Summary

Investigations on the use of LED modules for optimized color appearance in retail applications

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Novel LED modules for retail applications

"Lighting should create an ambience that complements the design and brand of the store"
Trends in retail suggest that physical stores are increasingly required to differentiate their value and create an engaging experience for customers in order to thrive in the face of online competition. In a changing retail landscape, bricks-and-mortar stores need to build on their advantages in terms of standing out and creating a personal, fun experience and relationship with customers. By using the right type of lighting for an application, retailers have a compelling tool to help create an ambience that fits with the brand and store. Lighting influences the mood and energy level of people. It also provides guidance and orientation and gives breadth and clarity. As such, good lighting can reduce stress for customers and contribute to creating a welcoming, comfortable and enjoyable place in which people linger longer. By helping products stand out and look their best in terms of colours, shape and texture, lighting can trigger curiosity, give extra accent to certain products and subtly navigate attention for example to sales, new or high revenue merchandize with the goal of increasing sales.

LED lighting brings flexibility and new opportunities to show products at their best
LED technology has developed tremendously over the past few years. Many lighting professionals might remember the first wave of white LED sources on the market. Their light was often dim, extremely cold and conveyed to colours an ugly and unnatural hue. Many who were not simply impressed by the label of "LED" yearned for the high quality, good colour rendering properties and warm white light of halogen.

As is often the case with many new technologies, the lighting industry responded by developing products, with more or less success, that mimic the light qualities of conventional sources (e.g. HID, halogen) while building on the benefits of LEDs (e.g. long lifetime, low maintenance, energy saving). Fortunately rapid gains in the efficiency paved the way for warm white LEDs to replace their early cold white counterparts in many applications. The Xicato® Artist Series® is a prime example of how far LED lighting has come in terms of light quality. Among LED sources, it is currently rated in the market as having the best colour properties – comparable to halogen.

With the present maturity of LED lighting, there is now growing focus to look beyond mimicking the light properties of conventional sources to taking advantage of the unparalleled opportunities that LEDs offer to fine-tune the spectral power distribution of a light source. A parallel can be drawn with learning to play music: first imitate, then originate. By cleverly designing the light spectrum, it is possible to generate various light impressions and optimise the colour appearance of objects within acceptable limits, for example. With this goal in mind, Xicato designed 4 different experimental modules that have chromaticites below the black body locus (BBL). This is in contrast to their commercial modules, which have chromaticities on the black body locus. All of these modules have a CCT of 3000K. Furthermore the spectra of the experimental modules were designed such that 2 have Ra > 80 and the other 2 have Ra > 95. Initial experimentation at Xicato showed that white objects appear brighter and crisper and that blue colours and colours containing blue such as pink and purple appear more vibrant under the experimental sources. The light sources used in the test are listed in the Table 1.

Light sources

Item	Module	Description	Ra	CCT (K)	Chromaticity x	Chromaticity y
1	**XSM8030** commercial	Color point on black body locus. Light quality on par with compact fluorescent and compact metal halide down lights	83	2935	0.4454	0.4131
2	**XSMBBBL-1/8030** experimental	Color point **below black body locus (BBBL)**. Blue content higher than in XSM8030	86	2951	0.4352	0.3948
3	**XSMBBBL-2/8030** experimental	Color point **further below black body locus**. Blue content even higher than in XSMBBBL-1/8030	86	2949	0.4317	0.3874
4	**XSM9530** commercial	Color point on black body locus. Light quality on par with halogen	98	2975	0.4497	0.4195
5	**XSMBBBL-1/9530** experimental	Color point **below black body locus**. Blue content higher than in XSM9530	97	2971	0.4306	0.3876
6	**XSMBBBL-2/9530** experimental	Color point **further below black body locus**. Blue content even higher than in XSMBBBL-1/9530	96	2948	0.4288	0.3815

Light technical data provided by Xicato, San Jose, CA

Research Set-Up

Twenty shoppers and more than forty lighting professionals from Europe participated in tests evaluating the attention-grabbing nature of display

Xicato commissioned independent lighting application researcher, Dr. Colette Knight, to design and carry out research to evaluate and compare the effect of the 4 experimental and 2 commercial modules on the attention-grabbing nature of different types of merchandize. More than 20 members of the public and forty lighting professionals from Europe were invited to the lighting laboratory of the Instituut Lichtontwerpen in Amsterdam to participate in the research. Individual interviews with the members of the public were conducted together with a market research agency, Klantkenners. The research with the professionals was organized in 7 different sessions each involving individually filled out questionnaires. Dr. Johan van Kemenade and Mr. Peter Raynham of University College London reviewed the research set-up and full report.

The participants were not informed about which modules were being evaluated. To evaluate the modules a mock-up shop was built. For accent lighting, a shelf divided into 3 sections each fitted with identical items was installed. The lighting control system enabled the 3 sections of the display shelf to be independently illuminated with a different spot. 2 modules of each type were installed for a total of 12 spotlights. This was done so that the same type of module could be evaluated in 2 different sections to reduce the influence of a bias for one of the sections. General lighting was provided by 4 downlights equipped with the same type of module. It was possible to switch between the 6 different types of modules used. This was achieved by installing 4 panels each containing the 6 different modules as shown in photograph of figure 1.

Figure 1: Experimental set-up to evaluate the effect of the modules in accent lighting and general lighting applications

Figure 2: Example of a participant doing the test

A variety of combinations (presets) of accent and general lighting were used to evaluate the 4 experimental and 2 commercial Xicato spot modules in accent and general lighting applications. In some presets, the average illuminance in the middle of all 3 sections of the display was comparable (~750 lx). In other presets, the average illuminance in 1 or 2 of the sections was set such that it was ~20% lower than in the 3rd section. These presets were used to evaluate whether or not the colour optimisation afforded by the experimental modules would enable lower light levels to be used while maintaining the appeal of the display. The order in which the presets was randomized between the respondents and groups.

It is clear that the effects of accent and general lighting are interdependent. Nevertheless in the research set-up, care was taken to focus the attention of the respondents initially on the effects of the accent lighting and then on the general lighting so that the appropriateness of the light spectra for both accent and general lighting could be evaluated.

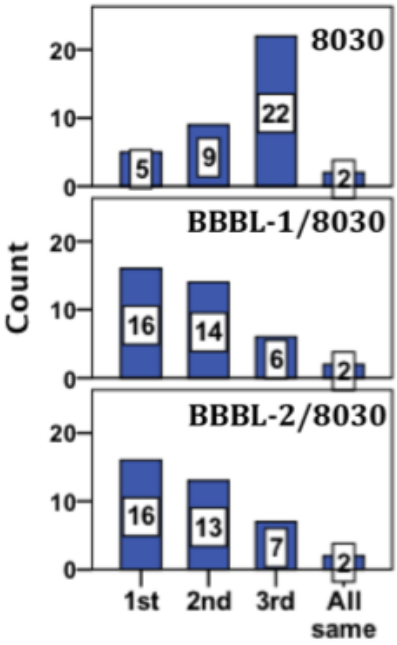
Results
"Lighting makes a big difference – it affects the image of the product"

All of the modules evaluated are widely recognized as having good, high quality white light. However, the results indicate that the different accent light sources have a profound effect on the image of the products and people's impressions about their quality. Additionally, it affects the ambience of the display, its attention-grabbing nature and whether the display appears warmer or cooler, or more striking or in harmony.

The table and histogram in figure 3 shows one example of the results. In this instance, the professionals were shown the 3 sections of the display lit with the commercial and 2 experimental modules with Ra >80 and asked to rank the sections in 1st / 2nd / 3rd order based on the attention-grabbing nature of the sections. However, the respondents were not forced to find differences between the sections. When the respondents perceived 2 sections to be equally good and better than the third section, then they were instructed to rank the 2 "better" sections as 1st and the least preferred section as 3rd. In this event, none of the sections were ranked 2nd. When 1 of the section was perceived to be better than the other two, but these two were perceived to be equal with regard to the specific attribute, then the respondents were instructed to rank the preferred section as 1st and the other 2 sections both as 2nd. In this event, none of the sections were ranked 3rd. Since it was possible for more than 1 section to be ranked 1st or 2nd and for none to be ranked 2nd or 3rd, the total number of 1st, 2nd and 3rd place positions in a given evaluation can deviate somewhat from each other.

More than 80% of the professionals (32 out of 38) chose a display lit with one of the experimental modules (BBBL-1/8030 or BBBL-2/8030) as the one that would grab their attention the most. The reasons given for the higher attention-grabbing nature were mostly related to the vibrancy of colours, in particular, red, pink and blue.

	Ranking (1st / 2nd /3rd)		
Nr. of Respondents	8030	BBBL-1/8030	BBBL-2/8030
11	3rd	2nd	1st
10	3rd	1st	2nd
5	2nd	1st	3rd
3	2nd	3rd	1st
3	1st	3rd	2nd
2	1st	2nd	3rd
2	All same		
1	3rd	1st	1st
1	2nd	2nd	1st
Total Nr. 1st places	**5** (3+2)	**16** (10+5+1)	**16** (11+3+1+1)
Total Nr. 2nd places	**9** (5+3+1)	**14** (11+2+1)	**13** (10+3)



Total Nr. 3rd places	**22** (11+10+1)	**6** (3+3)	**7** (5+2)
Total Nr. 'All same'	2	2	2

Figure 3: Table and histogram showing the results of the question "Which section would grab your attention the most?"

Specifically when the displays are lit with the experimental modules with chromaticity below the BBL, lighting professionals and members of the public often note that

- Colours of the items are more striking. In particular, blue and pink colours appear brighter and bolder
- White objects appear brighter, cleaner and stand out more from the distance
- Ambience of the display is cooler
- Individual objects stand out more distinctively in a group

There were a number of examples in the test that indicate that a deeper, more saturated appearance of colours enhances the appeal and perceived quality of some items. The respondents provided the following feedback about the opportunities and limitations of exploiting the effects of warm white light sources that enhance the appearance of colours:

- Light effects can be used to help specific products stand out and make a statement. This is consistent with the wishes expressed by the lighting professionals.
- However colour enhancement is clearly not for all applications. For some participants, and in some applications, more vibrant colours appear too strong and are perceived as being too artificial.
- Whether or not colour enhancement by lighting is appreciated depends on the merchandize targeted, type of store and the message that it wants to radiate.

For a generic display, brightness was not compensated by the experimental chromaticities. However the results suggest that for displays with mostly blue or blue containing colours, such as pink, there is an opportunity to reduce the light level by ~20% when sources with chromaticity below the BBL are used, while keeping the attention-grabbing nature of the display comparable to what it would be under a source with chromaticity on the BBL. As such, modules with colour points below the BBL can offer an opportunity for energy savings in specific applications.

In retail, good lighting is not only defined by how appealing and appetizing it makes the merchandize appear. The lighting is also expected to contribute to a warm and welcoming impression and be comfortable. People in the store should not be annoyed or disturbed by excessively high contrasts, stray reflections, blinding, hot spots or glare. Therefore the test also assessed how comfortable people feel being in a room lit with the experimental modules. In general, the commercial modules with colour points on the BBL are perceived as warmer. With the experimental modules where colour points were below the BBL, whites are perceived as cooler, crisper or having a slight pinkish tint. However, all sources were acceptable and while there were individual preferences, there were no statistically significant differences in how the respondents scored the 6 sources regarding the natural appearance of skin tones and perception of comfort. This result thus underscores that such experimental sources can successfully be used for general lighting.

The appreciation expressed by both professionals and shoppers of the light effects of the experimental modules in certain application strongly indicate that there is a role for light sources that provide a controlled vibrancy to compliment more natural sources. The combination can be used by lighting designers to reveal vivid colours and whites while maintaining a natural environment. Finally it also highlights the importance of specifying the colour point (or Gamut Area Index) in addition to the CCT and Ra as a selection criterion for retail lighting. Use of sources with colour points below the BBL that increase the colour saturation within acceptable limits can help enhance the in-store experience.