Dial in the Spectrum: Exploring Tunable White Lighting for a 911 Call Center

Wednesday, April 27th, 4:30PM

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Learning Objectives

1. Summarize the specific challenges with 24/7 high-stress computing work.
2. Describe methods of system design for tunable white solutions in shift work environments.
3. Compare occupant preference of four different lighting design approaches.
4. Identify opportunities to improve these visual environments while responding to very specific occupant needs.
Goals of the Project
Existing: Illuminance and CCT measurements
100% track lighting on
Track lighting off

- **Measurement Points:**
  - Measurement Points: 1, 2, 3, 4, 5, 6
  - **DAY - Illuminance**
  - **NIGHT - Illuminance**
  - **DAY - CCT**
  - **NIGHT - CCT**

- **Graphs:**
  - Diagram showing illuminance and CCT for different measurement points.
  - Y-axis: Illuminance, [lux]
  - X-axis: Measurement Point
  - **DAY - Illuminance**
  - **NIGHT - Illuminance**
  - **DAY - CCT**
  - **NIGHT - CCT**
HDRI luminance mapping
Day and Night Conditions: 100% track on
Existing Conditions Subjective Evaluation - GLARE

Daytime – Windows

Nighttime - Computer Screens
- Light sources
Existing Conditions Subjective Evaluation

Daylight
- Loves Views
- Hates Glare

Wants Personalized Controls in workstations
Experiment Set-up

- 4 new, 4 control
- Day/night shifts
- 2+ weeks long
- Subjective evaluation
- Data on spectrum and intensity – real time
Experiment Equipment Layout
Room layout
Respondents' Scheduling

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**Employee ID**

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Subjective Evaluation (sample)

1. Impressions of Light – Overall:
   a. During the day the lighting at my workstation is:
      
      | Too dim | 1 | 2 | 3 | 4 | Perfect | 5 | 6 | 7 | 8 | Too bright | 9 | N/A |
      |---------|---|---|---|---|---------|---|---|---|---|------------|---|-----|
      |         |   |   |   |   |         |   |   |   |   |            |   |     |

      Comments: __________________________________

   b. During the night the lighting at my workstation is:
      
      | Too dim | 1 | 2 | 3 | 4 | Perfect | 5 | 6 | 7 | 8 | Too bright | 9 | N/A |
      |---------|---|---|---|---|---------|---|---|---|---|------------|---|-----|
      |         |   |   |   |   |         |   |   |   |   |            |   |     |

      Comments: __________________________________

   c. The light from my computer screen monitors is enough for me to do tasks on my desk:
      
      | Disagree | 1 | 2 | 3 | 4 | Neutral | 5 | 6 | 7 | 8 | Agree | 9 |
      |----------|---|---|---|---|---------|---|---|---|---|------|---|
      |          |   |   |   |   |         |   |   |   |   |      |   |

      Comments: __________________________________

   d. I am bothered by the lighting at other people’s workstations:
      
      | Disagree | 1 | 2 | 3 | 4 | Neutral | 5 | 6 | 7 | 8 | Agree | 9 |
      |----------|---|---|---|---|---------|---|---|---|---|------|---|
      |          |   |   |   |   |         |   |   |   |   |      |   |

      Comments: __________________________________

   e. How often are the window blinds fully closed:
      
      | Rarely | 1 | 2 | 3 | 4 | Sometimes | 5 | 6 | 7 | 8 | Always | 9 |
      |--------|---|---|---|---|----------|---|---|---|---|--------|---|
      |        |   |   |   |   |          |   |   |   |   |         |   |

      Why? ________________________________________
Subjective Evaluation (sample)

3. Impressions of Light – Color:

   Candle Light  Summer Sun Light  Blue Sky Light

a. The glow from my computer screen is:

   Too yellow  1  2  3  4  Neutral  5  6  7  8  Too blue  9

   Comments: ____________________________________________

b. My overhead or desk-partition mounted light is:

   Too yellow  1  2  3  4  Neutral  5  6  7  8  Too blue  9

   Comments: ____________________________________________

c. My desk light is:

   Too yellow  1  2  3  4  Neutral  5  6  7  8  Too blue  9

   Comments: ____________________________________________
Lighting Controls Setup

Note: Automatic color temperature and intensity changes based on timeclock are possible, but were not utilized in this study.
Lighting Controls Setup (alt. options)

Separate intensity and CCT channel

Note: The setup shown above was not used in this study.
Lighting Controls Setup (alt. options)

Note: The setup shown above was not used in this study.
Lighting Controls Setup (alt. options)

Separate intensity and CCT channel

Cool
Warm

INTENSITY

Note: The setup shown above was not used in this study.
Subject Description

20 subjects (14 Female, 6 Male)

Note: 15 of 20 subjects reported at least one of below
Results: Example CCT Manipulation
Results: Example Intensity Manipulation
Results: CCT Preference

Workstation #

3  4  5  6
Results: Intensity Preference

Max = 27W  8W  24W  44W

- 3.8W
- 4.3W
- 9.8W
- 7.0W
Results: CCT by Time of Day
Results: Intensity by Time of Day
Results: CCT by Gender

Female (n=14)  Male (n=6)
Results: CCT by Age

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<td>20-24</td>
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Results: CCT by Self-Assessed Complications

- Eye Strain (n=8)
- Fatigue (n=6)
- Difficulty Staying Awake (n=4)
- Difficulty Sleeping (n=7)
- Difficulty Focusing (n=3)
Results: CCT by Employee

Individual Employees

Difficulty Sleeping
Results: General Assessment
Results: Overall Lighting Preference

Workstation 6:
“Best illumination of the workspace with minimal shadows or reflection, excellent range of adjustment, absolutely no eye strain”
Results: Overall Workstation Preference
Results: Summary

• Most adjustments were made between shifts
• All solutions resulted in similar energy usage
• Overall, preferred electric lighting color did not vary much from day to night
• Overall, preferred electric lighting intensity was higher at night
• Employees that indicated trouble falling asleep had generally kept their lights at a cooler color
• Employees that indicated trouble staying awake had generally kept their lights at a warmer color
• **Overwhelming preference to control both the intensity and the color of electric lighting**
• **Workstation 6 (indirect pendant) lighting was preferred and the only lighting that was considered comfortable**
Evaluation Feedback – What they did not like

• Downlight (too glary, bright, harsh)
• Existing track lighting (too bright)
Evaluation Feedback – What they liked:

• Indirect pendant (uniform, low glare lighting)
• Lighting behind computers (monitors less bright)
• Personal controls for dimming and color tuning
• Warmer CCT
Evaluation Feedback – Other Feedback:

- Monitors blocked the back panel lighting
- Sunrise causes glare
What next?

- Combine strategies (indirect lighting with personalized lighting)
- Personalized controls
- Shading options
Please remember to complete the course evaluations. Thank you.