LEDucation®

Designers Light Forum

Can Changes in Color Temperature Influence Subjective Impressions of an Environment?

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

At the end of the this course, participants will be able to:

1. Understand the basic principles of the Flynn work on subjective impressions of lighting systems.
2. Recognize the limitations of the Flynn studies on the influence of color temperature on subjective impressions
3. Understand the parameters of the study of chromaticity using tunable white on subjective impressions of an environment
4. Recognize the implications for design using tunable white to reinforce subjective impressions in an environment

The Influence of Chromaticity on Subjective Impressions in Lighted Environments

- *Introduction*
- *Methodology*
- *Results*
- *Conclusion*

The Influence of Light on Subjective Impressions

- Flynn Studies (“Psychology of Light”)

psy·chol·o·gy

Function: *noun*
Etymology: New Latin *psychologia,* from *psych-* + *-logia* -logy
1 : the science of mind and behavior
2 a : the mental or behavioral characteristics of an individual or group **b :** the study of mind and behavior in relation to a particular field of knowledge or activity
3 : a treatise on psychology

The Psychology of Lighting

- The Influence of Light on Preference
- The Influence of Light on Perception
- The Influence of Light on Impressions
- The Influence of Light on Behavior
- The Influence of Light on Mood

The Influence of Light on Subjective Impressions

- Flynn Studies (“Psychology of Light”)
- Supposition that lighting can have a significant effect on user attitudes & the atmosphere created by an environment by communicating consistent patterns of impressions among occupants

The Influence of Light on Subjective Impressions

- Kent State/GE Studies: 1971-1975
- Penn State Studies: 1975-1979

The Influence of Light on Subjective Impressions

- Two Research Techniques:
  - Semantic Differential Rating Scales
  - Multi-Dimensional Scaling

Semantic Differential Rating Scales

visually warm :_____:_____:_____:_____:_____:_____:_____: visually cool
dislike :_____:_____:_____:_____:_____:_____:_____: like
simple :_____:_____:_____:_____:_____:_____:_____: complex
pleasant :_____:_____:_____:_____:_____:_____:_____: unpleasant
hazy :_____:_____:_____:_____:_____:_____:_____: clear
public :_____:_____:_____:_____:_____:_____:_____: private
confined :_____:_____:_____:_____:_____:_____:_____: spacious
relaxing :_____:_____:_____:_____:_____:_____:_____: tense
bright :_____:_____:_____:_____:_____:_____:_____: dim
stimulating :_____:_____:_____:_____:_____:_____:_____: subduing
distinct :_____:_____:_____:_____:_____:_____:_____: vague
colorful :_____:_____:_____:_____:_____:_____:_____: colorless
functional :_____:_____:_____:_____:_____:_____:_____: non-functional
ordinary :_____:_____:_____:_____:_____:_____:_____: special
cluttered :_____:_____:_____:_____:_____:_____:_____: uncluttered
comfortable:_____:_____:_____:_____:_____:_____:_____: uncomfortable

Categories of Impression

- Impressions of Visual Clarity
- Impressions of Spaciousness
- Impressions of Relaxation
- Impressions of Privacy or Intimacy
- Impressions of Pleasantness and Preference
- Impressions of Warmth or Coolness

Lighting Modes

- Uniform / Non-Uniform Mode
- Overhead / Peripheral Mode
- Bright / Dim Mode
- Visually Warm / Visually Cool Mode

Lighting Reinforcement of Subjective Effects

Impression of Visual Clarity	• Bright, uniform lighting mode • Some peripheral emphasis, such as with high reflectance walls or wall lighting
Impression of Spaciousness	• Uniform, peripheral (wall) lighting • Brightness is a reinforcing factor, but not a decisive one
Impression of Relaxation	• Non-uniform lighting mode • Peripheral (wall) emphasis rather than overhead lighting
Impression of Privacy or Intimacy	• Non-uniform lighting mode • Tendency toward low light levels in the immediate locale of the user, with higher brightnesses remote from the user • Peripheral (wall) emphasis is a reinforcing factor, but not a decisive one
Impressions of Pleasantness and Preference	• Non-uniform lighting mode • Peripheral (wall) emphasis

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Impressions of Pleasantness and Preference	• Non-uniform lighting mode • Peripheral (wall) emphasis

Lighting Reinforcement of Subjective Effects

Table 12.2 | Subjective Impressions

Impression	Lighting Modes[a,b,c]	Design Implications	Example Reinforcing Techniques[d]	Typical Applications
Preference	• Perimeter • Nonuniform • Bright	• Use perimeter nonuniform lighting. Brighter effects help, but not necessary.	• A window wall or accenting a wall **AND** • Accenting wall art or accenting one or several architectural or material features and/or using decorative lighting, such as pendants, sconces, or table or floor lights placed intermittently around edges of room or area	• Most spaces • See Figure 12.12 • See Figure 12.13
Privacy	• Nonuniform • Dim • Perimeter	• Use nonuniform relatively dim lighting. Emphasis at periphery helps, but not necessary.	• Dim and somewhat spotty lighting effects from downlighting or using dim decorative lighting, such as pendants, sconces, or table or floor lights	• Upscale clubs • Upscale restaurants • Some residential spaces • Meditation spaces • See Figure 12.13
Relaxation	• Perimeter • Nonuniform • Dim	• Use perimeter nonuniform lighting. Dimmer effects help, but not necessary.	• Wallwashing one or two darker-toned walls or features or dim wallwashing one or two lighter-toned walls or features **AND** • Softly accenting select art and/or several architectural or material features and/or using decorative lighting, such as pendants, sconces, or table or floor lights placed intermittently around edges of room or area	• Casual areas • Conference rooms • Lounges • Sit-down restaurants • Waiting areas

Lighting Reinforcement of Subjective Effects

Table 12.2 | Subjective Impressions

Impression	Lighting Modes[a,b,c]	Design Implications	Example Reinforcing Techniques[d]	Typical Applications
Spaciousness	• Uniform • Perimeter • Bright	• Use uniform wall lighting. Brighter effects help, but not necessary.	• Window walls for at least two walls and/or wallwashing at least two walls ; consider wall reflectances of 60% or more for at least half the walls to be lighted	• Circulation • Assembly spaces • See Figure 12.14
Visual Clarity	• Bright • Perimeter • Uniform	• Create bright ceiling and worksurfaces with some emphasis on periphery. Uniform effects help, but not necessary.	• Skylights, relatively bright recessed lensed modular luminaires, recessed direct/indirect modular luminaires, or downlighting mixed with uplighting; consider ceiling reflectances of 90% **AND** • Window walls and/or wallwashing	• Work spaces • See Figure 12.15

a. Lighting modes are listed in order of most influential first.
b. Dim and bright are used in a relative sense. No quantitative design values are available. Surface reflectances affect senses of dim and bright.
c. Nonuniform as used here means that the patterns of light are applied intermittently, but not in a completely random or haphazard manner. Uniform indicates that the pattern or patterns of light are consistently or regularly arranged.
d. Daylight or electric light can be employed to achieve reinforcing techniques. Subjective impressions' techniques are combined with other lighting techniques as necessary to meet other design criteria.

Lighting Reinforcement of Subjective Effects

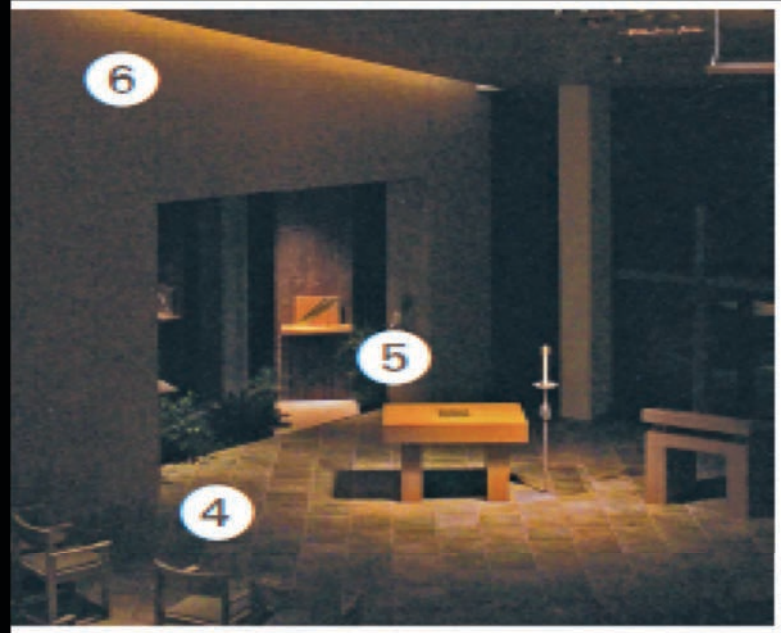


Figure 12.13 | Privacy and Preference
In a dimmed meditation scene, nonuniform lighting is used to define a dim zone in the vicinity of users ❹. Here, the adaptation effect created by bright focals relative to the dim background makes the dim seating areas appear even dimmer. Strong luminances achieved with CMH spotlights on the altar and tabernacle ❺ relative to the uniform but low-level house lighting allow for personal meditation in anonymity. In the users' periphery, the fluorescent slot ❻, although on dim setting, provides subtle wall accenting and works with the accenting of the tabernacle and altar to enhance preference impressions.
» Image ©2005 Gene Meadows

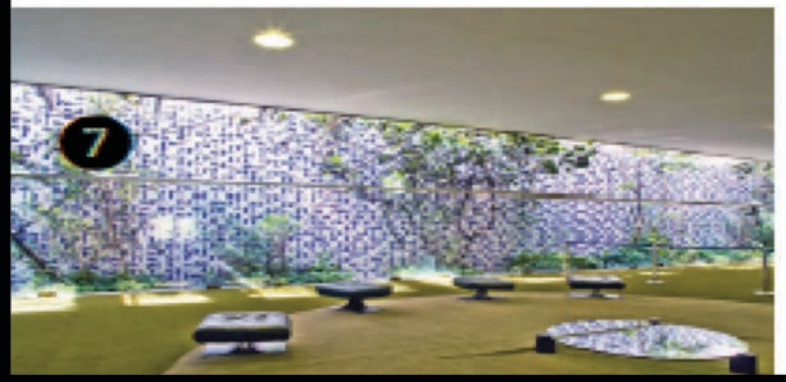


Figure 12.14 | Spaciousness
Uniform wall lighting elicits an impression of spaciousness ❼ at The Congresso Nacional do Brasil. Daylight is employed to achieve the uniform wall lighting in this lobby area.
» Image ©Alan Weintraub/Arcaid/Corbis

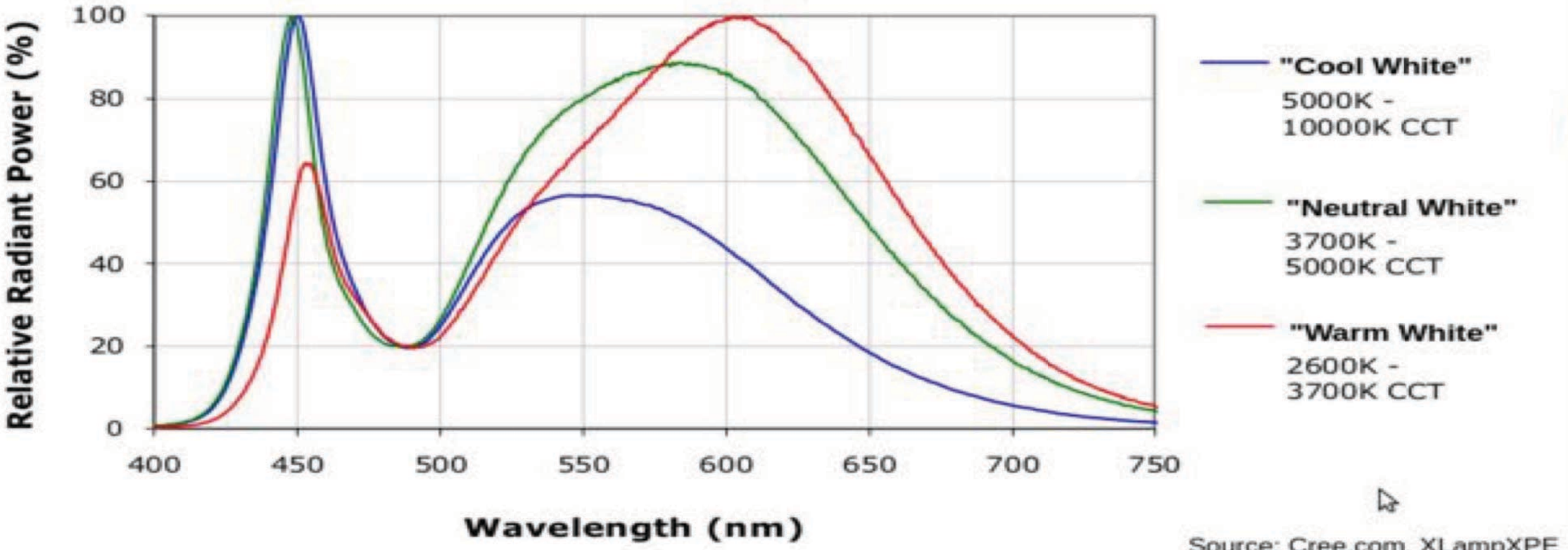
Lighting Reinforcement of Subjective Effects

Figure 12.15 | Visual Clarity
A uniform pattern of skylights offer a bright ceiling plane ❽. Skylighting combines with down-lighting and table lights to create a bright work plane zone. Wall lighting is uniform and bright ❾. All of which contributes to an impression of visual clarity—deemed an important factor for this adult reading area in a community library.
» Image ©Balthazar Korab Photography Ltd.

Flynn Study Sources

- *Incandescent*
- *Fluorescent*
  - *Cool white (4200 K; 62 CRI)*
  - *Warm white (3000 K; 51 CRI)*
- *Cool Deluxe Mercury (3900 K; 49 CRI)*
- *Phosphor Coated Metal Halide (3900 K; 65 CRI)*
- *High Pressure Sodium (2100 K; 24 CRI)*

White LED Spectra



The Influence of Chromaticity on Subjective Impressions in Lighted Environments

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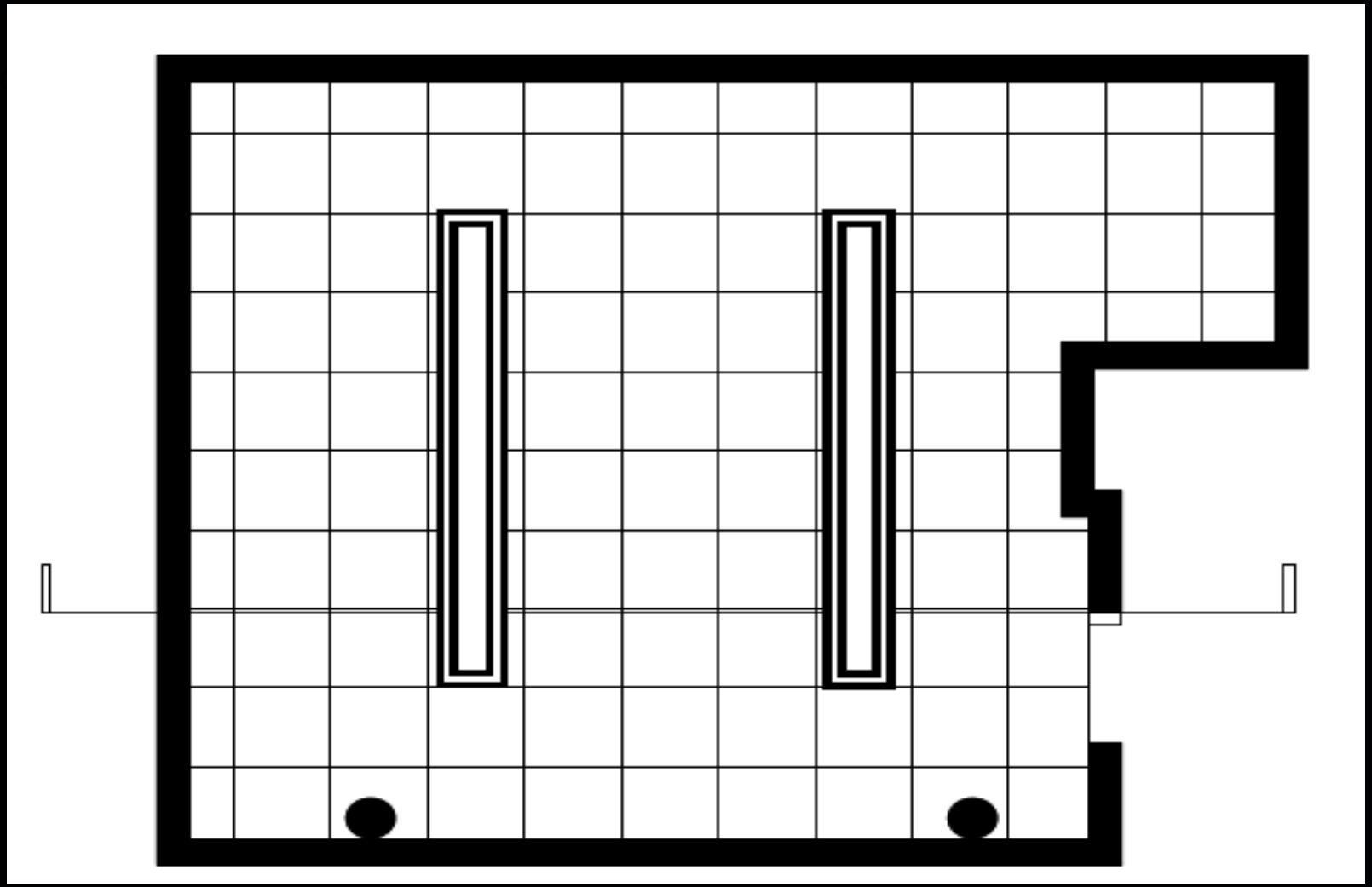
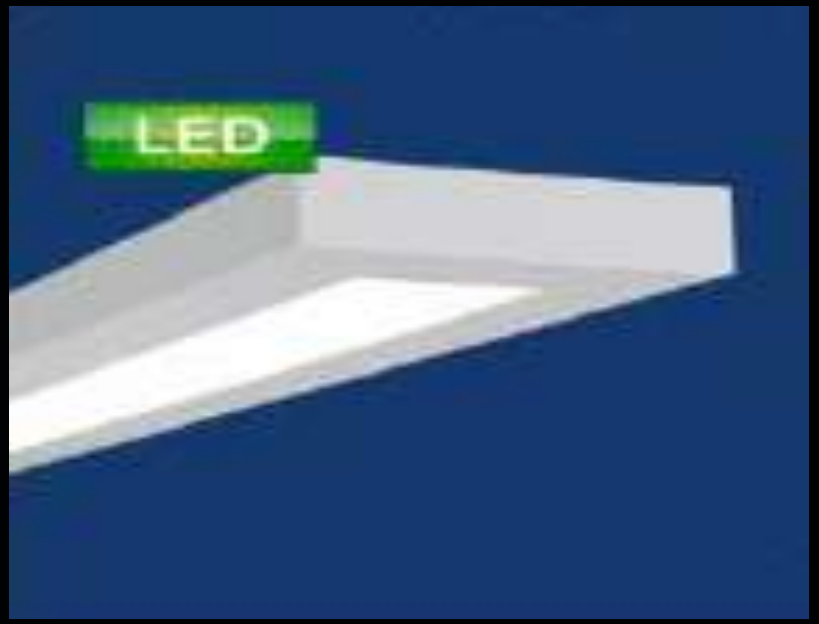
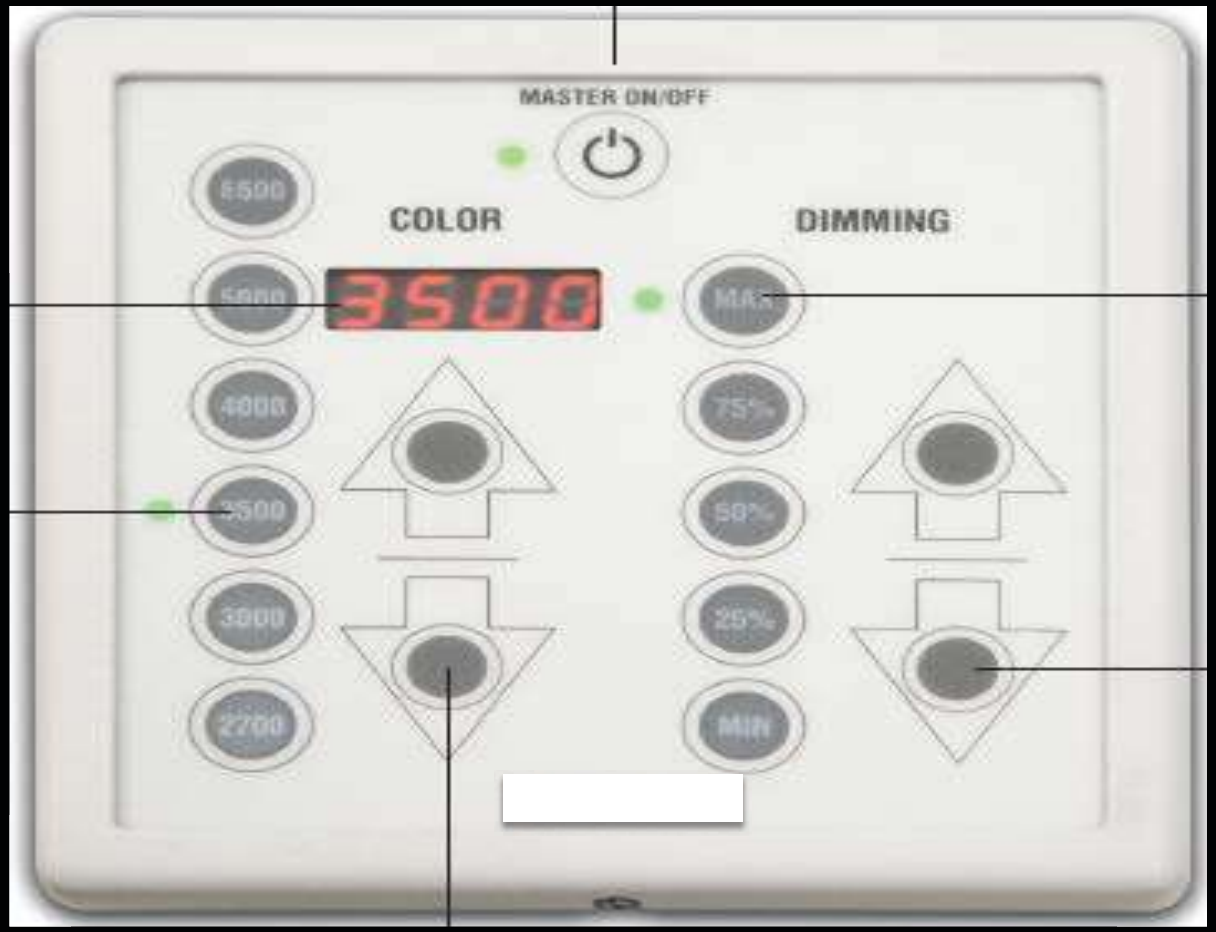
Reflected Ceiling Plan View of Experimental Room Showing Luminaire Locations

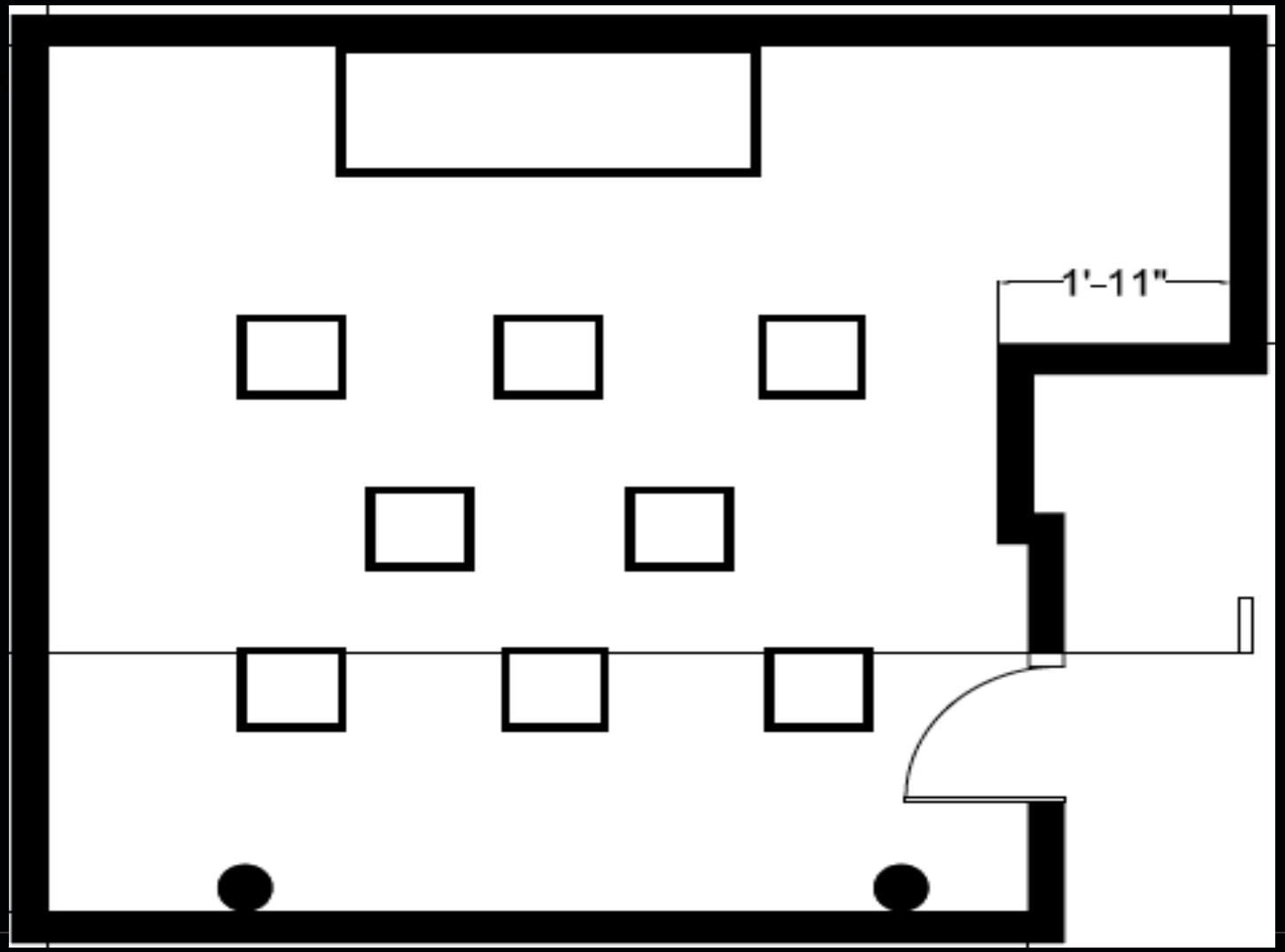


Experimental Room Luminaires & Controls





Plan View of Experimental Room Showing Subject Seating Locations



Experimental Conditions

- *Six color temperatures (2700, 3000, 3500, 4000, 5000, 6500)*
- *Twenty-eight subjects*
- *Overhead-peripheral, uniform-non-uniform, and bright dim (50 f.c.) held constant*
- *Illuminance and CCT measurements taken at all CCT levels to ensure consistency*
- *Two parts to testing (two dependent variables):*
  - *Ratings of each CCT on semantic-differential rating scales*
  - *Ratings of differences between paired color temperatures on scale of 1-10*

Flynn, 1979

IERI

A guide to methodology procedures for measuring subjective impressions in lighting

A major objective of IERI Project 92 has been the development of a research methodology for studying psychological and related subjective effects of illumination. In this sense, the study has made note of two aspects of human behavior that might be influenced, to some extent, by spatial illumination: (1) the effect of light on subject impression and attitude; and (2) the effect of light on performance and overt behavior. The

Experimenter Instructions (from Flynn, 1979)

APPENDIX 1

NARRATIVE INSTRUCTIONS FOR USE WITH BI-POLAR RATING SCALES

(room is prepared with an 'initial light setting'; subjects enter, and select seats; booklets with rating forms are at each seat location, with a blank cover sheet facing up)

experimenter: (read slowly) "THE RESEARCH YOU ARE PARTICIPATING IN TODAY IS PART OF A BROADER PROJECT STUDYING THE EFFECT OF ENVIRONMENTAL FACTORS ON SEVERAL KINDS OF HUMAN BEHAVIOR.

"THERE ARE SEVERAL PARTS TO THE RESEARCH THAT YOU CAN HELP US WITH TODAY. WE WILL EXPLAIN EACH ONE TO YOU AS WE GO ALONG.

"FIRST, YOU WILL NOTICE THAT THERE IS A GROUP OF FORMS BEFORE YOU ON THE TABLE. THE SPECIFIC INSTRUCTIONS ARE GIVEN ON THE FIRST PAGE."

(pause to allow each subject to turn over the blank cover page before him --- revealing an instruction sheet. copy of instruction sheet is on the following page in this attachment)

experimenter: "I'LL GO THROUGH THESE INSTRUCTIONS WITH YOU TO MAKE SURE WE'RE COMPLETELY CLEAR CONCERNING THE PROCEDURE."

(go to instruction sheet on the following page; read instructions aloud, while subjects follow along on their sheet)

The first thing you are to do is to rate this room on several rating scales. We are interested in the impressions, images, and moods this room has created for you. Of course, in some respects this room is unique, different from any other room you have seen. At the same time there are undoubtedly many similarities to other rooms you have seen. While you make the ratings we would like for you to take into account your past experience with various kinds of other rooms. In other words, you are to judge this room in terms of your past experience with other rooms.

The ratings are done in the following manner. If you would describe the room as very good, place an X on the scale as shown below:

bad : : : : : : X : good

If you feel the room is very bad, the X would be placed at the other end of the scale:

bad : X : : : : : : good

If you feel the room is moderately good or moderately bad, the X would be placed as follows:

bad : : : : : X : : good

OR

bad : X : : : : : : good

If you feel the room is only slightly good or slightly bad, the X would be placed as follows:

bad : : : : X : : : good

OR

bad : : X : : : : : good

Finally if you feel the room is neither good nor bad, the X would be placed in the middle of the scale representing a neutral position.

bad : : : X : : : : good

Each rating should be made in a similar fashion. Be sure to read both words at each end of a scale before you decide where to make the X. There are no right or wrong answers to this task in the usual sense. We want your subjective judgment concerning how the room appears to you.

(return to narrative without reference to instruction sheet)

"WE'LL NOW RATE THE ROOM.

"AFTER YOU'VE COMPLETED YOUR RATINGS, PLEASE TURN YOUR RATING FORM FACE DOWN ON THE TABLE (DESK) IN FRONT OF YOU --- AND YOU'LL RECEIVE FURTHER INSTRUCTIONS SHORTLY."

(subjects turn over instruction sheet to find a bi-polar rating form similar to FIGURE 1; subjects rate the room)

(after all subjects have completed ratings, experimenter will collect the 'initial' rating forms --- and distribute

UPON THE IMPRESSIONS AND MOODS CREATED FOR INDIVIDUALS USING THAT ROOM. AT THIS POINT, I'LL SHOW YOU SEVERAL DIFFERENT WAYS THAT THIS ROOM CAN BE ARRANGED IN TERMS OF LIGHTING. EACH SETTING WILL BE SHOWN FOR ABOUT 10-15 SECONDS, AND THERE WILL BE ____ SUCH SETTINGS.

"WHILE I AM SHOWING YOU THESE SETTINGS, PLEASE PAY ATTENTION TO THE KINDS OF IMPRESSIONS AND MOODS THAT THE SETTING SEEMS TO CREATE FOR YOU.

AFTER YOU HAVE BEEN SHOWN ALL ____ SETTINGS, WE WILL GO THROUGH THEM AGAIN, ONE AT A TIME. AFTER YOU'VE HAD A CHANCE TO ADAPT TO EACH SETTING DURING THIS SECOND SHOWING, YOU WILL BE ASKED TO RATE THE MOODS AND IMPRESSIONS CREATED BY THAT ARRANGEMENT ON A RATING SHEET LIKE THE ONE YOU INITIALLY COMPLETED.

"SO NOW I'LL BRIEFLY SHOW YOU THE DIFFERENT LIGHT SETTINGS."

(show the ____ light settings in the sequence that is applicable to group being tested; allow approximately 10-15 seconds for each in the initial showing)

experimenter: "NOW THAT YOU'VE HAD A BRIEF EXPOSURE TO ALL OF THE LIGHT SETTINGS, WE WOULD LIKE TO HAVE YOU RATE EACH OF THEM. USE THE NEXT FORM IN YOUR SERIES. IT WILL READ ____ AT THE TOP RIGHT. THIS NOTATION IDENTIFIES THE LIGHT SETTING.

"PLEASE DON'T TURN OVER THE COVER SHEET TO STUDY THE RATING FORMS YET."

(slight pause)

"EACH FORM IN THE BOOKLET IS EXACTLY LIKE THE ONE YOU COMPLETED EARLIER, AND THE RATINGS ARE MADE IN THE SAME WAY.

"THERE ARE ____ FORMS IN THE BOOKLET: ONE FOR EACH LIGHT SETTING. EACH FORM IS SEPARATED BY A BLANK SHEET.

"THE PROCEDURE FOR THE RATINGS IS AS FOLLOWS:

(1) VERY SHORTLY, I'LL SWITCH ON THE FIRST LIGHTING ARRANGEMENT.

(2) YOU'LL SIT APPROXIMATELY ONE-MINUTE WHILE YOUR EYES ADAPT TO EACH LIGHT SETTING. THEN I'LL ASK YOU TO TURN OVER THE BLANK COVER PAGE. AS I DO SO, I'LL CALL OUT THE NUMBER OF THE LIGHT SETTING. THIS NUMBER SHOULD BE THE SAME AS THE NUMBER IN THE UPPER RIGHT HAND CORNER OF THE FIRST RATING FORM IN YOUR BOOKLET. IF THE NUMBER IS NOT THE SAME, PLEASE CALL THIS TO MY ATTENTION.

(3) YOU MAY THEN BEGIN YOUR RATINGS OF THE LIGHT SETTING. STOP WHEN YOU COME TO THE NEXT BLANK SHEET.

(4) AFTER EVERYONE HAS COMPLETED THE FIRST RATING FORM, I'LL SWITCH TO ANOTHER LIGHT SETTING --- AND THE PROCEDURES WILL BE REPEATED UNTIL ALL ____ LIGHT SETTINGS HAVE BEEN RATED.

(5) IT IS IMPORTANT THAT YOU DO NOT BEGIN YOUR RATINGS OF A LIGHT SETTING UNTIL I TELL YOU TO DO SO."

(this last item is to insure that the subject goes through a period of adaptation to the new setting before the rating begins)

experimenter: "WHILE YOU ARE MAKING THESE RATINGS, PLEASE KEEP IN MIND THAT YOU ARE ASKED TO RATE THE MOODS, THE FEELINGS, THE IMPRESSION THAT THE LIGHT SETTING CREATES FOR YOU. BUT YOU ARE SPECIFICALLY ASKED TO MAKE THESE RATINGS IN TERMS OF COMPARISON (IN SO FAR AS YOU CAN) OF ONE LIGHT SETTING WITH THE OTHERS IN THE GROUP. IN OTHER WORDS, YOU WILL MAKE THE RATINGS OF A GIVEN LIGHTING ARRANGEMENT IN TERMS OF YOUR REMEMBERANCE OF THE EFFECTS CREATED FOR YOU BY THE OTHER LIGHT SETTINGS AS WELL.

"AGAIN, IN THIS EXPERIMENT, THERE ARE NO RIGHT OR WRONG ANSWERS AS SUCH. WE ARE INTERESTED IN YOUR SUBJECTIVE IMPRESSIONS."

(begin the ____ light settings; allow approximately 1-minute for adaptation to each before subjects turn over the blank sheet to begin the rating)

Semantic-Differential Rating Scales Used in Study (from Flynn, 1979)

beautiful	:	:	:	:	:	:	:	: ugly
hazy	:	:	:	:	:	:	:	: clear
large	:	:	:	:	:	:	:	: small
visually warm	:	:	:	:	:	:	:	: visually cool
dislike	:	:	:	:	:	:	:	: like
faces clear	:	:	:	:	:	:	:	: faces obscure
simple	:	:	:	:	:	:	:	: complex
pleasant	:	:	:	:	:	:	:	: unpleasant
glare	:	:	:	:	:	:	:	: no-glare
public	:	:	:	:	:	:	:	: private
confined	:	:	:	:	:	:	:	: spacious
relaxing	:	:	:	:	:	:	:	: tense
bright	:	:	:	:	:	:	:	: dim
stimulating	:	:	:	:	:	:	:	: subduing
distinct	:	:	:	:	:	:	:	: vague
satisfying	:	:	:	:	:	:	:	: frustrating
colorful	:	:	:	:	:	:	:	: colorless
functional	:	:	:	:	:	:	:	: non-functional
lively	:	:	:	:	:	:	:	: subdued
ordinary	:	:	:	:	:	:	:	: special
cluttered	:	:	:	:	:	:	:	: uncluttered
stable	:	:	:	:	:	:	:	: unstable

comments (if any): _____

_____

_____

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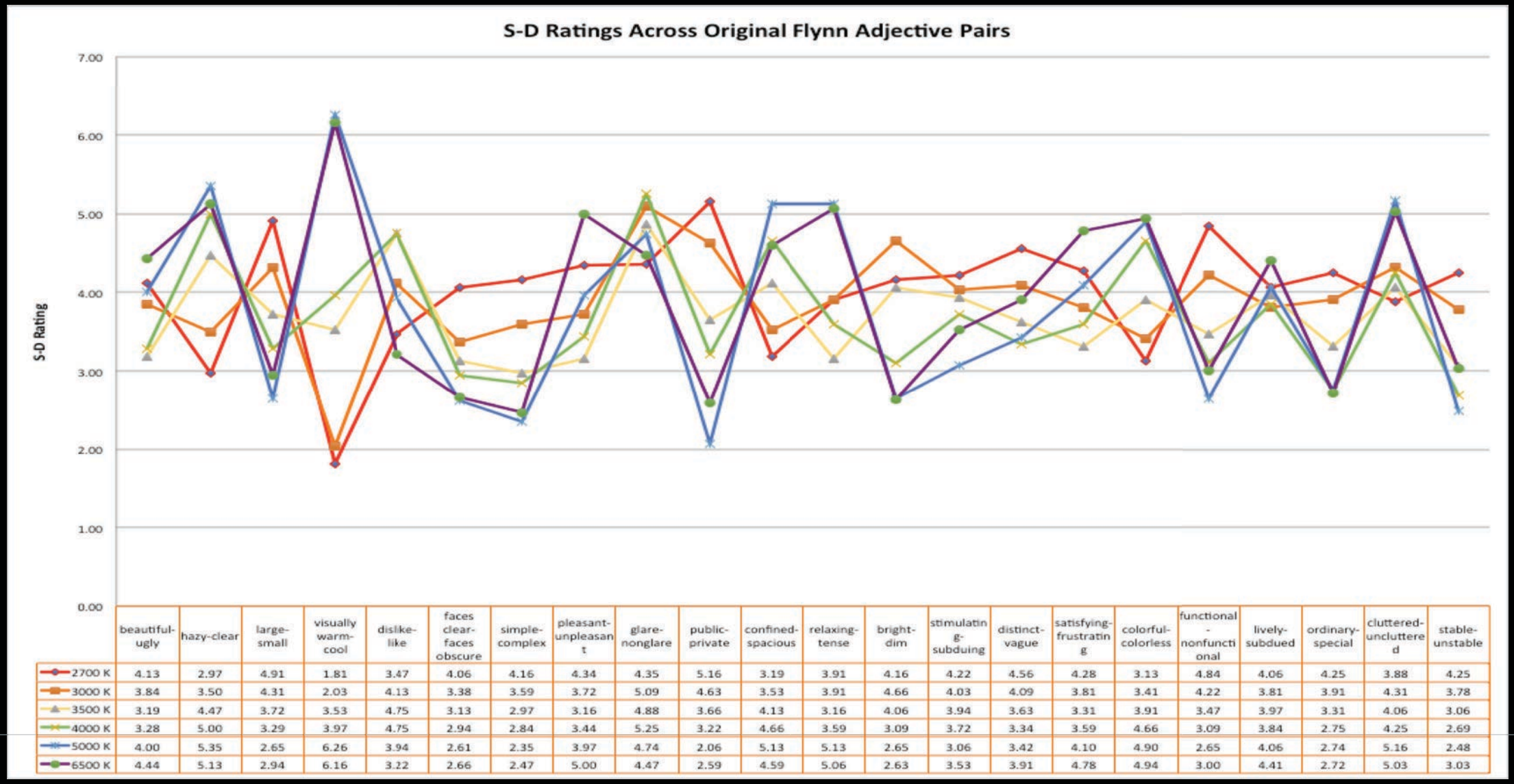
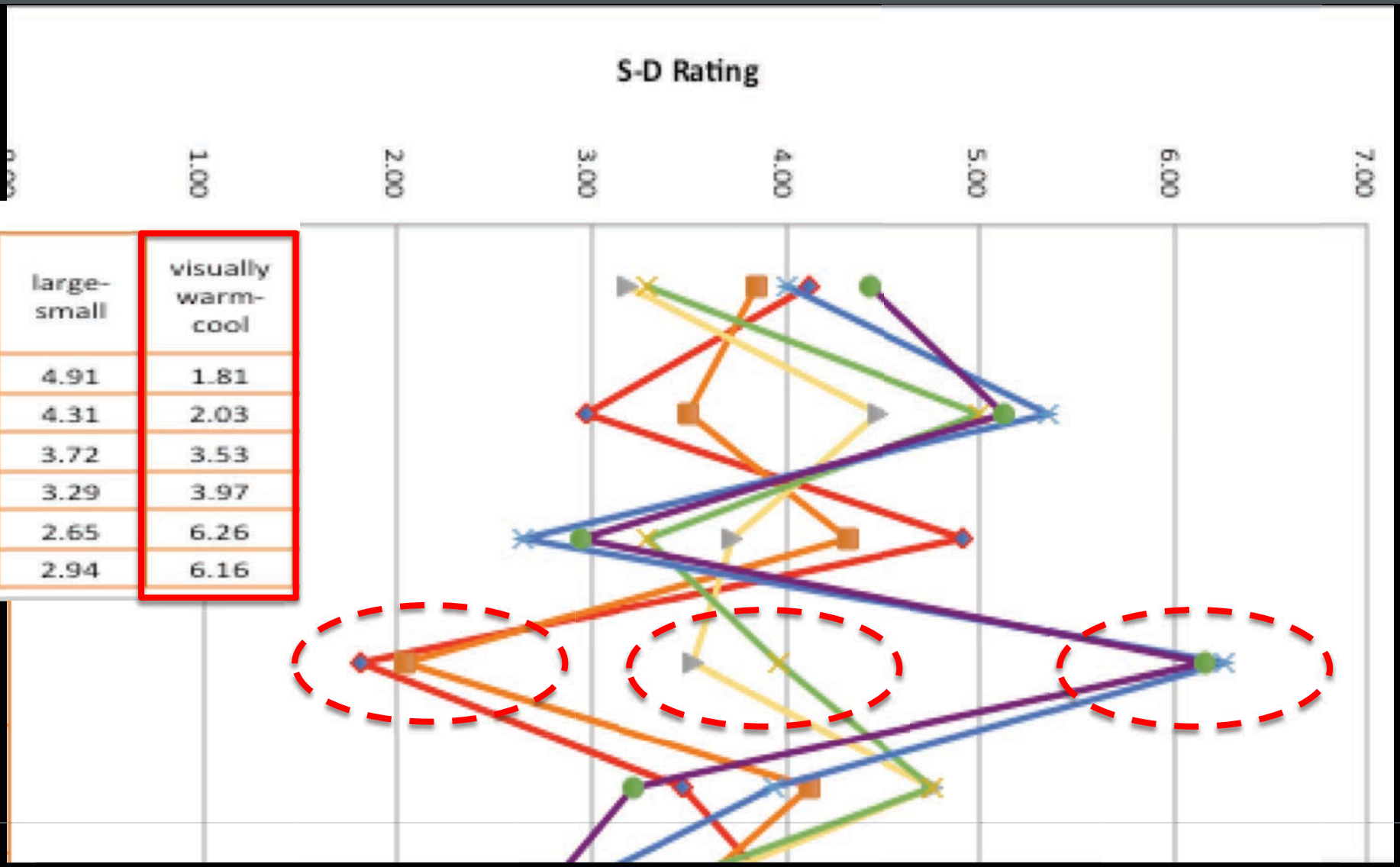
Plot of Mean Semantic Differential Ratings on Twenty-Two S-D Scales Used in Study



	beautiful-ugly	hazy-clear	large-small	visually warm-cool	dislike-like	faces clear-faces obscure	simple-complex	pleasant-unpleasant	glare-nonglare	public-private	confined-spacious	relaxing-tense	bright-dim	stimulating-subduing	distinct-vague	satisfying-frustrating	colorful-colorless	functional-nonfunctional	lively-subdued	ordinary-special	cluttered-uncluttered	stable-unstable
2700 K	4.13	2.97	4.91	1.81	3.47	4.06	4.16	4.34	4.35	5.16	3.19	3.91	4.16	4.22	4.56	4.28	3.13	4.84	4.06	4.25	3.88	4.25
3000 K	3.84	3.50	4.31	2.03	4.13	3.38	3.59	3.72	5.09	4.63	3.53	3.91	4.66	4.03	4.09	3.81	3.41	4.22	3.81	3.91	4.31	3.78
3500 K	3.19	4.47	3.72	3.53	4.75	3.13	2.97	3.16	4.88	3.66	4.13	3.16	4.06	3.94	3.63	3.31	3.91	3.47	3.97	3.31	4.06	3.06
4000 K	3.28	5.00	3.29	3.97	4.75	2.94	2.84	3.44	5.25	3.22	4.66	3.59	3.09	3.72	3.34	3.59	4.66	3.09	3.84	2.75	4.25	2.69
5000 K	4.00	5.35	2.65	6.26	3.94	2.61	2.35	3.97	4.74	2.06	5.13	5.13	2.65	3.06	3.42	4.10	4.90	2.65	4.06	2.74	5.16	2.48
6500 K	4.44	5.13	2.94	6.16	3.22	2.66	2.47	5.00	4.47	2.59	4.59	5.06	2.63	3.53	3.91	4.78	4.94	3.00	4.41	2.72	5.03	3.03

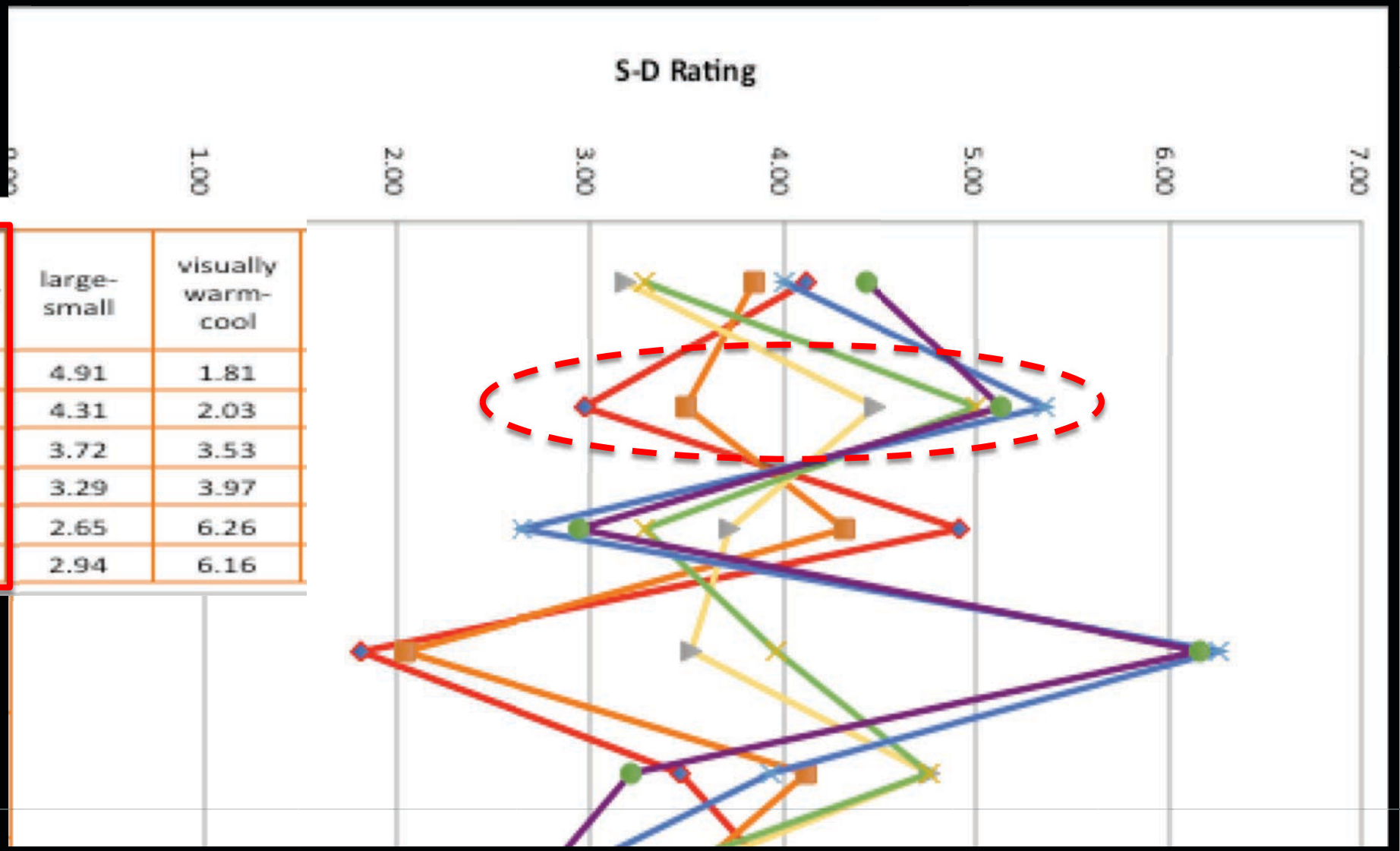
Plot of Mean Ratings on Visually Warm-Visually Cool Scale

	beautiful-ugly	hazy-clear	large-small	visually warm-cool
2700 K	4.13	2.97	4.91	1.81
3000 K	3.84	3.50	4.31	2.03
3500 K	3.19	4.47	3.72	3.53
4000 K	3.28	5.00	3.29	3.97
5000 K	4.00	5.35	2.65	6.26
6500 K	4.44	5.13	2.94	6.16



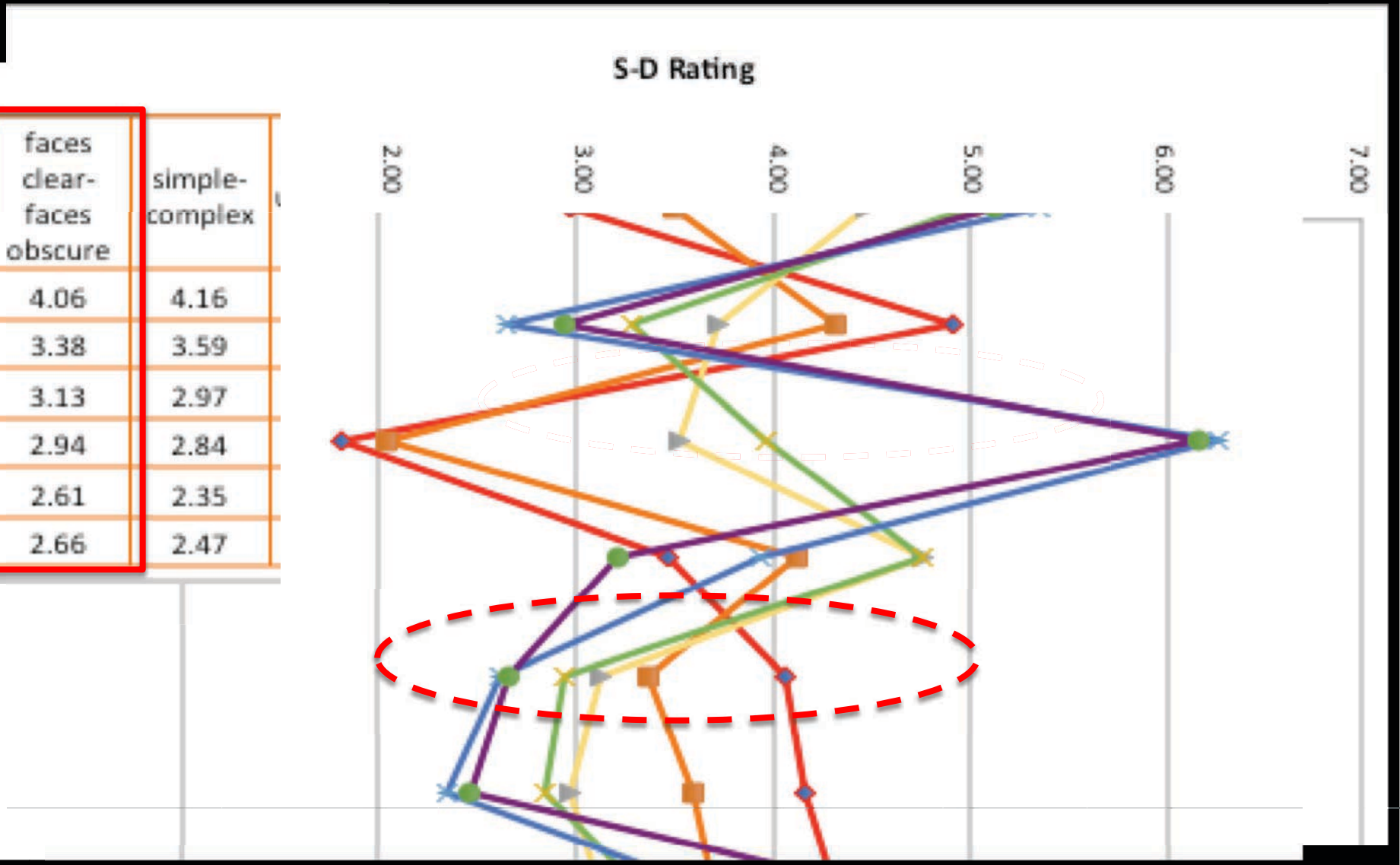
Plot of Mean Ratings on Hazy-Clear Scale

	beautiful-ugly	hazy-clear	large-small	visually warm-cool
2700 K	4.13	2.97	4.91	1.81
3000 K	3.84	3.50	4.31	2.03
3500 K	3.19	4.47	3.72	3.53
4000 K	3.28	5.00	3.29	3.97
5000 K	4.00	5.35	2.65	6.26
6500 K	4.44	5.13	2.94	6.16



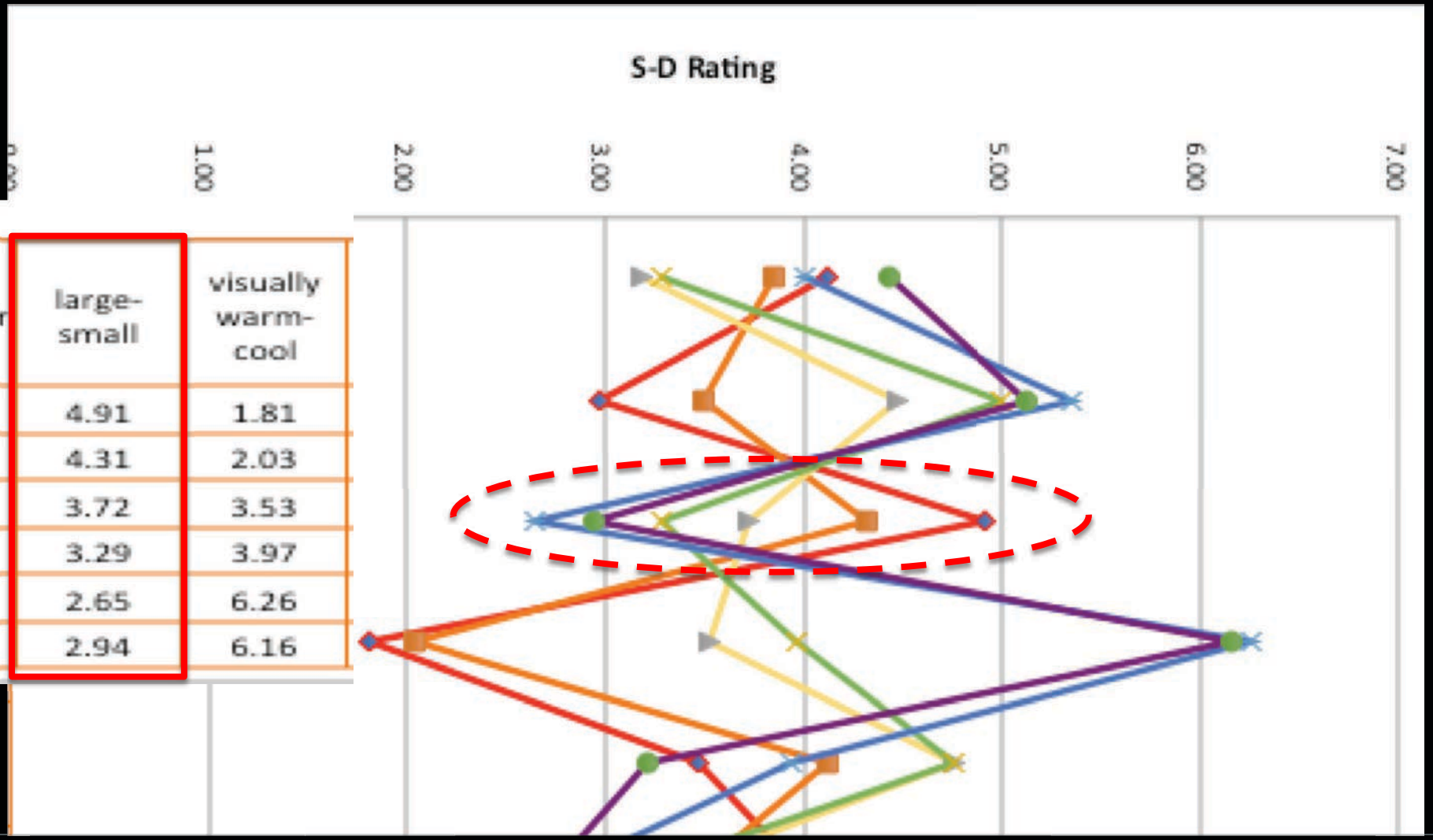
Plot of Mean Ratings on Faces Clear-Faces Obscure Scale

clear	large-small	visually warm-cool	dislike-like	faces clear-faces obscure	simple-complex
2700 K	1.81	3.47	4.06	4.16	
3000 K	2.03	4.13	3.38	3.59	
3500 K	3.53	4.75	3.13	2.97	
4000 K	3.97	4.75	2.94	2.84	
5000 K	6.26	3.94	2.61	2.35	
6500 K	6.16	3.22	2.66	2.47	



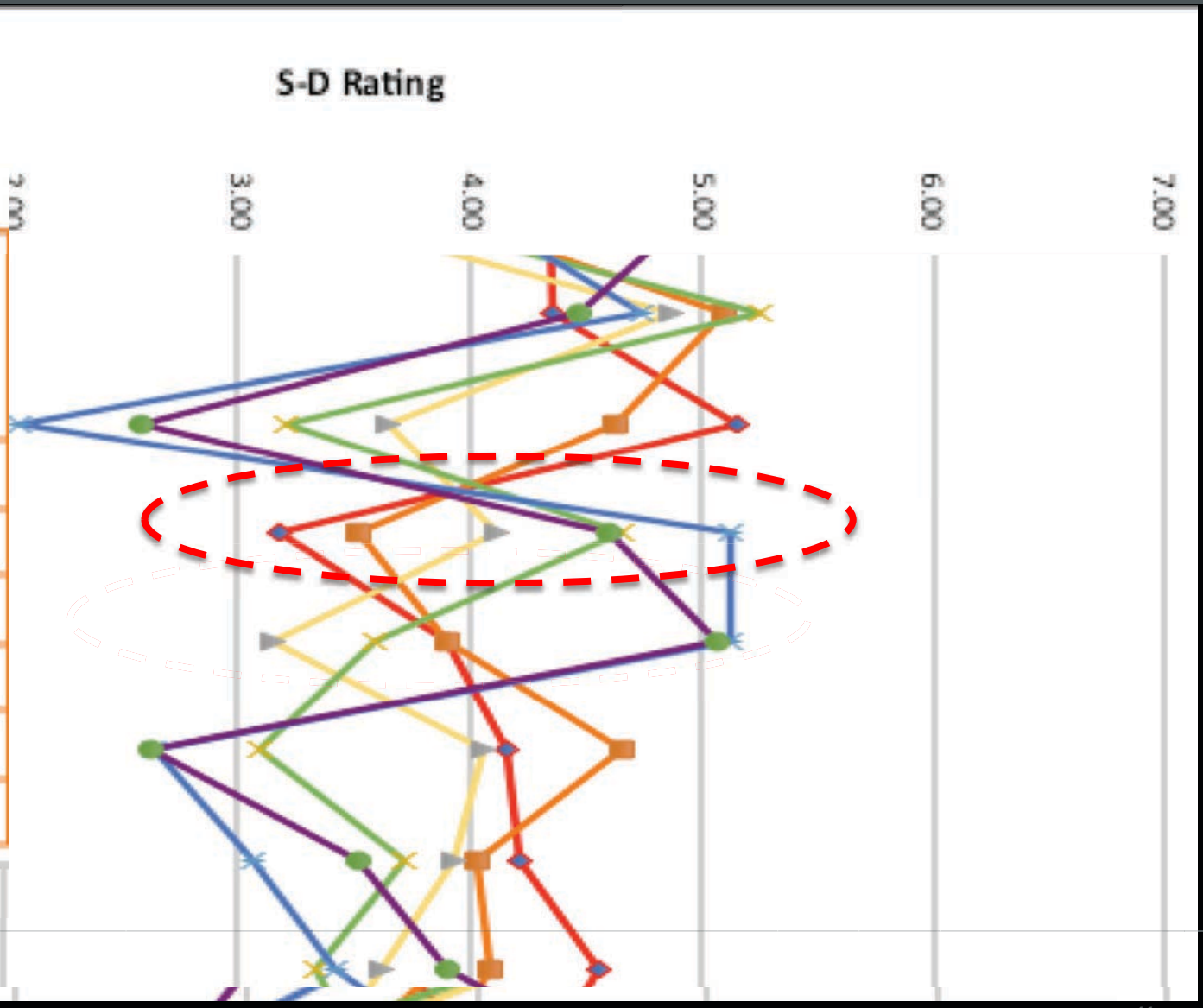
Plot of Mean Ratings on Large-Small Scale

	beautiful-ugly	hazy-clear	large-small	visually warm-cool
2700 K	4.13	2.97	4.91	1.81
3000 K	3.84	3.50	4.31	2.03
3500 K	3.19	4.47	3.72	3.53
4000 K	3.28	5.00	3.29	3.97
5000 K	4.00	5.35	2.65	6.26
6500 K	4.44	5.13	2.94	6.16



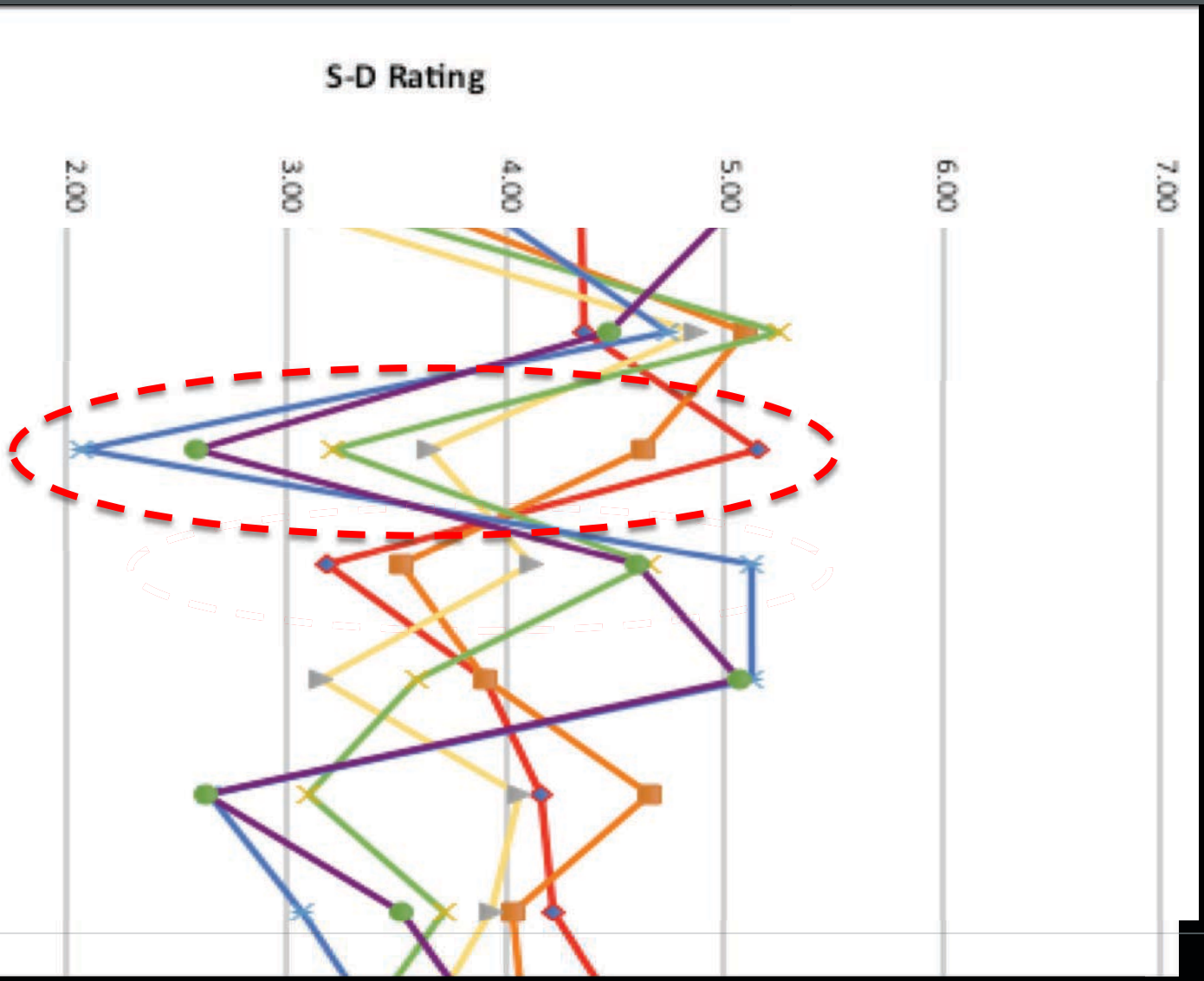
Plot of Mean Ratings on Confined-Spacious Scale

	glare-nonglare	public-private	confined-spacious	relaxing-tense	bright-dim	stimulating-subduing	distinct-vague
2700 K			3.19	3.91	4.16	4.22	4.56
3000 K			3.53	3.91	4.66	4.03	4.09
3500 K			4.13	3.16	4.06	3.94	3.63
4000 K			4.66	3.59	3.09	3.72	3.34
5000 K			5.13	5.13	2.65	3.06	3.42
6500 K			4.59	5.06	2.63	3.53	3.91

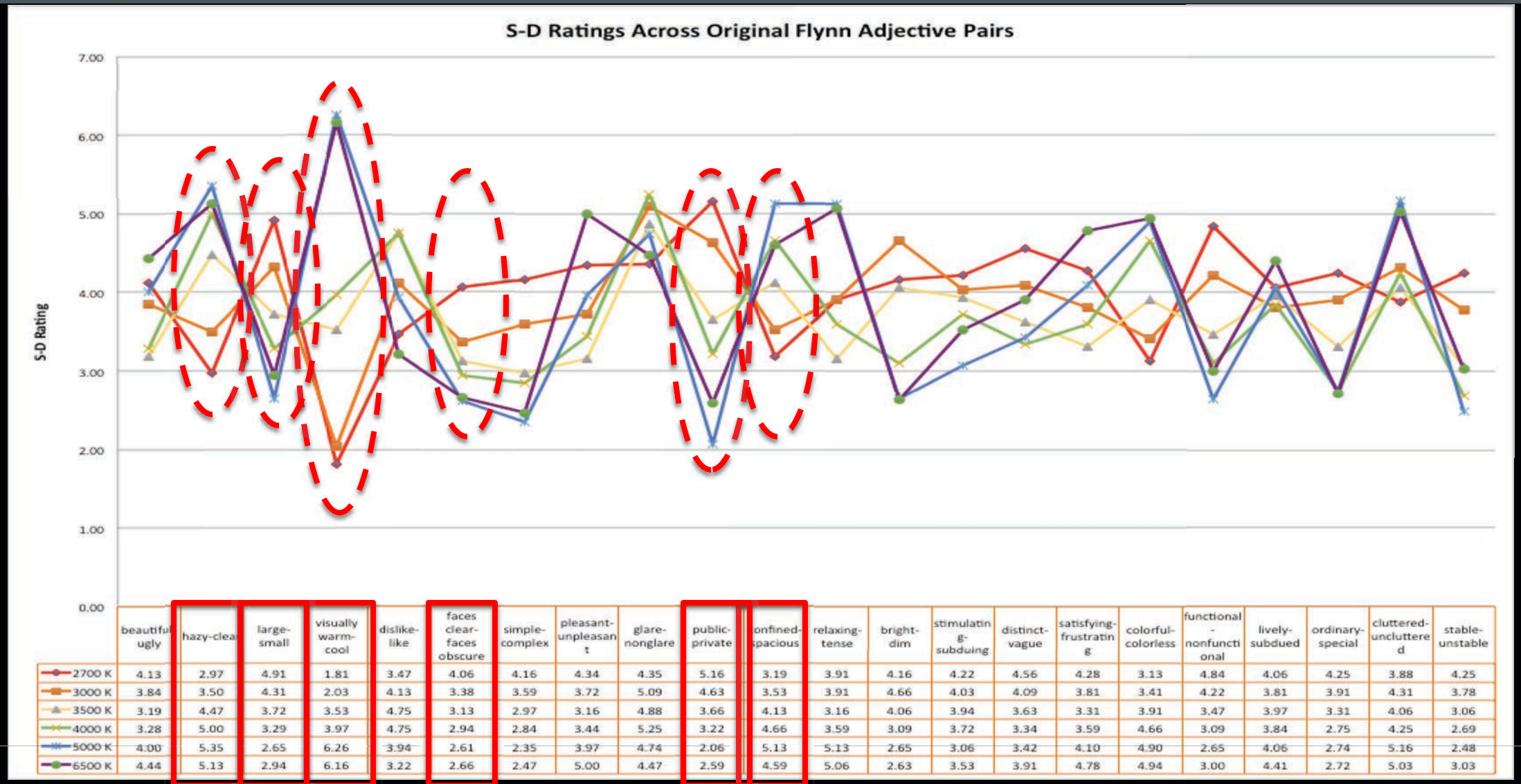


Plot of Mean Ratings on Public-Private Scale

ant-asan	glare-nonglare	public-private	confined-spacious	relaxing-tense	bright-dim	stimulating-subduing
2700 K		5.16	3.19	3.91	4.16	4.22
3000 K		4.63	3.53	3.91	4.66	4.03
3500 K		3.66	4.13	3.16	4.06	3.94
4000 K		3.22	4.66	3.59	3.09	3.72
5000 K		2.06	5.13	5.13	2.65	3.06
6500 K		2.59	4.59	5.06	2.63	3.53



Plot of Mean Semantic Differential Ratings on Twenty-Two S-D Scales Used in Study



	beautiful-ugly	hazy-clear	large-small	visually warm-cool	dislike-like	faces clear-faces obscure	simple-complex	pleasant-unpleasant	glare-nonglare	public-private	confined-spacious	relaxing-tense	bright-dim	stimulating-subduing	distinct-vague	satisfying-frustrating	colorful-colorless	functional-nonfunctional	lively-subdued	ordinary-special	cluttered-uncluttered	stable-unstable
2700 K	4.13	2.97	4.91	1.81	3.47	4.06	4.16	4.34	4.35	5.16	3.19	3.91	4.16	4.22	4.56	4.28	3.13	4.84	4.06	4.25	3.88	4.25
3000 K	3.84	3.50	4.31	2.03	4.13	3.38	3.59	3.72	5.09	4.63	3.53	3.91	4.66	4.03	4.09	3.81	3.41	4.22	3.81	3.91	4.31	3.78
3500 K	3.19	4.47	3.72	3.53	4.75	3.13	2.97	3.16	4.88	3.66	4.13	3.16	4.06	3.94	3.63	3.31	3.91	3.47	3.97	3.31	4.06	3.06
4000 K	3.28	5.00	3.29	3.97	4.75	2.94	2.84	3.44	5.25	3.22	4.66	3.59	3.09	3.72	3.34	3.59	4.66	3.09	3.84	2.75	4.25	2.69
5000 K	4.00	5.35	2.65	6.26	3.94	2.61	2.35	3.97	4.74	2.06	5.13	5.13	2.65	3.06	3.42	4.10	4.90	2.65	4.06	2.74	5.16	2.48
6500 K	4.44	5.13	2.94	6.16	3.22	2.66	2.47	5.00	4.47	2.59	4.59	5.06	2.63	3.53	3.91	4.78	4.94	3.00	4.41	2.72	5.03	3.03

Other Observations of Semantic Differential Ratings

- *Higher color temperatures tend to reinforce an impression of simplicity while lower color temperatures an impression of complexity (2.35 for 5000 K versus 4.16 for 2700 K)*
- *Lower color temperatures reinforce an impression of a more colorful environment while higher color temperatures an impression of a more colorless environment (3.13 for 2700 K versus 4.94 for 6500 K)*
- *Higher color temperatures tend to reinforce an impression of a more functional environment while lower color temperatures tend to reinforce an impression of a less functional environment (2.65 for 5000 K versus 4.84 for 2700 K)*
- *Lower color temperatures tend to reinforce an impression of a more special environment while higher color temperatures tend to reinforce an impression of a more ordinary environment (4.25 at 2700 K versus 2.72 at 6500 K)*

Other Observations of Semantic Differential Ratings

- *Several scales suggest a greater influence of mid-range color temperatures on the positive ends of several impressions*
  - *Beautiful-ugly*
  - *like-dislike*
  - *pleasant-unpleasant*
- *Mid-range color temperatures tend to play a larger role in influencing relaxation on the relaxation-tension scale while high or low color temperatures tend to reinforce an impression of tension.*

Mean Ratings of Difference When Comparing Appearance of Environment at Different Color Temperatures

The Influence of Chromaticity on Subjective Impressions in Lighted Environments

- *Introduction*
- *Methodology*
- *Results*
- *Conclusion*

Conclusions

- *The very clear difference (6.29 versus 1.81) on the visually warm-visually cool scale supports the conclusion that subjects were indeed responding to differences in color temperature when rating their subjective impressions.*
- *There is a distinct difference between the responses to high and low color temperatures in general, as well as mid-range color temperatures, but the responses tend not to discriminate between color temperatures at the high, low and mid-ranges.*
- *There is a strong influence of CCT on several impressions consistent with Flynn's other modes*
  - *Public-private*
  - *Clear-hazy*
  - *Spaciousness-confinement*

Limitations/Next Steps

- *Not equal steps in CCT (2700, 3000, 3500, 4000, 5000, 6000)*
- *Limited subject population (graduate design students in NYC)*
- *Classroom/work environment*
- *Other lighting characteristics held constant (no interactions of lighting characteristics)*

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The influence of chromaticity on subjective

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