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The Impact of Lighting on Impressions of Interior Space

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Abstract: It is the impact of lighting on human impression, mood, and behavior that has made lighting design one of the most important and specialized aspects of interior design. In designing interiors, designers must consider the placement and use of both artificial and natural light. A study was conducted involving 75 males and 75 females between the ages of 18 to 25, to assess the positive or negative responses to six rendered images of an interior livingroom space based on the aspects of clarity, spaciousness, relaxation, privacy, pleasantness, and order. Findings from this study have the potential to aid designers to design and visually present interior spaces that are the most aesthetically pleasing and conforming to the requirements set forth by the client.

Keywords: Artificial Lighting, Human Impressions, Interior Spaces, Natural Lighting

INTRODUCTION

Historically, architectural psychology has looked at the relationships between people and the “built” environment, and it has emerged as one of the most investigated fields in psychology. Most Americans would say that the majority of their time is spent indoors, whether in the office, school, recreational facilities, public buildings, or at home. It is for this reason that it becomes important to know how different elements in these environments are affecting impressions, moods, cognition, and behaviors. In recent years, surprising findings have emerged concerning interior and artificial lighting in buildings. For instance, one may not be concerned with the fact that the majority of schools use fluorescent lighting in classrooms as it is very economical. Yet one study performed in the United Kingdom found that certain luminance levels of fluorescent lighting actually caused headaches and impaired visual performance in school children (Winterbottom *et al.*, 2009). This study can leave one to wonder what other effects and roles lighting plays in the built environments we encounter every day. Flynn *et al.* (1973), Flynn (1977), Flynn & Spencer (1977) and Flynn *et al.* (1979) individuals. He began his research on people’s impressions and behavior with regards to altered environmental lighting in the 1970s. His experiments sparked much interest in previously overlooked elements of the built environment, and many have used Flynn’s research and methods as a basis for further investigation.

When designing the lighting for various rooms inside a home, residents often look for the most economical choices and overlooking to consider if the arrangement and choices of natural and artificial lighting are contributing to the desired mood and purpose of the space. While much research has been applied in the workplace, schools, and other public settings, there have been few studies done inside the home. This study provides new data about the effects of natural and artificial lighting have on individuals in the home, as it is where one should feel most comfortable.

This initial study was conducted on 75 male and 75 female between the ages of 18 to 25. A more extensive research will be conducted in the near future on subjects of higher age range. The 150 subjects were to assess positive or negative responses to six rendered images of an interior living room space based on the aspects of clarity, spaciousness, relaxation, privacy, pleasantness, and order. Each living room space was designed in the same manner, but the type of lighting (natural or artificial) and level of brightness was changed in each image to see how impressions of the space would change. The study also determined if the time of day as viewed through a window or the brightness of artificial light changes impressions. Findings from this study may assist interior designers and architects in creating interior spaces that are aesthetically pleasing, comfortable, and conform to client's requirements.

Studies on Lighting

Flynn *et al.* (1973), Flynn (1977), Flynn & Spencer (1977) and Flynn *et al.* (1979) was considered the pioneer of interior lighting psychology as he was the first to study lighting's impact on human cognition, mood, impression, and behavior. In his earliest studies of lighting psychology, Flynn found that lighting did have some effect on behavior and sensations of well-being (Flynn *et al.*, 1973). More importantly, he found that lighting effects could be evaluated through psychological procedures (Flynn *et al.*, 1973). Since the 1970s, many studies have built on Flynn's research. Durak *et al.* (2006) studied the qualitative aspects of a space by different lighting arrangements such as general lighting, wall washing, and cove lighting. Subjects rated a room based on clarity, spaciousness, relaxation, privacy, pleasantness, and order. They found a significant difference in preferences at different luminance levels. People rated rooms higher in clarity with higher luminance levels and rated rooms to be more relaxing at lower luminance. Rooms rated to be more private also had lower luminance levels. Pleasantness was enjoyed at both levels, but order was expressed at lower levels.

With these facts in mind, this study utilized the same methods as Flynn's i.e. by using the psychological tool of semantic differential scaling (Flynn *et al.*, 1973) in determining if individuals had a preference to natural or artificial light in an interior living room space. This study used the same categories established in the study by Durak *et al.* (2006) as they had already been determined to show useful, individual aspects of feelings towards a space.

Numerous studies of lighting have been applied to the workplace. Yildirim *et al.* (2007) studied employee satisfaction in open-plan office spaces to find out if access to a window with enough daylight and outside view added to the satisfaction of employees. Workers away from windows complained more of being easily disturbed and complained of inefficiency and lack of daylight. They also found employees near a window had more positive perception of the space. In 1995, Knez *et al.* investigated indoor lighting on cognitive performance via mood found that although both males and females were good at evaluating luminance levels, the room was consistently evaluated differently based on gender. "Cool" lighting induced the least negative mood in males while "warm" light induced the least negative mood in females. The least-negative moods in the first experiment brought the best cognitive performance.

The developments of high-tech rendering software have benefitted architects, designers, and engineers where they are able to create highly realistic images of what the built environment will look like before it is constructed. However, the question is whether computer-generated visualization of a building or structure can be perceived in the same ways as the real-life environment. Hendrick *et al.* (1977) was the first to compare real spaces with two-dimensional (2D) representations of those spaces. They found that visual experience was very similar for both cases. Daniel *et al.* (2001) studied if the perceived aesthetic beauty of forest vistas was interpreted the same way in different resolutions of images as they were when one was outdoors. They found that the same scene could be perceived very similarly, but only in higher levels of photo-realism (Daniel *et al.*, 2001). Fortunately, such levels of photo-realism can be offered in modern

architectural visualization software. As opposed to evaluating an environmental scene as a whole, Eissa *et al.* (2001) asked specifically if subjective evaluations of lighting in architectural spaces differed from real life arrangements to computationally rendered images of such spaces. They found that lighting in real life office spaces were evaluated similarly to photo-realistic renderings of the same spaces. One important tool Eissa *et al.* (2001) and Durak *et al.* (2006) used to measure the perception of the lit environment was semantic differential scaling. Veitch *et al.* (1996) tested the use of semantic differential scaling and reaffirmed its reliability.

The Experiment

Based on previous research, it is hypothesized that the greatest preferences in the six categories of clarity, spaciousness, relaxation, privacy, pleasantness, and order will be for the space designed with the brightest natural light (Figure 1).



Figure 1: Natural Lighting with the Sun Set in the Morning

This study investigated and provided answers to the following questions:

1. Does natural or artificial lighting have a significant impact on an individual's impressions of a room? If so, in what ways?
2. Is there a stronger preference toward either natural or artificial lighting?
3. Does the time of day through a window view or brightness of bulbs play a role?
4. Does gender have an impact on feelings toward a space?

This study was conducted with 150 college students between the ages of 18 and 25. The subjects included seventy-five males and seventy-five females. Subjects were shown six different rendered images of a living room space, created using Graphisoft Archicad 13 CAD software. Subjects viewed a PowerPoint slideshow of the images on a large projection screen in a classroom setting or on their personal computer screens. While some viewed the slideshow in a group setting,

the slideshow and questionnaire were also emailed to students so they could view and rate the spaces and complete the questionnaire as their schedules allowed.

Interior spaces with artificial lighting included furniture, two recessed lights, a floor lamp, and a table lamp. Spaces with natural lighting had four windows with a view of the sky. Spaces with artificial lights did not include any windows, and spaces which comprised windows did not include any artificial lighting.

The bright and dim lighting as well as the sun settings for the time of day were controlled according to the settings in Graphisoft Archicad. The walls and furniture were neutral colors to avoid any positive or negative feelings that other colors may cause. The neutral colors used were beige, ivory, taupe, black, gray, and white.

The six renderings included each of the following spaces:

1. a space lit strictly by artificial lighting set to a low level of brightness (Figure 2)
2. a space lit strictly by artificial lighting set to a medium level of brightness (Figure 3)
3. a space lit strictly by artificial lighting set to a high level of brightness (Figure 4)
4. a space lit strictly by natural lighting from a window with the sun set in the morning (Figure 5)
5. a space lit strictly by natural lighting from a window with the sun set in the afternoon (Figure 6)
6. a space lit strictly by natural lighting from a window with the sun set in the evening (Figure 7)

To prevent subjects from immediately noticing the gradual changes in brightness and day lighting, Figures 2 until Figure 7 were arranged in the following order for the this study: 4, 6, 2, 5, 7, and 3.

Each participant was given a questionnaire (refer to Appendix A) where each question corresponded to one of the slides. The six rendered images were arranged in a slideshow presentation. Each participant was given a questionnaire where he or she provided his or her gender, age, and major, recorded his or her feelings toward each individual space using semantic differential scaling developed by Flynn *et al.* (1973), Flynn (1977), Flynn & Spencer (1977) and Flynn *et al.*, (1979), and wrote a response to an open-ended question about the space. Subjects were asked to mark their age and gender to determine, based on the acquired data, if any of these variables made a difference in taste or preference.



Figure 2: Artificial Lighting Set to a Low Level of Brightness



Figure 3: Artificial Lighting Set to a Medium Level of Brightness



Figure 4: Artificial Lighting Set to a High Level of Brightness



Figure 5: Natural Lighting with the Sun Set in the Morning



Figure 6: Natural Lighting with the Sun Set in the Afternoon

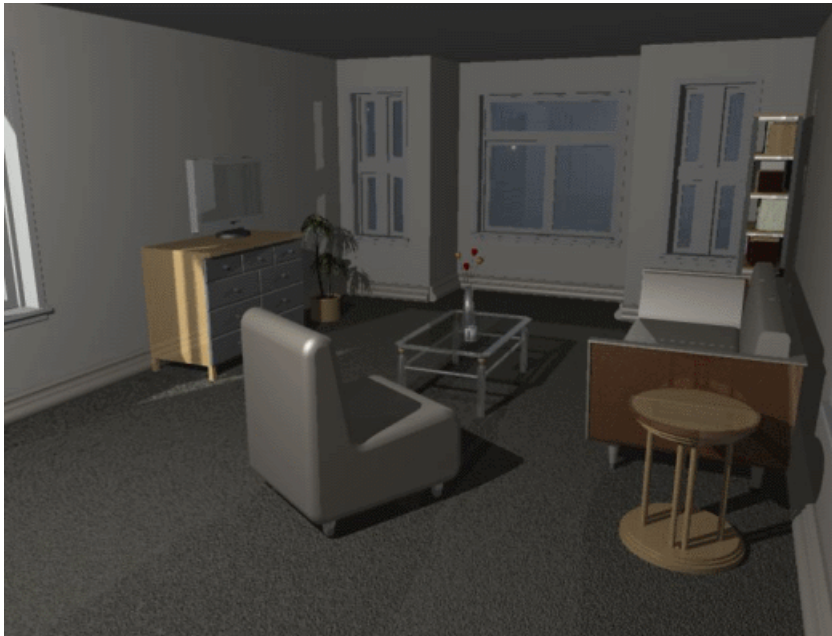


Figure 7: Natural Lighting with the Sun Set in the Evening

Subjects were asked to write their program of study to determine if an architecture major or interior designer major would view the elements of a designed space differently from those majoring in other programs. Each slide corresponded to Questions 2–7, and was also labeled

with a question number and space number. For example, the first slide was a space with artificial lighting set to a medium level of brightness and was labeled “Q2: Space #1” to represent that it corresponded with Question #2 on the questionnaire.

The semantic differential scale ranged from “-3” to “3” under each category. The “-3” represented the most negative feelings towards the space, while positive “3” represented the most positive feelings towards the space. Circling “0” meant that the individual’s feelings towards the space were neutral. Under each category of clarity, spaciousness, relaxation, privacy, pleasantness, and order, there were two bipolar terms which represented negative and positive impressions. For clarity, the terms were blurred and clear. For spaciousness, the terms were closed and open. For relaxation, the terms were stressed and relaxed. For privacy, the terms were public and private. For pleasantness, the terms were unpleasant and pleasant. For order, the terms were disordered and ordered. Subjects were provided as much time as needed to rate each of the slides on this scale.

After the experiment was completed, the ratings on the semantic differential scaling were analyzed to determine the average feeling toward each space based on the individual characteristics of clarity, spaciousness, relaxation, clarity, privacy, pleasantness, and order. To organize the data and summarize the feelings towards each space, the mean number that subjects marked on the scale was taken for each category and age group. The results were then organized into tables and graphs.

Analysis of Results

To organize the data and summarize each subject’s feelings towards each space, the 75 ratings made by males as well as the 75 ratings made by females were averaged to establish a mean value for each category. The mean values for the six categories of each space and a comparison of the overall ratings for males and females are shown in Figures 8 until Figure 15 and corresponding Tables 1 until Table 6.

Figure 8 and Table 1 show the ratings for males and females for the interior space that was lit only by artificial light set to a medium brightness level. As shown in Figure 8, females rated this space lowest in the categories of relaxation and spaciousness. The characteristics of clarity, privacy, and pleasantness were rated higher by males than females. Order was rated the highest of all the categories for both males and females.

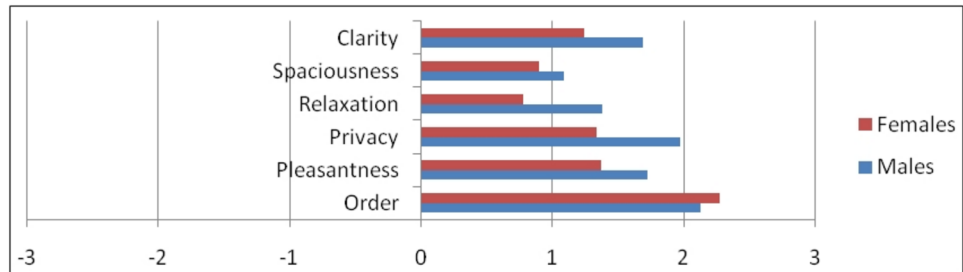


Figure 8: Artificial Light Medium

Table 1: Artificial Light Medium

Gender	Clarity	Spaciousness	Relaxation	Privacy	Pleasantness	Order
Female	1.24	0.90	0.78	1.34	1.37	2.27
Male	1.69	1.09	1.38	1.97	1.72	2.13

In the room with the natural light set in the afternoon (Figure 9 and Table 2), privacy had the lowest rating for both males and females. Females did not feel the room was as pleasant or relaxing as the males did. Again, order was rated highest for both males and females. Spaciousness also had high ratings for both males and females.

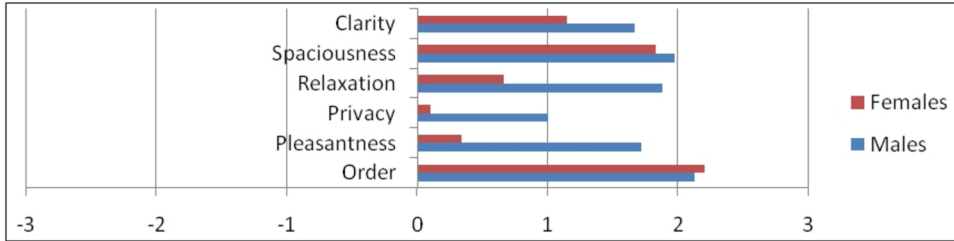


Figure 9: Natural Light Afternoon

Table 2: Natural Light Afternoon

Gender	Clarity	Spaciousness	Relaxation	Privacy	Pleasantness	Order
Female	1.15	1.83	0.66	0.10	0.34	2.20
Male	1.67	1.97	1.88	1.00	1.72	2.13

Figure 10 and Table 3 show that the ratings for clarity were extremely low for both males and females in the room with the artificial light set to low. While males rated spaciousness low at 0.72, women rated spaciousness much lower than men at -0.37. Females also rated pleasantness much lower than the males for the space. Privacy was rated the highest for both males and females.

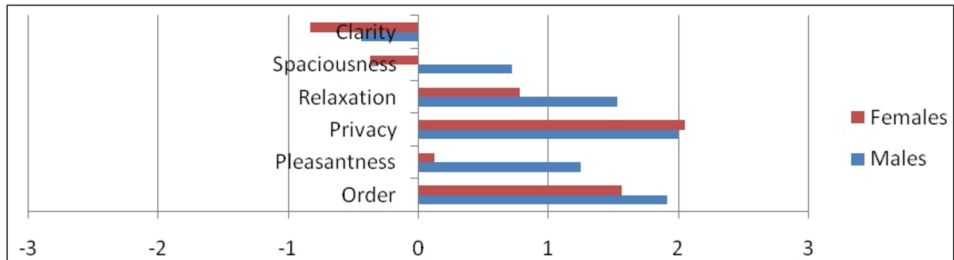


Figure 10: Artificial Light Low

Table 3: Artificial Light Low

Gender	Clarity	Spaciousness	Relaxation	Privacy	Pleasantness	Order
Female	-0.83	-0.37	0.78	2.05	0.12	1.56
Male	-.044	0.72	1.53	2.00	1.25	1.91

Figure 11 and Table 4 show the results for the space with natural light set in the morning. For this space, privacy was rated very low for females at -0.10. Males also rated privacy low at 1.13. Clarity, spaciousness, and order were rated very high for males and females, but relaxation ratings were slightly lower for females than men.



Figure 11: Natural Light Morning

Table 4: Natural Light Morning

Gender	Clarity	Spaciousness	Relaxation	Privacy	Pleasantness	Order
Female	1.88	2.05	0.95	-0.10	1.20	2.0
Male	1.97	2.16	1.88	1.13	1.84	2.31

Figure 12 and Table 5 show the results for the space with natural light set in the evening. Clarity was extremely low for women at -1.49 and also low for men at -0.03. Pleasantness was rated lower for this space by females than by males. Spaciousness, relaxation, and privacy were rated lower in females than males. Order had the highest ratings of the six categories for both genders. Overall, none of the ratings for this space were very high.



Figure 12: Natural Light Evening

Table 5: Natural Light Evening

Gender	Clarity	Spaciousness	Relaxation	Privacy	Pleasantness	Order
Female	-1.49	0.56	0.29	0.85	-0.51	1.73
Male	-0.03	1.06	1.38	1.03	1.06	1.53

In the room with the artificial light set to a high level of brightness (Figure 13 and Table 6), all categories were generally rated high for both men and women. While still rated high when compared to the rest of the spaces, spaciousness had the lowest ratings of the six.

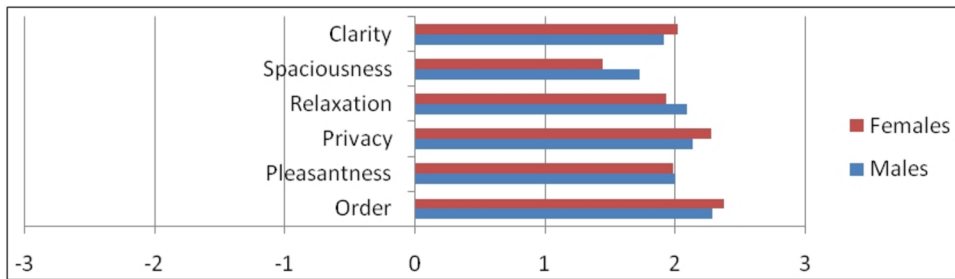


Figure13: Artificial Light High

Table 6: Artificial Light High

Gender	Clarity	Spaciousness	Relaxation	Privacy	Pleasantness	Order
Female	2.02	1.44	1.93	2.27	1.98	2.37
Male	1.91	1.72	2.09	2.13	2.00	2.28

Figure 14 allows one to easily compare female ratings for each of the six categories and spaces. Clarity was rated highest in the room with the artificial light set to a high level of brightness and the room with natural light set in the morning. The lowest ratings for clarity were in the rooms with the natural light set in the evening and the artificial light set on low.

Spaciousness was rated highest in the space with natural light set in the morning, followed by natural light set in the afternoon, and then artificial light set to a high level of brightness. Spaciousness ratings were lowest for natural light set in the evening and for the room with artificial light set to a low level of brightness.

For the category of relaxation, artificial light set to high was rated as the most relaxing. Natural light in the evening was rated the least relaxing. The other spaces all ranked about the same for the level of relaxation.

Privacy ranked highest for artificial light on high and artificial light on low and lowest for natural light in the morning and natural light in the afternoon. This was most likely due to the presence of windows.

Pleasantness was greatest for artificial light set to a high level of brightness and least for natural light in the evening. It was also low for artificial light on low and natural light in the afternoon.

Order was highest for the artificial light but also high for natural light in the afternoon and artificial light on medium. The rest of the rooms were rated about the same for this category.

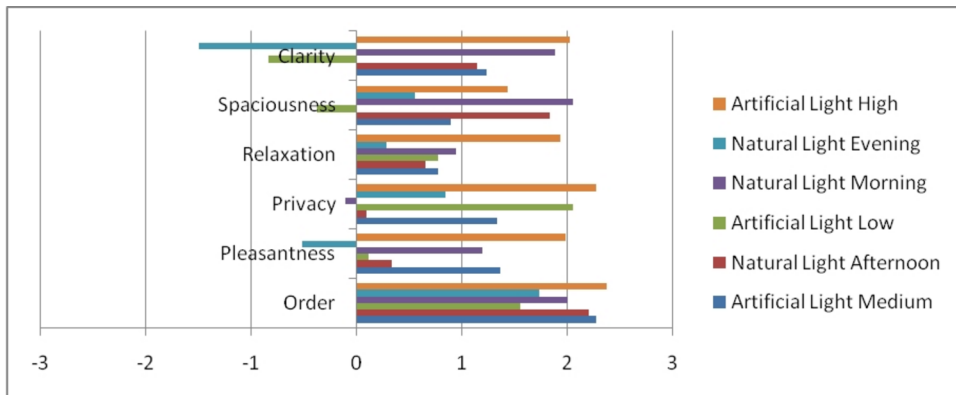


Figure14: Female Ratings of Spaces

Figure 15 compares male ratings for the six spaces. Clarity was rated highest for natural light in the morning. They also had positive ratings for the space with artificial light set to a high level of brightness. The space with natural light in the morning and the space with artificial light set to a high level of brightness were also the two spaces rated highest in clarity for female subjects. Natural light set in the evening and artificial light set to a low level of brightness were also the rated the lowest for males, although they were not rated quite as negatively for males as they were for females.

The males rated the natural light set in the morning and the natural light in the afternoon as the most spacious, just as the females did. The males still viewed artificial light set to low as least spacious, but, again, their ratings were not as negative as the female's. They also rated natural light in the evening and afternoon higher than the female's for the category of spaciousness.

The most relaxing spaces were artificial light set to a high level of brightness, natural light in the morning, and natural light in the afternoon. While the females rated these spaces positively, the ratings for males were significantly higher.

Privacy ratings were highest for artificial light high and close behind in ratings were artificial light set to a low level of brightness and artificial light set to a medium level of brightness.

Pleasantness had the highest ratings for artificial light high, just as the females. The women thought natural light in the evening was not very spacious, but the males rated every space higher in pleasantness than women.

The most positive ratings for order were natural light in the morning and artificial light high. Natural light in the afternoon and artificial light medium had the next highest ratings. These ratings were positive for women, but, again, males rated them even higher.

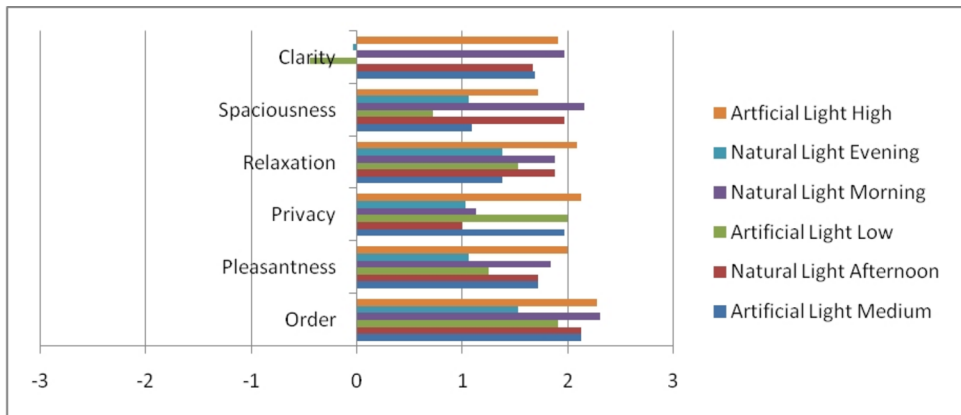


Figure15: Male Ratings of Spaces

A brief comparison between males and females in the ratings of each category are shown in Table 7:

Table 7: Summary of Male & Female Ratings

CATEGORY	SUMMARY OF RESULTS
Clarity	Regardless of the order in which the slides were presented, the rooms appeared to generally be rated in relation to their level of brightness. For both males and females, the brightest rooms tended to have the highest ratings for every category and the darkest rooms had the lowest ratings.
Spaciousness	The ratings under the category of spaciousness for both males and females were consistently higher in the spaces with natural light present, with the exception of the space with natural light set in the evening.
Relaxation	For males and females, the artificial light set to high was rated significantly higher than any other space as the most relaxing, and the natural light set in the evening was rated the least relaxing. Males also did not find the artificial light set to a medium level of brightness relaxing. The other spaces all ranked about the same for the level of relaxation.
Privacy	Males and females both ranked privacy highest for all the spaces lit strictly by artificial light. Ratings were lowest for natural light in the morning and natural light in the afternoon.
Pleasantness	Pleasantness had the highest ratings for artificial light set on high and lowest for natural light set in the evening for both males and females.
Order	Order was rated highest for the spaces with artificial light, but it was also rated high for natural light in the afternoon and artificial light set to a medium level of brightness. The remaining rooms were rated about the same. In this category, the ratings seemed to be lowest for the darkest spaces and grew higher as the spaces became brighter, regardless if the space was lit with natural or artificial light.

The open-ended remarks at the end of the questionnaire provided more insight into why subjects rated the spaces as they did.

Comments from female subjects:

Female Comment 1-“The time of day was a factor. It made a gorgeous room feel gloomy. The darker rooms were not as pleasant.”

Female Comment 2-“Slide 4 was the most comfortable because of the windows and light coming through. No natural daylight made it less clear and less comfortable.”

Female Comment 3-“The rooms with more light were more relaxing.”

Female Comment 4-“It felt more relaxed and private for the dark rooms. When windows were the focal point, they made it seem clearer, opened, and ordered.”

Female Comment 5-“Space #1 looks cold with the colors and lighting. Space #2 is also cold, but I liked the windows. Space #3 looks cozy with low lighting and a fireplace, but not my style. I liked the openness of Space #4. Space #5 was too dark, even with windows. Space #6 looks cozy.”

Female Comment 6-“I liked the windows and sunlight. I also liked the simplicity of the rooms.”

Female Comment 7-“The rooms with the fireplace and bookshelves were more relaxing and pleasant.”

Female Comment 8-“The windows make the space pleasant and clear but the dim rooms with lamps were also pleasant because they reminded me of reading a book next to a cozy fire.”

Female Comment 9-“The more lighting made it more pleasant, ordered, clear, and public. The room was more stressed with more light.”

Female Comment 10-“When the rooms were darker, they were more relaxed and more spacious when brighter. There was more privacy when they were darker too.”

Female Comment 11-“I was not wild about the grey color scheme. It reminds me of an office.”

Female Comment 12-“The windows in rooms 2, 4, and 5 make it feels more open.”

Female Comment 13-“The windows made it less private, but they also made the room appear larger.”

Female Comment 14-“The brighter the space, the more inviting it was.”

Female Comment 15-“Spaces #4 and #6 were my favorite because of the lighting.”

Female Comment 16-“The well lit spaces were more public.”

Female Comment 17-“I rated order by the arrangement of the furniture. I thought the rooms with bookcases looked more ordered.”

Comments from male subjects:

Male Comment 1-“More lighting was more pleasant. The dark shadows made me think disorder.”

Male Comment 2-“I prefer a darker room to relax. The brighter rooms felt more intense.”

Male Comment 3-“Space #6 was the most pleasant and relaxing. Space #5 was dark and gloomy. The rooms with the window were more pleasant but less private.”

Male Comment 4-“I can relax more with natural light.”

Male Comment 5-“I felt the rooms were disordered because of the arrangement of furniture. It’s not the arrangement I would’ve chosen. I am a fan of non-natural lighting but when it’s too intense, it’s distracting.”

While males did not give as many insights as females with responses to the open-ended question, the majority of comments were consistent with the mean values established for each space in Figures 14 and 15.

Some comments supported the belief that the brightness of the spaces as well as the presence or absence of windows played a role in how subjects rated the spaces. *Female Comment 1* stated, "The time of day was a factor. It made a gorgeous room feel gloomy. The darker rooms were not as pleasant." Referring to Figure 14, this is consistent with the data as the space with natural light set in the evening had the most negative feelings when compared to the other spaces. *Female Comment 13* believed that the windows made it less private but did make the room appear larger and *Female Comment 4* stated that windows made the space appear clearer, opened, and ordered. These statements were also consistent with the rankings as the rooms with windows had the highest ratings in spaciousness, but also the lowest for privacy.

Male comments concurred with female comments. *Male Comment 1* stated, "More lighting was more pleasant. The dark shadows made me think disorder," and *Male Comment 4* stated, "I can relax more with natural light."

One male participant, however, commented in *Male Comment 2* that darker rooms were more relaxing and the brighter rooms were more intense. While this comment is not necessarily consistent with the data in Figure 15 since males rated the brighter spaces as the most relaxing, it is interesting to note that this comment is consistent with the findings of the study of Durak *et al.* (2006), which found that subjects felt more relaxed in rooms with lower luminance levels.

Both female and male comments gave insight that the type and arrangement of furnishings alone could have affected the ratings. Three female comments inferred that the replacement of windows with a fireplace and bookcases in the rooms with artificial light changed the feeling of the space. *Female Comment 7* stated, "The rooms with the fireplace and bookshelves were more relaxing and pleasant," while *Female Comment 8* stated, "The windows make the space pleasant and clear but the dim rooms with lamps were also pleasant because they reminded me of reading a book next to a cozy fire." In agreement with the previous comments, *Female Comment 7* stated, "I rated order by the arrangement of the furniture. I thought the rooms with bookcases looked more ordered." *Male Comment 5* also stated that the participant felt the rooms felt more disordered due to the arrangement of furniture.

Along with the furniture arrangement, the color scheme of the room may have also invoked negative feelings as *Female comment 11* stated, "I was not wild about the grey color scheme. It reminds me of an office." Although this study was looking at impressions of the interior spaces based on natural and artificial light, some subjects may have focused more on the furniture present. As the living room is a more personal space than an office, it is understandable that every individual may have his or her own beliefs of the type and amount of items that should or should not be present in the space.

Discussion and Conclusions

The purpose of this study was to see male and female respond to changes in artificial and natural lighting in an interior living room space. Subjects rated the spaces on the aspects of clarity, spaciousness, relaxation, privacy, pleasantness, and order. Six rendered images of a living room space were consisted of three spaces lit strictly by artificial lighting set to a low level of brightness, a medium level of brightness, and a high level of brightness as well as three spaces lit strictly by natural lighting from a window with the sun set in the morning, the sun set in the afternoon, and the sun set in the evening. The six spaces were then presented in a random order in a slideshow format to 75 male and 75 female college students between the ages of 18 and 25. Each image was labeled to correspond with questions on a questionnaire.

The questionnaire consisted of semantic differential scales for subjects to rate their impressions of each space. Under each category of clarity, spaciousness, relaxation, privacy, pleasantness, and order, there were two bipolar terms which represented negative and positive impressions. For clarity, the terms were blurred and clear. For spaciousness, the terms were closed and open. For relaxation, the terms were stressed and relaxed. For privacy, the terms were public and

private. For pleasantness, the terms were unpleasant and pleasant. For order, the terms were disordered and ordered.

While it was hypothesized that the greatest preferences in all categories would be for the space with natural light with the sun set in the morning (Figure 1), the findings of this study implied that there was no strong preference toward natural or artificial light; the way in which subjects rated a space seemed to depend, instead, on the overall brightness of the space as well as the category being rated. The most positive ratings overall appeared to be for the space with the artificial light set to a high level of brightness and the space with natural light set in the morning.

The first question asked if natural or artificial lighting had a significant impact on an individual's impressions of a room and in what ways. The second question asked if there was a stronger preference toward either natural or artificial lighting. Again, the preferences toward natural or artificial light seemed to depend on the category being rated, but there were some significant differences between the spaces with natural or artificial for the categories of spaciousness and privacy. It can reasonably be concluded that windows make an area appear more spacious as both men and women consistently rated the two brightest rooms with windows present as the most spacious. It can also be concluded that individuals felt a sense of privacy in the spaces in which windows were not present as the highest ratings were for the three spaces lit strictly by artificial light at various levels.

The next question asked if the time of day through a window view or the brightness of bulbs played a role. It did not seem that the time or day or brightness of bulbs played a role in the rating of spaces, but, rather the overall brightness of the space did. These spaces had a large impact on clarity and order. The brightest spaces, such as the artificial light set on a high level of brightness and natural light set in the morning, had the highest ratings in clarity for both men and women. Order was rated highest for the spaces with artificial light, but it was also rated high for natural light in the afternoon and artificial light set to a medium level of brightness.

The last question asked if gender had an impact on feelings toward a space. Gender did not appear to make a significant difference in ratings of the spaces as both men and women generally rated the spaces in the same manner. While both males and females did not rate some spaces as high as others in some categories, females rated some spaces drastically lower than males. In the space with artificial light set to a low level of brightness, both males and females rated the space lower in spaciousness than every other space, the female mean value was in the negatives at -0.37, male mean value was low, but still in the positive range at 0.72. For natural light in the morning, privacy was rated lowest for both the males and females, but, again, the female mean value was negative at -0.10 while the male mean value was 1.13. For the space with natural light set in the evening, pleasantness females rated the space at -0.51 and males rated the space at 1.06. While females and males both rated the spaces in the same manner, females seemed to be more firm on the scale with their negative or positive opinions of the space.

While it was hypothesized that the greatest preferences for each category would be for the space with the brightest natural light, the most positive ratings depended on the aspects of the space and varied by category. Generally, the highest ratings were for the brightest spaces, regardless of the use of natural or artificial light.

The results of this study indicated that there was no significant difference in impressions of the spaces for males and females. Regardless of the order in which the slides were presented, the rooms appeared to generally be rated in relation to their level of brightness. For both males and females, the brightest rooms tended to have the highest ratings for every category and the darkest rooms had the lowest ratings. The ratings under the category of spaciousness for both males and females were consistently higher in the spaces with natural light present, with the exception of the space with natural light set in the evening. For males and females, the brightest spaces were rated as the most relaxing. Males and females seemed to both rank privacy in direct

relation to the presence or absence of windows; privacy ranked highest for all the spaces with only artificial light. Pleasantness had the highest ratings as well for the brightest spaces, such as artificial light set on high. Order was rated highest for the spaces with artificial light, but it was also rated high for natural light in the afternoon and artificial light set to a medium level of brightness. In this category, the ratings seemed to be lowest for the darkest spaces and grew higher as the spaces became brighter, regardless if the space was lit with natural or artificial light.

It is interesting to compare the findings of this study with the findings of the study performed by Durak *et al.* (2006). Durak studied the qualitative aspects of a space by different lighting arrangements such as general lighting, wall washing, and cove lighting. In this study, subjects also rated a room based on clarity, spaciousness, relaxation, privacy, pleasantness, and order. Although it focused strictly on interior artificial lighting arrangements, some results were similar to those found in this study. For instance, in Durak *et al.*, subjects rated rooms higher in clarity with higher luminance levels. In this study, subjects also rated the brightest spaces highest in clarity. Findings differed, however, for the categories of relaxation, privacy, and order. Durak *et al.* (2006) found that people rated rooms more relaxing, private, and ordered at lower luminance levels. This study found that people rated the brightest rooms highest in relaxation and order, and privacy was rated highest in rooms in which there were no windows present. Again, the study of Durak *et al.* did not directly compare natural and artificial lighting. Pleasantness was also found to be enjoyed at higher levels of brightness, while Durak *et al.* found that it was enjoyed at both high and low levels of luminance.

Limitations of the Study

The colors of the room may have had an effect on the ratings of the spaces. Research has shown that “cool” colors like blue and green are perceived as “relaxing” while “warm” colors like reds and oranges are perceived as more “active and stimulating.” The color palette in the rendered images was kept neutral to avoid mixing these impressions with those from the natural and artificial light. Some subjects, however, may have rated some spaces negatively, especially under the category of pleasantness, because of their first impression of the color scheme. For example, referring to *Female Comment 11*, one participant commented, “I was not wild about the grey color scheme. It reminds me of an office.”

Another factor may have been the room layout as some subjects rated the rooms strictly on the type of and arrangement of furniture. *Male Comment 5* stated, “I felt the rooms were disordered because of the arrangement of furniture. It’s not the arrangement I would’ve chosen.” If a subject’s first impressions of the spaces were negative, it may have affected his or her ratings when considering the categories. Also, some of the terms used may have been unclear and their definitions may have differed from person to person.

The color of lighting has also proven to have an effect on human impression. In a real interior space, different types of artificial lighting have various color temperatures. For this study, adding variations in the color temperature would have added too many variables. It would also be difficult to control the lighting color or exact luminance.

Another concern may have been the layout of the slides. The slides were presented in a random order to avoid subjects immediately noticing the presence or absence of windows. This may, however, have affected the subjects’ ratings as they may have rated the first space very high, perhaps at a “3,” but then found the next space more pleasing than the previous, but were unable to change their previous ratings.

Opportunities for Future Work

- A study conducted with older age group to see how their ratings compare to those ratings of the 18–25 age group for the categories of clarity, spaciousness, relaxation, privacy, pleasantness, and order.
- Other examples of interior spaces like kitchens, bedrooms, and studies could be used. This experiment looked strictly at what was preferred in a living room setting. The expected perception of how other rooms will most likely vary greatly. A kitchen, for instance, is often viewed as a women's space values and perceptions of a space such as this might vary between genders. To prevent the presence of too many variables, spaces in this study were presented with only natural light or artificial light.
- Combine both natural and artificial lighting arrangements to see how it would affect these categories. Spaces could also be presented in a virtual environment where subjects could navigate through the space in real time as they rated them.
- Use life-sized mock-ups spaces.
- Use images with natural light would yield a better measure of the subscale set and/or additional variables that highlight the differences between natural and artificial lighting.

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Appendix A Questionnaire

Q1) Please circle one of the following:

Age:		18	19	20	21	22	23	24	25
Gender:	Male	Female							
Major:									

Q2) Please rate your feelings towards Space #1 based on the following:

Clarity								
Blurred	-3	-2	-1	0	1	2	3	Clear
Spaciousness								
Closed	-3	-2	-1	0	1	2	3	Open
Relaxation								
Stressed	-3	-2	-1	0	1	2	3	Relaxed
Privacy								
Public	-3	-2	-1	0	1	2	3	Private
Pleasantness								
Unpleasant	-3	-2	-1	0	1	2	3	Pleasant
Order								
Disordered	-3	-2	-1	0	1	2	3	Order

Q3) Please rate your feelings towards Space #2 based on the following:

Clarity								
Blurred	-3	-2	-1	0	1	2	3	Clear
Spaciousness								
Closed	-3	-2	-1	0	1	2	3	Open
Relaxation								
Stressed	-3	-2	-1	0	1	2	3	Relaxed
Privacy								
Public	-3	-2	-1	0	1	2	3	Private
Pleasantness								
Unpleasant	-3	-2	-1	0	1	2	3	Pleasant
Order								
Disordered	-3	-2	-1	0	1	2	3	Ordered

Q4) Please rate your feelings towards Space #3 based on the following:

Clarity								
Blurred	-3	-2	-1	0	1	2	3	Clear
Spaciousness								
Closed	-3	-2	-1	0	1	2	3	Open
Relaxation								
Stressed	-3	-2	-1	0	1	2	3	Relaxed
Privacy								
Public	-3	-2	-1	0	1	2	3	Private
Pleasantness								
Unpleasant	-3	-2	-1	0	1	2	3	Pleasant
Order								
Disordered	-3	-2	-1	0	1	2	3	Ordered

Q5) Please rate your feelings towards Space #4 based on the following:

Clarity								
Blurred	-3	-2	-1	0	1	2	3	Clear
Spaciousness								
Closed	-3	-2	-1	0	1	2	3	Open
Relaxation								
Stressed	-3	-2	-1	0	1	2	3	Relaxed
Privacy								
Public	-3	-2	-1	0	1	2	3	Private
Pleasantness								
Unpleasant	-3	-2	-1	0	1	2	3	Pleasant
Order								
Disordered	-3	-2	-1	0	1	2	3	Ordered

Q6) Please rate your feelings towards Space #5 based on the following:

Clarity								
Blurred	-3	-2	-1	0	1	2	3	Clear
Spaciousness								
Closed	-3	-2	-1	0	1	2	3	Open
Relaxation								
Stressed	-3	-2	-1	0	1	2	3	Relaxed
Privacy								
Public	-3	-2	-1	0	1	2	3	Private
Pleasantness								
Unpleasant	-3	-2	-1	0	1	2	3	Pleasant
Order								
Disordered	-3	-2	-1	0	1	2	3	Ordered

Q7) Please rate your feelings towards Space #6 based on the following:

Clarity								
Blurred	-3	-2	-1	0	1	2	3	Clear
Spaciousness								
Closed	-3	-2	-1	0	1	2	3	Open
Relaxation								
Stressed	-3	-2	-1	0	1	2	3	Relaxed
Privacy								
Public	-3	-2	-1	0	1	2	3	Private
Pleasantness								
Unpleasant	-3	-2	-1	0	1	2	3	Pleasant
Order								
Disordered	-3	-2	-1	0	1	2	3	Ordered

Q8) Please record any comments you have toward the appearance of the spaces or why you believe you chose to rate the spaces as you did:

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