AN EVALUATION OF VISUALLY EXPANDING LIGHTING TECHNIQUES BY DESIGN AND NON-DESIGN STUDENTS

By

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CHAPTER I

INTRODUCTION

New houses being constructed today are smaller than houses constructed in years past because of increased costs of building materials, labor, and loans (Shelly, 1975; Weale, 1982; Willson, 1982). There is increasingly less land on which to build, compounded with increasing population. This situation lends fertile ground for psychological maladies (Willson, 1982).

Knowing the problems that can exist when people are forced to live in too small a space, interior designers and architects must create ways in which a given space can appear larger and more spacious. Builders must, in turn, realize the importance of including such ideas into their structures, and homeowners must also realize the effect these ideas will have on the overall physical and emotional health of the family the structure will house. The importance must be realized and justified because many of the ideas increase the initial cost of a home which might stall the purchase. Visually expanding spatial features are more easily and economically attained when they are included at the time of construction than when added later. For example, it is much easier and less expensive to install indirect lighting in a home at the time of construction when the wiring is being installed than to add it later.

A given space can appear more spacious through appropriate use of color, line, form, and texture--the elements of design. Light is another element which is important in design because the quantity and quality of light affects the way the other elements are seen by the viewer. This thesis is concerned with ways in which lighting can be used to visually enlarge a given space.

Some architects and designers are building lighting specifically for the purpose of visually enlarging the space (up-lights, down-lights, wall washers, track lighting, etc.) into their plans. Designers can also add to existing residences many types of visually expansive light fixtures which can accomplish similar visual effects as the built-in fixtures.

Before a luminous environment can be constructively designed, the components of a good luminous environment should be identified. According to Lam (1977):

> A good luminous environment helps us to do what we want to do and makes us feel good while we do it. Although it may seem simplistic, this statement summarizes the real objectives of lighting design--to provide a comfortable, pleasant, reassuring, interesting, and functional space for the people who will inhabit it. We are comfortable when we are free to focus our attention on what we want or need to see, when the information we seek is clearly visible and confirms our desires and our expectations, and when the background does not compete for our attention in a distracting way (p. 14).

Lam (1977) continues to state that when these conditions are met, the space is considered to be attractive and has an appropriate focus. People are distracted and made uncomfortable when what they see is irrelevant or confusing. For example, people have certain biological needs for such visual information as orientation: where they are, the shape and structure of the space, the nature and quality of furnishings and finishes, the identity of neighbors, who they are and what they are doing, the time of day, and the weather.

Before anyone can successfully achieve the goal of visually enlarging the space, a basic understanding of just how we see must be internalized. Zekowski (1981, p. 10) stated, "Visual perception demands sensitivity to both the science and the art of lighting. After all, without light we cannot see, and the way we light is the way we see." The eye has many abnormalities of which most people are unaware. Old sayings such as, "The camera never lies," and "Seeing is believing," do not apply when it comes to the human eye. The camera mindlessly records through its single lens what it "sees" onto film. The human eyes are two imperfect collectors of light; the brain interprets these signals before recording them, making individuals vulnerable to illusions and perceptions (Zekowski, 1981). Helms (1980, p. 12) refers to this as "Binocular Vision."

According to Weale (1982):

> The Gestalt school of psychology views perception as a dynamic process in which the whole is greater than the sum of its parts. The configuration of an object is perceived first; the details, later. This concept is of significance to the interior designer (p. 9).

Knowledge of visual perception can show designers how to trick the eye into seeing a space as visually larger than it really is by taking full advantage of space that is there. Application of this knowledge in the right places will help provide a more visually spacious environment at a lower cost than larger housing without these visually enlarging techniques. This will be beneficial for single family dwellings above ground and below ground, duplexes, and multifamily dwellings.

Purpose, Objective, and Hypotheses

The purpose of the study was to conduct a pilot study to explore lighting techniques which can be used to visually expand a given space and to determine which techniques are the most visually expansive. The objective which guided the study was to compare four lighting techniques: conventional (Technique A), conventional plus accent lighting (Technique B), increased wattages of conventional plus track (Technique C), and increased wattages of conventional plus track plus accent lighting (Technique D). This comparison was undertaken to determine which lighting technique was the most visually expanding.

The term "conventional task lighting" applies to lighting techniques that are likely to be found in most homes, table lamps, and floor lamps. In short, conventional task lighting is basic lighting to meet basic needs. Portable accent, non-task oriented lighting includes lighting above pictures, small portable decorative lamps, or any light which accentuates an object or area with no function lighting in mind. Track lighting consists of a number of individual fixtures which can rotate independently and can be moved along a track for complete flexibility of light direction.

Conventional methods were expected to be the least visually expansive technique used in the study; thus, Technique A served as the base against which all other techniques were evaluated. Conventional plus accents, lighting Technique B, was expected to be visually expansive to a very small degree. Increasing the wattages of the conventional lamps and using track, lighting Technique C, was expected to be the next most visually expansive. Using increased wattages of the conventional, plus accents and track, lighting Technique D, was expected to be the most visually expansive technique used in the experiment. This is not to say that it will always be desirable to turn all lights on at all times. Such is not only wasteful but unnecessary. It is the responsibility of designers to know the proper purpose of each type of lighting and use it accordingly. More is not always better in many circumstances, but especially in lighting.

The following hypotheses were tested:

> Hypothesis 1. The design group will evaluate the space differently from the non-design group under each lighting technique.
>
> Hypothesis 2. Lighting Technique C will be more visually expansive than lighting Technique B.
>
> Hypothesis 3. Lighting Technique D will be more visually expansive than lighting Technique B or C.

Definition of Terms

The following terms are defined as they apply to this study:

<u>Accent Light</u>. "Directional light which emphasizes objects or draws attention to a part of the visual field" (Egan, 1983, p. 225).

<u>Biological Needs for Visual Information</u>.

> Unceasing needs for visual information; not related to specific conscious activities, but rather related to the more fundamental aspects of the human relation to the environmebnt: orientation, defense, stimulation, sustenance, and survival (Lam, 1977, p. 7).

<u>Contrast</u>. "The relationship between the luminance of an object or area of interest and that of its immediate background. Mathematically, the difference between the luminances divided by the luminance of the background" (Lam, 1977, p. 7).

Diffusion. "Illumination which results from light coming from many directions, as opposed to light from one direction" (Westinghouse Lighting Handbook, 1964, p. 4).

Direct Lighting. "Lighting provided from a source without reflection from room surfaces" (Lam, 1977, p. 7).

Down-Lights. Lighting which is directed downward, frequently concealed in the ceiling, or attached to it (Weale, 1982).

Footcandle. The English unit of light intensity (Lam, 1977).

Glare. "An interference with visual perception caused by an uncomfortably bright light source or reflection; a form of visual noise" (Lam, 1977, p. 8).

Incandescent Lamp. "A wire sealed in a glass enclosure. Electric current, passing through the wire, heats it to incandescence and the wire emits light" (Nuckolls, 1976, p. 47).

Illumination. "Quantity of light per unit of surface area; the intensity or density of light falling on a surface (English unit: footcandle)" (Lam, 1977, p. 8).

Indirect Lighting. "Lighting provided by reflection, usually from wall and ceiling surfaces" (Lam, 1977, p. 8).

Lamp. "Complete light source unit, usually consisting of light-generating element (arc tube or filament), support hardware, enclosing envelope (bulb), and base" (Egan, 1983, p. 232).

Lumens. "The level of lighting is expressed in lumens per square feet. 1 lumen/ft =1 footcandle (the amount of light given by one candle at a distance of one foot from the point of measurement" (Friedmann, 1976, p. 238).

Luminous Environment. "The way in which the light characteristics of an interior affect the perception of the interior and influence the ability of people to perform work quickly, accurately, and easily in it" (Canter, 1975, pp. 81-82).

Perception. "A meaningful impression obtained through the senses and interpreted in the mind" (Lam, 1977, p. 8).

Recessed Light. Lighting which is placed in the ceiling and covered with louvers or with transparent or translucent panes (Weale, 1982).

Spotlight. Light which is directed at a precise spot to call attention to a center of interest (Weale, 1982).

Task Light. Light which is required for a specific activity (Weale, 1982).

Track Light. Recessed or surface-mounted electrified wireway to which adjustable lamp holders are attached (Weale, 1982).

Up-Lights. Light source which is directed upward (Weale, 1982).

Wall Washer. Lights focused on a wall for general lighting (Weale, 1982).

CHAPTER II

REVIEW OF LITERATURE

In recent history, Americans have chosen to live in the largest homes which they could afford to purchase and maintain. The size of the home was somewhat of a status symbol; the larger the home the more status was achieved. In the 1980's, the average new house is smaller because of increased costs of building materials, labor, and loans (Shelly, 1975; Weale, 1982; Willson, 1982). The population is increasing, therefore, there is less land to go around. The American dream is still for the large, spacious, single family dwelling; however, the expense of the large home coupled with less available time for maintenance by the family has turned the dream into a shrunken reality.

This chapter contains four major sections. The first section contains a discussion of some problems associated with living in confined spaces and the desirability of visually expanding such spaces. The second section deals with the way in which the human eye sees. The third section includes information about lighting for special needs. The fourth section contains information about various lighting techniques that can be used to create the illusion of expanded space and supporting research.

Spatial Needs

The need for adequate space has been documented for both humans and animals (Hall, 1969; Sommer, 1969; Ellenberger, 1971; Myers et al., 1971). Myers et al. (1971) report findings from their experiments with rabbits since it is often easier to do more thorough testing on research animals than on human beings:

> Under this regime, the most detrimental effects were measured in rabbits in the smallest living space, despite the fact that this was accompanied by a decrease in numbers of animals in the group. There were changes in index organs (liver, spleen, kidney), adrenal morphology and zonation, and behavior and reproduction. In the smallest space, rates of sexual and aggressive behavior increase significantly, especially among females, and wounding was higher. There was a fall-off in reproductive capacity in females--lower ovulation rates and smaller numbers of corpora lutea (p. 148).

The authors went on to report:

> There was great improvement of the quality of individual animals in each group as living space increased. Index organs and endocrines all showed the development of harmful effects in individual rabbits when living space was restricted. Sexual and aggressive behavior decreased and reproductive capacity increased with increasing space (p. 148).

The amount of space that a human being needs has not yet been determined, but spatial needs are definitely affected by culture. For example, Hall (1969) states that the Japanese prefer crowding in certain situations. "Japanese style" sleeping is having the entire family on the floor together, while "American style" sleeping is having each child in his or her own bedroom and the parents in their bedroom. Hall describes how people in the Arab world are crowded and overwhelmed with smells and high levels of noise so they appreciate much larger homes by our standards. Hall is stressing the cultural differences in people and how this affects the quantity of space needed by the human being. In other words, what is a basic need in Japan may not be within the basic limits in the Arab world or in the American way of life.

Americans have grown accustomed to a certain amount of space and when this space diminishes over a period of time, symptoms of deprivation may manifest. Just how these symptoms manifest is beyond the scope of this paper, but maladies do exist as a result of inadequate amounts of space (Hall, 1969; Sommer, 1969; Ellenberger, 1971; Myers et al., 1971).

Human Vision

This paper is concerned with combating the potential problems related to limited space by using appropriate lighting techniques. Interior designers and architects have at their disposal four main elements of design--color, line, form, and texture--the elements of design. Light is another element which is important in design because the quantity and quality of light affects the way the other elements are seen by the viewer. Zekowski (1981, p. 10) states, "The way we light is the way we see, and what is seen affects the way one feels about a space."

Zekowski (1981) further states:

> Visual perception demands sensitivity to both the science and the art of lighting. After all, without light we cannot see, and the way we light is the way we see. Lighting is just one of four aspects in the universal concept of visual perception. The four aspects are: function, color, form and light. The mind deals with all four of these aspects in a highly integrated and interlocked way. They are like a mobile; you cannot touch one part without moving all parts (p. 10).

Our eyes are not like cameras taking pictures on a flat piece of paper. Our eyes see what the brain interprets. Zekowski (1981) says it very well when he says:

> These anomalies are the fundamental differences between the camera and the human visual process: the camera has but one 'eye,' its single lens which collects light. It mindlessly records what it 'sees' onto film, with no interpretaton. The human eyes are two imperfect collectors of light and when the brain receives these light signals it interprets them first before it records them. As with all interpreters, the brain sometimes shows its bias (p. 10).

The bias Zekowski (1981) refers to is not only the subjective differences in people, but the psychological factors that affect all of us equally in a predictable manner. An example of a physiological factor Zekowski is referring to is the blind spot all humans have and yet are totally unaware. In other words, the blind spot affects the way objects are seen, but the viewer is unaware of this physiological phenomenon. What is seen is not necessarily the way things really are. Murch (1973) states:

> Man moves through a world of constant external and internal stimulation. Affected by the objects and events of his surroundings, he interprets them in terms of his experience and modifies his behavior accordingly. This constant interaction with the environment and the associated mental process of interpreting the impact and import of external events characterize the process known as perception (pp. 1-2).

Imagine a smooth wall surface with a convex circle. Shine a light from above the convex circle and it looks convex; shine the light from beneath the convex circle and it will look concave. The reason for this is that the interpretation of shape is based on the unconscious assumption that the light is coming from above, the natural direction of sunlight (Lam, 1977).

Aside from becoming aware of the many imperfections of the eye and familiarizing oneself with the way things are perceived, one must also be aware of the basic biological needs to be met by lighting. Lam (1977) states:

> I contend that as human beings we all share certain needs which I will call biological information needs: needs to understand the nature and structure of our immediate environment, needs which are rooted in Darwinian drives for survival and security, needs which transcend the scope of aesthetic squabbles based on personal fancy or on merely cultural distinctions between groups of human beings (p. 5).

Lam (1977) defines biological needs as unceasing requirements for knowledge that are not related to specific conscious activities, but rather related to basic aspects of the human relation to the environment: orientation, defense, stimulation, sustenance, and survival. Some of these are subconscious or subconscious only at times but nonetheless relevant in our daily lives. All are basic to human nature regardless of cultural differences.

Lighting for Special Needs

After meeting a minimal requirement for the basic biological information needs, the designer is ready to deal with such factors as task lighting, mood lighting, accent lighting; and, when the situation warrants it, visually expanding space lighting. Lam (1977, p. 15) put it very well when he said, "different lights for different sites."

This does not necessarily mean just more footcandles to meet these other needs. It is not important to fill every corner of a space with light--Lam (1977, p. 15) calls this the "shot gun approach." He advocates instead a "rifle approach" which directs the right amount of light in the right direction; the "right watts for the right spots" (Lam, 1977, p. 15). Sometimes all that is necessary is the redistribution of the number of watts in a more relevant manner.

Too often in housing plans interior lighting design has suffered because, according to Lam (1977), a good luminous environment was treated as an extravagance. It was treated as "icing on the architectural cake, the last thing to be added and the first thing to be dropped when the budget ran low" (p. 4). This accounts for the poor lighting in most homes.

Lam (1977) goes on to say:

> At the very heart of the approach to the design of the luminous environment which is outlined in this book lies the belief that as human beings we evaluate an environment according to how well that environment is structured, organized, and illuminated to satisfy all of our needs for visual information. These needs derive from both the activities in which we choose to engage and the biological information needs related to the very essentials of human nature which are always present regardless of the specific activity which holds our attention at any one time (p. 5).

Lam (1977) states that the brain analyzes and perceives the entire visual field, and not its individual aspects; therefore, to measure the light in footcandles is irrelevant. Four main factors are needed for adequate vision to take place: (1) adequate contrast in the lighting, (2) glare-free lighting, (3) adequate time to perceive, and (4) adequate amount of light. The lack of any of these factors results in a loss of visual perception. An example of this would be in a room with adequate footcandles (according to the standards set by the Illuminating Engineering Society) and still one would be unable to see a person sitting across the room or to read the daily newspaper if glare exists as a result of a poorly selected light fixture. The simple addition of more footcandles will not solve the problem, but the redistribution of the existing footcandles would help. Perhaps the addition of a baffle on the fixture or a different fixture entirely would be in order.

The point to be made, however, is that the amount of light is not as important as the quality; it is the quality, not the quantity which matters in lighting. Lam (1977) put it this way:

> There is no simple one-to-one relationship between measured luminance levels and the apparent brightness of objects as they are perceived by the viewer. Similarly, one cannot derive any simple quantitative formula to predict either the meaning which will be given to a particular stimulus or the emotional and evaluative responses which it will trigger. People perceive information and visual relationships, not absolute intensity levels of light. The final impression which will be lodged in the brain is principally determined by whether the stimulus is meaningful or meaningless, clear or ambiguous, relevant or irrelevant, expected or unexpected. These are the real questions which must be decided in the course of lighting design (p. 70).

Gestalt philosophy is another way of expressing the occurrence of perceiving the entire visual field before its individual aspects. Lam (1977, p. 8) states the definition of Gestalt philosophy this way: "An environment, situation, group of objects, or combination of these elements which is perceived as an integrated whole rather than as an assemblage of unrelated parts."

Weale (1982) explains the Gestalt school of psychology this way:

> The Gestalt school of psychology views perception as a dynamic process in which the whole is greater than the sum of its parts. The configuration of an object is perceived first; the details, later. This concept is of significance to the interior designer (p. 9).

This is to say that an entire room is perceived as being generally inviting or uninviting; spacious or cramped, before an element can be identified as the reason for the particular perception. This is the Gestalt philosophy in practice.

Lighting can significantly influence the way in which the whole is perceived. There are few objects in the universe that produce or radiate light. These few are very important to us as living and learning beings: the sun, incandescent light sources, and gasses in fluorescent tubes. Most things, however, do not emit light, but reflect light from these sources. Thus, as Haber and Hershenson (1980, p. 4) put it, "The characteristics of light that reach our eyes are functions of the characteristics both of the sources of light and of the surfaces of objects that reflect it."

Lighting specialists seem to agree that it is up to the architects and interior designers to maximize the effects of available light sources. This requires a great deal of reading, years of practicing and experimenting, and being open minded to new ideas and new products on the market.

Lighting to Visually Expand Space

Many methods exist for using lighting to visually expand space. Accent lights are one approach that can be used. According to Flynn and Segil (1970):

> The eye is involuntarily drawn to bright objects or to areas that contrast with the general background. Use of this technique can be effective in situations where it is desirable to direct the observer's attention and interest to predetermined detail, while subordinating other items, areas, or surfaces (pp. 10-11).

Too many accent lights and a room can create visual clutter. Flynn and Segil (1970) state:

> The lighting design should generally be such that meaningless or confusing spatial cues are minimized.
>
> Clutter in the visual field is analogous to noise in a sonic evaluation. This is a particularly significant factor when intense visual effort is required. Above certain levels of information input (which vary with the individual's concentration at a given point in time), visual performance appears to decrease in proportion to the increase in random visual cues that the mind must assimilate and process. These reductons in visual performance often reflect an increase in search time. For this reason, when intensive vigilance or complex tasks are involved (such as those involving safety, high performance in spatial comprehension, or complex work tasks), the visual field should be simplified by minimizing irrelevant or meaningless cues. Spotlighting, luminaire patterns, wall lighting, etc., should, in these situations, be developed to simplify the process of orientation and spatial definition (p 13).

Egan (1983) states that when spaciousness is a desired subjective impression, brightness of light can be used as a reinforcement for this desired perception. He goes on to state that wall washing and accent lights contribute to the overall feelings of spaciousness. Washing a wall with light can be achieved by the use of track lighting mounted on the ceiling. The track lighting can be used to wash a wall with light. Shemitz (1982) points out:

> A wall is a termination of space. However, by making it brighter than the floor or ceiling, it is possible to extend that space visually. If the wall is reflective (light in color) when properly illuminated, it can diffuse and redirect light back into the space. Like the ceiling, it too can provide flattering fill light (p. 225).

Zekowski (1981) also feels that an even wall wash is the more perfect wash, evenly lit from top to bottom and side to side for certain purposes like creating an illusion that the wall is further away. He feels that an uneven wash is more dramatic.

Flynn et al. (1973) found that making the wall(s) brighter than the floor and ceiling gives a greater feeling of spaciousness than when the wall(s) are more subdued. Their study consisted of six different lighting techniques viewed by 96 people who judged the techniques on five factors, spaciousness being one of the factors. Flynn et al. state:

> . . . we find indications that there is considerable selectivity in the process of visual experience--a search for meaningful information. This suggests that light can be discussed as a vehicle that facilitates the selective process and alters the information content of the visual field. It further suggests that lighting design should be evaluated, in part, for its role in adequately establishing cues that facilitate or alter the user's understanding of his environment and the activities around him (p. 87).

Flynn et al. (1973) discovered through their tests that lighting variables do bring out some consistent and apparently shared feelings for the viewers. They also discovered that, "The limited wall lighting also improved 'perceptual clarity' somewhat, and significanty affected the impression of 'spaciousness'" (p. 90). They also state, ". . . higher brightness levels tended to produce an impression of increased 'spaciousness'" (p. 89).

It is believed by the researcher that students trained through coursework in art, architecture, and interior design will see things differently as a result of that training. The more a person observes certain things, like interior environments, the more that is really seen and absorbed in a new experience. A prepared observer will see details not seen by the unprepared observer. Zekowski (1983) reports on the advantages of being prepared in the design field:

> The concept is universal. It applies to biology, football--and equally to lighting education. . . . These

> lessons could have been learned and errors avoided if critical observation of lighting environments had been used for self-study. Observation is skill; a trained reaction of the education mind. People often 'see' but they don't 'observe' (pp. 28-29).

Summary

As American homes decrease in size it becomes more important to maximize the available space. Lighting is one way to utilize the potential of available space in these smaller homes. Lighting techniques that have the potential of visually expanding spaces include conventional lighting, accent lighting, and track lighting in selected applications. Research findings indicate that higher brightness levels tend to produce an impression of increased spaciousness. There is a need for further research in evaluating various lighting techniques and the perception of space by design trained verses non-design trained viewers.

CHAPTER III

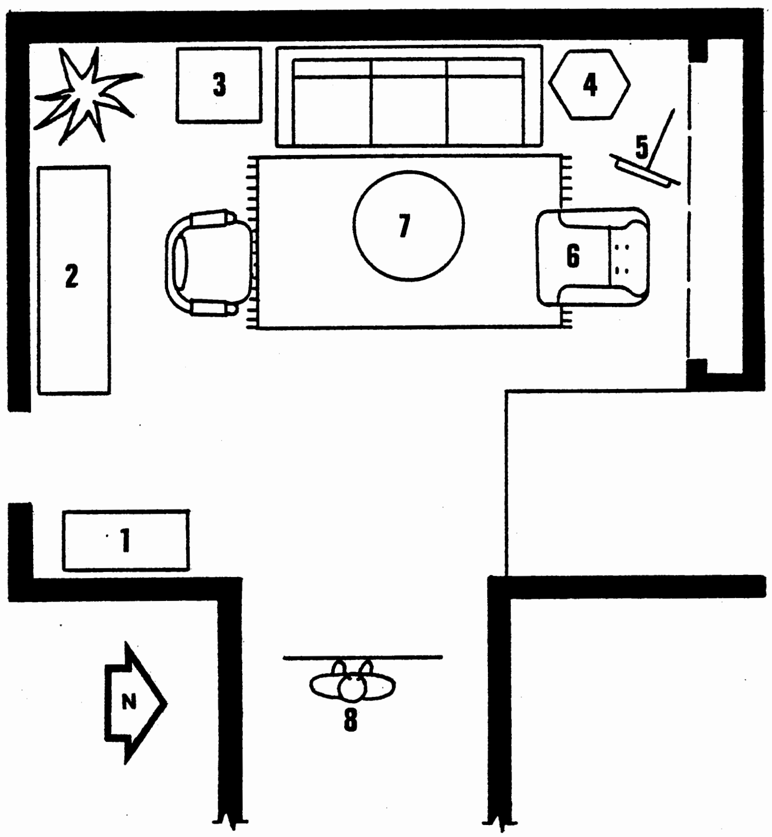
METHODOLOGY

Research Design

The test of lighting techniques was conducted in a model living room in Shepherd's Carriage House, a local furniture gallery (Figure 1). The experimental room was a living room setting equipped with four different lighting techniques which were used to provide alternative spatial feelings in that space. The room had ceilings of eight and one-half feet in height, giving a feeling of more spaciousness than the usual eight feet high ceilings. However, this ceiling height was consistent throughout all lighting techniques in this experiment. The model room contained no windows, giving it a somewhat artificial feeling, although this fact was taken into consideration when the room was chosen. This disadvantage worked as an advantage because natural light did not interfere with the artificial lighting being tested. Because residential environments are used at some periods when natural light is not available, this windowless room provided a good setting for testing these hypotheses.

The room setting within the furniture gallery was the laboratory in this experiment. Experimentation provides a means to an end in this research project. According to Best (1981):

> Experimentation provides a method of hypothesis testing. After experimenters define a problem they propose a tentative answer, or hypothesis. They test the hypothesis



1. Armoire/entertainment center
2. Buffet and oil painting above
3. Square end table
4. Hexagonal end table
5. Easel with oil painting
6. Fully upholstered chair
7. Round coffee table
8. Viewer behind viewing line

Figure 1. Experimental Room

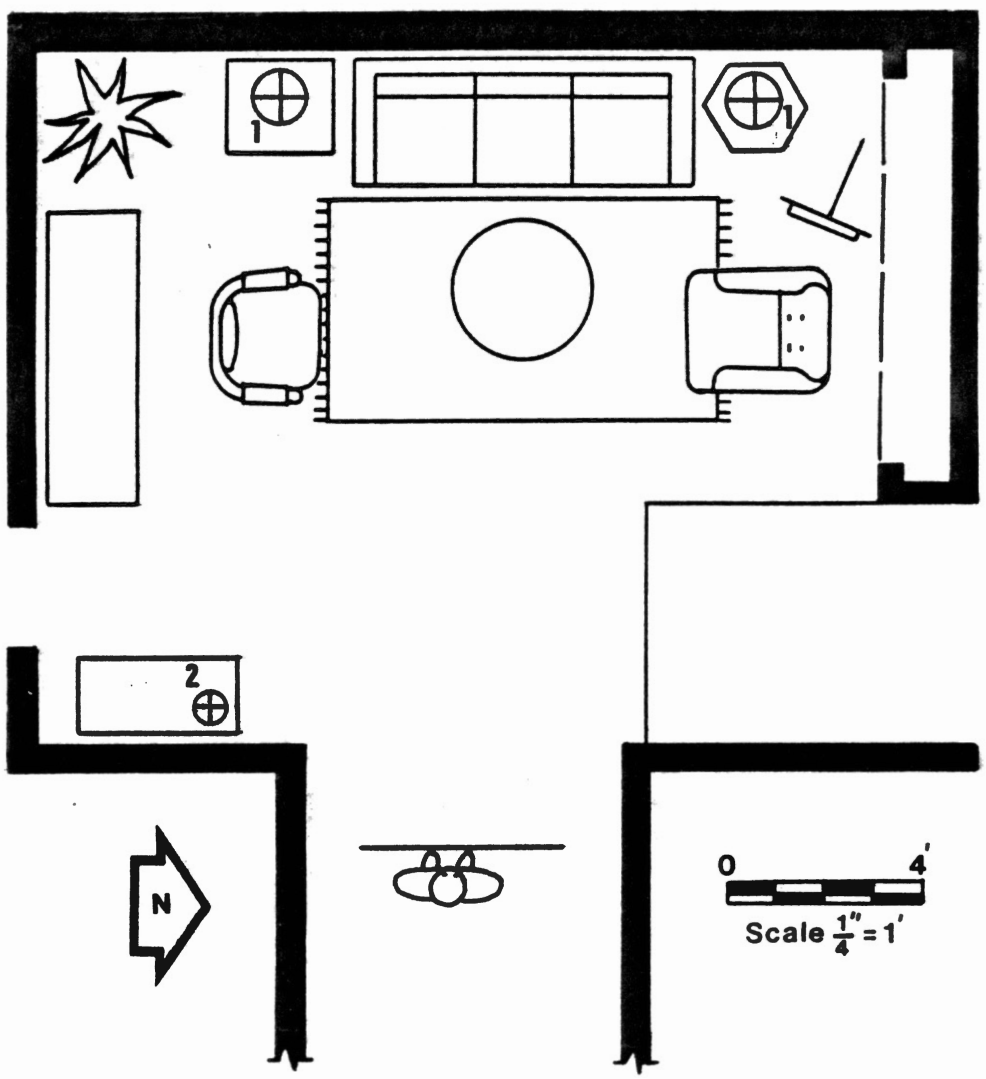
> and confirm or disconfirm it in the light of the controlled variable relationship that they have observed. It is important to note that the confirmation or rejection of the hypothesis is stated in terms of probability rather than certainty (p. 57).

The room was designed with conventional three-way switch table lamps at each end of the sofa. A small portable lamp was on top of the armoire/entertainment center to illuminate that corner These lamps were used to meet the basic needs for this room. Lighting Technique (Figures 2 and 3) A consisted of the table lamps on low, 50 watts each, and the small portable lamp at 60 watts. The small portable light on the armoire/entertainment center was used to help provide balance in the lighting.

After meeting the basic needs for lighting in this experimental room, techniques were employed to visually enlarge the space through the use of lighting. Three accent lights were used to visually expand the room's dimensions. Too many accent lights and the room would have added visual clutter. Accent lighting consisted of: (1) double bulb picture light (25 watts each bulb) shining downward on a large oil painting placed above the buffet, (2) an adjustable accent light (60 watts) placed on the floor beneath the square end table directed up toward the preserved palm in the corner of the room, and (3) a floor lamp with the globe (60 watts) tilted to permit the light to be directed toward the picture on the easel in the corner (Figures 4 and 5).

The double bulbed picture light above the oil painting hanging above the buffet was also used to highlight this area. The wall was more noticeable in Technique B and D because of this accent light.

The accent light directed up toward the palm was used to visually expand that corner in Techniques B and D. Willson (1979) states:



Lighting	Light Source	Watts	Lumens
1. 2 Table Lamps	PS	(50 ea) 100	(580 ea) 1160
2. Portable Lamp	A	60	855
Totals		160	2015

Figure 2. Lighting Technique A

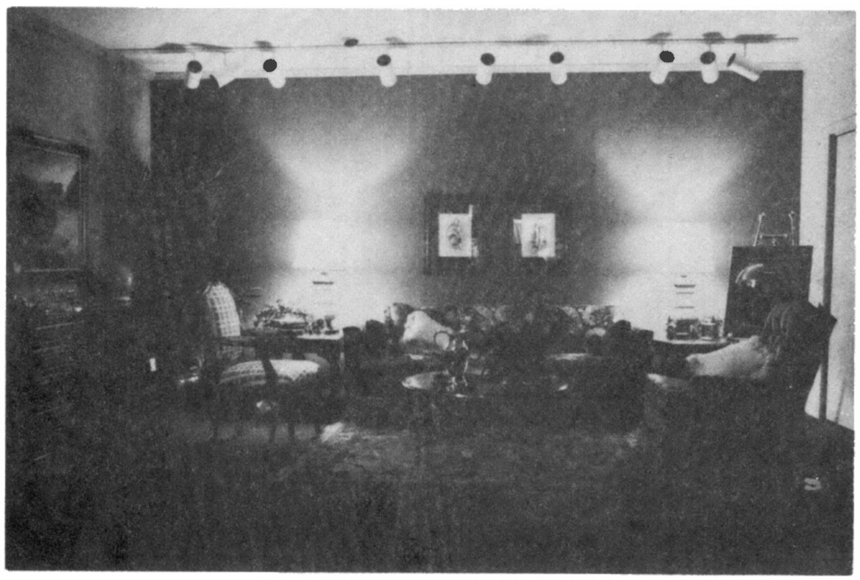
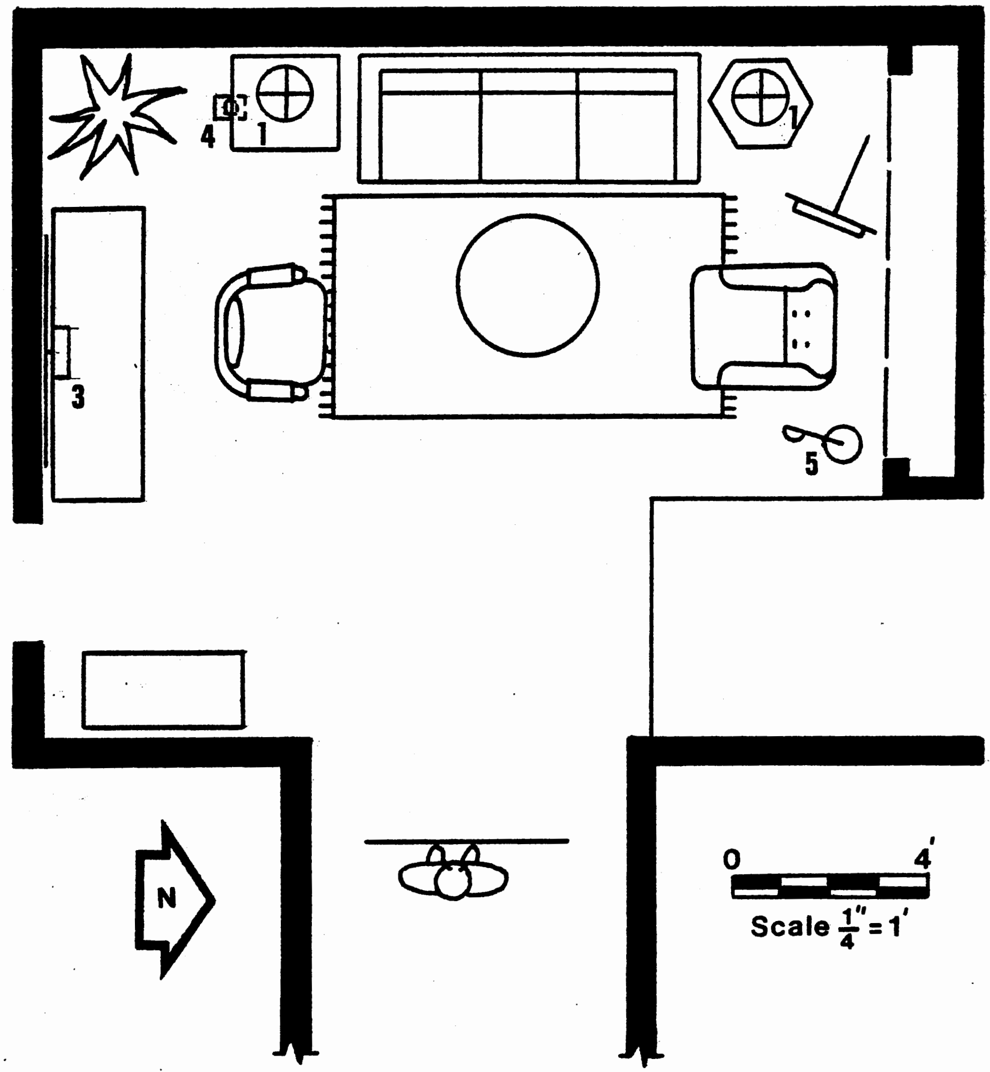


Figure 3. Photograph: Lighting Technique A



Lighting	Light Source	Watts	Lumens
1. 2 Table Lamps	PS	(50 ea) 100	(580 ea) 1160
3. 2 Picture Light Bulbs	Tubular	(25 ea) 50	(235 ea) 470
4. Accent Light	A	60	855
5. Floor Lamp	A	60	855
Totals		270	3340

Figure 4. Lighting Technique B

Figure 5. Photograph: Lighting Technique B

> Portable uplight fixtures are most often used to light foliage, to cast lovely shadows on a ceiling. I prefer to use portable accent light fixtures for this, however, for they are adjustable and the ability to aim the light to that part of the foliage you want to highlight is valuable (p. 249).

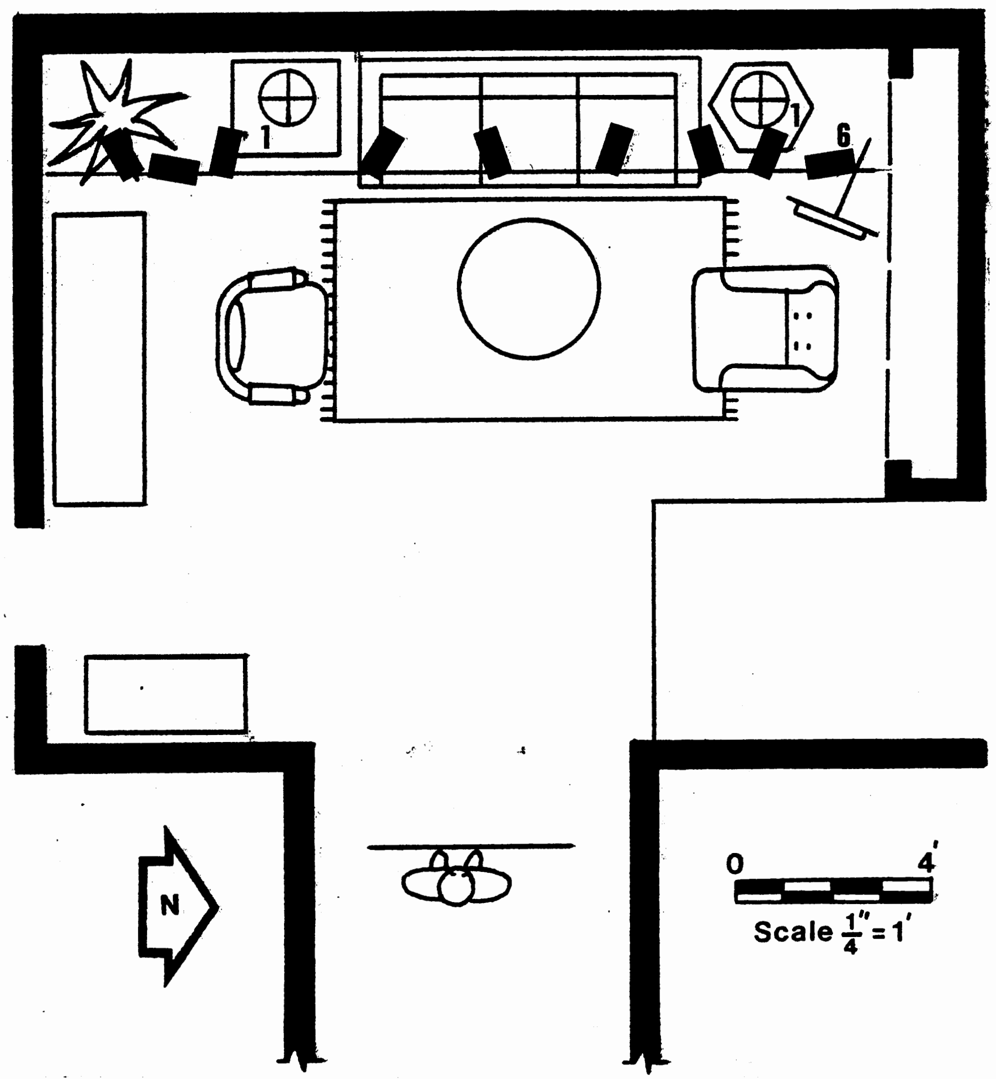
The portable accent fixture used to light the palm was constructed in such a way as to provide flexibility, both horizontally and vertically.

The floor lamp located next to the fully upholstered chair was structured to provide light for more purposes than just task lighting. The globe was made to swivel and tilt to direct light upward toward the wall and ceiling. In Techniques B and D it was used to direct light toward the oil painting resting on the brass easel in the corner. Spill-over light filled the corner, making this area appear larger for the same reasons as the accent light on the palm provided more visual space.

Another visually expanding space technique was the use of track lighting, used in lighting Techniques C and D (Figures 6 and 7; 8 and 9). The track lighting mounted on the ceiling 30 inches from the wall and running the width of the room directed light on the walls from nine canisters.

It is preferable to light a wall evenly from top to bottom; however, working within the constraints of the furniture gallery, this was not possible, but it is to be noted at this point that lighting the wall evenly might have produced greater results.

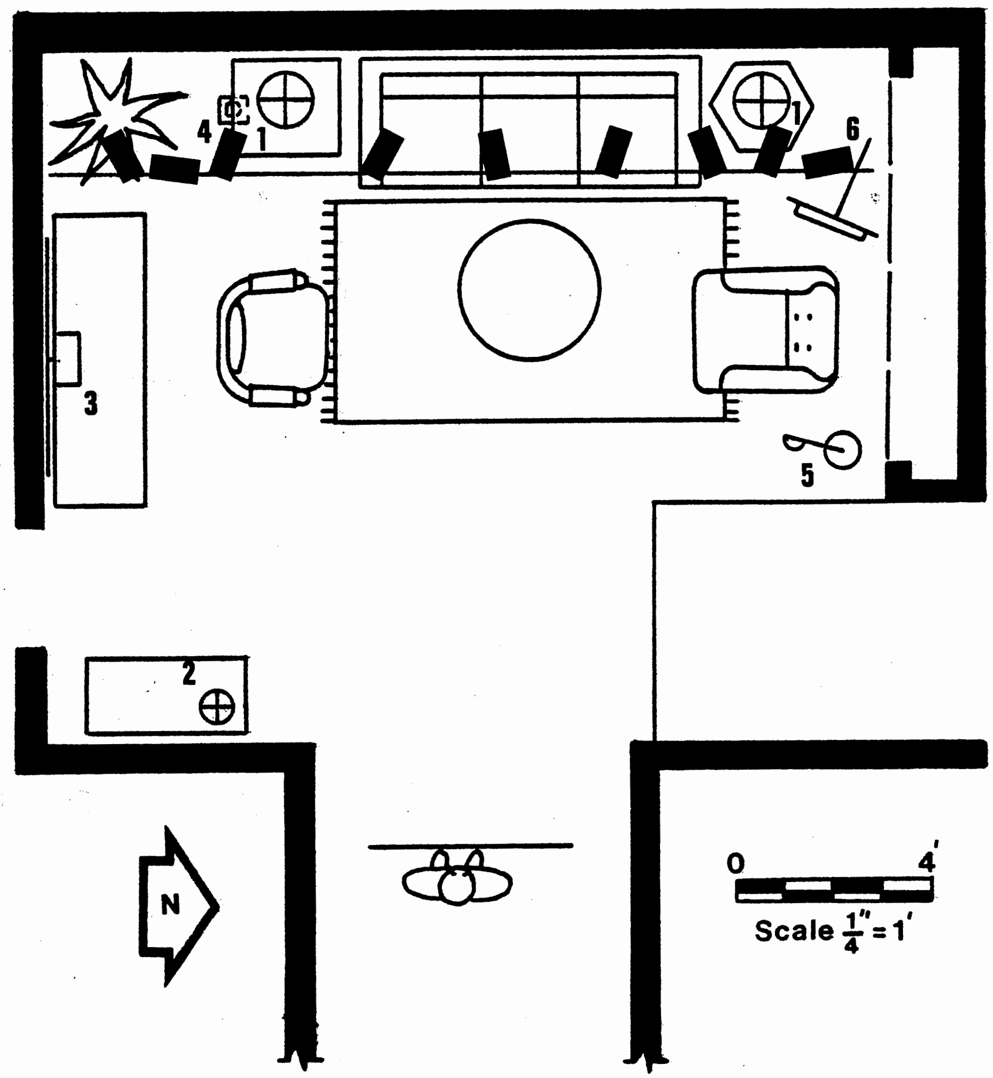
The experimental room had no windows to affect the interior lighting. The south door was blocked with a solid oak, tri-panel screen. The room was dark during the experiment (no windows, electric lights turned off). The entrance on the east was used by the subjects



Lighting	Light Source	Watts	Lumens
1. 2 Table Lamps	PS	(150 ea) 300	(2220 ea) 4440
2. 9 Track Canisters	Reflector	(75 ea) 675	(750 ea) 6750
Totals		975	11190

Figure 6. Lighting Technique 6

Figure 7. Photograph: Lighting Technique C



Lighting	Light Source	Watts	Lumens
1. 2 Table Lamps	PS	(150 ea) 300	(2220 ea) 4440
2. Portable Lamp	A	60	855
3. 2 Picture Light Bulbs	Tubular	(25 ea) 50	(235 ea) 470
4. Accept Light	A	60	855
5. Floor Lamp	A	60	855
6. 9 Track Canisters	Reflector	(75 ea) 675	(750 ea) 6750
Totals		1205	14225

Figure 8. Lighting Technique D

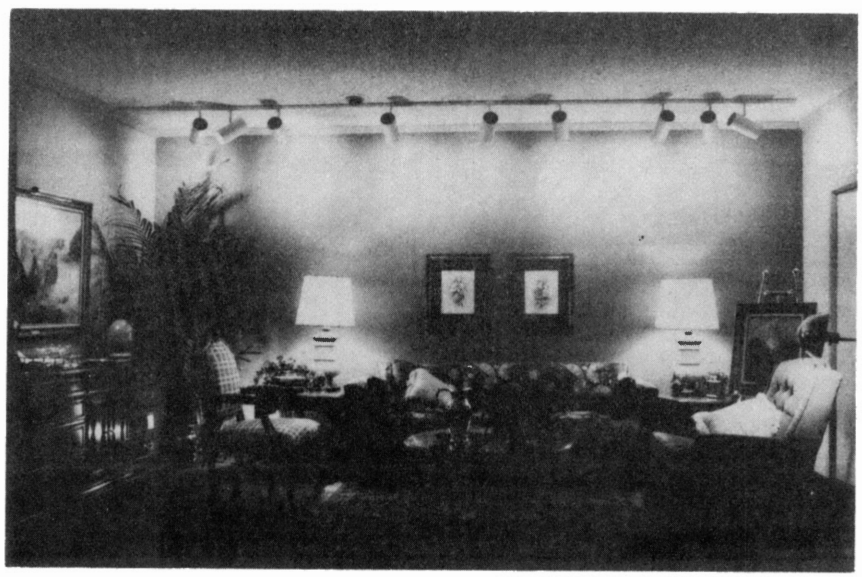


Figure 9. Photograph: Lighting Technique D

to view the room. This hallway was dark at the entrance to the viewing room with only one down-light (75 watts) approximately 10 feet behind the viewing line.

Population and Sampling

The ideal sampling for this project would have been a random sampling of the population incorporating people from every walk of life, every adult age group, both sexes, and varying economic backgrounds. However, limitations of time and financial resources necessitated compromises. The sampling was a purposive sample drawn from classes in the Department of Housing, Design, and Consumer Resources and the School of Hotel and Restaurant Administration at Oklahoma State University in the spring of 1983. These classes were used because of their accessibility, manageable numbers, and low cost.

The students in these classes were divided into two groups according to their delared major and background coursework in art, architecture, and interior design. The design group consisted of 44 students with design majors who were expected to have a greater sensitivity to design elements because of their education in design. The non-design group was comprised of 23 students with very little, if any, design training.

Instrumentation

A Biographical/Demographical Questionnaire was designed to acquire information about each subject in the research project (Appendix A)--information such as age, sex, educational status, major, and minor. The last requested the number of hours of university level coursework in each of the following subject areas: art, architecture, interior design, and psychology. This information was used to determine the appropriate group in which to place each subject for the analysis.

The Spatial Perception Questionnaire was developed so that the response to questions 2, 3, and 4 would be based on comparison to question 1 (Appendix B). A mid-point response of "10" was provided for question 1 to indicate a base measurement. The Likert Scale of 1 to 19 was used for these questions. The Biographical/Demographical Questionnaire and the Spatial Perception Questionnaire were pretested and adjustments made before being administered to the research subjects.

Data Collection

On the first day of the experiment, 37 students from the design group were asked to view the room four at a time for 30 seconds. They were then asked to read question one of the Spatial Perception Questionnaire which was answered for them to provide a base for evaluation. After all of the 37 had seen the room illuminated with lighting Technique A and had read question one, they waited in an adjoining room. Then, in groups of fours, they each viewed the room again for 30 seconds with lighting Technique B, read question two, and responded accordingly. After all of the 37 had evaluated the room illuminated with lighting Technique B, the procedure was repeated for lighting Techniques C and D.

The following day at approximately the same time, the non-design group (31 students) went through the process in the same manner.

Weather conditions were similar for both days, so the effect of the weather was consistent for both groups. It is important to mention the weather conditions even though no windows were present in the room because the moods of people are affected by weather and could have had an influence. The weather was consistent, so its influence can also be assumed to be consistent.

An analysis of the Biographical/Demographical Questionnaire revealed that seven respondents from the non-design group really belonged in the design group because they had extensive coursework in some design area. These seven were moved to the design group.

Assumptions and Limitations

The researcher assumed each student could retain the perception of each view in their memory throughout the entire session of seeing each view. However, it is felt by the researcher that shortening the time between the viewing of alternate techniques would make the comparisons more accurate.

As with any research method, there are certain limitations which exist. Lighting design had to be done within the constraints of the furniture gallery. For example, permanent lighting (e.g., recessed lighting) could not be added to the gallery. The sampling method was limited by available time and money. Because a purposive rather than a random sample was used, inferences to larger groups are quite limited.

The dark floor surface and dark wall surfaces presented another limitation to the study. Dark surfaces absorb lumens, thus requiring a large number of watts to produce an acceptable amount of light. Lighter surfaces would reflect available light, thus fewer watts would be required to accomplish the same amount of brightness. The lighting techniques utilizes for this study were chosen on the basis of availability and ease of installation for the general population.

Analysis

The first hypothesis for this study was tested by Student's t (Steel and Torrie, 1960).

$$t = \frac{\bar{X}-\mu}{s_{\bar{X}}}$$

An F (folded) statistic was used to test for equality of variances between the two unpaired groups (Steel and Torrie, 1960). The t' was used in place of Student's t to determine significant differences between means where variances were not equal. The formula is:

$$t' = \frac{w_1 t_1 + w_2 t_2}{w_1 + w_2}$$

where $w_1 = s_1/n_1$

$w_2 = s_2/n_2$

t_1 = value of student's t for n_1-1 d.f.

t_2 = value of student's t for n_2-1 d.f.

Data for all respondents were coded and punched into IBM data cards. The computer software program Statistical Analysis System was used to calculate all statistics (Helwig and Council, 1979). The test used for Hypotheses 2 and 3 was a paired comparisons test using t-test procedure. Because the t-test was not designed for paired comparisons, new variables were created for the differences between each of the paired variables.

B-C Light = Score for lighting Technique C - Technique B

B-D Light = Score for lighting Technique D - Technique B

C-D Light = Score for lighting Technique D - Technique C

Then the t-test was used to obtain the probability value for the hypothesis that the difference is equal to zero (Helwig and Council, 1979).

CHAPTER IV

FINDINGS

Introduction

The findings of the experiment with four lighting techniques are presented in this chapter. The first section describes the characteristics of the design and non-design subgroups. The second section presents the findings from the testing of the three hypotheses.

Description of Sample

Table I shows the characteristics of the respondents in each of the groups tested. The design group had 39 in the 20-24 age bracket; 2 in the 25-30 age bracket; and 3 in the over 30 age bracket. Of the 7 males and 37 females, 3 were sophomores; 27 were juniors; 11 were seniors; and 3 were graduate students. Thirty-nine were interior design majors; one majored in architecture; two majored in art; and two majored in housing. Minors in the group consisted of one in landscape architecture; three in art; three in marketing; two in business; and one in French. The questionnaire also reflects the large number of design and design-related credit hours taken by the students in the design group as compared with the smaller number taken by the non-design group.

The non-design group consisted of 2 under the age of 20; 18 in the 20-24 age bracket; 1 in the 25-39 age bracket; and 3 over the age of 30.

TABLE I

PERSONAL CHARACTERISTICS OF SAMPLE

Characteristics	Design Group Frequency	Design Group Percentage	Non-Design Group Frequency	Non-Design Group Percentage
Age				
Under 20			2	8
20-24	39	88	18	75
25-30	2	5	1	4
Over 30	3	7	3	13
Total	44	100	24	100
Sex				
Male	7	16	14	59
Female	37	84	10	41
Total	44	100	24	100
Educational Status				
Freshman			2	8
Sophomore	3	7	3	13
Junior	27	61	6	25
Senior	11	25	13	54
Graduate	3	7		
Total	44	100	24	100
Major				
Interior Design	39	88		
Architecture	1	2		
Art	2	5		
Hotel & Restaurant Adm.			22	92
Housing	2	5		
Other			2	8
Total	44	100	24	100
Credit Hours In:				
Art				
3 or less	7	16	24	100
4-12	30	68		
13-24	3	7		
25+	4	9		
Total	44	100	24	100
Architecture				
3 or less	39	89	24	100
4-12	4	9		
13-24				
25+	1	2		
Total	44	100	24	100
Interior Design				
3 or less	7	16	23	96
4-12	2	5	1	4
13-24	8	18		
25+	27	61		
Total	44	100	24	100

Of the 14 males and 10 females, 2 were freshmen; 3 were sophomores; 6 were juniors; and 13 were seniors. Twenty-two were Hotel and Restaurant Administration majors and two had some "other" major. Minors included four in various divisions of business; two in marketing; and one each in journalism and French.

Tests of Hypotheses

For the purpose of statistical testing, the first hypothesis for this study was stated in the null form:

> Hypothesis 1. There will be no difference between design and non-design students in terms of their response to perception of space in the test room under each of three lighting techniques.

This hypothesis was testing using the Student's t assuming equal variance and with an adjusted t' assuming unequal variance. The F test for the hypothesis of equal variance revealed that the variances were not equal for the design and non-design groups. The F values and significance levels for each lighting application are shown in Table II.

TABLE II

F VALUES AND SIGNIFICANCE LEVELS FOR TEST OF EQUAL VARIANCE BETWEEN DESIGN AND NON-DESIGN GROUPS

Lighting Technique	F Value	Significance
B	2.05	.041
C	3.04	.002
D	2.78	.002

Because the test revealed that variances were not equal, the t' for unequal variances was utilized in the test for significant differences between means. The results of the t' tests for Hypothesis 1 are shown in Table III.

The findings show that the mean scores for lighting Techniques C and D were significantly different between the design and non-design groups at the $p < .05$ level. Means for lighting Technique B were significantly different at the $p = .15$ level. Although this difference is above the usually accepted $p = .05$ level, it was decided that there was sufficient evidence that design and non-design groups did evaluate the perceived space differently. Thus, the null Hypothesis 1 was rejected and the design and non-design groups were analyzed separately for the other hypotheses.

Hypotheses 2 and 3 were stated in the null form for statistical testing as follows:

Hypothesis 2. There will be no difference in the perceived size of the room under lighting applications C and B.

Hypothesis 3. There will be no difference in the perceived size of the room under lighting applications D and B or C.

The paired comparison analysis used to test Hypotheses 2 and 3 is shown in Table IV. In order to use a t-test, it was necessary to create variables that reflected the difference in scores between pairs of lighting techniques. These variables were created as follows:

B - C Light = Score for lighting Technique C - Technique B

B - D Light = Score for lighting Technique D - Technique B

C - D Light = Score for lighting Technique D - Technique C

The t-test used here tests the hypothesis that the difference between any pair of lighting techniques is equal to zero (Helwin and Council, 1979).

TABLE III

THE t' VALUES AND SIGNIFICANCE LEVELS FOR DIFFERENCES IN MEANS OF THE DESIGN AND NON-DESIGN GROUPS FOR THREE LIGHTING TECHNIQUES

Lighting Technique and Group	n	Mean	Standard Deviation	Standard Error	t' for Unequal Variance	Degrees Freedom	Significance Level
Technique B							
Design	44	11.4	2.15	.32			
Non-Design	24	10.4	3.08	.63	1.46	35.5	.15
Technique C							
Design	44	14.3	1.89	.29			
Non-Design	24	12.6	3.30	.67	2.41	31.5	.02
Technique D							
Design	44	16.7	2.51	.38			
Non-Design	24	14.3	4.17	.85	2.54	32.3	.02

Table IV shows that significant differences were found between all lighting applications by the design group and by the non-design group. The greatest differences were found between lighting Techniques B and D for both groups. The mean difference between Techniques B and D was 5.25 for the design group and 3.9 for the non-design group. These larger differences were expected because Techniques B and D were the most extreme of the lighting techniques.

TABLE IV

PAIRED COMPARISON ANALYSIS FOR DIFFERENCES IN SCORES OF THREE LIGHTING TECHNIQUES FOR DESIGN AND NON-DESIGN GROUPS

Lighting Score Variables	n	Mean	Variance	Standard Error	t	Significance Level
Design Group						
B-C Light	44	2.93	3.18	.269	10.90	.0001
B-D Light	44	5.25	7.54	.414	12.68	.0001
C-D Light	44	2.31	3.80	.294	7.88	.0001
Non-Design Group						
B-C Light	24	2.2	12.78	.730	3.03	.0060
B-D Light	24	3.9	24.95	1.020	3.84	.0008
C-D Light	24	1.7	11.17	.682	2.50	.0198

The mean score for the lighting Techniques B through D increased in the hypothesized direction. Table III showed that Technique D was seen as the most visually expansive (mean 16.7 for the design group and

14.3 for the non-design group). Technique B was seen as the least visually expansive (mean 11.4 for the design group and 10.4 for the non-design group). Thus, null Hypotheses 2 and 3 were rejected.

CHAPTER V

SUMMARY

The purpose of the study was to conduct a pilot study to explore lighting techniques that can be used to visually expand a given space and to determine which techniques are the most visually expansive.

The test of the four lighting techniques was conducted in a model living room of a local furniture gallery. The purposive sample was drawn from classes in the Department of Housing, Design, and Consumer Resources and the School of Hotel and Restaurant Administration at Oklahoma State University in the spring of 1983. After evaluation of the Biographical-Demographical Questionnaire, the students were divided into two groups according to their background coursework in art, architecture, and interior design.

A Spatial Perception Opinionnaire was administered to all 68 participants and a t-test was used for analysis of difference in mean scores. For the purpose of statistical testing, the first hypothesis for the study was stated in the null form:

> Hypothesis 1. There will be no difference between design and non-design students in terms of their response to perception of space in the test room under each of three lighting techniques.

This hypothesis was rejected because significant differences were found between design and non-design students, with design students being more sensitive to spatial expansion.

The design group was expected to see things differently than the non-design group because of the design training and experiences encountered by the design group. This is consistent with ekowski's (1983) philosophy on the trained observer. All the training and experiences would be useless if the design students could not perceive a design situation more discriminately than those who have not been so trained.

Hypotheses 2 and 3 were stated in the null form for statistical testing as follows:

> Hypothesis 2. There will be no difference in the perceived size of the room under lighting application C and
>
> Hypothesis 3. There will be no difference in the percei of the room under lighting application D and B or C.

The findings indicated significant differences in the perceived space for the various lighting techniques. The students in both groups saw a greater difference between Technique B and D because these were the most extreme of the lighting techniques. Technique used the least visually expansive lighting, and Technique D most visually expansive lighting. Technique C was observed as being more visually expansive than, B and less visually expansive than D. Thus, these hypotheses were rejected.

These findings support the findings of the Flynn et al. (1973) study that increased brightness is accompanied by perception of larger space. These findings also suggest that the direction and type of light (upward from accent lights and onto the wall from track lighting) may be important in increasing the illusion of space.

It is concluded that the design students saw the room as being larger than the non-design students, which might indicate that the design students are more sensitive to a finer degree of variation in lighting techniques.

It is also concluded that because a difference was observed by both design and non-design groups, lighting can make a difference in the perceived size of a room. Lighting Technique D was observed to be the most visually expansive of the three techniques; therefore, when it is desirable to visually expand space through the use of lighting it can be accomplished by using track light to wash the wall(s) in addition to accent light to draw attention to other parts of the room, and by increasing the wattages. However, part of the illusion of increased space was no doubt associated with the increased wattage, but this study does not permit the separation of the effect of technique and amount of wattage.

This pilot study utilized lighting techniques that are easily accessible to and easily installed by the average consumer. Lighting recessed into the ceiling for the purpose of wall washing and accent lighting might be a superior technique to track lighting and portable accent lights. This, of course, would require an electrician for installation and therefore would incur a higher cost. Recessed lighting also reduces visual clutter on the ceiling, which might be crucial in certain room situations, and when properly installed, can eliminate "hot spots."

It is also recommended by the researcher that further study be done to compare like wattages in different techniques instead of comparing different techniques consisting of varying wattages. It might be helpful to record a detailed, technical measurement of the amount of light in the room setting under the different lighting techniques.

It is also suggested that future studies provide for a shorter time span between viewing each lighting technique for more accurate comparisons. A master control panel for all the lighting applications would help achieve this. It is recommended that comparisons might be more accurate if respondents were to first judge the size of the room under fluorescent light, producing an even, shadowless environment.

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APPENDIXES

APPENDIX A

BIOGRAPHICAL/DEMOGRAPHICAL QUESTIONNAIRE

Biographical/Demographical Questionnaire

The purpose of the following questionnaire is to give the researcher background information on each student.

1. What is your age?

____ Under 20

____ 20-24

____ 25-30

____ Over 30

2. What is your sex?

____ Male

____ Female

3. What is your educational status?

____ Freshman (0-29 Hours)

____ Sophomore (30-44 Hours)

____ Junior (45-74 Hours)

____ Senior (75 or More Hours)

____ Graduate Student

____ Other

4. What is your major? Check more than one if applicable.

____ Interior Design

____ Architecture

____ Art

____ Hotel and Restaurant Administration

____ Housing

____ Other (Please Specify) ____________________________________

5. Do you have a minor? ____ Yes ____ No

If Yes, Please specify ____

6. Please indicate number of credit hours you have in each of the following areas:

____ Art ____ Interior Design

____ Architecture ____ Psychology

APPENDIX B

SPATIAL PERCEPTION OPINIONNAIRE

Spatial Perception Opinionnaire

Stand on the viewing line and look at the room for approximately 30 seconds. The midpoint (10) indicates the size of the room with this lighting - lighting application "A". On the scale, "1" indicates a very small living area and "19" indicates a very large living area. This lighting application at "10" on the scale will be your base point.

Very Large 19 18 17 16 15 14 13 12 11 (10) 9 8 7 6 5 4 3 2 1 Very Small

Now indicate your evaluation of the size of the room with lighting application "B". Use the above number (10) as a base point and then indicate how much larger or smaller (or the same) the room appears with this lighting compared to lighting application "A". Circle the appropriate number.

Very Large 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 Very Small

Now indicate your evaluation of the size of the room with lighting application "C". Use lighting application "A" as your base point and then indicate how much larger or smaller (or the same) the room appears with this lighting. Circle the appropriate number.

Very Large 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 Very Small

Now indicate your evaluation of the size of the room with lighting application "D". Use lighting application "A" as your base point and then indicate how much larger or smaller (or the same) the room appears with this lighting. Circle the appropriate number.

Very Large 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 Very Small

VITA

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Candidate for the Degree of

Master of Science

Thesis: AN EVALUATION OF VISUALLY EXPANDING LIGHTING TECHNIQUES BY DESIGN AND NON-DESIGN STUDENTS

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