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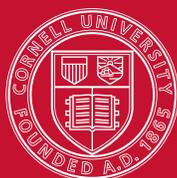


Cornell Hospitality Report

Examining the Effects of Full-spectrum Lighting in a Restaurant

by Stephani K.A. Robson and Sheryl E. Kimes, Ph.D.

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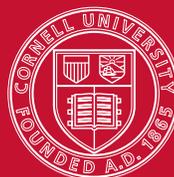
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Examining the Effects of Full-Spectrum Lighting in a Restaurant

by Stephani K.A. Robson and Sheryl E. Kimes, Ph.D.

EXECUTIVE SUMMARY

A simple test of full-spectrum light found that changing the lamps in a restaurant's dining room had no noticeable effect on diners' purchases or the length of time at table. The study was motivated by the common perception that full-spectrum light increases people's sense of well-being, which should, in turn, result in behavioral changes. With the cooperation of a table-service restaurant that has two similar dining rooms, the study involved changing the lights in one of those dining rooms. With the lamps replaced, the researchers compared average checks and meal durations between the dining rooms, and also compared the main dining room sales when it had regular incandescent light with sales during the full-spectrum light test. None of the comparisons showed any difference between the regular lighting and the full-spectrum lighting with regard to customers' purchases. Because the change to full-spectrum light in this study was intentionally subtle to conform to the operator's needs, future research should involve a more controlled study that also manipulates and takes into account changes in the brightness of the light. However, the results of this study do not support claims that full-spectrum light affects diners' activities.

ABOUT THE AUTHORS

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Examining the Effects of Full-Spectrum Lighting in a Restaurant

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Lighting is a large contributor to diners' overall restaurants experience. A common belief among restaurateurs is that subtle environmental effects such as music or lighting influence guests' behavior, whether that means increased table turns or higher spending. Managers' beliefs about how atmospheric elements affect diners are based to some extent on conjecture and anecdotal information.¹ Moreover, any beliefs might be susceptible to manufacturers' claims about the effectiveness of particular lighting or sound systems. One such claim is that full-spectrum lighting—light that appears similar to natural daylight—increases sales. For this report, we investigated whether full-spectrum lighting actually influences diners in a full-service restaurant, whether by encouraging them to spend more or by speeding up their meal. We first discuss lighting, and provide a brief overview of what is known about lighting's effects on behavior. We then summarize the results of our research that tested full-spectrum lighting against regular incandescent lighting in an operating dining environment. We conclude by examining claims regarding full-spectrum lighting.

¹ C.S. Areni, "Exploring Managers' Implicit Theories of Atmospheric Music: Comparing Academic Analysis to Industry Insight," *Journal of Services Marketing*, Vol. 17, No. 2 (2003), pp. 161-184.

Lighting in Restaurants

Restaurant designers often put considerable emphasis on lighting to create warm, inviting, or even dramatic effects. While a simple take-out operation might use only the familiar and utilitarian ceiling-mounted fluorescent fixtures because of their low cost, full-service restaurants often apply some combination of hanging fixtures (pendants), recessed down lights, small spotlights on tracks or cables, and table-top accent lights to create atmosphere in the dining room. The lighting budget can reach well into the tens of thousands of dollars for a high-end restaurant. A designer's lighting decisions are typically made according to the desired lighting effect, although a good designer will also take into account ongoing costs for energy and of replacing bulbs (called "lamps") over time.

Perceived brightness, color temperature, and light quality all combine in an effective lighting design, and any of these aspects might influence diners' behavior. Perceived brightness is largely a function of lamp wattage, but that is modified with shielding by means of lenses or shades.

Color temperature expresses the apparent color of the light, whether bluish, reddish, or yellow, for instance. Color temperatures that have been measured relative to a standard using the Kelvin scale are usually termed "corrected" color temperatures.² Most lamps have a corrected color temperature rating listed on the packaging. As a comparison, everyday incandescent lamps have a corrected color temperature of around 2,500°K and appear warmer, or more yellow, than cool-appearing, fluorescent lights, which have a corrected color temperature of around 4,500°K and appear bluer to most people. A final light variable, light quality, which can be affected by the type of shade, light placement, and the type of lamp, relates to the way the light appears to a viewer. The intensity of an incandescent lamp filament stands in contrast to the more uniform, less intense fluorescent lamp. The attributes of fluorescent light, coupled with its longer lamp life and lower energy costs, make it a popular choice for back-of-house areas and some dining areas (particu-

² M. Rea, L. Deng, and R. Wolsey, "Full-spectrum Light Sources," *Lighting Answers* (National Lighting Product Information Program, Rensselaer Polytechnic Institute, Troy, NY), Vol. 7, No. 5 (2003) .

Claims regarding the effects of full-spectrum light need to be investigated.

larly in quick service or take-out operations), but it does not allow as much creative freedom to the designer as does incandescent light.

Most people prefer the warm, flattering light given off by incandescent lamps to that of fluorescents. Because incandescent lighting lends itself to being focused or directed, designers can use incandescent lamps of several types to define areas in the restaurant, highlight key functions (such as a food display or an open kitchen), emphasize textures on the walls or ceiling, and establish a mood. Pendants over individual dining tables can make each table feel intimate, while ceiling-mounted spotlights can be trained on menu boards, artwork, carving stations, or back bars to draw the guest's attention and add life to the dining room.

The availability of so-called full-spectrum light—intended to match daylight—has added another choice for restaurant designers. A popular choice for residential use, full-spectrum light is supposed to render colors so that they appear more natural and attractive, and some vendors assert that this form of light enhances people's mood, sharpens mental awareness, and even increases sales in retail environments, among other benefits.³ Lamps with a corrected color temperature of greater than 5000°K can be considered to be full-spectrum, although we know of no standard within the lighting industry for the color temperature of full-spectrum lamps. Full-spectrum lighting is available in both fluorescent and incandescent forms.

Most people recognize that fluorescent lights are more energy efficient than incandescent lamps.⁴ Moreover, full-spectrum lighting tends to have a shorter life than lamps with cooler corrected temperatures, making the full-spectrum light a more costly investment for the operator. Nevertheless, restaurateurs and designers may be attracted to incandescent, full-spectrum lighting because of its ability to render colors well or because of its claimed effects on customers. We examine the accuracy of these claims of behavioral effects, particularly in view of the higher price of full-spectrum lighting.

³ *Ibid.*

⁴ *Ibid.*

Research on Lighting

Recently, researchers have examined how atmospheric elements in the service environment affect customers. Most of these studies have focused on manipulating music or scent, and sometimes music and scent in combination.⁵ These two atmospheric elements are relatively easy to adjust. In most of these studies, modest but significant effects have been identified that appear to influence customer behavior.

Unlike music and scent, lighting in service environments has not been extensively studied despite being acknowledged as an important element of the consumer experience.⁶ Manipulating lighting in a real environment is more challenging than manipulating music or scent, and therefore many of the studies that involve lighting rely on adjusting light levels using existing fixtures⁷ or simply changing the brightness setting when showing videos of restaurants to participants.⁸ Some studies have examined the apparent color temperature of the lighting, finding that warm light encourages feelings of comfort,⁹ although this effect appears to vary by gender.¹⁰

⁵ See: A.C. North, A. Shilcock, and D.J. Hargreaves, "The Effect of Music Style on Restaurant Customers' Spending," *Environment and Behavior*, Vol. 35, No. 5 (2003), pp. 712-718; J-C. Chebat and R. Michon, "The Impact of Ambient Odors on Mall Shoppers' Emotions, Cognition, and Spending: A Test of Competitive Causal Theories," *Journal of Business Research*, Vol. 56 No. 7 (2003), pp. 529-539; and A.S. Mattila and J. Wirtz, "Congruency of Scent and Music as a Driver of In-store Evaluations and Behavior," *Journal of Retailing*, Vol. 77 (2001), pp. 273-289.

⁶ R.J. Donovan and J. R. Rossiter, "Store Atmosphere: An Environmental Psychology Approach," *Journal of Retailing*, Vol. 58, Spring (1992), pp.34-57.

⁷ C.S. Areni and D. Kim, "The Influence of In-store Lighting on Consumers' Examination of Merchandise in a Wine-store," *International Journal of Research in Marketing*, Vol. 11(1994), pp.117-125.

⁸ J. Baker, M. Levy, and D. Grewal, "An Experimental Approach to Making Retail Store Environmental Decisions," *Journal of Retailing*, Vol. 68, No. 4 (1992), pp. 445-460.

⁹ B. Lyman, *A Psychology of Food: More Than a Matter of Taste* (New York: Van Nostrand Reinhold, 1989).

¹⁰ I. Knez, "Effects of Indoor Lighting on Mood and Cognition," *Journal of Environmental Psychology*, Vol. 15 (1995), pp. 39-51.

Many studies have been done using daylight or natural light, determining that daylight appears to have significant effects on people, such as reduced agitation in Alzheimer's patients,¹¹ improved healing after surgery,¹² and increased purchasing in a discount store.¹³ Studies have found that warm-color lighting influences mood¹⁴ and is preferred for residential and other casual settings.¹⁵ This appears to have some basis in human biology: humans have photoreceptors that are sensitive to the chromatic character of light, exhibiting increased arousal under bluish (or "cooler") light and reduced arousal in warmer (reddish) light.¹⁶

There have been many claims regarding the effects of full-spectrum fluorescent lighting in office settings, including improvements in task performance, visual acuity, and sense of well-being. However, independent research into the effects of full-spectrum lighting on health, mood, and productivity has found inconsistent results. Some studies indicate that full-spectrum light has such favorable effects,¹⁷ while others found no significant evidence.¹⁸ We could find only a single proprietary study performed by a consultant

¹¹ M. LaGarce, "Lighting Affects Behavior of Alzheimer's Patients," *Journal of Interior Design*, Vol. 28, No. 2 (2002), pp.15-25.

¹² R.S. Ulrich, "Effects of Health Facility Interior Design on Wellness: Theory and Scientific Research," *Journal of Health Care Design*, Vol. 3 (1991), pp. 97-109.

¹³ L. Heschong, R.L. Wright, and S.Okura, "Daylighting Impacts on Retail Sales Performance," *Journal of the Illuminating Engineering Society of North America*, Vol. 31, No. 2 (2002), pp. 21-25.

¹⁴ I. Knez and C. Kers, "Effects of Indoor Lighting, Gender and Age on Mood and Cognitive Performance," *Environment and Behavior*, Vol. 32, No. 6 (2000), pp. 817-831.

¹⁵ J.E. Flynn, "A Study of Subjective Responses to Low Energy and Non-uniform Lighting Systems," *Lighting Design and Application*, 7 (1977), pp. 6-15.

¹⁶ D.M. Berson, F.A. Dunn and T. Motoharu, "Phototransduction by Retinal Ganglion Cells that Set the Circadian Clock," *Science*, Vol.295, February 8 (2002), p. 1070.

¹⁷ W.P. London, "Full-spectrum Classroom Light and Sickness in Pupils," *The Lancet*, Vol. 330, No. 8569 (1987), pp. 1205-1206.

¹⁸ J.A. Veitch and S.L. McColl, "Full-spectrum Lighting: A Review of its Effects on Physiology and Health," *Psychological Medicine*, Vol. 31 (2001), pp. 949-964.

to a lighting system manufacturer that offered evidence of positive effects of a dynamic full-spectrum lighting system on duration, mood, and customer attitudes in a retail environment.¹⁹

We have found little published research examining the influence of lighting in restaurants. A few authors have made connections between lighting and food consumption habits, but there is little agreement in the few studies done of dining under different lighting conditions.²⁰ Only one study appears to present any evidence of changes in lighting's effect on diners. In that one, Sommer found that bar patrons had shorter lengths of stay and consumed fewer drinks in brightly lit environments.²¹

Certainly one goal of restaurant lighting is to create an attractive, pleasant setting for a meal. Pleasure has been linked with spending behavior and restaurant preference, which are mediated by emotions that can be influenced by lighting's character.²² So it might be surmised that pleasing lighting may encourage higher spending that is motivated by people's favorable emotional response to the environment. Light—both in terms of its color and its brightness—has also been shown to influence arousal,²³ which in turn affects consumer behavior.²⁴ However, arousal in a restaurant setting must be considered carefully; diners have different preferred levels of arousal depending on the desired

¹⁹ M. L. Tullman, *Dynamic Full Spectrum Digital Lighting of Retail Displays Positively Affects Consumer Behavior* (Boston, MA: Color Kinetics Incorporated, 2000).

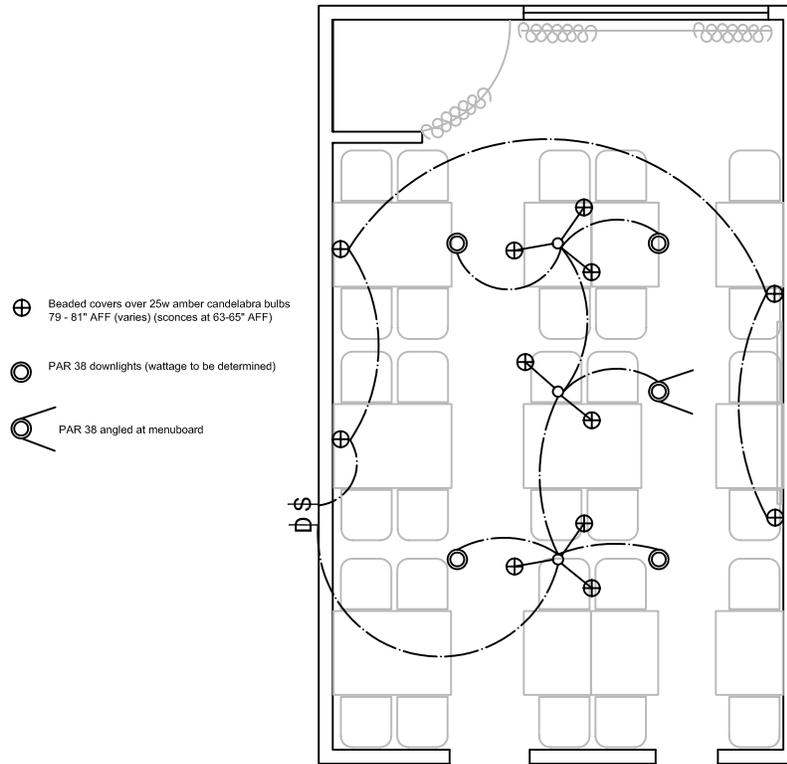
²⁰ B. Lyman, op.cit., and N. Stroebele and J.M. De Castro, "Effect of Ambience on Food Intake and Food Choice," *Nutrition*, Vol. 20, No. 9 (2004), pp. 821-838.

²¹ R. Sommer, *Personal Space: The Behavioral Basis of Design* (Englewood Cliffs, NJ: Prentice-Hall, 1969).

²² E. Sherman, A. Mathur, and R.B. Smith, "Store Environment and Consumer Purchase Behavior: Mediating Role of Consumer Emotions," *Psychology and Marketing*, Vol. 14, No. 4 (1997), pp. 361-378.

²³ D.L. Butler and P.M. Biner, "Preferred Lighting Levels: Variability Among Settings, Behaviors and Individuals," *Environment and Behavior*, Vol. 19 (1987), p. 695.

²⁴ M.P. Gardner, "Mood States and Consumer Behavior: A Critical Review," *Journal of Consumer Research*, Vol. 12 (1985), pp.281-300.

EXHIBIT 1**Reflected ceiling plan of experimental dining room**

experience.²⁵ Environments that are too arousing can be overstimulating and unpleasant, whereas insufficient arousal can be perceived as dull and uninteresting.²⁶ A key factor, then, in determining the appropriate lighting for a restaurant would be adjusting the light to be sufficiently arousing but not excessively so. The literature, however, does not make clear what such a light level might be. With the dozens of lighting choices available to a restaurant operator, making an informed decision when planning a restaurant environment becomes more challenging without tests of different types of lighting in a real dining setting.

²⁵ J. Wirtz, A.S. Mattila, and R.L.P. Tan, "The Moderating Role of Target-arousal on the Impact of Affect on Satisfaction: An Examination in the Context of Service Experiences," *Journal of Retailing*, Vol. 76, No. 3 (2000), pp. 347-365.

²⁶ A. Mehrabian and J. Russell, *An Approach to Environmental Psychology* (Cambridge MA; MIT Press, 1974).

Testing Full-spectrum Lighting

We developed four hypotheses about how full-spectrum lighting might influence dining patrons' behavior, based on findings from the lighting and consumer behavior literature. In general, we hypothesized that full-spectrum incandescent lighting (cooler light) would shorten dining duration, while regular incandescent lighting (warmer light) would lengthen it. This is consistent with research which suggests that more arousing environments result in faster dining speed.²⁷ We also hypothesized that a more arousing environment such as that generated by cooler light would increase spending, whereas warmer light would result in lower spending.

²⁷ R.E. Milliman, "The Influence of Background Music on the Behavior of Restaurant Patrons," *Journal of Consumer Research*, Vol. 13, No. 2(1986), pp. 286-289.

To base our study on objective observation, we purposefully did not examine guests' preferences regarding lighting, nor did we ask for self-reports regarding responses to lighting conditions. We did not want the possibility of influencing diners' behavior by calling attention to the lighting with a questionnaire. Another reason for limiting the study to observed behavior was to align the study with actual actions rather than with perceptions. However, we were careful to keep the lighting we tested consistent with the concept of the restaurant and realistic for a dining operation.

For the test, we altered lighting conditions in a full-service, casual dining restaurant in upstate New York. The facility has two distinct dining environments: a 30-seat main dining room with windows on one side of the space, and a secondary 36-seat dining space with expansive windows on two sides. (The restaurant also has a separate bar area, which was not examined in our study.) Because the windows in the main dining room were flanked by heavy window treatments and only a small proportion of the wall space admitted natural light, we elected to change the lighting only in the main dining room. This allowed us to use the secondary dining room as a comparison for control purposes. We also collected data only during the evening, when lighting conditions in both dining rooms were least likely to be affected by daylight. Thus, we were able to control the light conditions relatively closely without disturbing patrons' typical dining experience.

Existing lighting in the main dining room consisted of three ceiling-mounted pendants, clustered in groups of three, mounted at between 79" and 81" above the floor. Each fixture held a single 25-watt amber-colored incandescent "chandelier-style" lamp, shielded by a handmade shade of wire and glass beads. In addition to the three pendant fixtures, the main dining room had five ceiling-mounted spotlights, each with a 75-watt halogen lamp mounted 89" above the floor. These fixtures were track-mounted and could be aimed in any direction, but were positioned to illuminate circulation routes and to provide focus lighting on wall-mounted menu blackboards. Finally, the space included four wall-mounted sconces, each with a 25-watt incandescent chandelier lamp similar to that used by the pendants, and shielded in the same manner. The sconces were wired to a single circuit with a simple on-off switch, while the pendants and ceiling-mounted fixtures were wired together on a single 40-amp circuit with a dimmer switch. A reflected ceiling plan of the main dining room is shown in Exhibit 1.

The room had no other lighting, although some light from the service areas and the open kitchen at the rear of the room could be seen in the dining area. This light was not strong and we didn't feel it would influence the dining experience in the main dining room. The light fixtures and

their placement in the secondary dining room were similar, allowing it to serve as a good basis for comparison.

We conducted two light manipulations over a seven-week period, as described below. In each study period, measurements of light levels were taken with a photographer's light meter at the start of the study period and on two other evening occasions during each phase of the study to ensure consistency across lighting conditions. Tables throughout the restaurant were identified by number in the point-of-sale system, allowing us to collect sales and duration data by date and table type. Thus, we could compare each table with similar tables in the other dining room. This allowed us to control for variations in customer behavior that may have occurred due to day of the week, weather conditions, menu specials, and other factors that would be consistent for all parts of the restaurant. We also collected point-of-sale data for a representative four-week period prior to the study period so that typical spending and duration behavior for each dining room could be assessed.

We studied the effects of three lighting conditions: existing lighting conditions (the "baseline"); a "pendants-only" condition, in which we installed full-spectrum chandelier lamps in the sconces and pendant lights only, but left the regular incandescent track lights untouched; and an "all lighting" condition in which we used full-spectrum lamps in all of the fixtures in the main dining room. Because of the limited availability of full-spectrum lamps that would fit the restaurant's existing fixtures, the experimental lamps burned at a slightly higher wattage than the baseline lamps did. To fix that, we adjusted the dimmer switch to compensate and conducted the periodic checks with the light meter to ensure that the light levels were consistent across the three lighting conditions. The shift manager was made aware of the importance of maintaining consistent light levels during data collection periods, but the restaurant's other employees were not informed that a study was taking place. In all other respects, the restaurant operated in its usual fashion.

Because the POS system's reporting functions were not able to provide party-size data for each transaction, we analyzed only two-top tables. This gave us a reliable calculation of party size (two), because this restaurant seated singletons in the bar area. Dining duration was measured as the elapsed time from the opening of a table's check to the closing of that check as recorded in the POS. This measure of duration, while imperfect, has proved to be a reliable method of collecting duration data for large sample sizes.²⁸ Spending was measured as the total value of each party's check divided by the number of seats at the table. Lastly, we created a com-

²⁸ S.E. Kimes, R.B. Chase, S. Choi, P.Y. Lee, and E.N. Ngonzi, "Restaurant Revenue Management: Applying Yield Management to the Restaurant Industry," *Cornell Hotel and Restaurant Administration Quarterly*, Vol. 39, No. 3 (1998), pp. 32-39.

EXHIBIT 2**Sample sizes by lighting condition and dining area**

Lighting condition	Main dining room (experimental space)	Secondary dining room (control)	Total observations
<i>Baseline</i>	250	419	669
<i>Pendants only</i>	250	412	662
<i>All fixtures</i>	162	274	436
<i>Total</i>	662	1,105	1,767

posite variable—spending per minute (SPM)— by dividing the average check by the duration to get a simple measure of each table’s performance.²⁹

Results

A total of 2,888 transactions for two-top tables were recorded during the experimental period across the two dining environments. Further analysis revealed that for some of these transactions, tables had been combined to accommodate larger parties, so those observations were deleted from the analysis, as were any tables with a dining duration that was unusually short (under 10 minutes) or long (over 3 hours). Exhibit 2 summarizes the resulting sample.

The differences in the sample sizes were largely a function of the number of tables for two in each dining space; the control room had six deuces, while the main dining room had only three. In addition, the all fixtures data-collection period was nine days shorter than the other data-collection periods, a fact that largely accounts for the smaller samples for that treatment in both dining spaces. We shortened the all fixtures data collection period because of a seasonal slowdown that takes place near the December holidays; we wanted to ensure that all of our data was collected on typical days for the restaurant. However, even with unequal groups to compare, the relatively high number of observations in each condition reflects favorably on the study’s validity.

As an initial measure of the influence of full-spectrum lighting on guest behavior, we computed and compared the means and standard deviations for average check and duration for each dining area for each lighting condition (Exhibit 3). Spending and duration in the two dining spaces showed

consistent significant differences, regardless of the lighting condition. Diners both stayed longer and spent more money in the secondary dining room than they did in the main dining room. (For confirmation, POS data from this restaurant collected for an earlier study was evaluated, and this pattern of duration and spending across the two dining areas was found in that study as well.) We could not determine why this might be the case. The dining rooms have identical menus and operating hours, as well as similar décor, table spacing, and layout. The chief difference is that the secondary dining room has many more windows than the main dining room has. We believe that this factor deserves further study, but we cannot see how this affects our study because light from the exterior was kept to a minimum by collecting data only at night. Despite the stronger performance in the secondary dining room in all conditions, this room still serves as a useful control, as the degree of variation for each lighting condition can still be compared between the two dining rooms.

The average check in the main dining room was significantly lower in the all-fixtures lighting condition than it was in the baseline condition, but in all other cases, there was no significant difference in spending, duration, or spending per minute in the three different lighting conditions in the main dining room.

In fact, we recorded declines in spending per minute across all three lighting conditions in both dining areas (see Exhibit 4). Controlling for server, day of the week, and table location within each dining room did not change our results.

It was possible that normal variations in spending and duration behavior from day to day masked any modest effects of lighting condition. So, we prepared an additional analysis of average check and duration in each dining room for each day of our study. For this analysis, the data collec-

²⁹ See: S.E. Kimes and S.K.A. Robson, “The Impact of Table Characteristics on Dining Duration and Spending,” *Cornell Hotel and Restaurant Administration Quarterly*, 45, No. 4 (2004), pp. 333-346.

EXHIBIT 3

Average check and dining duration by dining area and lighting condition

	No manipulation	Pendant fixtures only	All fixtures
Main dining room	Mean (Standard deviation)		
<i>Average Check</i>	\$27.41 (\$10.98)	\$26.05 (\$10.39)	\$25.32 (\$9.15)*
<i>Duration</i>	59 minutes (:24)	57.8 minutes (:24)	59.4 minutes (:24)
<i>Spend per Minute (SPM)</i>	\$0.99 (\$.37)	\$0.95 (\$.36)	\$0.93 (\$.37)
Secondary Dining Room	Mean (Standard deviation)		
<i>Average Check</i>	\$32.86 (\$17.27)	\$33.30 (\$16.33)	\$31.22 (\$16.51)
<i>Duration</i>	61.2 minutes (:18)	62.5 minutes (:24)	66 minutes (:24)
<i>Spend per Minute (SPM)</i>	\$1.11 (\$.51)	\$1.11 (\$.48)	\$1.00 (\$.49)

* Significant difference from baseline, $p < .05$.

tion period ran from September 23, 2006, to December 18, 2006, resulting in 87 days of observations. Although the restaurant operated every day during the study period, special dates such as Halloween and Thanksgiving had distinctive customer profiles. Moreover, on a few days, private parties had exclusive use of the secondary dining room, and so we removed these dates from the analysis. Statistical analysis that compared the differences in average check and duration between each dining area for each day of the study once again indicated that there was no significant difference across the different lighting conditions.

Discussion

These analyses together appear to indicate that the provision of full-spectrum lighting in the main dining room had no significant effect on check averages or meal duration. There was one small but significant reduction in mean average check between normal conditions and the all-full-spectrum lighting condition in the dining room we tested, but this was the only significant effect observed. Duration remained statistically consistent across all three lighting conditions in this space, as did spending per minute.

While it may be tempting to attribute the decrease in average check to the switch to full-spectrum lighting, a closer look at the data shows that there was a modest reduction in average check in both the main dining room and secondary dining room as the experiment went on. The fact that this change occurred in the dining room in which the lights were not manipulated as well as in the one where we changed the lighting indicates that some factor or factors other than the full-spectrum lighting are influencing spending. It is possible that the change in the seasons may be affecting average check, given the approaching December holidays. Also, students make up a significant portion of this restaurant's

clientele, and student bank balances are quite possibly depleted at the end of the term. Whatever the explanation for this small decline in guest spending, it cannot be attributed to the provision of full-spectrum lighting.

Duration stayed roughly the same in the main dining room, while it increased slightly in the secondary dining room over the course of the study. Again, this is unlikely to be a function of the lighting, as the change occurred in the room where the lighting was not manipulated. It is difficult to pinpoint what might be causing this longer duration in one part of the restaurant but not another, but it is possible that the restaurant's practice of seating larger parties in the secondary dining room might have affected service to other tables in that dining room, including the two-tops we studied. Large parties become more common in December, and therefore the variations in service speed would be more marked during this period.

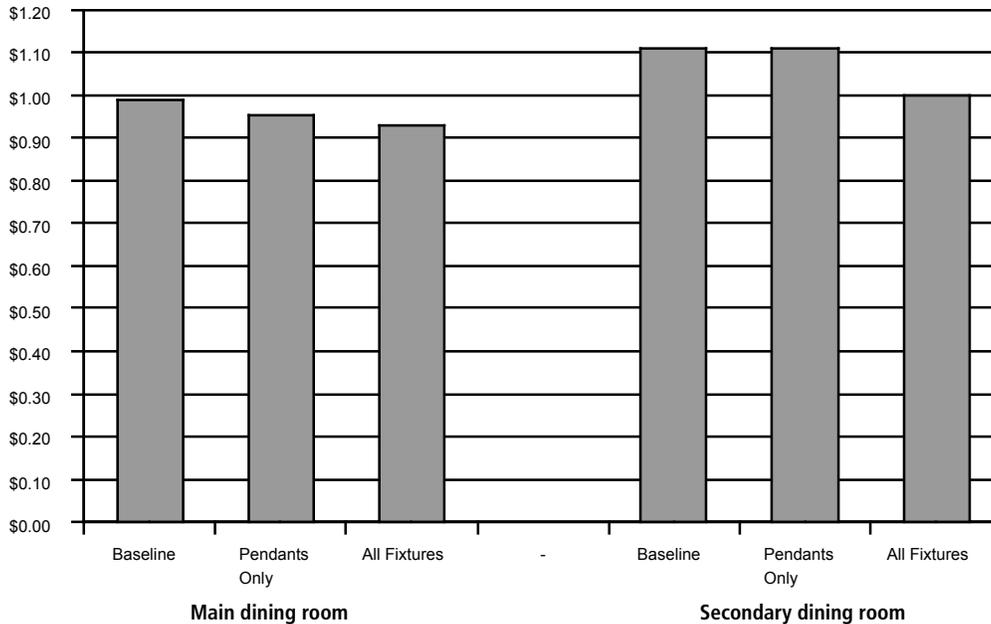
Other controllable aspects of the dining experience that can influence diners' purchasing and table duration are differences between servers, days of the week, and the location of the table.³⁰ We tested for the effects of these three factors, but we found no statistical support for any of them as contributing to the spending and duration variation we observed in the two rooms. Clearly, more study is needed.

Our finding that full-spectrum lighting had no effect on diners' behavior is consistent with studies of full-spectrum fluorescent lighting performed in office environments. Notwithstanding manufacturers' claims, several researchers have been unable to identify a significant effect of full-spectrum lighting on performance, mood, or health. We note that none of these studies was performed in a service setting.³¹

³⁰ *Ibid.*

³¹ J.A.Veitch, "Revisiting the Performance and Mood Effects of Informa-

Spending per minute by dining area and lighting condition



Even though our experiment examined full-spectrum incandescent light rather than full-spectrum fluorescent lighting, the fact that a significant effect on users could not be identified strengthens the literature regarding the inability of full-spectrum lighting to influence behavior significantly in everyday settings.

Implications for Managers

This study fails to support the claims of some lighting manufacturers that full-spectrum lighting can influence consumers' behavior. Equipping a restaurant dining room with full-spectrum lighting resulted in neither an increase in spending nor a change in the length of the meal. Although we did see some variation in spending and dining duration in the two dining rooms we tested for this study, it seems clear to us that these variations are due to effects other than the full-spectrum lighting.

Managers who are looking for ways to increase revenue by manipulating the dining environment often look to

products like full-spectrum lighting which are promoted as being "better" for customers than regular lights. We see no such advantage, especially given that full-spectrum lighting is more costly to purchase, needs to be replaced more frequently, and is less efficient in terms of light output than regular incandescent light. Based on this study we must suggest that restaurant managers save their funds and stick to the familiar incandescent lamps when choosing or replacing bulbs in dining room fixtures.

It should be noted that we only tested incandescent lights in this study. Compact fluorescent light is a much more economical form of lighting and has attracted a great deal of attention because of its reduced energy costs compared to incandescent light. Governments are even exploring ways to legislate the use of compact fluorescent light as a way to combat global warming by cutting back on energy demands.³² The availability of compact fluorescent lamps that can fit in many common light fixtures has made them

tion about Lighting and Fluorescent Lamp Type," *Journal of Environmental Psychology*, Vol. 17 (1997), pp. 253-262.

³² W.L. Hamilton, "Ideas and Trends: Illuminating; Incandescence, Yes. Fluorescence, We'll See," *The New York Times*, January 7, 2007.

This study offers little evidence that full-spectrum lighting makes any difference to diners' purchases.

an appealing choice financially, although many people are unhappy with the relatively flat light these lamps provide. High corrected color temperature options (over 5000°K) are available in compact fluorescent form, but they are often marketed under different proprietary brand names rather than as “full-spectrum.”

We did not examine compact fluorescent lighting in our study due to the limitations of the existing fixtures in the restaurant. Even though compact fluorescents are sold in a variety of shapes and sizes, they still have a comparatively massive base that does not fit every fixture. We could not find full-spectrum compact fluorescent lamps that would fit many of the fixtures in the dining room. But the fact that full-spectrum lighting did not appear to have any influence on dining duration or spending suggests that restaurant operators may want to choose the least expensive lamp option if moving choosing compact fluorescent lighting. In any event, we suggest being wary of claims that full-spectrum choices will be better for the operation. Of course, if the cooler light given off by full-spectrum lamps is preferred for aesthetic reasons, an operator might be able to justify their higher life cycle cost as a cost of the design. However, the visual effects of these lamps cannot be said to improve the restaurant's bottom line in any significant way.

Limitations and Conclusion

Although this experiment examined consumers' behavior in a field setting rather than in a laboratory, its real-world setting raises some important limitations. The concerns of the restaurant operator limited the study's lighting manipulations to ones that would not substantially compromise the design intent of the restaurant. When seen side by side with normal incandescent light, most people see full-spectrum light as markedly different, but without such a reference, it may be that the dimmed full-spectrum incandescent light was too similar to regular incandescent light to have an effect on guests. Testing a variety of lighting types (e.g., full-spectrum and regular fluorescent; natural daylight) in a laboratory setting where conditions can be carefully controlled may result in a more significant finding regarding light's effects.

Light levels, or brightness, also influence how people perceive lighting. In keeping with the restaurant operator's wishes, we did not test different light levels in this study, even though earlier research in other types of environments suggests that brighter lighting may have a significant effect on arousal and, thus, duration and spending. Further studies should be performed in a restaurant setting where brightness can be tested.

We made every attempt to control external factors in the study, but it remains only a quasi-experiment due to the lack of random assignment of patrons to lighting conditions. We were also unable to control patrons' demographics. Thus, lighting might have had a significant effect on a small subset of customers, but that may have been masked in the larger sample. Although the restaurant where the study took place is popular with a wide range of people, it seems not to appeal to old customers. Those people might be more sensitive to lighting than are young people, whether because of the physical changes in vision or long-established preferences.³³ While lighting has been studied in nursing homes and other institutional settings with old individuals, it does not appear that any studies have looked at lighting in restaurants or other service environments in relation to customers' age.

Last, the findings here represent results from a single restaurant operation. As with all research, replication in comparable settings may give us a better understanding of what influence, if any, that lighting has on restaurant patron spending and length of stay.

In summary, there appears to be little evidence that full-spectrum lighting makes any difference to diners' purchases in a full-service restaurant. While much more needs to be done to determine what types of lighting are the best choice for a restaurant operator, this study suggests removing one family of options from consideration. The extra purchase cost and ongoing operational costs of full-spectrum lighting do not appear to be offset by any benefit in customer spending or duration. ■

³³ M. LaGarce, *op. cit.*

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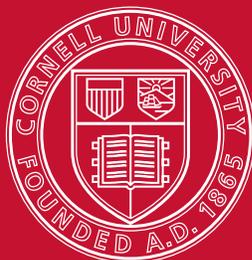
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