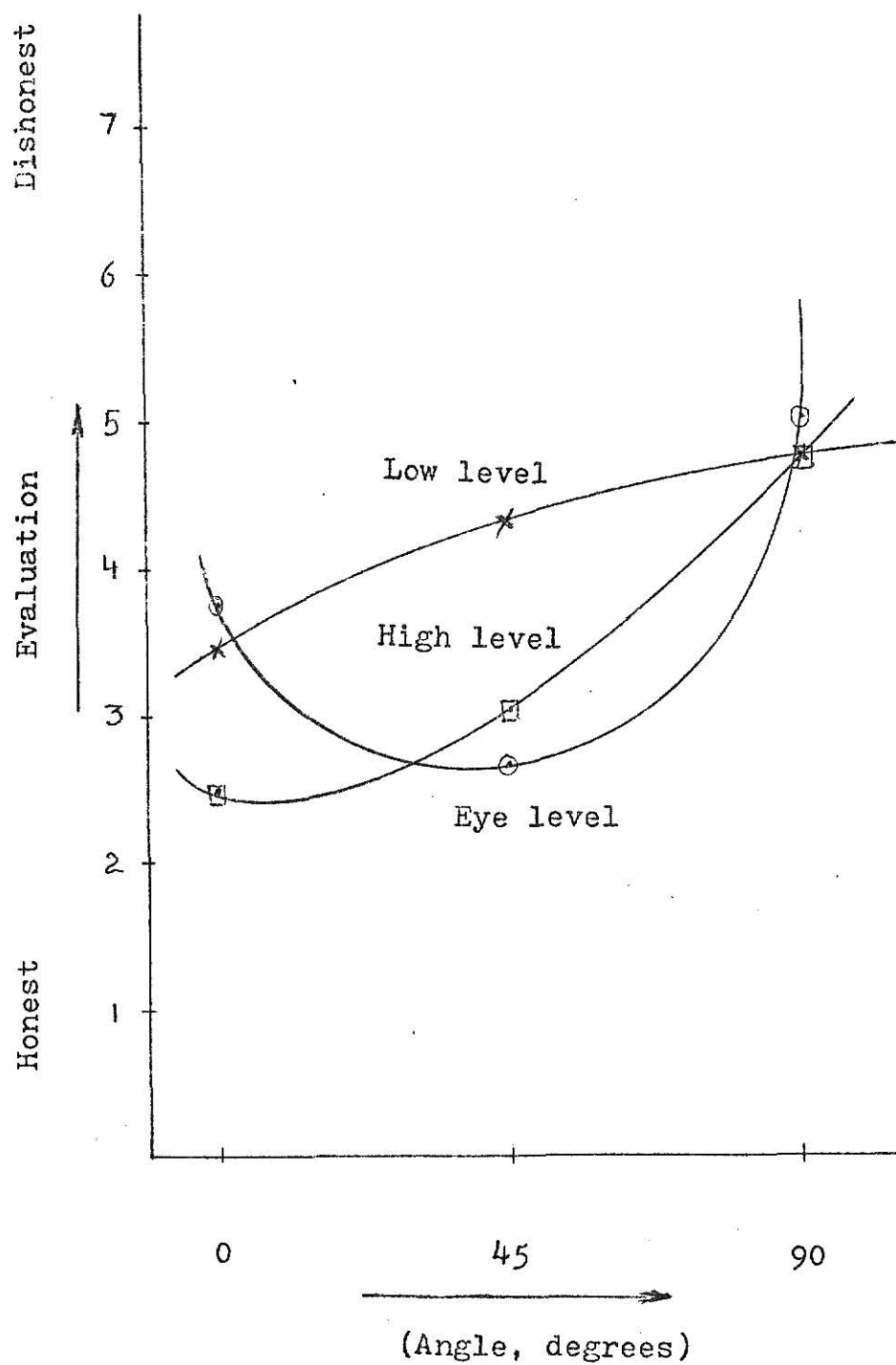


Figure 14. Mean evaluation vs. angle at the three levels of illumination.

TABLE 16. Analysis of variance of intelligibility test error scores.

<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>D.F.</u>	<u>Mean Square</u>	<u>F</u>
Angle (A)	18.34	2	9.17	1.82
Level (L)	6.01	2	3.00	0.59
Sex (S)	13.88	1	13.88	2.75
A x L	2.22	4	0.55	0.11
A x S	10.07	2	5.03	1.00
L x S	1.07	2	0.53	0.10
A x L x S	2.55	4	0.63	0.12
Subject (P)	90.66	18	5.03	
Error	233.93	144	1.62	
Total	378.77	179		

DISCUSSION

Subjective Reactions

Analysis of variance, in this research, was performed separately for each of the poor judgments at a confidence level of 95% ($\alpha = 0.05$). Results are shown in Tables 8, 9, 10, and 11. These results indicate that for all the four judgments, angle of illumination, level of illumination and sex of the models and subjects are significantly different. Also the interaction between illumination angle and level of illumination is significant for all the four judgments. The means of subjective judgments were plotted against illumination angles and levels of illumination (Figures 7, 8, 9 and 10).

Results of analysis of Tukey's (HSD) test, at $\alpha = 0.05$, are shown in Tables 12, 13, 14 and 15 for the four different scales. The means of subjective judgments were plotted against the interactions between angle and level of illumination (Figures 11, 12, 13 and 14). The four curves for four judgments scales show almost the same trend. Looking at Tables 12, 13, 14 and 15 and the corresponding Figures 7, 8, 9, 10, 11, 12, 13 and 14 several findings are evident.

In all the cases, lighting from 90° to the side is poor. In the hypothesis set before this research, this condition was not expected to give pleasing effects. Fischer's research and Kumar's pilot study also showed that illumination from 90° to the side was poor and gave unpleasing effects. However, Barton, Spivack and Powell rated this lighting condition as satisfactory

as compared to illumination from straight in front.

In general, lighting below eye level is the poorest, lighting at eye level is intermediate and lighting above eye level is judged as good and these results are as expected. The hypothesis set before this research for the preference of level of illumination in order was above eye level, eye level and below eye level. In the research of Barton, Spivack and Powell preference for the illumination level in order was below eye level, above eye level and eye level. However their results were not backed up by statistical analysis.

While lighting from below eye level is generally poor, at 0° it gives an intermediate effect. In Barton, Spivack and Powell's study, lighting from below eye level was judged good at 45° , intermediate at 90° and poor at 0° .

Lighting at eye level ranges from poor to good depending on the angle. Eye level illumination is judged as unpleasant at 90° , intermediate at 0° and pleasant at 45° . Barton, Spivack and Powell's research also showed that for eye level illumination, the most pleasing effects were at 45° . However, eye level illumination in their study was judged as unpleasant at 0° and intermediate at 90° , so there is agreement in the last case.

Lighting above eye level is good at 0° , intermediate to good at 45° and intermediate at 90° . Barton, Spivack and Powell's study, however, showed that the most pleasing effect for above eye level illumination was at 90° , intermediate at 45° and poor

at 0° . These results are just opposite to the percent study's results. Fischer stated that above eye level illumination was judged most pleasing at 0° and was not preferred at 90° .

No combination with level made 90° lighting satisfactory except the above eye level illumination. In Barton, Spivack and Powell's study this combination was judged also to give most pleasing effect. Whereas other two levels at 90° were judged to give intermediate effects. In Fischer's study the least preferred combination was above eye level at 90° and Kumar's pilot study also indicated that eye level illumination at 90° was poor.

While with an exception of combination of 45° angle and below eye level illumination, other 45° angle and level combinations are judged good. This also supports the hypothesis that it was expected that the 45° angle would generally be preferred over the other two and illumination level in order of preference would be above eye level, eye level and below eye level. In Barton, Spivack and Powell's research, however, the angle of 45° was judged good to satisfactory for all the three levels of illumination. The levels in order of preference were below eye level, eye level, and above eye level. In Kumar's pilot study, eye level illumination at 45° was ranked as good.

Combination of 0° and above eye level illumination is always judged to give pleasing effects. Where as the other two levels at 0° are judged as satisfactory and the order of preference for the two is below eye level and eye level. Barton,

Spivack and Powell's research indicated that no level made 0° lighting satisfactory. However, Fischer's research stated that combination of above eye level at 0° was most pleasing. Kumar's pilot study also indicated that eye level illumination at 0° gave a satisfactory effect.

Table 17 shows, in tabular form, the results of various studies on angle and level of illumination combinations on pleasantness. The research indicates significant differences between sexes for both the models and subjects. This was attributed basically due to the change in expressions on the face of the models. As commented by most of the subjects, females looked more pleasing irrespective of the angle and level of illumination. Some subjects commented that preference for female photographs was natural. However, there was no significant difference between the interactions of sex with angles and levels of illumination. This essentially indicates that illumination angles and levels have the same pleasing and unpleasing effects for both males and females. This is in contrast to Kumar's pilot study and Barton, Spivack and Powell's research that there was an indication of difference in opinions for positions on the basis of sex. It is frequently observed that when ever illumination is needed at someplace an entire area is merely blanketed with a monolevel of illumination from overhead sources. Though the amount of illumination may be sufficient, but it may not give pleasing effects. The primary objective should be to provide each individual with the blend of light

source most suitable for his needs. That is why in restaurants, for example, to create atmosphere or mood at particular places, local lighting arrangements are used instead of diffuse light from overhead sources. The present study would help the designer in the setting up of such local lighting arrangements at various places.

Speech Intelligibility

Mean intelligibility error scores in Table 5 indicate that the minimum number of errors were at 45° for eye level illumination. In the hypothesis it was expected to be for above eye level illumination at 45° . Statistically, however, there were no significant differences found between the variables in intelligibility tests. The research by Sumby and Pollack and Neely's study did indicate that speech intelligibility is increased by vision. Kumar's pilot study showed a significant difference between the sex of the subjects. Female subjects did better than males. Kumar concluded that as all the subjects were good friends of the speaker, females tried to do their best due to psychological reasons. It was earlier planned to have at least 2-4 speakers for the intelligibility tests but the idea was dropped due to some practical implications.

In the present research, though, the direction of illumination was changed. Subjects could view the speaker's face and lip movements at all the testing portions. Apparently, that is why this study does not show any significant effects in the

results of intelligibility error scores at various testing conditions. So it can be stated that main consideration should be given to subjective evaluation reactions in designing illuminating conditions with present dimensions.

Further Studies

Table 17 shows the results of studies on the effect of angle and level combinations on pleasantness. It is clear from the table that more research is needed for some angle and level combinations because of inconsistencies or lack of research in various studies, especially for above eye level illumination at 0° and 90° and below eye level illumination at 45° .

Further research in this field of study could also be carried out using fluorescent lamps as source of illumination with various combinations of both horizontal and vertical angles. A large number of models for photographs would also be suitable with one important factor to be considered while taking the photographs is that the same expressions of all the models. For example, a very little smile on face or frown or sneer would at once put the same photograph in extreme category, irrespective of illumination condition. It would also be appropriate to increase the number of speakers in the intelligibility tests.

TABLE 17. Results of studies on the effect of angle and level combinations on pleasantness.

Levels		Angle		
		0°	45°	90°
Above eye level	Present Study	Good	Good	Satisfactory
	Present Hypothesis	Satisfactory	Good	Satisfactory
	Kumar's Pilot Study	Not Tested	Not Tested	Not Tested
	Barton, Spivack and Powell's Study	Poor	Satisfactory	Good
	Fischer's Study	Good	Not Stated	Poor
Eye level	Present Study	Satisfactory	Good	Poor
	Present Hypothesis	Poor	Satisfactory	Poor
	Kumar's Pilot Study	Satisfactory	Good	Poor
	Barton, Spivack and Powell's Study	Poor	Good	Satisfactory
	Fischer's Study	Not Stated	Not Stated	Not Stated
Below eye level	Present Study	Satisfactory	Poor	Poor
	Present Hypothesis	Poor	Poor	Poor
	Kumar's Pilot Study	Not Tested	Not Tested	Not Tested
	Barton, Spivack and Powell's Study	Poor	Good	Satisfactory
	Fischer's Study	Not Stated	Not Stated	Not Stated

CONCLUSION

The following conclusions can be drawn from the present research work:

1. Above eye level illumination is pleasing at 0° and 45° and satisfactory at 90° .
2. Eye level illumination is best at 45° , satisfactory at 0° and poor at 90° .
3. Below eye level illumination is satisfactory at 0° but displeasing at 45° and 90° .
4. Illumination from straight in front (0°) gives pleasing effects for above eye level illumination and is satisfactory for other two levels.
5. Illumination from the side (45°) is pleasing at eye level and above but unpleasing below eye level.
6. Illumination from extreme side (90°) is satisfactory above eye level illumination but unpleasing for other two levels.
7. Listener's intelligibility in the speech intelligibility does not change when speaker and listener sat face to face at a distance of six feet (with a background noise of 85 dB(A)) and illumination on speakers face was from nine directions.

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APPENDIX

TABLE A1. Subjects evaluation for photographs on seven point scale with extremes "Friendly" (1) vs. "Hostile" (7) for male model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	5	4	4	5	5	7	6	6	7
	2	7	4	6	6	5	7	4	7	7
	3	7	6	5	6	4	5	4	4	7
	4	4	4	2	5	7	7	4	6	7
	5	6	6	6	4	4	5	4	7	3
	6	7	6	7	7	3	6	2	4	5
	7	5	6	5	4	2	4	4	2	2
	8	5	6	5	7	4	6	4	5	5
	9	4	6	7	5	6	7	3	7	6
	10	3	4	5	5	6	7	5	6	7
Male	11	7	5	4	3	2	5	1	2	7
	12	5	3	4	3	4	6	5	5	6
	13	6	6	6	6	7	7	3	7	6
	14	5	5	5	5	6	7	4	5	6
	15	3	3	3	3	2	3	1	2	2
	16	5	6	6	4	3	7	1	2	7
	17	5	5	5	3	2	6	1	3	7
	18	7	3	6	5	5	4	5	7	6
	19	4	5	5	6	7	7	5	6	7
	20	7	7	7	4	4	7	1	2	6

TABLE A2. Subjects evaluation for photographs on seven point scale with extremes "Friendly" (1) vs. "Hostile" (7) for male model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	5	5	4	2	1	3	3	5	3
	2	7	4	6	4	5	6	3	7	2
	3	5	4	4	3	1	5	4	5	2
	4	4	5	5	4	2	7	3	7	4
	5	6	6	6	3	2	4	7	1	3
	6	6	5	7	4	3	6	5	3	3
	7	4	5	5	3	3	3	1	1	1
	8	5	6	5	5	4	5	4	4	4
	9	5	5	7	4	1	2	6	4	4
	10	4	3	6	4	5	6	6	4	4
Male	11	2	7	6	3	2	4	1	6	4
	12	4	5	4	3	3	5	3	5	2
	13	5	6	5	5	4	5	5	5	4
	14	4	5	4	4	4	4	5	4	4
	15	2	3	3	2	1	2	2	2	2
	16	6	6	5	1	2	7	3	7	4
	17	5	5	5	2	4	4	1	7	6
	18	3	4	4	3	4	2	4	5	6
	19	5	4	4	5	1	7	2	6	3
	20	6	7	6	2	1	5	1	5	3

TABLE A3. Subjects evaluation for photographs on seven point scale with extremes "Friendly" (1) vs. "Hostile" (7) for female model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	2	3	4	5	4	5	1	6	1
	2	5	5	5	3	3	4	1	6	1
	3	4	4	4	1	5	6	2	7	3
	4	3	6	5	6	2	3	1	2	2
	5	5	3	5	2	1	2	4	1	2
	6	6	5	7	2	2	4	1	2	1
	7	6	4	6	1	1	3	1	1	1
	8	5	5	5	5	4	4	4	2	2
	9	5	3	5	3	5	3	2	1	2
	10	2	3	2	4	5	4	4	5	3
Male	11	5	7	6	1	2	4	1	5	1
	12	3	4	5	2	2	4	2	6	1
	13	6	3	5	2	4	5	2	3	2
	14	4	3	3	2	2	4	4	3	3
	15	2	2	2	1	2	2	1	1	1
	16	4	5	6	2	5	7	1	7	3
	17	4	4	5	3	3	4	1	7	4
	18	5	4	3	3	3	3	2	2	3
	19	2	2	4	3	5	4	1	6	6
	20	4	5	5	3	2	6	1	6	2

TABLE A4. Subjects evaluation for photographs on seven point scale with extremes "Friendly" (1) vs. "Hostile" (7) for female model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	3	2	2	3	2	4	2	2	3
	2	2	4	2	4	2	3	4	4	3
	3	2	3	1	2	2	3	3	3	5
	4	3	3	1	2	3	3	5	6	6
	5	2	3	2	2	4	3	6	5	3
	6	4	6	3	3	1	4	1	1	2
	7	3	3	5	3	1	2	1	2	2
	8	2	3	2	1	1	3	3	2	1
	9	4	4	2	1	3	2	2	3	1
	10	1	1	1	2	1	1	3	5	2
Male	11	6	3	3	3	2	3	2	2	3
	12	2	4	4	3	2	3	2	3	3
	13	1	3	4	2	3	3	3	4	2
	14	3	3	3	3	2	2	3	4	2
	15	1	2	1	1	1	1	1	1	1
	16	6	4	6	2	1	7	3	5	7
	17	4	4	5	3	2	4	1	1	6
	18	2	2	3	1	1	3	2	4	3
	19	2	4	1	1	3	5	3	3	3
	20	5	4	6	2	3	6	1	3	5

TABLE B1. Subjects evaluation for photographs on seven point scale with extremes "Happy" (1) vs. "Sad" (7) for male model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	6	7	7	6	4	6	5	5	6
	2	7	7	7	4	4	6	4	4	4
	3	7	6	6	4	3	5	1	2	5
	4	5	5	4	3	7	7	5	7	6
	5	4	7	7	7	7	7	5	7	7
	6	7	7	7	5	6	6	6	6	5
	7	5	5	6	7	6	7	2	5	6
	8	7	7	7	5	5	6	4	6	6
	9	7	7	7	5	4	4	1	2	3
	10	6	6	7	4	5	5	5	7	6
Male	11	7	5	7	2	5	5	1	4	7
	12	5	6	7	6	5	7	6	7	7
	13	5	6	6	6	5	7	5	5	5
	14	5	5	6	6	6	6	4	4	6
	15	5	4	4	4	4	4	4	5	5
	16	6	7	7	3	2	5	1	4	5
	17	6	5	5	4	4	6	1	6	7
	18	7	5	7	5	4	6	4	6	7
	19	4	7	7	5	4	7	3	7	6
	20	7	7	7	3	4	6	1	3	5

TABLE B2. Subjects evaluation for photographs on seven point scale with extremes "Happy" (1) vs. "Sad" (7) for male model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	7	7	4	3	3	6	6	5	5
	2	6	7	6	5	2	5	7	6	5
	3	6	7	4	1	2	6	3	7	5
	4	4	6	7	6	3	7	7	6	6
	5	5	3	4	6	3	4	2	3	5
	6	6	7	5	6	3	4	5	2	5
	7	5	6	5	7	7	7	5	6	5
	8	5	5	6	5	5	5	6	4	4
	9	6	7	6	3	5	4	2	3	2
	10	4	4	3	3	4	3	4	3	6
Male	11	4	3	5	3	2	3	1	4	6
	12	5	6	5	5	4	5	5	6	5
	13	4	3	4	4	3	5	5	5	5
	14	5	5	5	4	4	5	5	4	4
	15	4	5	4	4	4	4	4	4	4
	16	5	6	7	4	2	5	1	6	3
	17	5	4	4	3	4	6	2	7	3
	18	4	4	4	3	3	5	6	2	6
	19	6	5	4	3	5	6	3	6	6
	20	4	5	5	3	2	4	1	6	3

TABLE B3. Subjects evaluation for photographs on seven point scale with extremes "Happy" (1) vs. "Sad" (7) for female model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	3	5	6	3	4	4	1	6	2
	2	3	3	3	2	6	7	4	7	1
	3	7	4	6	2	2	3	3	3	1
	4	3	5	4	2	2	4	2	2	2
	5	2	2	2	3	1	1	5	3	2
	6	6	4	4	1	2	4	2	2	3
	7	3	7	3	7	2	7	7	2	7
	8	5	4	4	4	5	4	4	4	4
	9	7	6	6	3	1	4	1	1	1
	10	2	5	3	5	4	3	5	5	3
Male	11	1	5	6	1	2	4	2	3	2
	12	4	4	5	3	4	4	2	6	2
	13	3	3	5	2	3	5	4	4	2
	14	3	4	4	2	3	4	4	4	2
	15	4	4	4	3	4	4	3	4	3
	16	7	4	7	3	1	6	1	5	2
	17	4	4	4	2	3	4	1	7	5
	18	5	6	3	2	3	5	6	4	2
	19	4	1	3	2	5	5	1	6	5
	20	4	5	5	2	2	4	1	3	2

TABLE B4. Subjects evaluation for photographs on seven point scale with extremes "Happy" (1) vs. "Sad" (7) for female model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	1	2	2	1	2	2	3	4	5
	2	3	4	4	6	2	3	7	7	3
	3	5	4	5	1	2	6	1	3	4
	4	5	3	3	1	1	4	1	2	3
	5	2	4	2	4	2	3	4	6	2
	6	5	4	4	1	2	3	1	3	3
	7	2	7	3	3	1	2	6	5	7
	8	2	3	3	3	3	3	3	3	2
	9	6	6	6	4	5	3	1	1	2
	10	3	2	1	5	1	1	6	5	3
Male	11	2	3	5	3	3	4	6	6	6
	12	4	4	5	3	3	3	2	4	4
	13	4	1	2	4	2	3	5	5	3
	14	3	3	3	3	2	2	5	4	2
	15	3	3	3	3	4	4	3	4	3
	16	6	6	4	4	1	3	2	7	5
	17	4	5	4	3	2	4	1	2	7
	18	1	1	1	2	2	2	3	3	2
	19	2	4	1	2	1	1	3	3	3
	20	5	4	7	2	2	3	1	2	6

TABLE C1. Subjects evaluation for photographs on seven point scale with extremes "Preferred" (1) vs. "Nonpreferred" (7) for male model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	6	7	7	5	6	7	5	6	7
	2	7	7	4	5	6	6	2	7	3
	3	6	7	7	6	4	7	1	3	4
	4	4	7	4	6	5	6	5	6	5
	5	7	7	7	5	5	5	1	2	2
	6	7	7	7	5	4	6	2	2	4
	7	7	6	7	3	2	5	1	2	4
	8	7	7	7	5	5	6	1	1	1
	9	7	7	7	7	2	6	3	1	2
	10	3	5	7	6	4	7	5	7	7
Male	11	6	6	7	3	3	6	1	2	5
	12	6	5	7	4	6	6	5	7	7
	13	7	6	7	3	5	7	2	3	5
	14	7	7	7	6	5	6	2	3	4
	15	5	6	4	3	5	7	2	1	2
	16	4	7	7	3	2	5	1	3	6
	17	7	5	7	4	4	6	1	2	7
	18	6	7	7	4	3	5	2	2	2
	19	5	7	6	5	3	6	1	4	7
	20	7	6	7	4	3	7	2	1	5

TABLE C2. Subjects evaluation for photographs on seven point scale with extremes "Preferred" (1) vs. "Nonpreferred" (7) for male model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	3	5	4	4	1	6	1	2	2
	2	6	5	4	4	3	7	3	1	3
	3	5	7	5	1	3	6	1	2	3
	4	7	7	7	4	5	7	3	6	6
	5	6	7	6	4	5	4	2	3	1
	6	5	7	6	4	3	5	1	2	2
	7	6	7	5	3	4	4	1	1	1
	8	5	6	6	2	4	7	1	3	1
	9	7	7	7	5	4	7	3	6	4
	10	4	3	3	5	4	5	7	6	6
Male	11	6	7	5	1	3	6	2	4	2
	12	7	5	5	4	3	5	4	6	4
	13	7	6	6	4	2	6	3	4	3
	14	7	7	6	4	4	6	1	4	2
	15	4	6	5	3	3	7	2	2	3
	16	6	7	3	2	1	5	1	4	3
	17	7	6	5	4	4	5	1	7	5
	18	6	7	6	4	3	4	1	1	2
	19	6	7	5	4	3	6	1	3	2
	20	5	7	6	4	3	6	1	6	5

TABLE C3. Subjects evaluation for photographs on seven point scale with extremes "Preferred" (1) vs. "Nonpreferred" (7) for female model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	3	4	5	1	5	5	1	7	2
	2	5	6	7	2	4	5	1	6	1
	3	4	4	5	2	2	7	1	5	3
	4	3	4	5	2	2	3	4	1	2
	5	6	7	6	4	2	3	1	3	1
	6	6	7	6	4	3	5	1	3	2
	7	6	5	7	2	2	4	1	1	1
	8	5	6	7	3	2	7	1	1	1
	9	7	7	7	3	2	6	1	4	1
	10	2	3	3	4	5	3	7	4	4
Male	11	3	7	7	1	2	6	1	4	2
	12	5	3	7	2	3	4	2	7	1
	13	5	5	7	1	1	6	2	4	1
	14	7	7	7	3	4	6	1	4	2
	15	3	5	6	2	4	7	1	3	2
	16	5	4	7	3	3	7	1	6	2
	17	6	5	7	1	3	5	1	7	5
	18	6	7	7	3	2	5	1	1	1
	19	6	4	5	5	3	6	1	7	2
	20	6	7	7	2	2	6	1	7	4

TABLE C4. Subjects evaluation for photographs on seven point scale with extremes "Preferred" (1) vs. "Nonpreferred" (7) for female model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	2	3	3	1	2	2	3	4	4
	2	4	6	4	5	3	4	3	2	2
	3	5	6	6	3	4	7	2	1	3
	4	3	1	1	1	1	3	2	2	2
	5	7	6	6	4	4	5	2	2	3
	6	6	5	7	4	3	5	1	1	3
	7	7	6	7	3	2	4	1	2	1
	8	5	4	6	4	2	7	1	1	1
	9	7	7	7	5	4	6	3	2	1
	10	2	2	1	1	3	1	3	5	2
Male	11	6	5	6	5	3	6	2	2	4
	12	4	4	4	2	1	2	3	3	2
	13	6	5	7	3	4	5	1	2	4
	14	7	6	6	5	4	6	1	3	4
	15	6	5	5	3	3	7	2	2	3
	16	4	6	7	2	1	5	2	3	5
	17	5	6	5	5	3	5	1	2	7
	18	7	5	6	4	3	5	2	2	1
	19	7	7	3	4	5	6	1	2	4
	20	7	5	5	3	2	4	1	3	7

TABLE D1. Subjects evaluation for photographs on seven point scale with extremes "Honest" (1) vs. "Dishonest" (7) for male model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	7	7	6	6	6	6	5	7	7
	2	7	4	4	7	5	5	3	4	6
	3	6	5	5	5	3	4	2	4	7
	4	7	7	6	3	2	2	2	3	2
	5	7	7	5	4	1	7	1	5	7
	6	4	7	7	6	6	7	2	5	6
	7	7	5	5	4	5	4	6	4	4
	8	6	6	6	5	5	6	5	5	5
	9	7	6	7	3	2	6	1	1	3
	10	5	7	6	5	2	5	4	6	7
Male	11	5	6	6	4	4	5	2	3	7
	12	4	5	5	3	4	6	3	6	7
	13	5	5	4	4	6	3	3	4	5
	14	5	6	7	5	6	7	4	5	7
	15	6	5	6	4	3	4	1	1	3
	16	5	6	6	4	2	5	1	3	7
	17	7	6	7	5	3	6	1	2	7
	18	6	6	7	6	4	6	3	7	7
	19	5	7	7	2	1	6	3	3	6
	20	7	7	7	3	3	6	2	2	6

TABLE D2. Subjects evaluation for photographs on seven point scale with extremes "Honest" (1) vs. "Dishonest" (7) for male model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	5	2	5	1	2	5	1	4	2
	2	4	5	5	3	2	3	1	2	1
	3	3	4	2	1	1	3	3	4	2
	4	7	7	3	1	1	4	3	4	4
	5	4	4	7	2	4	3	1	2	2
	6	7	7	5	3	5	4	2	2	2
	7	5	6	6	3	2	4	2	1	1
	8	5	5	6	4	4	5	5	4	4
	9	5	6	5	2	1	3	4	2	5
	10	6	4	3	4	4	3	3	4	3
Male	11	4	6	2	2	1	6	2	6	2
	12	5	4	5	4	4	5	5	7	2
	13	6	4	5	3	2	4	2	2	3
	14	6	5	5	4	5	4	6	4	5
	15	5	5	4	3	3	5	3	1	3
	16	5	7	5	4	2	6	1	6	3
	17	7	5	6	3	3	5	1	7	2
	18	6	6	2	1	4	5	7	4	2
	19	5	5	4	2	1	2	3	6	3
	20	5	7	5	3	2	3	2	6	2

TABLE D3. Subjects evaluation for photographs on seven point scale with extremes "Honest" (1) vs. "Dishonest" (7) for female model one.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	3	3	4	1	3	4	2	4	1
	2	3	3	4	2	3	6	1	6	1
	3	2	4	2	3	4	5	3	7	3
	4	5	7	7	5	1	2	5	1	2
	5	3	4	4	1	3	5	2	1	1
	6	4	4	5	1	1	3	1	3	1
	7	6	5	5	2	2	4	3	2	3
	8	4	5	5	4	5	5	4	4	4
	9	4	4	4	2	1	3	1	1	4
	10	3	6	7	2	3	3	5	6	2
Male	11	4	6	5	1	1	7	1	7	1
	12	2	4	6	1	2	5	1	7	1
	13	6	6	6	4	3	6	4	5	5
	14	3	4	3	3	2	5	3	2	1
	15	4	4	4	4	4	4	2	4	1
	16	4	5	7	3	3	5	1	6	2
	17	5	4	7	1	3	5	1	5	3
	18	3	7	5	3	5	6	5	4	1
	19	5	4	4	2	1	2	3	3	3
	20	3	4	6	1	2	5	1	6	1

TABLE D4. Subjects evaluation for photographs on seven point scale with extremes "Honest" (1) vs. "Dishonest" (7) for female model two.

		Illumination Angle								
		90°			45°			0°		
		LEVEL								
Sex	Subject	High	Eye	Low	High	Eye	Low	High	Eye	Low
Female	1	1	3	1	2	3	4	2	2	4
	2	3	4	4	5	2	2	1	4	5
	3	4	2	2	3	4	1	2	3	4
	4	7	7	7	1	1	5	3	6	4
	5	4	2	3	2	1	3	2	2	1
	6	5	4	3	3	1	5	2	2	1
	7	5	6	3	4	3	3	2	3	1
	8	4	5	3	3	3	4	3	2	2
	9	3	4	4	3	4	3	1	2	2
	10	3	5	5	5	1	3	1	5	5
Male	11	5	5	3	2	1	5	2	3	6
	12	3	3	3	2	1	3	2	1	4
	13	4	3	4	2	1	2	1	1	3
	14	3	4	2	2	2	2	1	3	3
	15	4	4	2	3	4	4	1	2	1
	16	6	4	7	2	1	5	3	4	6
	17	4	5	4	3	4	4	1	1	5
	18	3	3	2	5	1	5	6	4	4
	19	4	5	6	2	1	2	3	3	3
	20	5	4	4	1	1	2	1	3	4

EFFECT OF DIRECTION OF ILLUMINATION
ON
THE PLEASANTNESS AND INTELLIGIBILITY

by

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ABSTRACT

This report describes research relating direction of illumination, pleasantness and speech intelligibility. The basic purpose of this research was to study how people react subjectively when they view a person under different horizontal and vertical angles of illumination and to study the effect of different horizontal and vertical illumination angles on the speakers intelligibility, during communication.

Subjects rated photographs taken under different horizontal and vertical illumination angles on different scales to measure pleasantness and the number of error scores were the measure of intelligibility.

Results of this study show that above eye level illumination is pleasing at 0° and 45° and satisfactory at 90° . Eye level illumination is best at 45° , satisfactory at 0° and poor at 90° . Below eye level illumination is satisfactory at 0° but displeasing at 45° and 90° .

Illumination from straight in front (0°) gives pleasing effects for above eye level illumination and is satisfactory for other two levels. Illumination from the side (45°) is pleasing at eye level and above but unpleasing below eye level. Illumination from extreme side (90°) is satisfactory, above eye level illumination but unpleasing for other two levels.

Listener's intelligibility in speech intelligibility does not change and the reason for this nonsignificance apparently was due to the fact that the subjects could view the speaker's

face and lip movements clearly at all lighting positions.

Results show some illumination directions giving pleasing effects over others. The results of this study are compared with earlier research work and the comparison show that more research work is needed in certain directions of illumination to have wide understanding in this field.