Reducing lighting energy use in retail display windows

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ABSTRACT

A field study was conducted at three clothing stores to validate previous laboratory findings indicating that colored LEDs used as background display lighting could: 1) lower the power demand of accent lighting by up to 50 percent; and 2) provide greater attention capture and visual appeal than current lighting practice.

Blue LEDs provided a colored background for window mannequins by illuminating white backdrops. Eliminating fluorescent general lighting and reducing the number and wattage of halogen accent lamps in the display windows reduced the lighting power demand by up to 50 percent. During an eight-week period, more than 700 shoppers rated the attractiveness, eye-catching ability, comfort, and visibility of four different lighting conditions. The results of this field study showed that by introducing color contrast between the displayed objects and the background, the power demand of the accent lighting could be reduced by up to 50 percent without sacrificing visual appeal, visibility, ability to capture the attention of shoppers, and the ability to see the colors of the objects on display. Furthermore, the sales of the products on display were not affected by the 50 percent reduction in lighting.

Keywords: Retail, display window, accent lighting, illumination, colored, blue, background, light-emitting diodes, LEDs, sales.

1. INTRODUCTION

Lighting is a key design element that contributes to the identity, comfort, and visual quality of a retail store. For many specialty stores, the lighting design reflects the retailer's image and works in concert with other design components to feature the store's merchandise and present an image consistent with the store's selling strategy. For example, in warehouse and mass merchandise stores, the lighting design may lean more toward simplicity and efficiency, and light levels are usually high and uniform throughout the space. In exclusive boutiques, on the other hand, the lighting design may lean more toward sophistication and light levels are relatively low and vary throughout the store, as the lighting design depends less on general illumination and more on accent lighting. Regardless of store type, merchandise lighting is designed to meet a number of goals, including attracting and guiding customers, helping customers evaluate merchandise, facilitating the final purchase, and flexibility.[1]

Specialty stores rely on display windows to feature expensive or seasonal merchandise and create points of interest to attract potential customers. Retail lighting designers usually take advantage of the main characteristics of light to create an image consistent with the store's selling strategy. Characteristics such as distribution, intensity, and color of the light are powerful design elements that contribute to the overall image of the store and complement the objects on display. However, among the many recommended considerations for successful display lighting, high light levels and high illuminance contrast between the display objects and their background stand out as two of the most commonly used lighting techniques. In order to create an eye-catching and dramatic display, the illuminance of a store window's accent lighting can be 10 to 30 times greater than that of the surrounding area.[1] The recommended illuminance for display window accent lighting can be as high as 5000 lx for nighttime conditions or 10,000 lx for daytime conditions.[1]

Furthermore, these windows oftentimes feature several incandescent reflector lamps that typically add up to 750-1500W per window and remain on at least 15 hours per day.[2] Moreover, in recognition of how important the lighting of display windows can be, the ASRHAE/IESNA 90.1-2004 standard allows an extra 1.6 W/ft^2 for highlighting purposes. In some cases, such as when a display is enclosed by ceiling-height partitions, the additional lighting is exempt from the total lighting power density calculation.[3] Inevitably, these practices translate to high energy use and cost. Indeed, the U.S. Department of Energy estimates that lighting accounts for 37 percent of total energy use in retail buildings nationwide.[4]

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Despite rising energy costs and continual efforts by energy-saving advocates, retailers are usually wary of saving energy in their stores by simply reducing light levels. Fears of changing the store's image, reducing merchandise visibility, or losing customers' attention to adjacent or competing stores with brighter displays have resulted in few changes to current practice. New lighting technologies, such as LEDs, may offer opportunities for energy savings. However, given their functional and performance differences, new technologies often cannot directly replace existing technologies using the same designs and techniques. It is also difficult to anticipate how people may perceive the change from one lighting technology to another in any given application.

The design approach of the present study challenges current practice and aims to demonstrate that by using innovative lighting techniques implemented with the appropriate technology, energy savings can result while preserving or even improving the store's image. The current project aimed to address energy savings in display windows without compromising the key elements of retail design: store image, merchandise attractiveness, ability to capture shoppers' attention, and sales.

1.1 Background

Simeonova et al. investigated the use of color contrast in retail display windows as an option to reduce the high illuminance contrast between the display and background commonly found in this application.[2] The goal of their study was to use colored light in the background of the display to determine whether color contrast can substitute for illuminance contrast while keeping the same visual appeal and visibility of the display.

For their study, Simeonova et al. designed two laboratory human factors experiments using two identical displays side by side.[2] The reference and test displays were illuminated with halogen incandescent reflector lamps on both the background and the displayed objects. The test display also featured an LED system able to illuminate the background. The goal of the first experiment was to determine whether a colored background had greater visual appeal and attention-capture ability than the white background at the same luminance. The goal of the second experiment was to determine whether a colored background of approximately the same brightness as the white background could be used instead of a high illuminance contrast, thereby allowing for the reduction of accent lighting without compromising the display's visual appeal, the ability to capture attention, and the viewer's ability to see the displayed items clearly.

Simeonova et al. concluded that the use of colored light in the background can offer greater attention capture and visual appeal.[2] Additionally, the study determined that by using this technique, the light output of the accent lighting in the display could be reduced by up to 50 percent without sacrificing the display's visual appeal or the subject's ability to see objects clearly. Further, the study showed that for white light only (i.e., display and background), simply decreasing the illuminance of the background and accent lighting proportionately, so as to save energy but keep the illuminance contrast constant, did not achieve preference ratings as high as those with a colored background. Finally, the researchers also concluded that to fully quantify the effects of colored LED lighting in retail display windows, a field study in an actual store environment was necessary.

1.2 Present study

To build upon prior laboratory results and to further research in the area of retail lighting using LEDs, a field study was conducted to investigate the use of colored LEDs in display windows. Ideally, a field study of retail lighting will evaluate not only energy savings, but also shoppers' preferences, behaviors, and retail sales. Since lighting works as part of a store's atmosphere, it may be beneficial to see whether certain lighting treatments produce certain effects or changes. The goals of this study were to: (1) demonstrate a reduced energy use of up to 50 percent for accent lighting in retail display windows; (2) maintain the visibility of the display window merchandise while enhancing the windows' visual appeal and attention-capture ability; and (3) maintain or improve retail sales in the store where the new lighting had been installed.

2. METHODOLOGY

The field study was designed to evaluate shoppers' lighting preferences and to quantify energy savings and sales for each of four lighting conditions in three retail stores of a clothing chain. Surveys of shoppers were collected and sales from each store were monitored over an eight-week period.

2.1 Retail stores

A popular, nationwide retail clothing store chain agreed to participate in the field study. Three stores located in suburban shopping malls in the Los Angeles, California area were selected for the project. Each store featured a different number and size of display windows and slightly different lighting systems, including 32-watt T8 linear fluorescent lamps in luminaires along the top and bottom of each window or 26-watt compact fluorescent lamps (CFLs) in recessed luminaires. The accent lighting in the three stores consisted of 60-watt PAR30 halogen lamps in a ceiling-mounted track system. Figure 1 shows a general view of a typical display window in each of the three stores.

Fig. 1. Interior view of a typical window in Store 1 (left), Store 2 (center), and Store 3 (right). Note the linear fluorescent or recessed compact fluorescent luminaires for general illumination and the PAR30 halogen lamps used for accent lighting.

2.2 LED luminaires

The desired lighting effect was a uniformly illuminated colored background. The varying display window conditions at each store led to the creation of a custom slim-profile LED luminaire with a very narrow beam distribution (Figure 2). Nine 5-foot-long LED luminaires were built for this study in anodized aluminum. Each luminaire featured sixty 1-watt blue (peak wavelength of 470 nm) LEDs and five drivers. The average input power of the luminaires was 92 W.

Each LED featured a 10-degree beam lens to provide a wall-washing effect over the length of the background posters and to control as much as possible any spill light onto the mannequins. The luminaires were hung from the ceiling, at a distance of 12 to 18 inches from the poster, depending on the window condition.

Fig. 2. Custom LED luminaires built for the study. The luminaires were hung from the ceiling or existing aluminum tracks used for poster displays. The distance to the poster ranged from 12 to 18 inches.

2.3 Experimental lighting conditions

Four lighting conditions were evaluated during the study period: the typical lighting condition plus three experimental lighting conditions using blue LED luminaires. A new lighting condition was presented every two weeks in each store window from February 16, 2004 to April 17, 2004.

1. **Lighting condition 1: LEDs and 30% window lighting power reduction – Weeks 1 and 2**
   Blue-colored LEDs illuminated white poster backdrops added for the study. Fluorescent general lighting was eliminated and a combination of 50-watt and 60-watt PAR30 lamps highlighted the window mannequins.
2. **Lighting condition 2: LEDs, 30% window lighting power reduction, and colored posters – Weeks 3 and 4**
   This lighting condition was similar to the first, but included colored marketing posters added adjacent to the white poster backdrops.
3. **Lighting condition 3: LEDs, 50% window lighting power reduction, and colored posters – Weeks 5 and 6**
   This lighting condition was similar to the second, but a lesser number of 45-watt PAR30 lamps highlighted the mannequins.
4. **Lighting condition 4: Typical lighting – Weeks 7 and 8**
   The lighting was restored to the typical condition (linear 32-watt T8 or 26-watt compact fluorescent general lighting plus 60-watt PAR30 halogen lamps), and poster displays were restored to the typical condition (colored marketing posters only; no white backdrops)

Figure 3 shows each experimental lighting condition used in the three stores.

Lighting condition 1: LEDs and 30% window lighting power reduction

Lighting condition 2: LEDs, 30% window lighting power reduction, and colored marketing posters

Lighting condition 3: LEDs, 50% window lighting power reduction, and colored marketing posters

Lighting condition 4: Typical lighting and marketing posters

Fig. 3. The four lighting conditions evaluated in each store. Conditions 1, 2 and 3 used blue LEDs as background display lighting.

2.4 Data collection

The following data were collected for each store and lighting condition.

2.4.1 Photometric and power measurements

Illuminance and luminance measurements were taken on the vertical surfaces of the mannequins and backdrop posters in each store window for each lighting condition under daytime and nighttime conditions. Figure 4 shows a typical layout of the locations where the measurements were taken. These measurements were taken to evaluate light level changes between lighting conditions and stores, and to monitor the LED light output over the period of the study.

At the time of changing one lighting condition to the next, the electric power of the display lighting was recorded along with a detailed list of the light sources used in each window.

2.4.2 Shopper opinion surveys

Shopper opinions about the attractiveness, eye-catching ability, comfort, visibility, and appropriateness of the display lighting were gathered from a survey designed by the authors and administered by a market research firm.

During each two-week period for each experimental condition, staff from the market research firm surveyed mall shoppers about the lighting conditions presented. Data collection activities were completed on the same day of each week for all eight weeks (Tuesdays at Store 1, Wednesdays at Store 2, and Thursdays at Store 3). Data collection began one hour after each store opened and continued until one hour before each store closed on alternate hours.

Shoppers were randomly selected to complete surveys with the following questions:

1. How eye-catching are the displays?
2. How clearly can you see the merchandise in the displays?
3. How accurately can you see the colors of the merchandise in the displays?
4. How appealing does the lighting make the merchandise look?
5. How comfortable are the displays to look at?
6. How appropriate are the displays for this store?
7. Overall, how much do you like the lighting of the displays?
8. How attractive are the window displays here compared to those in other stores selling similar merchandise?

For the first seven questions, shoppers could answer “Not at all,” “Somewhat,” “Definitely,” or “Very.” For the last question, shoppers could answer “Much less,” “Less,” “About the same,” “More,” or “Much more.” Shoppers were welcome to make any optional comments about the lighting in the window displays. As a token for completing the survey, shoppers were given $5 gift certificates to use at any of the chain’s stores. In total, 713 shoppers (31 percent males, 69 percent females) were surveyed during the eight-week period.

2.4.3 Sales data

Retail sales for each store during each experimental condition were collected by the chain’s headquarters using an existing automated system. For comparison, the same sales data also were collected for three matched or “peer” stores in the Los Angeles area. Sales at each store were also compared with sales for the same period of the previous year.

3. RESULTS

3.1 Photometric and power measurements

Table 1 shows the average illuminances on the mannequins and the backdrops across windows for each store and each lighting condition. Because this study explored issues of illuminance and contrast, ideally the contrast ratio between the background and mannequin lighting should have remained constant across all windows. The limitations of the field study, including changing lamps and frequent re-aiming of accent lamps, made this unfeasible. Additionally, although measurements were taken in a consistent manner (Figure 4), the frequent changes of posters and mannequins positions throughout the study meant that light levels could not be measured at the same point each time.

Over the course of the study, LED light level differences on the poster backdrops remained within 20%, with the LEDs running at full light output during the experimental lighting conditions. These changes were the result of differences in the measurement position changes, rather than light output degradation. Differences in accent light levels on the mannequins remained within 27% across comparable lighting conditions (i.e., typical lighting documented before the start of the project and after being restored to its usual condition). These differences are reasonable, considering the mannequin, clothing, and poster changes that occurred in the window displays between these two conditions, and are most likely unnoticeable.[5]

For lighting conditions 1 through 3 (blue LED illumination on backdrops), the accent light levels on the mannequins were gradually reduced to an average across stores of 26% (30% nominal reduction) and then to 49% (50% nominal reduction). This change occurred with reductions in the number and wattage of accent lights to reduce power demand by an average across stores of 32% and 47%, respectively.

Table 1. Average illuminance and standard deviation (in parentheses) across windows for each store and each lighting condition at night (no daylight contribution). The background measurements are from the blue LED illumination, whereas the mannequin measurements are from the white accent lighting.

		Lighting condition 1 LEDs + 30% power reduction	**Lighting condition 2** LEDs + 30% power reduction + color posters	**Lighting condition 3** LEDs + 50% power reduction + color posters	**Lighting condition 4** Typical lighting
Store 1	Background	1337 lx (667 lx)	1435 lx (354 lx)	1167 lx (671 lx)	488 lx (55 lx)
	Mannequins	412 lx (181 lx)	313 lx (140 lx)	234 lx (114 lx)	682 lx (289 lx)
Store 2	Background	1089 lx (564 lx)	1159 lx (703 lx)	1008 lx (594 lx)	562 lx (282 lx)
	Mannequins	680 lx (500 lx)	560 lx (347 lx)	260 lx (214 lx)	673 lx (331 lx)
Store 3	Background	762 lx (251 lx)	739 lx (225 lx)	674 lx (199 lx)	536 lx (47 lx)
	Mannequins	541 lx (332 lx)	348 lx (165 lx)	316 lx (198 lx)	753 lx (84 lx)

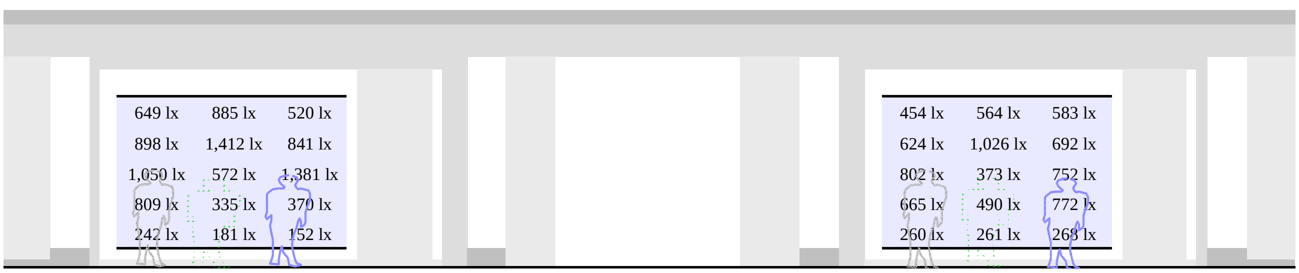


Fig. 4. The typical grid of vertical illuminance and luminance measurements taken for each window (Store 3, lighting condition 1 in this example). The top two rows indicate measurements on the background (i.e., blue illumination), whereas the lower three rows indicate measurements on the mannequins (i.e., accent lighting).

Table 2 shows the connected electric load and estimated annual energy use for all the windows in each store for each lighting condition. The table also shows the percentage reduction of each lighting condition compared to the typical lighting. The annual energy use calculations are based on 108 hours per week, 52 weeks per year. The lighting in the stores is controlled via a centralized service that turns the lighting circuits on and off at a preset time.

Table 2. Connected electric load, annual energy use, and percentage reduction from existing lighting for all windows in each store. The estimated annual energy use calculations are based on 108 hours per week, 52 weeks per year.

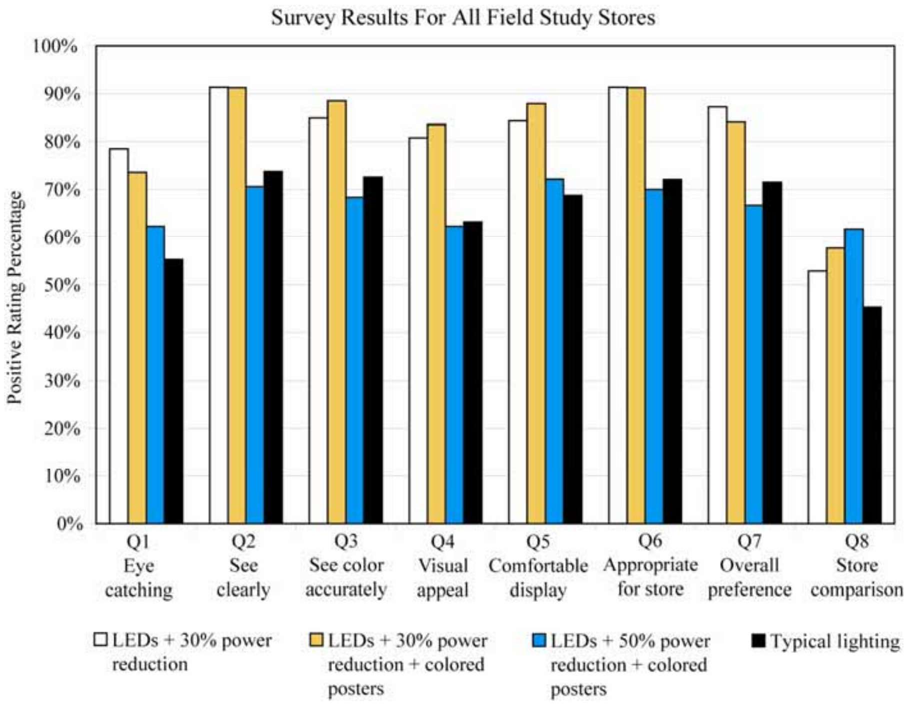
		Lighting condition 1 LEDs + 30% power reduction	**Lighting condition 2** LEDs + 30% power reduction + colored posters	**Lighting condition 3** LEDs + 50% power reduction + colored posters	**Lighting condition 4** Typical lighting
Store 1	Electric load	1063 W	1063 W	886 W	1585 W
(4 windows)	Energy use	5970 kWh/y	5970 kWh/y	4976 kWh/y	8901 kWh/y
	Reduction	33%	33%	44%	0%
Store 2	Electric load	756 W	756 W	586 W	1140 W
(3 windows)	Energy use	4246 kWh/y	4246 kWh/y	3291 kWh/y	6402 kWh/y
	Reduction	34%	34%	49%	0%
Store 3	Electric load	634 W	634 W	454 W	890 W
(2 windows)	Energy use	3561 kWh/y	3561 kWh/y	2550 kWh/y	4998 kWh/y
	Reduction	29%	29%	49%	0%
Average reduction		**32%**	**32%**	**47%**	**0%**

3.2 Shopper opinion surveys

Figure 5 shows the results from the shopper opinion survey for all three stores combined. The graphs show the percentage of positive responses for each question in the survey (possible answers “Definitely” and “Very” were considered as positive). Table 3 shows the summary of a chi-square statistical analysis carried out to determine the effect of each lighting condition on subjects’ evaluations of the windows.

Overall, the use of colored LEDs with a 30% power reduction (lighting conditions 1 and 2) produced a statistically significant improvement on all questions compared with the typical lighting. Between the two 30% power reduction conditions (i.e., with and without colored posters), there were no statistically significant differences for any question. This result implies that color contrast instead of illuminance contrast could be used in shop windows with varied backgrounds and objects on display. For the 50% power reduction condition (lighting condition 3) compared with the typical lighting, the results showed a statistically significant difference only for the question of whether the LED condition was more attractive than the window displays of other stores. As expected, for most of the surveyed questions, the use of colored LEDs with a 30% power reduction produced a statistically significant improvement over the 50% power reduction.

In summary, these results agree with the findings of Simeonova et al.[2] By using colored LEDs to illuminate the background, the accent illuminance on the displayed objects can be greatly reduced; therefore, the amount of power used for accent lighting in display windows can be reduced by up to 50% without negatively impacting shoppers’ perceptions of the window. However, colored LEDs and accent light level reductions of less than 50% can improve shoppers’ perceptions while saving a significant amount of power.



Q1. How eye-catching are the displays?

Q2. How clearly can you see the merchandise in the displays?

Q3. How accurately can you see the colors of the merchandise in the displays?

Q4. How appealing does the lighting make the merchandise look?

Q5. How comfortable are the displays to look at?

Q6. How appropriate are the displays for this store?

Q7. Overall, how much do you like the lighting of the displays?

Q8. How attractive are the window displays here compared to those in other stores selling similar merchandise?

Fig. 5. Shopper opinion survey results averaged across the three stores for each lighting condition.

Table 3. Summary of the chi-square test analysis. Shaded cells indicate a statistically significant difference (p<0.05).

Statistical comparisons	Q1. Eye catching	Q2. See clearly	Q3. See color accurately	Q4. Visual appeal	Q5. Comfortable display	Q6. Appropriate for store	Q7. Overall preference	Q8. Store comparison
30% reduction, no colored posters × colored posters	0.344	0.869	0.404	0.599	0.407	0.869	0.490	0.425
30% reduction × typical lighting	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.006**	**0.024**
50% reduction × typical lighting	0.221	0.578	0.438	0.438	0.540	0.753	0.380	**0.003**
30% reduction × 50% reduction	**0.027**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.507

3.3 Sales data

In order to understand the impact of the lighting conditions on sales, the sales for the three test stores were compared with three other stores used as controls for this study, also located in the Los Angeles area. In addition, sales at the six stores were compared with the prior year's (2003) totals. For each store, sales data were collected starting two weeks (Wk 0a and 0b) prior to the installation of the first experimental condition until to two weeks (Wk 9 and 10) after the typical lighting condition. In the prior year, sales data were collected for the same period. Figure 6 shows the sales data in arbitrary units to preserve the store's confidentiality.

The data indicate that in both years, sales totals at the test stores were generally lower than at the control stores. Also in both years, the sales trends for a given week at each store were similar. A detailed analysis of the sales data showed that the change to blue LED lighting and the reduction of accent light levels during weeks 1 through 6 did not affect sales, either positively or negatively.

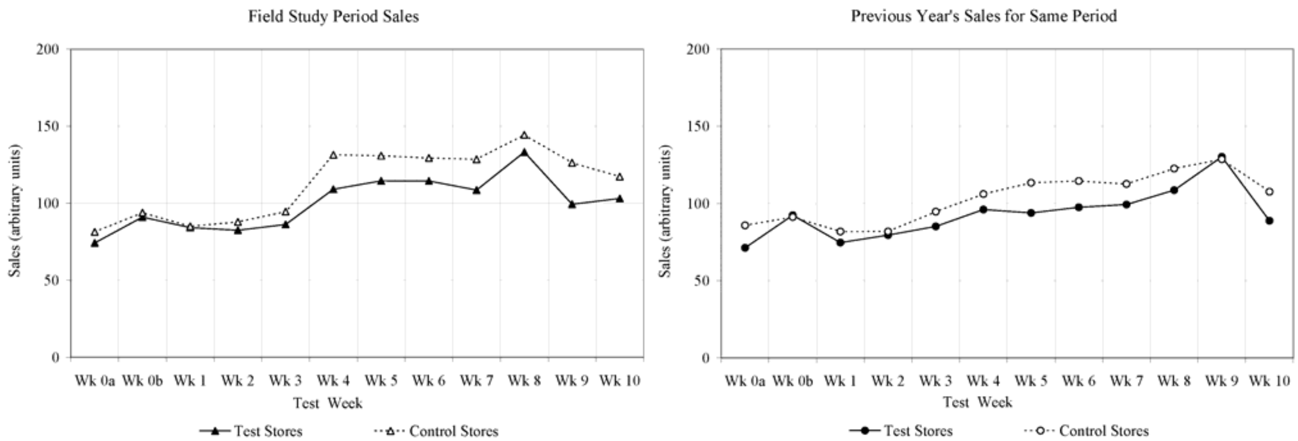


Fig. 6. Retail sales for the field study period (left) and the same period in the previous year (right) for the test stores and the matched control stores. The blue LED experimental conditions ran from Wk 1 to Wk 6, and the typical lighting condition ran from Wk 7 to Wk 8.

4. DISCUSSION

The addition of colored lighting to the display window background produced statistically significant positive effects. The use of color contrast instead of illuminance contrast allowed the windows' lighting power to be reduced up to 50% without a negative impact on merchandise visibility or shoppers' opinions of the windows' visual appeal. Blue LEDs were selected for this study, but it is likely that the lighting design could be recreated using any LED color available to suit the window designer's chosen theme. From a practical point of view, the performance (luminous efficacy and life) of different colored LEDs differ between each type, which will affect the overall power consumption and life of the LED luminaires.[6,7] The number and type of accent lamps selected for a window, as well as any added general lighting, also will alter the window's total power consumption. Additionally, the color contrast effect may differ, depending on the LED color chosen; for example, pastel pink LED background lighting with white accent lighting will not produce as strong of a contrast as will blue LED background lighting with white accent lighting.

Beyond evaluating energy savings and shoppers' lighting preferences, this study attempted to find a possible connection between lighting and retail sales. Although energy savings and opinions can be easily measured and analyzed, the effect of lighting on sales is much more complex. The effect that light has on a person's behavior is real and can be significant, but is usually of unknown magnitude and is unreliable. Behavior is subject to many factors besides lighting. For example, in retailing, lighting can draw attention to merchandise, but it cannot guarantee a sale.[8] The closer a desired behavior (such as wanting shoppers to look at a store's windows) is to the natural behavior of the visual system, the more likely it is that lighting will generate that behavior. The visual system is designed to detect changes in the visual field; therefore, the eyes will be drawn to contrasts and deviations, such as flashing lights or colored lights.[9] In fact, light and color can have such a strong influence on people's attention so as to even physically attract customers toward a retail display and set a tone for the store's atmospherics.[10] Research has also shown that light and color strongly influence the perceived image of a store and its pricing strategy.[11]

The change in retail sales during the study period was evaluated as a shopper behavior that could potentially be influenced by the change in lighting. Several previous in-store studies have looked at the effects of lighting on consumer behavior and sales.[12-15] Areni and Kim found that brighter lighting influenced shoppers to examine and handle more merchandise, but illumination level had no significant effect on the time spent at the display or on sales.[12] Cuttle and Brandston studied the effect of relighting two furniture galleries with higher illuminances and a more even light distribution.[13] Sales in one gallery increased 35%, but the other gallery had no consistent change in sales. Boyce et al. tracked sales at a supermarket.[14] The refurbished bakery section, which included changes to the lighting, layout, and display methods, experienced a significant increase in sales during the first 10 weeks after the reopening, though the remainder of the store, which underwent changes in lighting only, did not experience any significant increase in sales. Summers and Hebert investigated the approach-avoidance behaviors of shoppers at two types of retail stores (a hardware store and a Western apparel/feed store), specifically the amount of time at display, the number of items touched, and the number of items picked up under two lighting treatments (ambient lighting only and ambient lighting plus supplemental display lighting).[15] They found that the supplemental display lighting treatment produced different effects on consumer behavior depending on the type of store.

In summary, while shopper behavior can be measured, it is difficult to determine the mechanism behind any change in behavior when evaluating lighting changes.[8,11,15] The connection between lighting and sales may be nearly impossible to establish because of other factors that influence shoppers' purchase decisions, such as product quality, price, and fit. In this study's findings, sales during the experimental period were similar to those in the prior year and were comparable to other stores. Therefore, the lighting most likely did not affect sales.

Although the existing lighting design of the stores already featured an energy-efficient system (the average power per window in the three stores was 400 watts), with the addition of LED illumination on the backdrops it was possible to attain an average power savings of 47%. Simeonova et al. reported that the typical retail window measuring 10 linear feet requires approximately 750-1500 watts and uses approximately 6200 kWh per year.[2] On the basis of these estimates, retailers that cut half of the lighting wattage in their windows can reduce their electric bill by approximately $310 per year per window (at a rate of 10 cents per kWh). Given the longer life of LEDs, retailers may also save up to an additional $150 per window per year on relamping, cleaning, and maintenance, bringing the total savings for LED window lighting up to $470 per year. This assumes no maintenance over the life of the LED systems and fewer accent lamps illuminating the displays. Presently, there are more LED products that can be used to recreate this design in a retail application. A price survey during the summer of 2005 estimated the cost of a commercial LED system similar to the one built for this study to be from $2000 to $5000 per window. Considering the incremental cost of the LED system at that time (ranging from $1000 to $4000 per window), the payback time can be anywhere from two to ten years. LED system costs are expected to decrease in the coming years, shortening the payback time. Further, improvements in LED technology also will lead to greater energy savings. For example, the nominal light output of the LEDs used in the study was 10-lumen per 1-watt LED.[16] Currently, the same product is rated at 16-lumen.[17]

5. CONCLUSIONS

This study aimed to show the potential for energy savings in retail display windows by using colored light in the background and reducing the power used for accent lighting. The results from more than 700 surveys showed that this technique can be used successfully. In summary, the data show that if used with a colored background, an accent lighting power reduction of up to 50% is possible without compromising the aesthetic value of the display. A 30% accent lighting power reduction can significantly improve the subjective responses and save energy. The use of blue colored light in the display background and the reduction of accent light levels did not affect sales in any of the test stores.

One issue requiring further study is the appropriate luminance contrast ratios between backgrounds of different colors and the mannequin lighting. Ideally, for a given color, the luminance contrast ratio should remain constant, regardless of changes in window displays, to ensure maximum visibility and shopper acceptance.

The luminaires built for this study provided relatively uniform illumination over the length of the backdrops. While a uniform wall-wash is the most desirable, a soft gradient from top to bottom is acceptable in most applications, especially where mannequins or other display objects block the lower portion of the background. As a guideline, illuminance ratios of approximately 4 to 1 (top to bottom) are acceptable and usually achievable with standard products. For example, a linear luminaire with an asymmetric distribution would be appropriate. It is also important to select the right background material, aiming angle, and luminaire setback distance to help achieve uniformity and avoid specular reflections.

Different LED products are now available in the market for wall-washing, including linear luminaires with a continuous row of LEDs (e.g., in 4-foot lengths), single units of smaller lengths (e.g., 1-foot), and linear products with asymmetric distributions (e.g., wall-washers). As LED technology advances, product offerings increase, and prices decrease, it will be easier and much more cost-effective to implement the colored background technique described in this study.

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