

Proceedings

EXPERIENCING LIGHT 2009

International Conference on the Effects of Light on Wellbeing

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Keynotes and selected full papers
Eindhoven University of Technology,
Eindhoven, the Netherlands, 26-27 October 2009

Volume Editors

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ISBN: 978-90-386-2053-4

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Reference specification:

Name Author(s), “Title of the Article”, In: Proceedings of EXPERIENCING LIGHT 2009 International Conference on the Effects of Light on Wellbeing (Eds. Y.A.W. de Kort, W.A. IJsselsteijn, I.M.L.C. Vogels, M.P.J. Aarts, A.D. Tenner, and K.C.H.J. Smolders), 2009, pp. X (startpage) – Y (endpage).

The Effects of Lighting on Atmosphere Perception in Retail Environments

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ABSTRACT

The present study's objective was to investigate the contribution of lighting in evoking an atmosphere in naturalistic environments, among the extensive set of other environmental cues. In a field study involving 57 clothing stores, lighting attributes (e.g., brightness, contrast, glare and sparkle) and context (i.e. the shop interior) were assessed and quantified independently. These data were then used to predict four dimensions of perceived atmosphere of these stores in multiple regression analyses. A hierarchical procedure was chosen, with context variables entered in the first block and lighting attributes in the second block. We were thus able to determine the effects of lighting on perceived atmosphere, while controlling for context effects. Both lighting attributes and interior qualities were successfully related to perceived atmosphere. Our most important finding was that, even given the substantial contribution of design elements in retail environments, lighting does play a significant role in evoking atmospheres.

Keywords

Lighting, environmental assessment, atmosphere perception, retail environments, Multiple regression, card-sorting

INTRODUCTION

As any light designer, light researcher, and even layperson will confirm, lighting and ambiance are intimately related. Literature indicates that lighting characteristics can influence emotions, mood and cognition, and atmosphere and spatial impressions, although at times the collected

findings are inconclusive. With respect to emotions for instance, some studies report more pleasant emotions with higher light intensity levels [1], whereas others report no significant effects [2,3]. Fleisher et al. [1] demonstrated that a combination of high illuminance levels and a relatively large indirect lighting component resulted in higher feelings of dominance. Cool white light was shown to be arousing [1], while a more complex pattern emerged in a second study, reporting positive effects of colour temperature on male participants' mood, yet negative effects on females' moods [2].

Literature reports of several studies investigating the way people assess lighting directly. Hawkes, Loe and Rowlands [4] suggest that people categorize lighting using the lighting characteristics brightness and interest (or uniformity). Flynn and colleagues [5] added a third dimension (overhead – peripheral). Unfortunately, both studies [4,5] used a sample size too small for a robust factor analysis. Veitch and Newham [6], who tackled this problem working with 292 participants, demonstrated that people categorize lighting in terms of the three dimensions: brightness, visual attraction, and complexity.

Literature also describes how lighting can affect people's environmental impressions (for a review see [7]). As one of the first, Flynn, Hendrick, Spencer and Martyniuk [5] used a realistic interior (i.e. conference room) and found an effect of lighting on subjective evaluations of the environment, perceptual clarity and spaciousness. This research, together with several follow-up studies, summarized in [7], suggests that in the North American society and culture, there are at least six broad categories of human impression that can be influenced or modified by

lighting design: perceptual clarity, spaciousness, relaxation and tension, public versus private space, pleasantness, and spatial complexity (sometimes liveliness). After relating the impression dimensions to lighting characteristics, Flynn [7] suggested several design guidelines: For perceptual clarity, the designer should apply bright and peripheral lighting. An impression of spaciousness (i.e., the space is perceived as large) is achieved when applying uniform and peripheral lighting. Pleasant and relaxing impressions are the result of peripheral and non-uniform lighting. And lastly, to establish a 'private' impression, the designer can select non-uniform and dimmed lighting.

Houser, Tiller, Bernecker and Mistrick [8] varied the direct/indirect lighting ratio and concluded that walls and ceiling contribute to the perception of overall brightness when work plane illuminance is held constant. Also, rooms appear more spacious with higher ratios of indirect lighting, and rooms with relatively high levels of indirect lighting are favoured over light settings with less than 60% indirect lighting. Literature thus establishes that lighting is able to influence environmental impressions.

Yet although literature reports of studies indicating that lighting characteristics influence moods and emotions, cognition, and environmental impressions, there are hardly any studies that have established these effects outside the laboratory. Although it is one thing to prove that variations in lighting in an otherwise controlled environment have an impact on environmental impressions, showing that lighting actually contributes to atmosphere perception in naturalistic environments, i.e., in the real world is quite another, let alone ascribing this to specific lighting attributes. This is exactly what the current study set out to do. And it did so in a type of environment with substantial variations in interior design, and where atmosphere has been proven to matter significantly: retail environments.

Retail Environments

Retail environments communicate the stores' image and purpose to customers [9], they can evoke emotional reactions [10], impact the customers' ultimate satisfaction with the service [11], and even the money and time spent in the store [12]. Therefore, creating the right environmental setting is of prime importance for shop owners. To create the desired ambiance, lighting may have its contribution, but it is only one of the numerous elements, such as furnishing and finishing of the shop's interior, size, crowdedness, and music, that play a role.

Different categorizations for these environmental characteristics are proposed. Bitner [9] suggested three groups: ambient conditions; spatial layout and functionality; and signs, symbols and artefacts. Berman and Evans [13] included the exterior of the shops and came to four groups: general interior; the layout and design; the point-of-purchase and decoration; and the exterior of the shop. Turley and Milliman [14], in turn, added a fifth category: human variables. Most recently Baker, Parasuraman, Grewal & Vos [15] proposed a model in

which the environmental cues were divided into three categories: design, ambient, and social variables.

Since environments include such an extensive variety of stimuli, while on the other hand consumers perceive environments holistically [16] it is essential to seek general variables as descriptors that grasp the main influence of the environment [17]. Kaplan [18] suggested that four environmental dimensions can predict preference for an outdoor environment: complexity, mystery, coherence and legibility. Environmental complexity refers to visual richness, ornamentation, information rate, diversity and variety in an environment [19], and is shown to have a linear relationship with interest (arousal) and a curvilinear (inverted U) relationship with preference (pleasure) [19,20,21], meaning that moderate levels of complexity are most preferred. Another important environmental dimension is order [20], which is related to the extent of coherence, legibility, organization, and clarity of an environment [19]. In studies of urban environments (summarized by Nasar [22]) order has been shown to have a positive impact on pleasantness and a negative impact on arousal. Except for the inverted U relationship between complexity and pleasantness, all these relationships are confirmed for retail environments [23].

We conclude that lighting has a potential contribution to perceived ambiance, but is only one of the numerous elements that may play a role. Our question was whether lighting would play a role that was measurable, and if yes, which lighting attributes would have the most substantial contribution.

METHOD

Design

Fifty-seven clothing stores participated in a field study, exploring the contribution of lighting to environmental impressions, controlling for other contextual influences. For each of these stores the three categories of variables – perceived atmosphere, lighting attributes, and context (i.e., the shop's interior design) – were assessed and quantified. Assessments were made independently of each other, by different groups of experts (lighting) or lay people (atmosphere, context). We then performed multiple regression analyses on perceived atmosphere dimensions with lighting attributes and context as independent variables.

Participants & Shops

For this field study 57 shops were selected. The stores were all located in the city centre of Eindhoven, a mid-size Dutch city, to enable participants and experts to visit all the shops in one morning or afternoon. In order to prevent statistical confounds caused by the type of product sold,

only fashion shops were selected to participate¹. Low and high-end shops were avoided for the same reason. Within this selection of shops, which still presented a wide variety of shop interiors and fittings we expected that structural confounds between lighting configuration and interior design would be limited. Nonetheless, in order to control for this eventuality we also assessed and quantified the style of the shops' interiors.

To assess context, i.e., the interior design of the stores, twenty participants were recruited from a participant database of the university. The group consisted of ten males and ten females, ranging in age between 19 and 44, with an average of 28 years. The respondents were not familiar with the shops participating in the study.

Seven lighting experts participated in the assessment of the lighting and lighting fixtures in the stores. Their ages ranged between 29 and 58, with an average of 46, five were male and two female.

For quantifying perceived atmosphere, six participants were recruited from the university's database. The participants did not have specific affinity to lighting or the shops participating in this study. Three participants were male and three were female. Their ages ranged between 22 and 29, with an average of 24.5 years.

Measurements & Procedure

Context Characterization

A card-sorting experiment was performed to characterize the shops' interior designs. Pictures of these interiors were printed on A5 photo paper and served as cards. The photographs were all taken inside the shop, from the same position at which participants rating the atmosphere (see below) would be standing. In taking the pictures, we avoided photographing ceilings and lighting fixtures where possible. Initially two pictures were taken per shop. After a pilot study we reduced the number of cards to 87, by removing one picture per shop if both pictures were always categorised in the same groups. The participants performed the experiment individually to assure independence of grouping strategies [24].

Participants were instructed to think of a discriminating quality they felt could serve as a base for sorting the shops, e.g. 'cluttered'. They then sorted the pictures of the shops into five piles² (ranging from totally not applicable to

totally applicable), based on the chosen quality. This was repeated, until the participant could not come up with another discriminating quality.

In total the 20 participants performed 59 categorizations. Multiple correspondence analysis was then performed on these data, yielding two dimensions on which the shops varied (inter-dimensional correlation -.006). We labelled them 'legibility' (order-disorder) and 'warmth' (warm-cold), based on the labels participants had given for their categorizations. Each shop's scores on these dimensions were used in the multiple regression analyses reported below, to account for the variability of shop interiors.

Lighting Attributes

A panel of experts assessed the lighting in the shops during a site visit. For this they used a questionnaire developed also in cooperation with lighting experts. The questionnaire consisted of 31 items, probing established lighting attributes such as brightness, contrast (i.e., uniformity), colour temperature, glare and sparkle, and modelling, as well as the relative contribution of different types of lighting (i.e. general, accent, architectural, decorative) and the lighting installation (see Table 1). Each of the seven experts filled out one questionnaire per shop (i.e., 7 times 57 in total) individually. They visited the shops between ten o'clock in the morning and half past noon, avoiding the busiest hours. Also, their visits were scheduled within a period of three weeks, to minimize the chance of interiors being redecorated. Order effects, e.g. as a result of learning, tiredness or boredom, were controlled by varying the order in which each expert visited the stores.

Inter-rater reliabilities were computed to determine the level of agreement among the experts. Cronbach's alpha's between experts' scores for each individual item ranged from .635 to .940, with an average of .804 (see Table 1). These reliabilities were more than satisfactory, indicating a high level of agreement among the experts in scoring the lighting attributes of the shops. The scores of the experts were averaged to compute each shop's score.

¹ Since the type of lighting often differs with the type of product, yet product class may also influence atmosphere perception, this could result in structural relations between lighting and ambiance not really attributable to the lighting per se.

² Although a division over five piles was desired, the participants were instructed to first create three piles – not applicable, neutral or applicable. Then they were asked to divide the neutral pile into three piles again – less applicable, neutral or more applicable. This resulted in 5 piles in total. This procedure was followed because the

pilot study pointed out that this procedure would lead to the most evenly spread division of the pictures over the five piles.

Table 1. Inter-rater reliabilities of lighting questionnaire items

Item	Cronbach's alpha	Item	Cronbach's alpha
General lighting	.940	Accent lighting	.942
Decorative lighting	.805	Architectural lighting	.933
Brightness back walls	.870	Brightness horizontal plane	.823
Brightness ceiling	.820	Brightness floor	.819
Brightness side walls	.892	Brightness overall	.915
Colour temperature light	.759	Colour temperature total space	.813
Glare	.889	Sparkle	.822
Luminance ratio back walls	.789	Luminance ratio horizontal plane	.825
Luminance changes back walls	.691	Luminance changes horizontal plane	.719
Luminance ratio ceiling	.635	Luminance ratio floor	.765
Luminance changes ceiling	.677	Luminance changes floor	.638
Luminance ratio side walls	.816	Luminance ratio overall	.766
Luminance changes side walls	.775	Luminance changes overall	.773
Conspicuous lighting installation	.628	Patterned lighting installation	.778
Amount of fittings	.906	Different fittings	.841
Modeling	.865	Mean	.804

Factor analyses (Principal Component with Varimax rotation) of the data resulted in six dimensions qualifying attributes of the lighting configuration: contrast, brightness, glare and sparkle, contrast on the ceiling, aesthetics of lighting installation, and decorative lighting. The score for each of the dimensions was determined by averaging the scores of the items contributing to that particular dimension. For instance the score for the factor glare was calculated by averaging the scores for accent lighting, glare and sparkle. Correlations between the six factors are reported in Table 2.

Table 2. Lighting attributes correlation matrix

	bright ness	glare & sparkle	contrast of ceiling	lighting install.	decor. Lighting
contrast	.402	.620	-.056	-.092	.089
bright ness		.399	.165	.206	-.198
glare & sparkle			-.051	.041	.047
contrast of ceiling				.202	-.111
lighting install.					.043

Each shop's scores on these lighting attributes were used in the multiple regression analyses reported below, to account for the variability of the shop lighting.

Atmosphere Perception

In the third phase, six (new) participants also visited all the shops (following different routes, to vary the order in which shops were assessed) and rated the ambiance in each of them. For measuring perceived atmosphere a short version of Vogels' [25] instrument was used. This questionnaire measures perceived atmosphere in four dimensions: cosiness, liveliness, tenseness and detachment. After deliberation with Vogels, 18 of the original 38 items were selected (4 or 5 per dimension), with seven-point Likert scales ranging from totally not applicable to totally applicable. Participants scored each shop on each of these items. They were not aware that the study was focused on lighting and were not instructed to pay particular attention to lighting or lighting fixtures.

Internal consistencies of these atmosphere dimensions were determined by calculating Cronbach's alpha for each of the six participants (see Table 3). Averaged values indicated acceptable (>.60) to good (>.80) reliabilities. The level of agreement between participants was determined by calculating inter-rater reliabilities (Cronbach's alpha) per dimension. The values are reported in Table 3. Correlations between the scores on the different atmosphere factors are displayed in Table 4.

Table 3. Internal consistencies and inter-rater reliabilities of the atmosphere scales

	Average internal consistency*	Inter-rater reliability**
Cosiness	.83	.65
Liveliness	.77	.76
Tenseness	.79	.42
Detachment	.61	.84

*: averaged over 6 participants' individual internal consistency scores; **: between the 6 participants' scores on that dimension.

Table 4. Correlations between scores on atmosphere dimensions

	Liveliness	Tenseness	Detachment
Cosiness	.330	-.613	-.309
Liveliness	1.000	-.340	-.789
Tenseness		1.000	.310

RESULTS

Multiple regression analyses were performed predicting perceived atmosphere dimensions with the two context variables and the six lighting attributes as predictors. Note that in these analyses, the 57 shops were the cases (they made up the rows in the statistical database). Four separate analyses were performed - one for each atmosphere dimension.

We first performed multiple regression analyses on atmosphere dimensions, exploring only lighting attributes as candidate predictors in a stepwise procedure. The

obtained significant beta-weights are displayed in Table 5. Brightness contributed significantly to three atmosphere dimensions: cosiness (negatively), tenseness and detachment. Contrast significantly decreased perceived tenseness. Glare & sparkle contributed significantly to liveliness and negatively to detachment.

Table 5. Significant beta coefficients of regression analyses without context variables

Lighting characteristics	Not controlled for context effects			
	Cosy	Lively	Tense	Detached
R²	.336**	.312**	.180	.249*
Brightness	-.588***		.484**	.354*
Contrast			-.362*	
Glare & Sparkle		.469**		-.382*

Note: Results of 4 separate regression analyses, with the 4 atmosphere dimensions as respective dependent variables. N=57. * p<.05, ** p<.01, *** p<.001

Table 6A. Hierarchical regression predicting cosiness

Cosiness	β coefficients		R ²	R ² change
	Step 1	Step 2		
Block 1 (context)			.105	
Legibility	-.158	-.132		
Warm	.281 *	.246		
Block 2 (lighting)			.384**	.279 **
Contrast		.058		
Brightness		-.499 **		
Glare & Sparkle		-.007		
Contrast of ceiling		-.206		
Lighting installation		.039		
Decorative lighting		-.153		

Note: * p<.05, ** p<.01, *** p<.001

Table 6B. Hierarchical regression predicting liveliness

Liveliness	β coefficients		R ²	R ² change
	Step 1	Step 2		
Block 1 (context)			.407 ***	
Legibility	-.590 ***	-.496 ***		
Warm	-.247 *	-.146		
Block 2 (lighting)			.522 ***	.115
Contrast		.093		
Brightness		-.128		
Glare & sparkle		.293 *		
Contrast of the ceiling		-.123		
Lighting installation		.158		
Decorative lighting		-.026		

Controlled Regression Analyses

We then repeated the analyses, yet this time controlling for contextual variables. A hierarchical procedure was chosen, with context descriptors comprising the first block and lighting attributes the second block. We could thus determine the effects of lighting on perceived atmosphere while controlling for context effects. In the first block, context variables were entered (Table 6). Adding the lighting attributes after this first block generally improved the predicted variance. Moreover, for three atmosphere dimensions, at least one lighting attribute had a significant beta-weight. Brightness significantly and substantially decreased perceived cosiness, and increased perceived tenseness. Glare and sparkle contributed to the perceived liveliness of fashion stores. Furthermore, the shops' legibility was shown to significantly decrease perceived liveliness and increase perceived detachment.

Table 6C. Hierarchical regression predicting tenseness

Tenseness	β coefficients		R ²	R ² change
	Step 1	Step 2		
Block 1 (context)			.059	
Legibility	.119	.051		
Warm	-.212	-.116		
Block 2 (lighting)			.189	.130
Contrast		-.298		
Brightness		.445 *		
Glare & sparkle		.043		
Contrast of the ceiling		-.059		
Lighting installation		-.157		
Decorative lighting		.102		

Note: * p<.05, ** p<.01, *** p<.001

Table 6D. Hierarchical regression predicting detachment

Detachment	β coefficients		R ²	R ² change
	Step 1	Step 2		
Block 1 (context)			.652 ***	
Legibility	.806 ***	.765 ***		
Warm	.056	.033		
Block 2 (lighting)			.682 ***	.030
Contrast		.013		
Brightness		.170		
Glare & sparkle		-.175		
Contrast of the ceiling		-.003		
Lighting installation		-.064		
Decorative lighting		.033		

DISCUSSION

Light and ambiance are intimately related, yet we know of very few studies that have attempted to measure how much lighting actually contributes to atmosphere perception in naturalistic environments. The current study attempted to do just that. Also, we hoped to attribute any contribution we might find to more or less specific lighting attributes. And indeed we did manage to verify that lighting contributes a measurable part to atmosphere assessments. This contribution was modest, and we did not establish significant effects for each dimension of atmosphere, but in view of the challenges we met, our findings were certainly satisfactory.

Measuring light's contribution in naturalistic settings proved to be quite a complex exercise. For one, one is dependent on the natural range and variance of lighting used in 'real' settings, and has to find a way of categorising or even quantifying that. In the current study, experts scored the lighting in each of the 57 shops, using a questionnaire specially developed to this end. Inter-rater reliabilities between these experts indicated that this produced a reliable and robust measure, which was more detailed and comprehensive than what could have realistically been possible with objective measurements.

A second obstacle in natural settings is accounting for the substantial variance and contribution of intervening variables. Based on the literature, we expected that especially the shop's interior and social variables would play an important role in defining the atmosphere. The social setting we tried to control by selecting time slots that were not too long and avoided the busiest hours. The shops' interiors were controlled first by limiting them to a certain type of product (clothing) and excluding the extreme ends of the price levels. Second, since this still left us with a huge range of different interiors – e.g. cluttered to spacious, old-fashioned to trendy, warm wooden furniture to cool metal racks and stands – we made an attempt to characterise and quantify these interior styles using the card-sorting method. These data enabled us to characterise all 57 shops by their location in a two-dimensional space stretching from orderly to disorderly and from warm to cold. We were not able to control the soundscapes (e.g., the music playing in the shop) or the shops' exteriors.

A third obstacle in the present research was measuring ambiance or atmosphere. We were not aware of existing standardized instruments for measuring atmosphere in retail environments, or other types of environments for that matter. Instruments most often used are probably the sets of semantic differentials, similar to the one we used in the present study. We preferred this measure [25] to other ones, for instance the well-known set developed by Russell, Mehrabian, and colleagues (e.g., see [17]), since it was specifically targeted to atmosphere perception, and its dimensions appeared closer to what we intended to measure than the dimensions typically coming from those sets (generally something like evaluation, arousal and potency).

The current instrument worked well in terms of the internal consistencies of its subscales, yet in hindsight it does not necessarily cover all relevant aspects of atmosphere. Also, it could have been interesting to also have probed characteristics such as 'spaciousness' or 'perceptual clarity' directly. This would have made it easier to compare the present study's findings to those reviewed earlier, for instance by Flynn [7]. However, we felt the current measure was closer to the 'atmosphere' concept, and we had to restrict the number of items, since each participant would have to fill out the questionnaire 57 times (!), one for every shop.

However, we feel that with these 57 shops, we have managed to create a large enough sample to guarantee a good variance in our core dependent and independent variables: lighting attributes and atmospheres, and to perform the multiple regression analyses on. We were in fact quite happy and proud to have been able to recruit that many shops to participate in the study. This potentially also illustrates the interest of these shops' owners in the role that lighting plays in the success of their business.

The first set of regression analyses showed how several lighting attributes were related to atmosphere dimensions. The most important attributes were brightness, contrast, and glare and sparkle. At least one, and sometimes two of these attributes significantly predicted each of the four dimensions.

In the second set of regression analyses, context variables were entered first, before entering the lighting attributes. This way we minimised the chance of confounds caused by naturally occurring relationships between interior design and lighting attributes, which might otherwise lead us to overestimate light's contribution to atmosphere perception. In fact, since the lighting in the shops was also recorded on the photographs used for the context quantifications, the present results are probably an underestimation of the impact of the lighting on perceived atmosphere.

Although some correlations decreased or disappeared, others remained, showing a consistent contribution for instance of brightness to the cosy-dimension (the brighter the impression of the shop, the less confined/intimate/romantic/relaxing was the atmosphere). Glare and sparkle added most to liveliness (the more glare and/or sparkle, the more energising/lively/stimulating was the atmosphere). Brightness contributed positively to the tenseness dimension (the more brightness, the more threatening, tense, uneasy and unfriendly the atmosphere). This was in fact quite unexpected, and not in line with earlier findings, which generally relate brightness to more positive evaluations. This may be specific to this type of environment and definitely calls for more research. No specific lighting attribute was related to detachment. This dimension was largely predicted by the contextual variable 'legibility' (running from disorder to order). The more legible the environment was, the more formal and businesslike the atmosphere. This same legibility

characteristic contributed negatively to the liveliness of the shop.

Conclusion

This study provides a better understanding of the impact of lighting on perceived atmosphere in a retail environment. Lighting attributes and interior qualities were successfully related to perceived atmosphere. Granted, the amounts of variance predicted for each of the dimensions of atmosphere are generally modest, and typically only one of the lighting attributes had a significant individual contribution. However, considering the wide variety of shop interiors, clothing collections, music played et cetera, we nonetheless consider the findings striking and encouraging for light designers and researchers: even in the enormous set of visual environmental cues present in retail environments, lighting does play a significant role in creating an ambiance.

ACKNOWLEDGMENTS

We thank the lighting experts of Philips Lighting for cooperating in developing and performing the lighting questionnaire.

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