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Designers Light Forum

Bridging the uncanny valley

Enhancing the user experience of smart lighting control

Brent Protzman, Ph.D.
Director – Building Science & Standards Development
Lutron Electronics
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CONTINUING EDUCATION AIA

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Learning Objectives

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

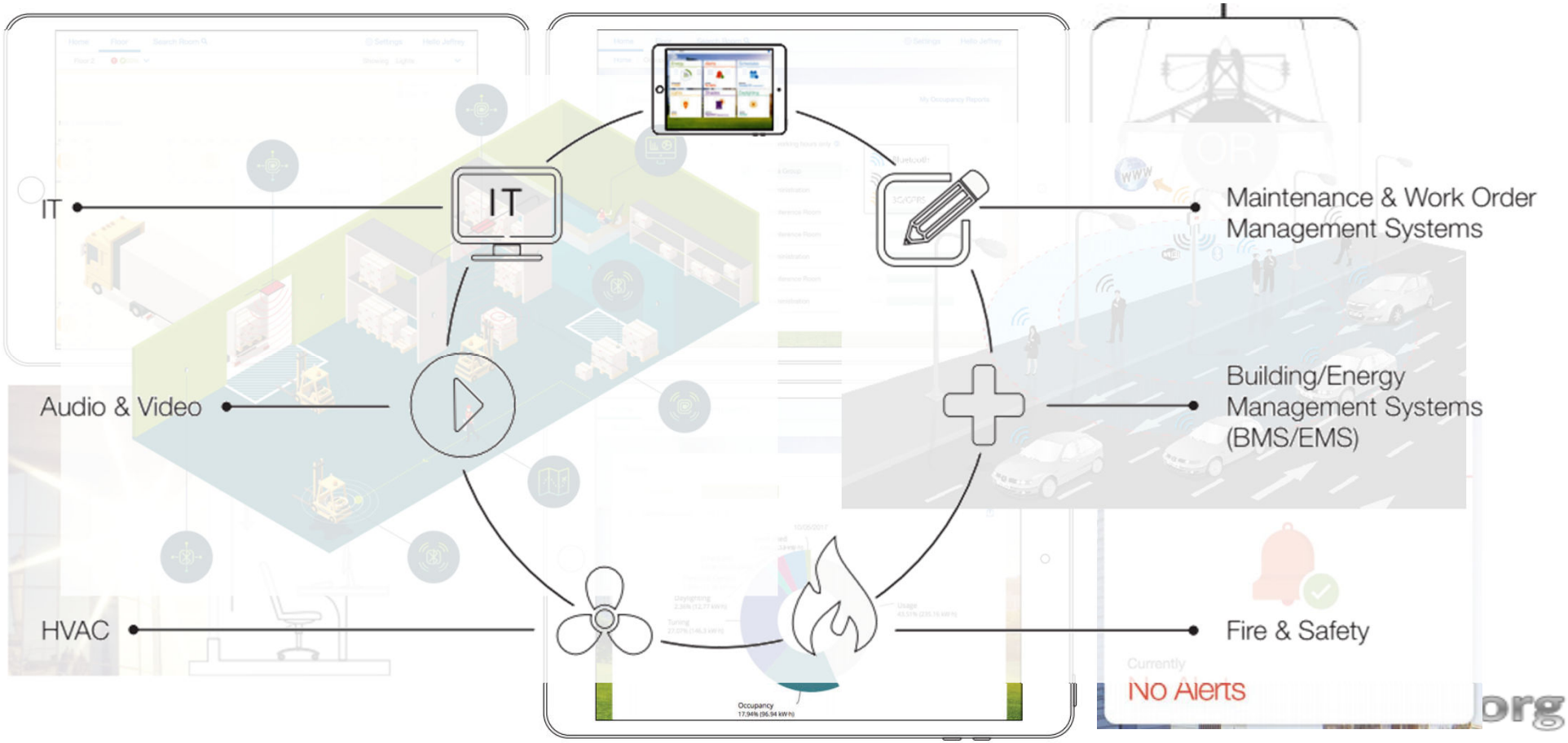
1. Understand the uncanny valley of smart lighting and its impact on occupants when systems are not customized to the end user.

2. Implement the process for customizing smart lighting systems based on lighting narratives and documenting the sequence of operations.

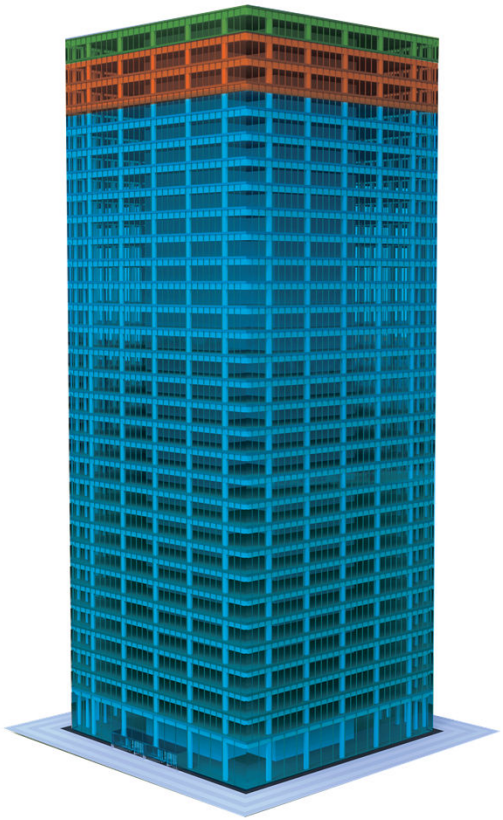
3. Apply example control sequences to new projects that meet the needs of the end user and are documented to minimize implementation errors.

4. Explain the importance and complexity in creating fully personalized lighting, as well as the pitfalls to avoid as learning algorithms are employed.

Smart lighting brings great opportunities at a risk to occupant comfort and productivity



The value of occupant performance greatly outweighs the cost of operations and energy usage

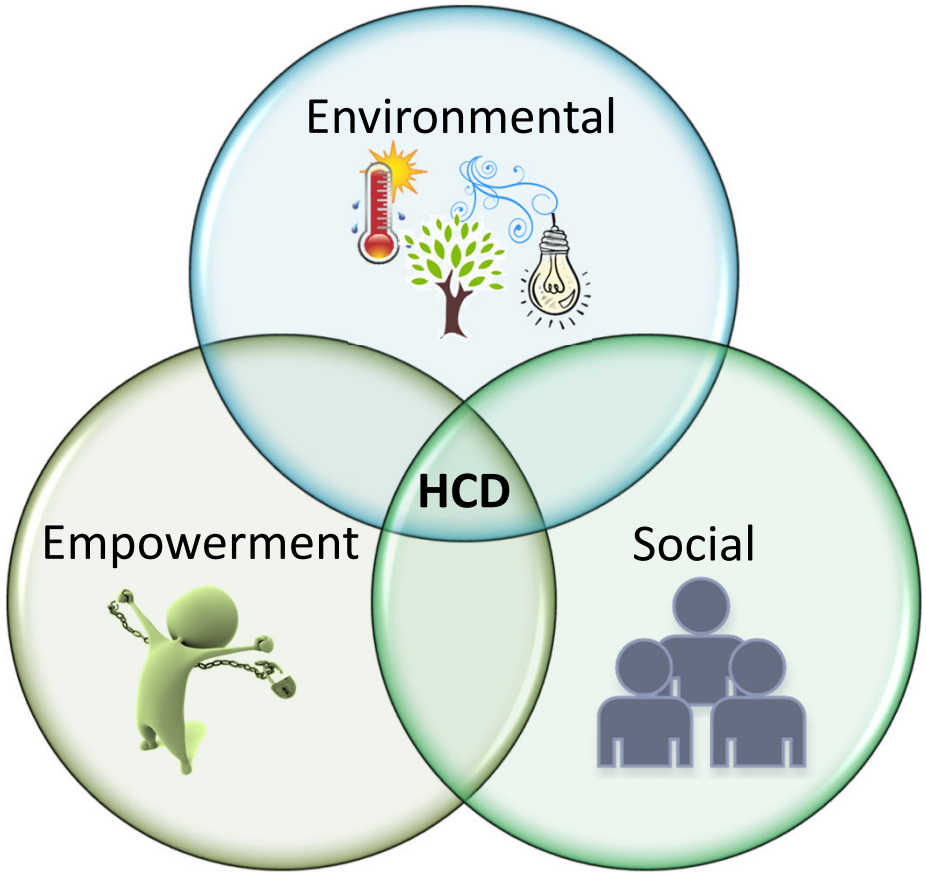


Annual Costs for Commercial Buildings

- **Energy: $3/ft²** ($30/m²)
- **Operations/Rent: $30/ft²** ($300/m²)
- **Salaries: $300/ft²** ($3000/m²)

Source: Rocky Mountain Institute. 2012. Guide to Building the Case for Deep Energy Retrofits.

Optimized design for occupants can improve well-being and productivity, particularly when personalized.



Enhanced office design has been shown to improve employee well-being (up to 31%) and productivity (up to 15%).

Source: Knight, C & Haslam, A. 2010. The relative merits of lean, enriched, and empowered offices: an experimental examination of the impact of workspace management strategies on well-being and productivity. Journal of Experimental Psychology. Vol: 16(2). 158-172.

Smart lighting control systems not designed for the occupants can have detrimental effects

COMPLICATED

- Controls not intuitive
- Too many options

DISRUPTIVE

- System reacts too often
- System reacts too fast or slow

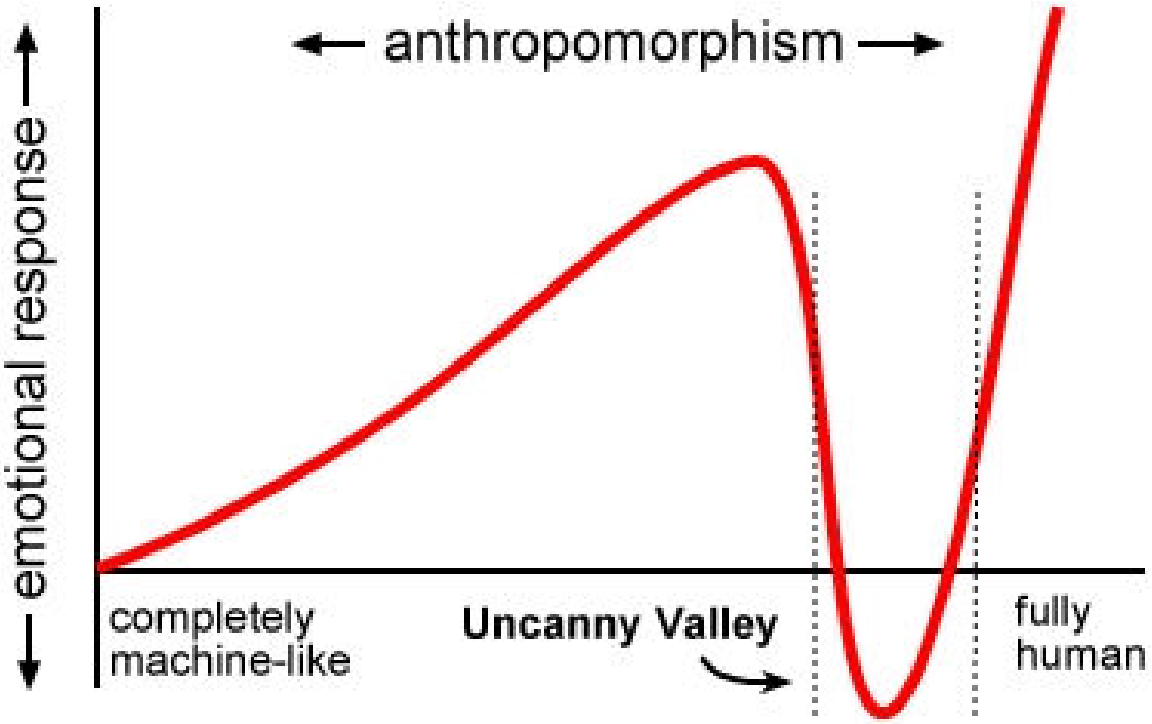
COGNITIVE DISSONANCE

- Not customized to application
- Not sensing correctly
- Product failure

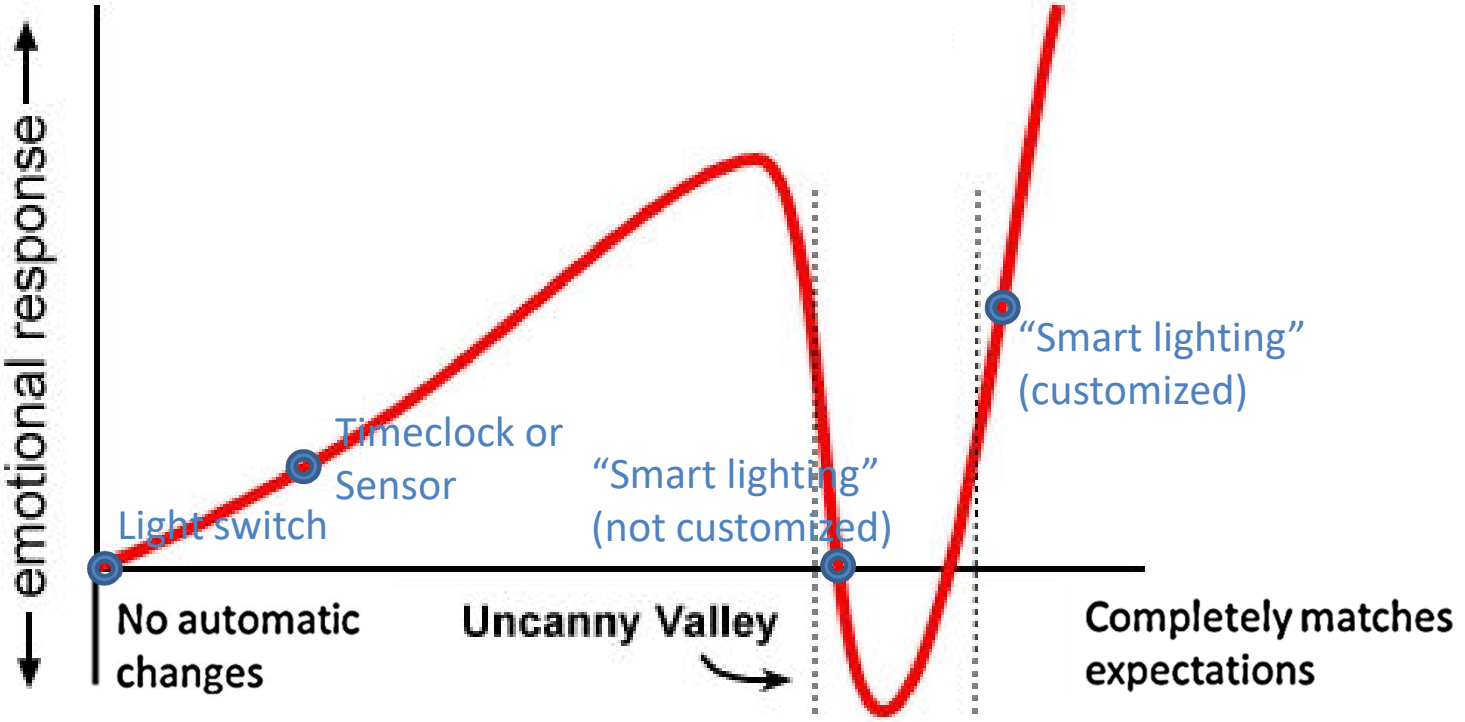
POOR AESTHETICS

- Detracts from architectural beauty
- Cluttered and disorganized

There is a negative dip in acceptance when non-human objects or images appear nearly human



A similar negative dip in acceptance when “smart” control systems don’t quite meet user expectations



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Setting the right environment requires multiple user experience considerations

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How to customize a lighting control system to create the right user experience

SEQUENCE OF OPERATIONS (SOO)

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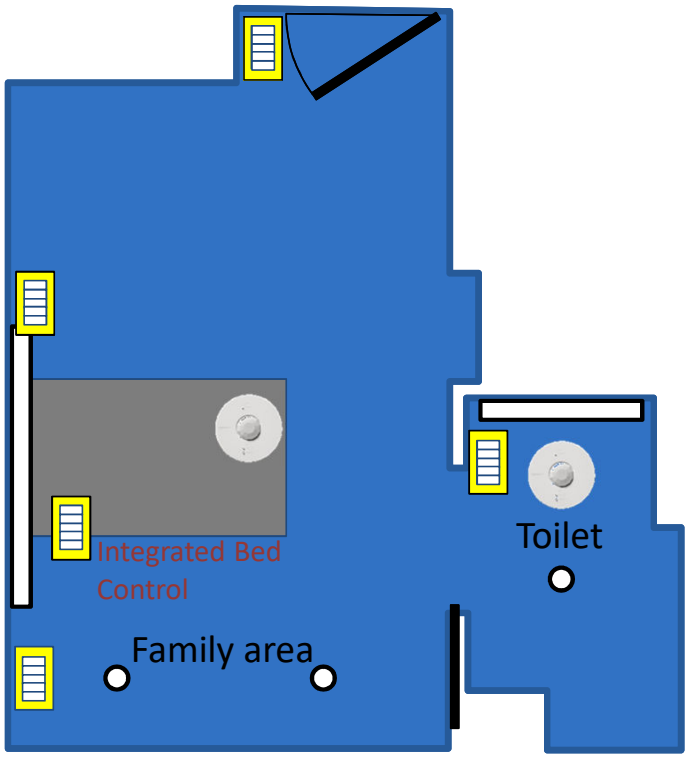
A sequence of operations (SoO) defines how the system operates, setting the user experience

Even spaces with only a few lighting control strategies require an SoO

Spaces with complicated control functionality require deep consideration and detailed documentation



Lighting zones and control locations

Setting	Output
Full On	100%
High	60%
Medium	35%
Low	5%
Off	0%

Engraving and scene settings

Time	Illuminance (FC)	CCT (K)
6AM	0	2400
6:30AM	20	4000
7AM	40	6000
11AM	40	6000
1PM	25	3500
4PM	25	3500
9PM	20	3500
10PM	20	2400

Lighting CCT/Intensity schedule

Defining a good SoO follows the typical architectural design process

Project requirements
- Codes
- Integration needs

Define scenarios
- Interview end users
- Understand tasks and usage for each space
- Develop scenarios that define experiences
- Any special needs?

Evaluate desired lighting control response
- For each scenario
- Consider both user personas and key individual users
- Visualize interactions

Write the lighting narrative
- For each scenario
- Review with end users

Complete documentation
- Finalize narratives
- Timeclock schedule
- Control locations
- Scene setting schedule
- Floorplan that illustrates SoO categories
- Engraving (if needed)

Critical Note: Customized user experience (aka SoO) must be space and user dependent!

There are many tools in the controls toolbox to define the right user experience

- Dimming light levels
- Color temperature (white tuning)
- Scene control
- Control zones
- Daylight zones
- Timeclock scheduling
- Manual ON vs Auto ON
- Partial OFF (when vacant)
- Fade rates for dimming
- Fade rates for white tuning
- Fade rates upon occupancy/vacancy
- Visual communication (e.g. blink warn)
- Modify control based on occupancy
- Modify control based on time of day
- Modify control based on occupancy and time of day

Don’t forget these!

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Developing an SoO for a few common spaces

SOME EXAMPLES

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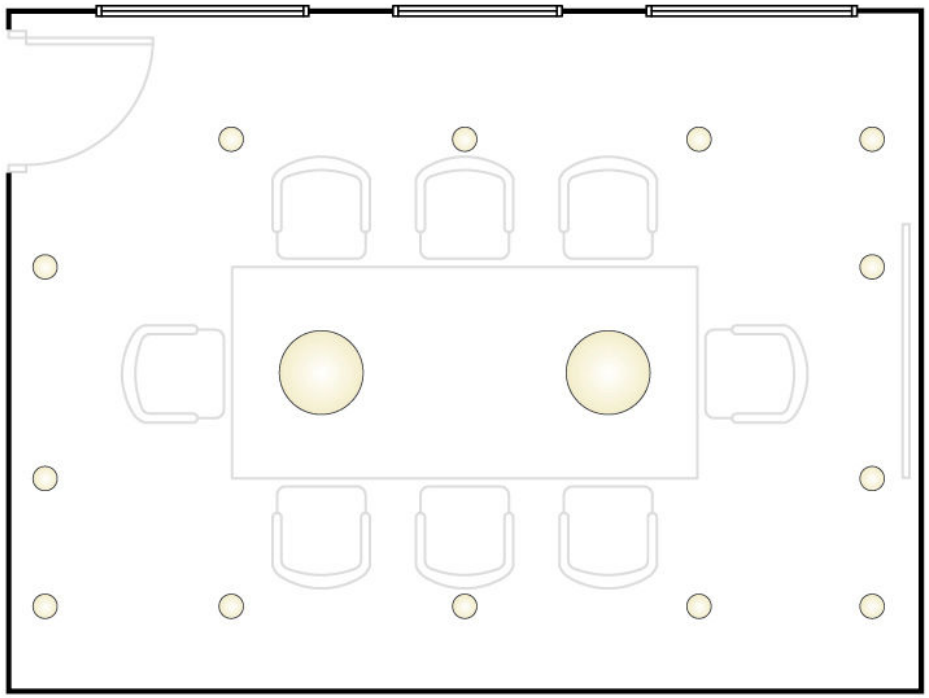
CONFERENCE ROOM : Research Project Requirements

Code: IECC 2015

- Manual control
- Occupancy sensing (30min delay)
  - Manual ON or Partial ON
  - Automatic Full OFF
- Daylight control (dimming to off)

Integration: Project specific

- HVAC



CONFERENCE ROOM: Define Lighting Scenarios

"When presenting, we use the tv, but it is important that the people have enough light to take notes"

"PRESENT" SCENE:

- Lights on the tv wall are off.
- All other downlights are set to 50%.
- Ceiling mount lights are set to 25%.

"Medical images are sometimes presented where it's critical to see the screen."

"A/V" SCENE:

- Lights on the tv wall are off.
- Downlights are set to 25%.
- Ceiling mount lights are set to 10%.

"We often have breakout group discussion where we try to promote innovation through creativity"

"DISCUSSION" SCENE:

- Perimeter lights are set to 80%
- Downlights are set to 50%.
- Ceiling mount lights are set to 25%.

CONFERENCE ROOM: Define Lighting Scenarios

Daylight dimming to OFF
(Energy code Daylight control)

DAYLIGHTING:

- All lights automatically increase, decrease, and shut off according to daylight availability.
- Manual control of lights does not set the lights above the current level set by daylight.

"I often enter the room with my arms full of equipment for class"
(Energy code Automatic Shutoff)

OCCUPANT ENTERS:

- General lights turn on to 70%.
- Perimeter lights do not turn on.

OCCUPANT EXITS:

- All lights automatically shut off 30 minutes after all occupants leave.

Thermostat setback
(HVAC Integration)

OCCUPANT ENTERS:

- Thermostat setpoint is set to 72°F.

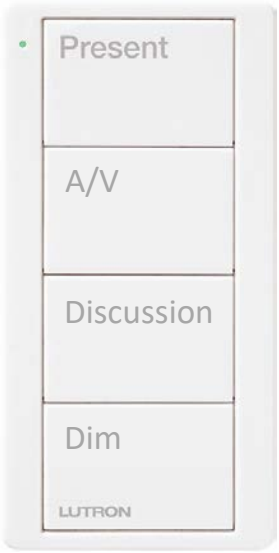
OCCUPANT EXITS:

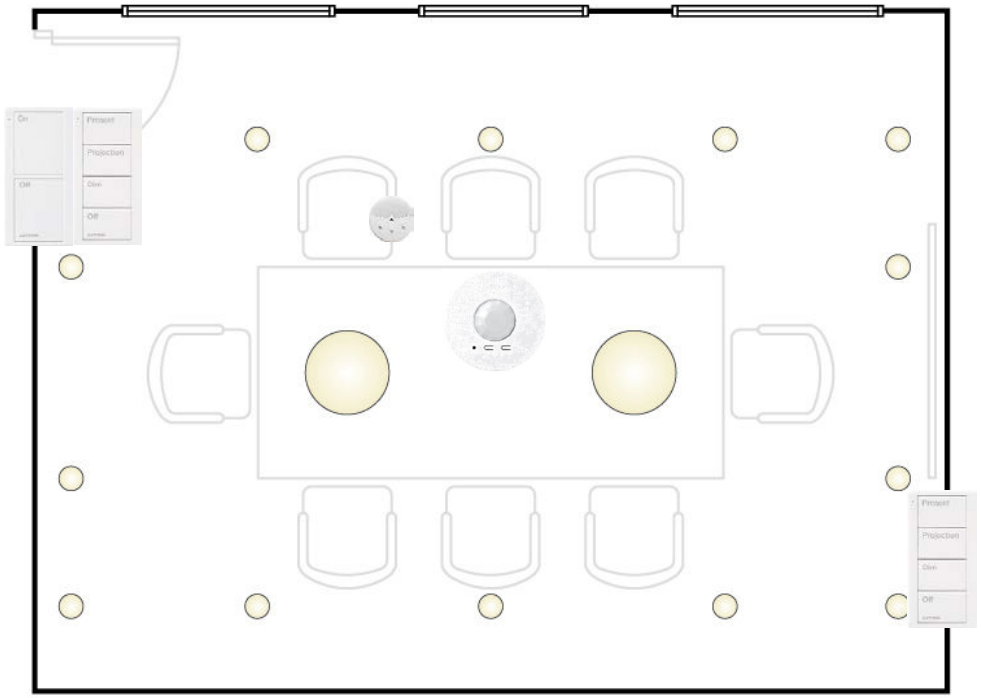
- Thermostat setpoint is set to 68°F.

CONFERENCE ROOM: Documenting the SoO

Lighting Narratives

Event Schedule





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CLASSROOM: Documenting the SoO

Daylight & Shade Control:

- Motorized shades automatically modulate position based on sun position and daylight levels at the window to minimize glare while maximizing views.
- The shade control allows manual override to fully open, fully close, raise, or lower the shades.
- All lights automatically increase, decrease, and shut off according to daylight availability. There are two independent daylight zones.
- Manual control of lights does not set the lights above the current level set by daylight.

Entry/Exit:

- Upon entry: lights are not automatically turned on, they must be manually turned on by the occupant according to the light scene they select.
- Upon exit: all lights are automatically shut off within 30minutes of all occupants leaving the room.

"Relax" Scene:

- White board lights are set to 80%.
- Ambient lights are set to 50%.
- Shades modulate based on daylight conditions.

"Instruction" Scene:

- White board lights are set to 100%.
- Ambient lights are set to 100%.
- Shades modulate based on daylight conditions.

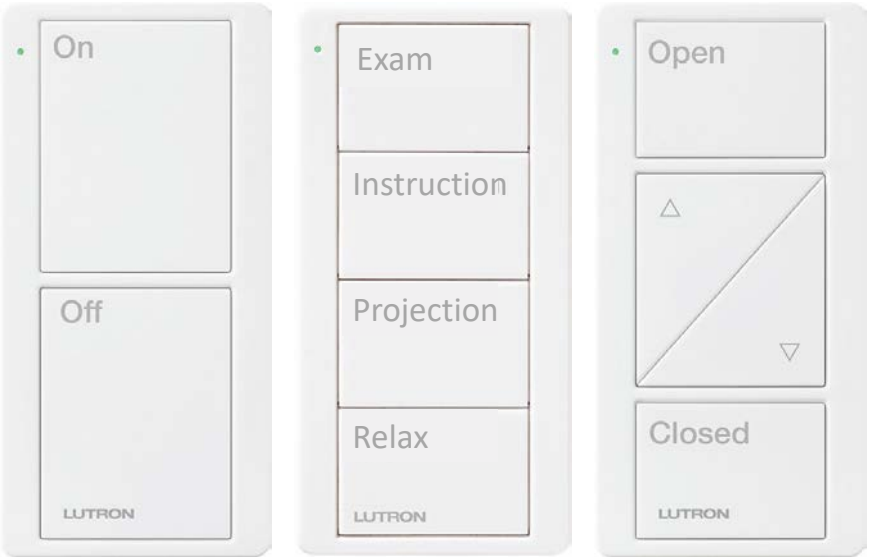
"Projection" Scene:

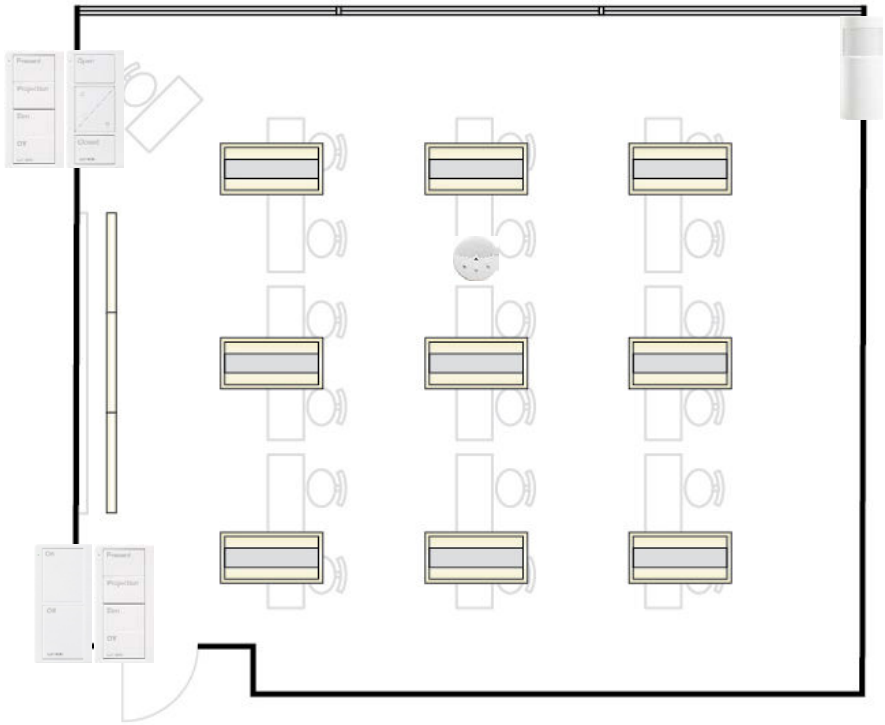
- White board lights are set to full off.
- Ambient lights are set to 40%.
- Shades are lowered to be fully closed.

"Exam" Scene:

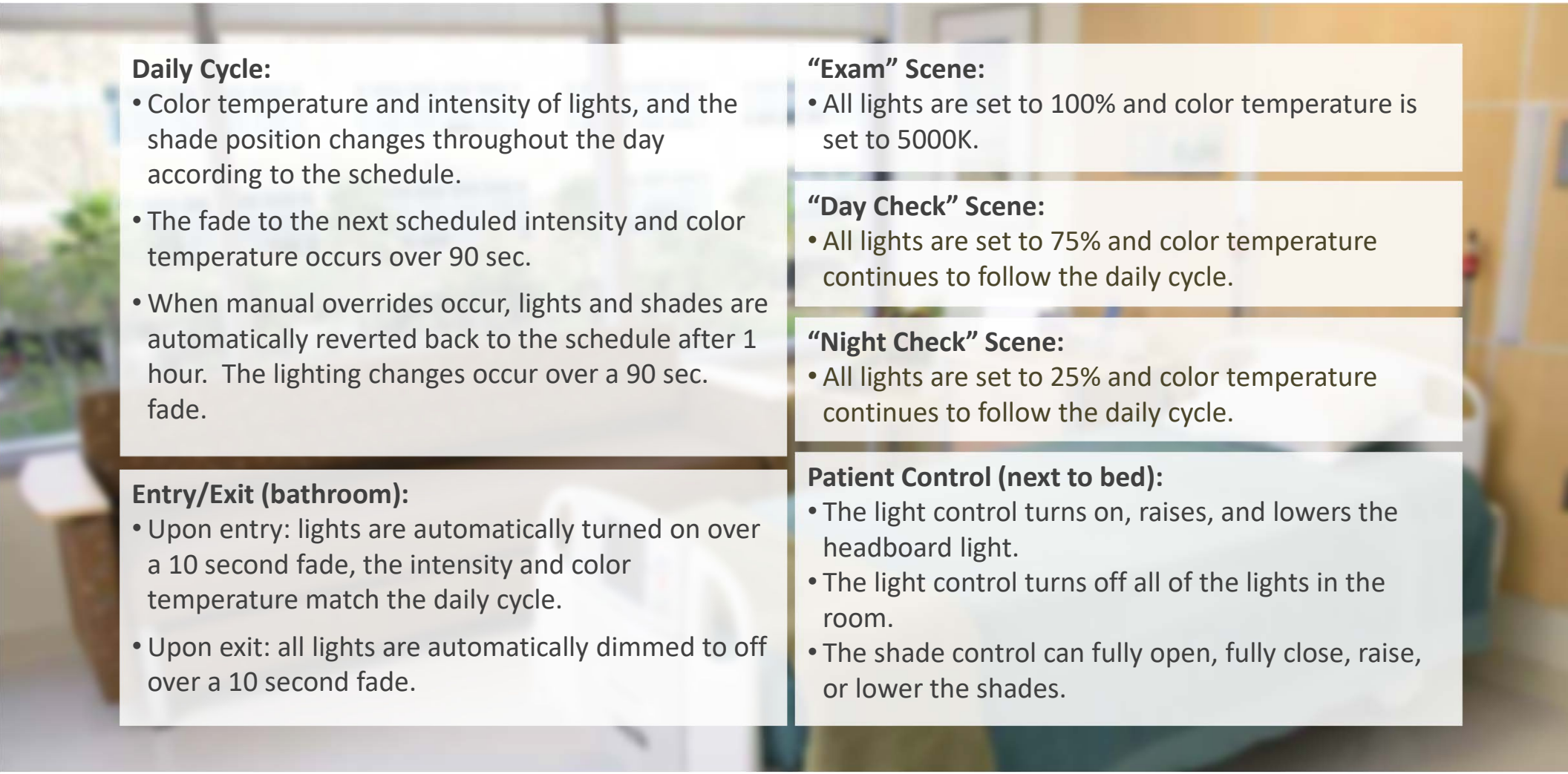
- White board lights are set to 50%.
- Ambient lights are set to 100%.
- Shades are lowered to be fully closed.

CLASSROOM: Documenting the SoO





PATIENT ROOM: Documenting the SoO



Daily Cycle:
- Color temperature and intensity of lights, and the shade position changes throughout the day according to the schedule.
- The fade to the next scheduled intensity and color temperature occurs over 90 sec.
- When manual overrides occur, lights and shades are automatically reverted back to the schedule after 1 hour. The lighting changes occur over a 90 sec. fade.

Entry/Exit (bathroom):
- Upon entry: lights are automatically turned on over a 10 second fade, the intensity and color temperature match the daily cycle.
- Upon exit: all lights are automatically dimmed to off over a 10 second fade.

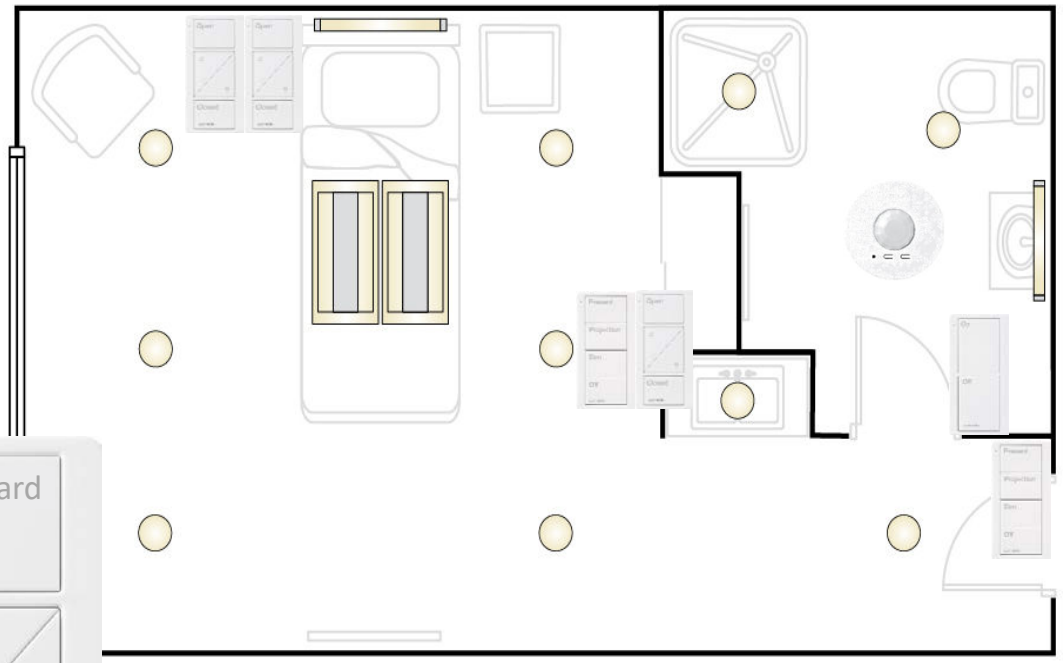
"Exam" Scene:
- All lights are set to 100% and color temperature is set to 5000K.

"Day Check" Scene:
- All lights are set to 75% and color temperature continues to follow the daily cycle.

"Night Check" Scene:
- All lights are set to 25% and color temperature continues to follow the daily cycle.

Patient Control (next to bed):
- The light control turns on, raises, and lowers the headboard light.
- The light control turns off all of the lights in the room.
- The shade control can fully open, fully close, raise, or lower the shades.

PATIENT ROOM: Documenting the SoO



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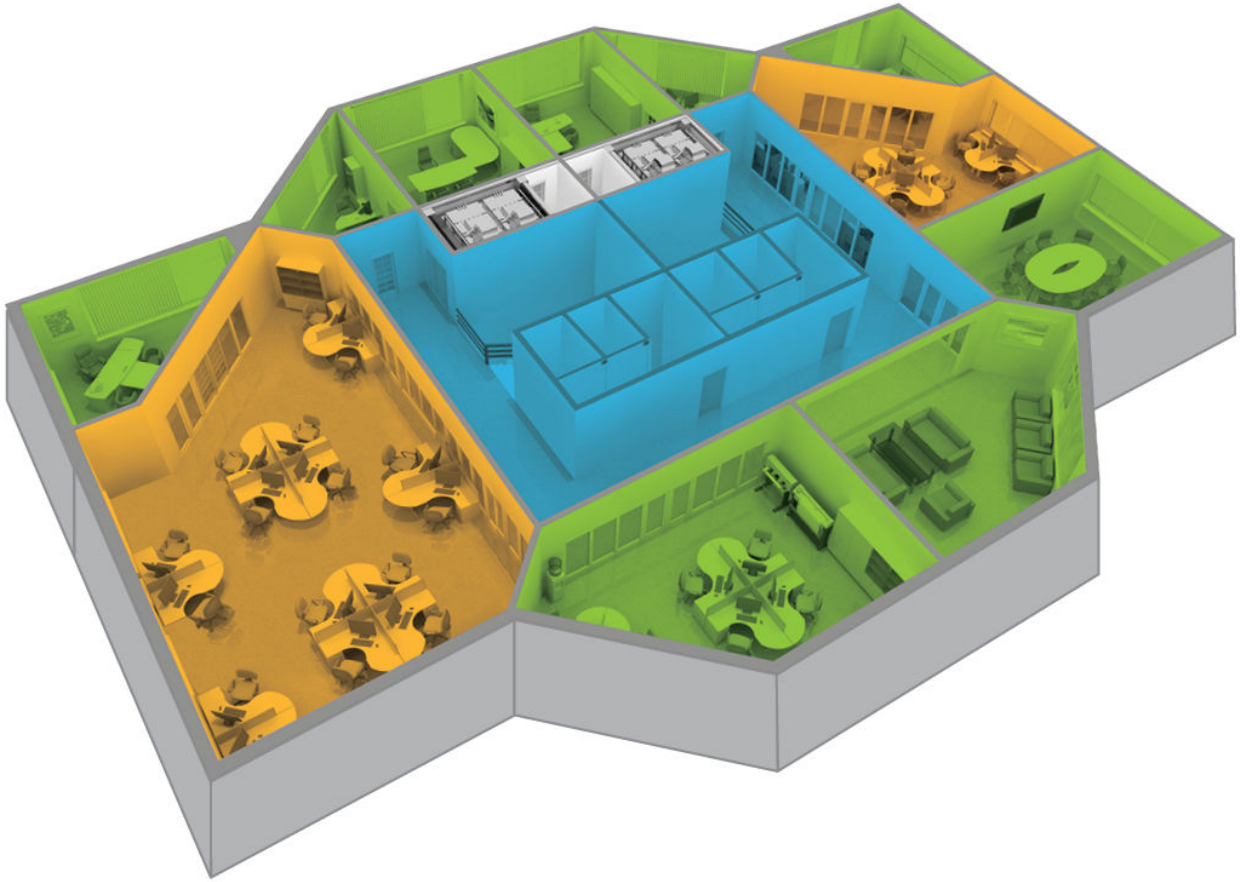
FLOORPLAN: Documenting the SoO



SoO Key:

- Core Area
- Office Area A
- Office Area B
- Restroom

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The future of user experience in Lighting Controls

OPTIMIZING FOR INDIVIDUALS

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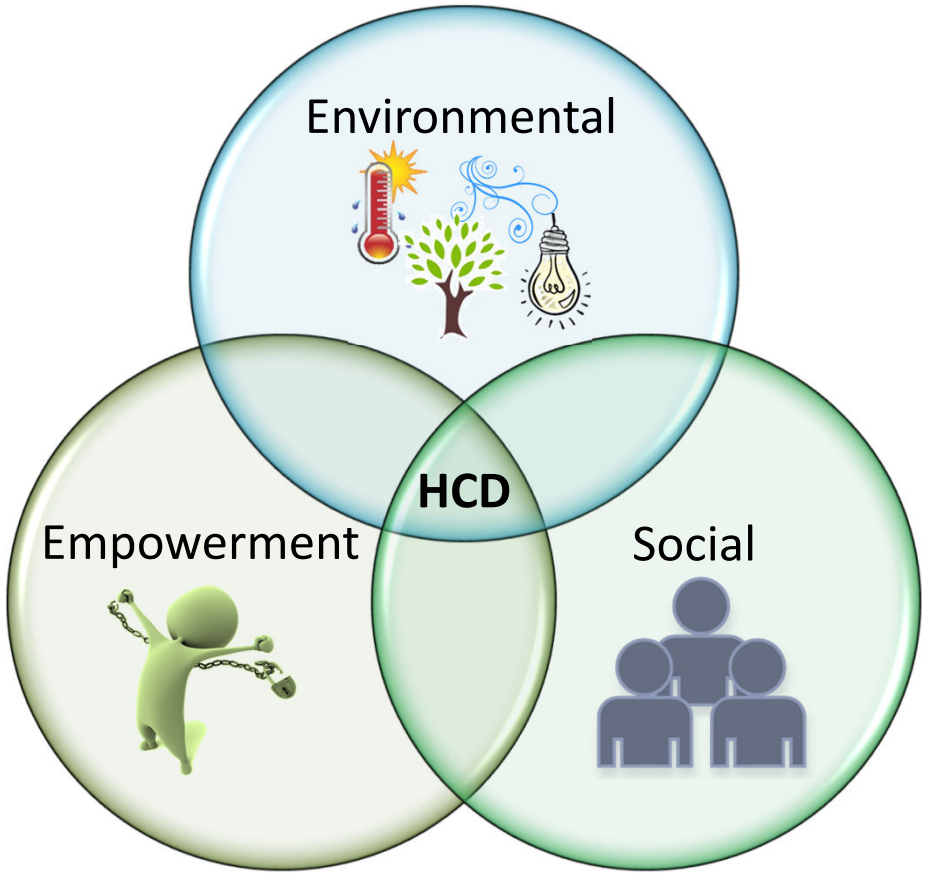
Optimized design for occupants can improve well-being and productivity, particularly when personalized.

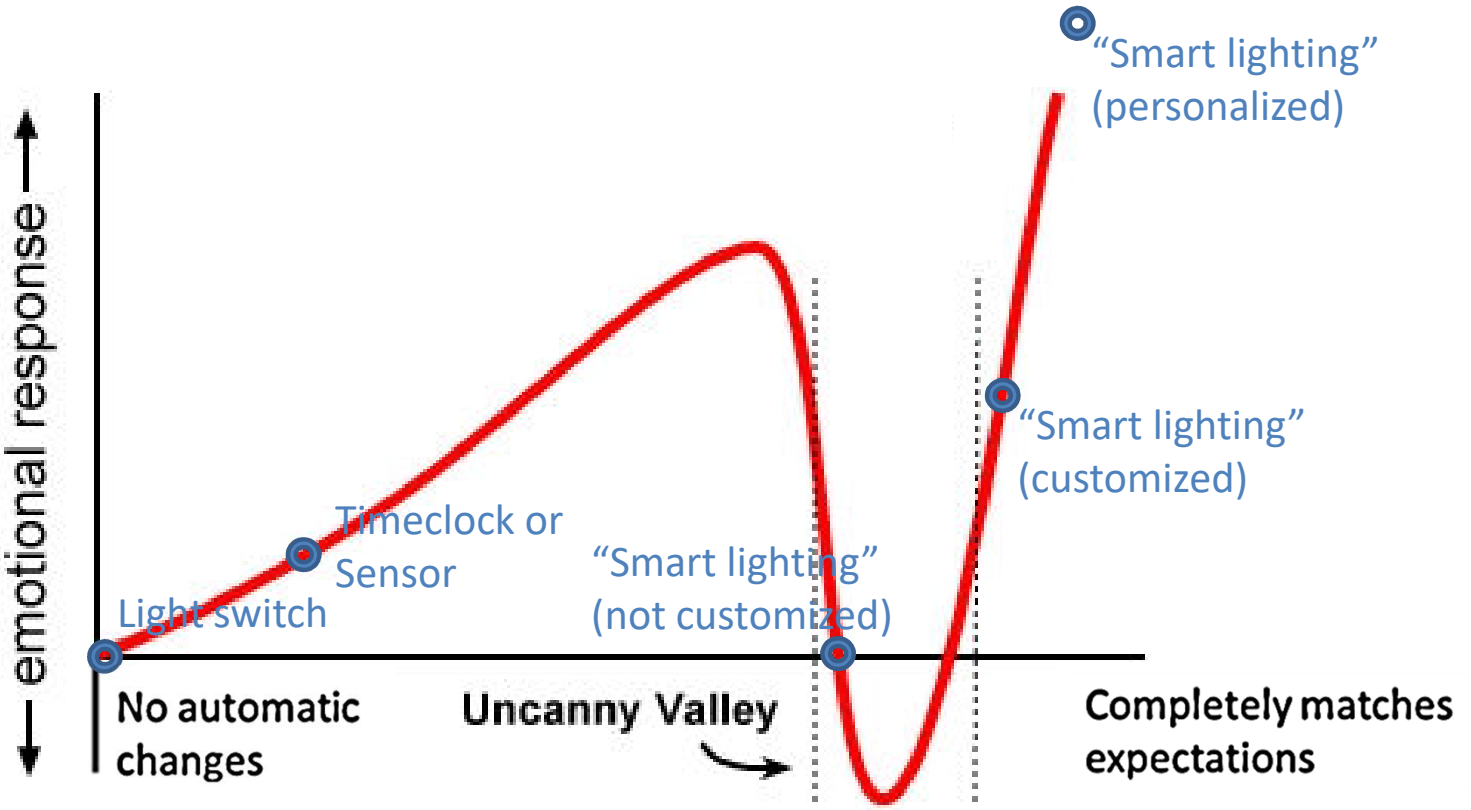


Enhanced office design has been shown to improve employee well-being (up to 31%) and productivity (up to 15%).

Further improvements in well-being and productivity were found when employees were able to personalize their workspace.

Source: Knight, C & Haslam, A. 2010. The relative merits of lean, enriched, and empowered offices: an experimental examination of the impact of workspace management strategies on well-being and productivity. Journal of Experimental Psychology. Vol: 16(2). 158-172.

User experience is optimized systems react to individual needs (or at least personas) instead of space needs



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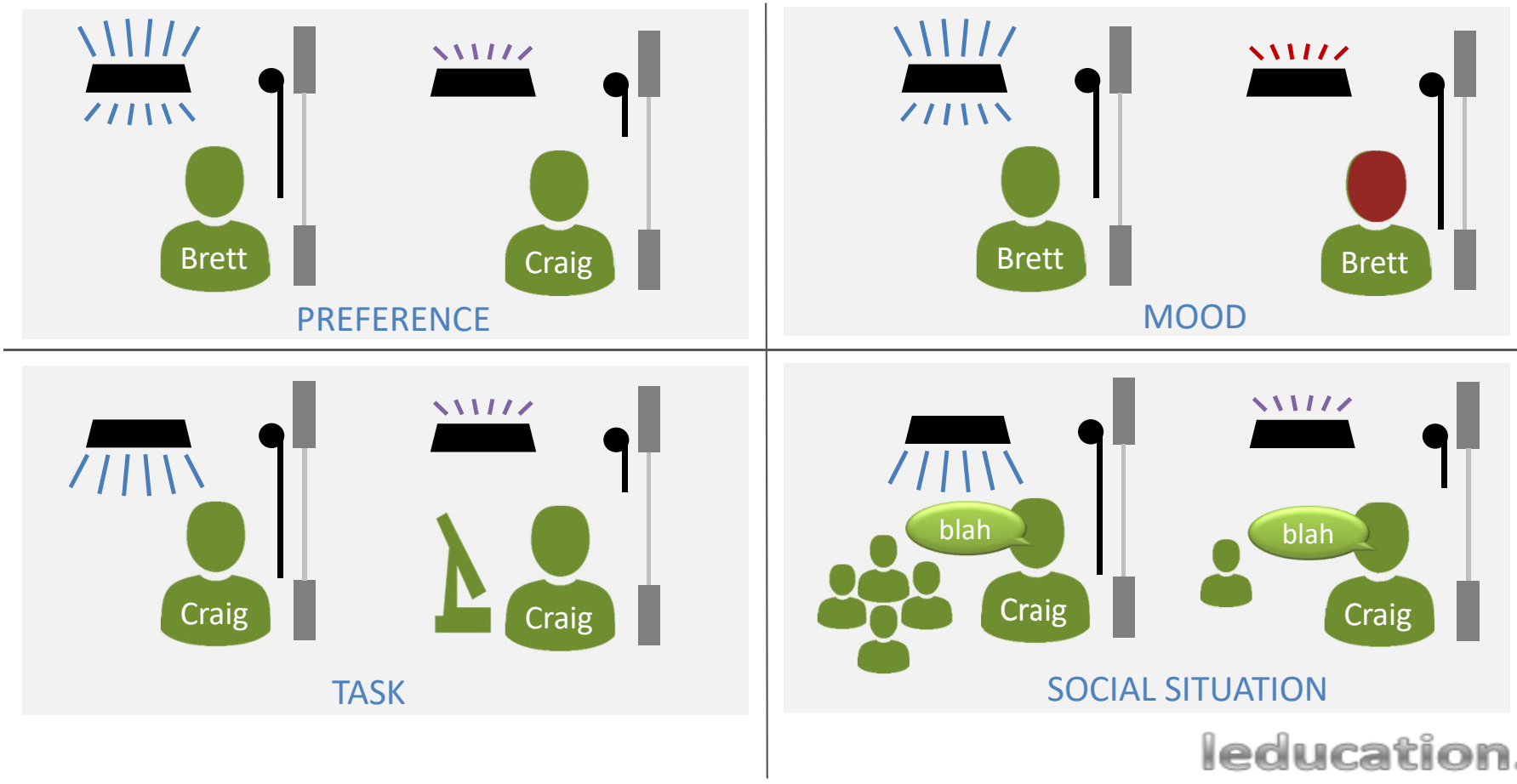
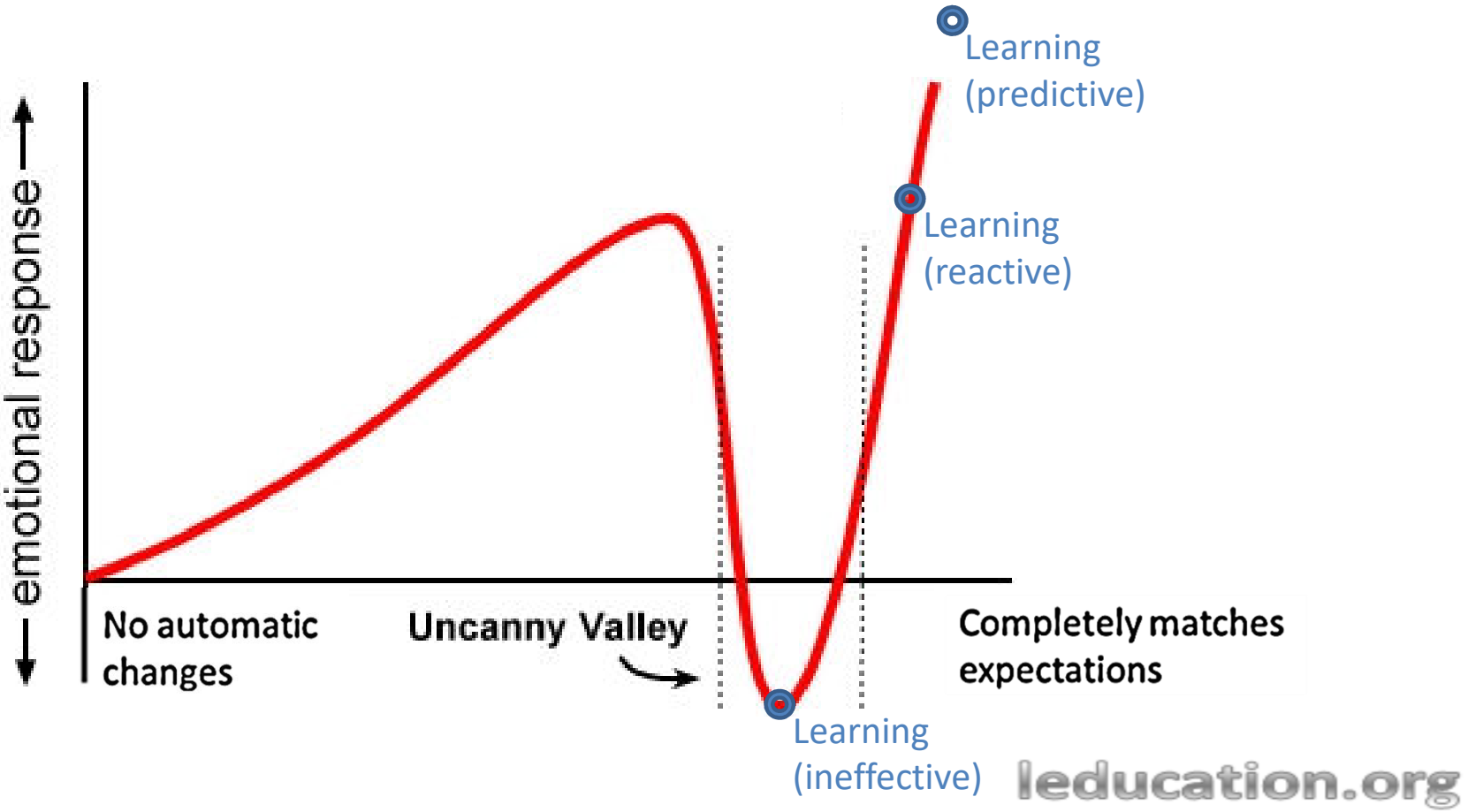
For a truly personalized user experience, systems need to learn user preferences of individuals

MANUAL CONTROL			
	Environment	Empowerment	Social
AUTOMATED CONTROL			
	Environment	Empowerment	Social
MANUAL & AUTOMATED			
	Environment	Empowerment	Social

Optimizing for individuals requires insight into personal preference, mood, task, and social situation



There are three types of learning: reactive, predictive, and ineffective



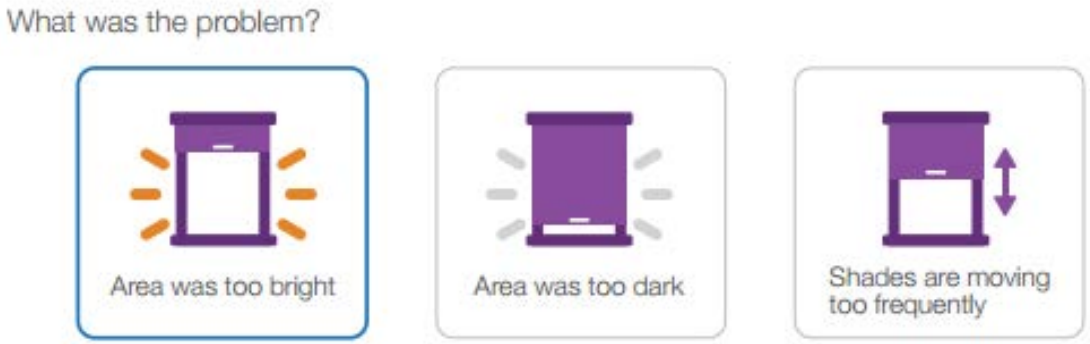
Reactive learning improves the system based on conscious decisions by the users

User defined

- Survey applications
- Helper wizards

Automated

- User overrides
- Changes to system settings



When the user doesn't directly define the problem, there is much greater likelihood of cognitive dissonance.

Predictive learning improves the system based on user activity and preference history

System Integration

- Aggregate sensing across systems
- Access to wearable data
- Predict activity, mood, social needs…

Profile Generation

- Learn common preference profiles
- Aggregate learning across buildings

When the user hasn't yet perceived the problem, there is exponential likelihood of cognitive dissonance.

Systems that optimize for user experience require greater intelligence and integration

1. Lighting should be integrated into broader human centric design
2. Systems that can link preferences across building type are needed
3. Lighting systems must work…every time

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If you remember nothing else…

PRESENTATION SUMMARY

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User experience is critical in smart lighting systems

Key Takeaways:

1. Smart lighting systems add value, but require greater consideration for user experience.
2. User experience is more important than operational and energy efficiency combined.
3. A customized SoO dramatically increases user acceptance.
4. Lighting systems of the future will provide personalized lighting that reacts to task, mood, and social situation.
5. Systems that learn need to be nearly 100% effective or there will be considerable user disruption and frustration.

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Answers not guaranteed…

QUESTIONS?

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This concludes The American Institute of Architects Continuing Education Systems Course

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Contact Information:

Brent Protzman, Ph.D.

Director – Building Science & Standards Development

Lutron Electronics

bprotzman@lutron.com

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