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Lighting in retail environments: Atmosphere perception in the real world

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Although ambient lighting and atmosphere are intuitively related, there is a paucity of empirical, naturalistic data supporting such a relation. The objective of this study was to investigate the contribution of lighting in evoking an atmosphere in the real world, amongst the extensive set of other cues available there. In a field study involving 57 clothing stores, lighting attributes (e.g. brightness, contrast, glare and sparkle) and context (i.e. the shop's interior) were assessed and quantified independently. These data were then used to predict four dimensions of perceived atmosphere in hierarchical regression analyses. Lighting attributes and interior qualities were both related to perceived atmosphere. This indicated that, even given the substantial contribution of design elements in retail environments, lighting plays a role in evoking atmosphere.

1. Introduction

As any lighting designer, lighting researcher, or even layperson will confirm, lighting and ambiance are intimately related. Literature indicates that lighting can influence emotions, mood and cognition as well as 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 levels,[1] whereas others report no significant effects,[2,3] Fleischer *et al.*[1] have demonstrated that a combination of high illuminances and a relatively large indirect lighting component result in higher feelings of dominance. Cool white light has also been shown to be arousing.[1] Others report a more complex pattern, indicating positive effects of colour temperature on male participants' moods, yet negative effects on females' moods,[2] although a later study reported the reverse effect.[4]

Several studies are available investigating the way people assess lighting directly. Hawkes *et al.*[5] suggest that people categorise lighting using two dimensions – brightness and interest (or non-uniformity). Flynn *et al.*[6] added a third dimension – overhead versus peripheral lighting distribution. Sadly, both studies[5,6] used a sample size too small for a robust factor analysis. Veitch and Newsham,[7] who did tackle this problem in a larger scale study, demonstrated that people categorise lighting in terms of three dimensions – brightness, visual attraction and complexity.

The literature also describes how lighting can affect people's environmental impressions.[8] As one of the first in this field, Flynn *et al.*[6] used a realistic interior, a conference room, and found an effect of lighting on subjective evaluations of the environment, perceptual clarity and spaciousness. This research,

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together with several follow-up studies,[8] suggests that in 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[8] suggested several design guidelines: For perceptual clarity, the designer should apply bright and peripheral lighting. An impression of spaciousness is achieved when applying uniform and peripheral lighting. Pleasant and relaxing impressions are the result of peripheral and non-uniform lighting. Lastly, to establish a 'private' impression, the designer can select non-uniform and dimmed lighting.

Houser *et al.*[9] 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 rooms with less than 60% indirect lighting. In summary, based on a number of controlled laboratory experiments, it is fair to conclude that lighting is able to influence impressions of the environment.

Yet, although the literature contains 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. 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, that is, in the real world, is quite another, let alone ascribing this to specific lighting attributes. This is exactly what the study described in this paper 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.

2. Retail environments

Retail environments communicate the stores' image and purpose to customers,[10] they can evoke emotional reactions,[11] impact the customers' ultimate satisfaction with the service,[12] and even the amount of money and time spent in the store.[13] Therefore, creating the right environmental setting is of prime importance for shop owners. To create the desired ambiance, lighting may make a contribution, but it is only one of numerous elements that play a role, such as the furnishing and finishes of the shop's interior, size, crowdedness and music.

Different classifications for these environmental characteristics have been proposed. Bitner[10] suggested three groups as follows: Ambient conditions; spatial layout and functionality; and signs, symbols and artefacts. Berman and Evans[14] included the exterior of the shops and came to four groups as follows: General interior, the layout and design, the point of purchase and decoration, and the exterior of the shop. Turley and Milliman[15] added a fifth category – human variables. Most recently, Baker *et al.*[16] proposed a model in which the environmental cues were divided into three categories as follows: Design, ambient variables and social variables.

Since environments include such an extensive variety of stimuli, while on the other hand consumers perceive environments holistically,[17] it is essential in consumer research to seek variables – dimensions – that describe general but central characteristics of the environment.[18] Kaplan[19] suggested that four environmental dimensions can predict preference for outdoor environments – complexity, mystery, coherence and legibility.

Environmental complexity refers to visual richness, ornamentation, information rate, diversity and variety in an environment,[20] and has been shown to have a linear relationship with interest (arousal) and a curvilinear (inverted U) relationship with preference (pleasure),[20–22] meaning that moderate levels of complexity are most preferred. Another important environmental dimension is order.[21] This is related to the extent of coherence, legibility, organisation and clarity of an environment.[20] In studies of urban environments (summarised by Nasar[23]), order has been shown to have a positive impact on pleasantness and a negative impact on arousal. Although these factors were originally hypothesised to influence preferences with outdoor environments, all these relationships have also been confirmed for retail environments, except for the inverted U-shaped relationship between complexity and pleasantness.[24]

We conclude that lighting has a potential contribution to perceived ambiance but is only one of numerous elements that may play a role. In investigating whether such effects could indeed be established in everyday retail environments, it would be good to also try to quantify the role of the remaining contextual variables present. Our question was whether lighting would play a role that was measurable, and if yes, which lighting attributes would make the most substantial contribution.

3. Method

3.1. 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 – context (i.e. the shop's interior design), lighting attributes and perceived atmosphere – were assessed and quantified independently by different raters. Descriptive appraisals of the lighting situation in each of the stores were made by seven independent lighting experts; descriptive appraisals of each store's design and layout were made by 20 independent raters (lay people); affective appraisals of each store's atmosphere were made by six independent raters (also lay people). We then performed multiple regression analyses on perceived atmosphere dimensions, with the stores as units of analysis, and with lighting attributes and context as independent variables. Below, we will first briefly describe the sample of shops in this study. We will then report the methods for data collection and preparatory analyses for each of the three categories of variables – context characterisation, lighting attributes and atmosphere perception – separately.

3.2. Shops

The 57 stores examined were all located in the city centre of Eindhoven, a midsize Dutch city, to enable raters 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 participate.[a] Low and high-end shops were avoided for the same reason. Low- and high-end fashion shops were avoided for the same reason. The range of shops examined still presented a wide variety of shop interiors and fittings, but we expected structural confounds between lighting configuration and interior design to be limited. Nonetheless, in order to control for this eventuality, we also assessed and quantified the style of the shops' interiors.

3.3. Part one: Context

A store's design and layout likely influence the atmosphere perceived by customers. In the

[a]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.

current study, where multiple shops are visited with a range of interior designs, this could add a substantial amount of error to the data, leading to an underestimation of the contribution of lighting. On the other hand, if the design of the shops' interiors and their lighting plan co-vary, because both are part of the same design concept, or because the same designer had been responsible for both, this could result in an over-estimation of lighting's influence on atmosphere perception. We therefore wanted to control for the design of the shops' interior. For this purpose, we needed to quantify the interior designs on dimensions meaningful to customers. A card-sorting technique was used to elicit these dimensions and simultaneously quantify the shops on them. Sorting has been used for decades in psychology and anthropology as an eliciting tool for hidden 'folk taxonomies' or subjective categorisations. Black[25] described its aim as 'to elicit data which give native classifications of phenomena, how people perceive their environment . . . to get descriptive categories which are 'psychologically real'. Multiple correspondence analysis (MCA) was used to subsequently represent and analyse the sorting data. MCA is an exploratory technique that reduces the data into a lower dimensional representation.[26–28] MCA is a popular descriptive technique to explore the relationships among multiple categorical variables and one of the techniques recommended for the analysis of sorting data.[29]

Twenty[b] participants were recruited from a participant database of the university. The group consisted of 10 males and 10 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.

A card-sorting experiment was performed to characterise the shops' interior designs. Pictures of these interiors were printed on A5 photo paper and presented as cards. The photographs were all taken inside the shops, from where the participants rating the atmosphere (see below) would be standing. In taking the pictures, we avoided photographing ceilings and luminaires 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. We did this to lower the burden on participants. The participants performed the experiment individually to assure independence of grouping strategies.[31]

Open card sorting was employed: Participants were instructed to think of a discriminating quality they felt could serve as a base for sorting the shops, for example, 'clutteredness' or 'attractiveness'. They then sorted the pictures of the shops into five piles[c] (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 categorisations. MCA was then performed on these data, yielding two dimensions on which the shops varied (accounting for 31% and 19% of the variance, respectively, inter-dimensional correlation −0.006). Figure 1 shows the cards plotted against these dimensions, which we labelled 'legibility' (order–disorder) and 'warmth' (warm–cold), based on the labels participants had given for their categorisations. 'Legibility', 'order', 'luxury' and

[b]In the other two phases, we employed a smaller number of raters as these involved long and intensive measurement sessions for the site visits. For the context characterisation, a larger sample of 20 respondents was needed to ensure a robust and reliable dimensional structure.[30]

[c]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 five piles in total. This procedure was followed because the pilot study pointed out that this procedure would lead to a more balanced division of the pictures over the five piles.

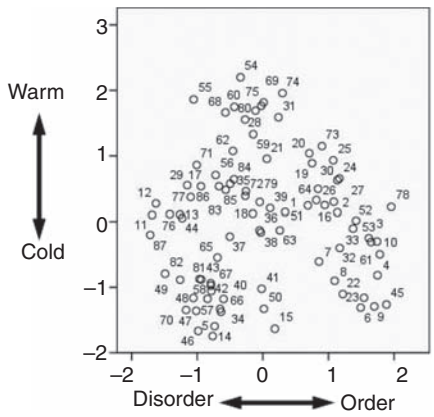

Figure 1 The shops plotted against two dimensions, legibility (disorder–order) and warmth (cold–warm). Legibility accounted for 31% of the original variance. Warmth accounted for 19% of the original variance

'traditional' were typical qualities that characterised the high end of the first dimension, the low end received such labels as 'chaotic', cheap' and 'trendy'; qualities like 'warm', 'old-fashioned' and 'cosy' described the high end of the second dimension, shops at the lower end were characterised as 'cold', 'modern' and 'uncomfortable'. For the shops with two cards in the experiment, the scores were averaged. Each shop hence received two scores, one for each dimension, characterising them in terms of these two clusters of attributes ('legibility' and 'warmth', respectively). These scores were used in the multiple regression analyses reported in Section 4 to account for the variability of shop interiors.

3.4. Part two: Lighting attributes

The second category of variables that needed to be measured pertained to the characterisation of the lighting design. To measure the lighting attributes of the shops, a dedicated lighting attributes questionnaire was developed. There are numerous metrics available to characterise a lighting situation. However, because of the complexity and flexibility of the human visual system and the differences between different people, these metrics are inevitably approximations of what people really perceive.[32] Adaptation is one of those problems. People unconsciously adapt to the brightness and even to the colours of an environment.[32] Moreover, current objective measurement techniques for field research would not realistically enable us to characterise the lighting situation in sufficient detail.

3.4.1. Participants

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

3.4.2. Measurements and procedure

A questionnaire was developed in cooperation with lighting experts to reliably characterise the lighting situation in each of the shops on the most important and meaningful attributes. 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 four characteristics of the lighting installation (Table 1). In line with the work of Houser *et al.*,[9] the brightness and contrast ratings were separated between the ceiling (C), sidewalls (S), back wall (B), horizontal products (H; e.g. products laid out on tables), floor (F) and overall room (Figure 2). Since there is often more light installed on the back wall compared to the sidewalls, these two variables were separated. As contrast can be an ambiguous concept, this was divided in an item for 'the number of luminance changes' and an item probing 'the luminance change ratio'. For both items, illustrations were included (Figure 3) to give a better indication of what had to be evaluated.

Each of the seven experts filled out one questionnaire for every shop in the study

Table 1 Inter-rater reliabilities of the lighting questionnaire items

Item	Cronbach's alpha	Item	Cronbach's alpha
General lighting	0.940	Accent lighting	0.942
Decorative lighting	0.805	Architectural lighting	0.933
Brightness back walls	0.870	Brightness horizontal plane	0.823
Brightness ceiling	0.820	Brightness floor	0.819
Brightness sidewalls	0.892	Brightness overall	0.915
Colour temperature light	0.759	Colour temperature total space	0.813
Glare	0.889	Sparkle	0.822
Luminance ratio back walls	0.789	Luminance ratio horizontal plane	0.825
Luminance changes back walls	0.691	Luminance changes horizontal plane	0.719
Luminance ratio ceiling	0.635	Luminance ratio floor	0.765
Luminance changes ceiling	0.677	Luminance changes floor	0.638
Luminance ratio sidewalls	0.816	Luminance ratio overall	0.766
Luminance changes sidewalls	0.775	Luminance changes overall	0.773
Conspicuous lighting installation	0.628	Patterned lighting installation	0.778
Amount of fittings	0.906	Different fittings	0.841
Modelling	0.865	Mean	0.804

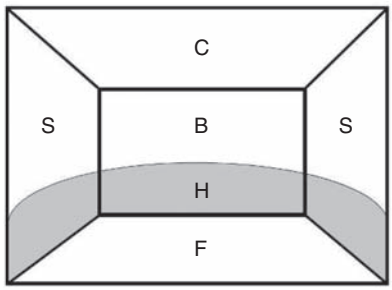

Figure 2 The division of the space for the brightness and contrast ratings

(i.e. 7 times 57 in total), individually, during a site visit. They visited the shops between 10 in the morning and half past noon, avoiding the busier hours. Also, their visits were scheduled within a period of 3 weeks to minimise the chance of interiors being redecorated. Varying the order in which each expert visited the stores controlled for order effects, as might occur as a result of learning, tiredness or boredom.

3.4.3. Analysis

Inter-rater reliabilities were computed to determine the level of agreement among the lighting experts. Cronbach's alpha between experts' scores for each individual item ranged from 0.628 to 0.942, with an average of 0.804 (Table 1). These reliabilities were more than satisfactory, indicating a high level of agreement among the lighting experts in scoring the lighting attributes of the shops. The scores of the experts were averaged to compute each shop's scores.

Factor analyses (principal component with varimax rotation) of the data resulted in six dimensions for attributes of the lighting configuration – contrast, brightness, glare and sparkle, contrast on the ceiling, aesthetics of the lighting installation and decorative lighting. The first dimension, labelled 'contrast', consisted of almost all the luminance changes and luminance ratio items, except for the ones on the ceiling (see Table 1 for a list). We labelled the second dimension 'brightness' because it comprised every single brightness item. The third dimension, labelled 'glare and sparkle', contained the items glare, sparkle and accent lighting. This was a logical combination as sparkle is a desired and pleasant form of glare, which is often created by accent lighting. The two items concerning the luminance changes and luminance ratio of the

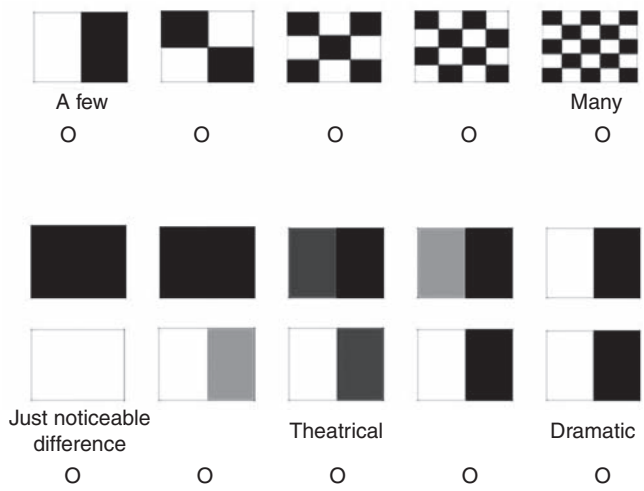

Figure 3 Scales probing the number of luminance changes (upper) and the luminance change ratio (lower)

Table 2 Lighting attributes correlation matrix

	Brightness	Glare and sparkle	Contrast of ceiling	Lighting installation	Decorative lighting
Contrast	0.402	0.620	−0.056	−0.092	0.089
Brightness		0.399	0.165	0.206	−0.198
Glare and sparkle			−0.051	0.041	0.047
Contrast of ceiling				0.202	−0.111
Lighting installation					0.043

ceiling, and these two alone, loaded high on dimension four, which therefore was labelled 'contrast on the ceiling'. Two items probing the characteristics (pattern and conspicuousness) of the lighting installation formed the fifth dimension, labelled 'aesthetics of the lighting installation'. The sixth dimension solely consisted of the item probing the amount of decorative lighting.

The score for each of the factors was determined by averaging the scores of the items contributing to that particular dimension. For instance, the score for the factor glare and sparkle was calculated by averaging the scores for accent lighting, glare and sparkle. Correlations between the six factors are reported in Table 2. Each shop's scores on these six lighting attributes were used as predictors of perceived atmosphere in the multiple regression analyses reported in Section 4.

3.5. Part three: Atmosphere perception

In the third phase, six (new) participants visited all the shops and rated the ambiance in each of them. We were not aware of any existing standardised instruments for measuring the atmosphere in retail environments, or other types of environments for that matter. Instruments most often used in this type of environmental assessment are sets of unipolar or bipolar items, targeted at measuring emotions directed towards something in the environment, or the emotional impact of the environment, such as the well-known set developed by Russell and Mehrabian[18] and

Craik and Feimer.[33] However, the goal in this study was not to probe the emotional impact of the environment on customers, but rather, to measure perceptions of qualities of the environment, similar to what Küller[34] describes. These qualities are characteristics of the environment perceived by observers, rather than describing an actual (affective) state of the observer. Küller[34] states 'Although emotions may shift quite rapidly, the qualities projected onto the environment remain much more stable'. Küller and colleagues[34] developed an instrument consisting of eight dimensions, applicable to a large range of environments. Vogels[35] has also developed an instrument to measure atmosphere perception exactly in this line of thinking and has tested it in retail environments. We selected Vogels' measure,[35] since it was specifically targeted to atmosphere perception in these types of environments, and its dimensions appeared closest to what we intended to measure. The shops' atmospheres were characterized on four dimensions: Cosiness, liveliness, tenseness and detachment.

3.5.1. *Participants*

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

3.5.2. *Measurements and procedure*

For measuring perceived atmosphere, a short version of Vogels' instrument[35] was used. This questionnaire measures perceived atmosphere on four dimensions as follows: cosiness, liveliness, tenseness and detachment. The reduction of items was necessary to make sure filling in the questionnaire 57 times became practically feasible. After consultation with Vogels, 18 of the original 38 items were selected, four or five per atmosphere dimension (Table 3). Seven-point Likert scales were used, ranging from totally not applicable to totally applicable. Again, we varied the order in which shops were assessed by taking raters along different routes past all of them. Raters were directed to the spot from which the photographs used for context characterisation had been taken, overlooking a substantial part of the shop and well away from the entrance to prevent outdoor conditions playing too much of a role. After a few

Table 4 Internal consistencies and inter-rater reliabilities of the atmosphere scales

	Average internal consistency*	Inter-rater reliability**
Cosiness	0.83	0.65
Liveliness	0.77	0.76
Tenseness	0.79	0.42
Detachment	0.61	0.84

*Averaged over six participants' individual internal consistency scores.
**Between the six participants' scores on that dimension.

Table 3 Selected atmosphere words

Dimensions	Cosiness	Liveliness	Tenseness	Detachment
Items	Cosy	Lively	Tense	Business
	Cosy	Stimulating	Terrifying	Formal
	Intimate	Inspiring	Oppressive	Cool
	Pleasant	Cheerful	Threatening	Chilly
	Safe		Uncomfortable	

Cosy is mentioned twice because there are no different English terms available for the two Dutch atmosphere terms.

Table 5 Correlations between scores on the atmosphere dimensions

	Liveliness	Tenseness	Detachment
Cosiness	0.330	−0.613	−0.309
Liveliness	1.000	−0.340	−0.789
Tenseness		1.000	0.310

Table 6 Significant beta coefficients of the regression analyses without context variables

Lighting characteristics	Cosy $R^2 = 0.336$	Lively $R^2 = 0.312$	Tense $R^2 = 0.180$	Detached $R^2 = 0.249$
Brightness	−0.588***		0.484**	0.354*
Contrast			−0.362*	
Glare and sparkle		0.469**		−0.382*

Note: Results of four separate regression analyses, with the four atmosphere dimensions as respective dependent variables, $N = 57$.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

minutes of adjustment to the lighting, they scored each shop on each of these 18 items, that is, on all four dimensions. They were not aware that the study was focused on lighting and were not instructed to pay particular attention to lighting or luminaires.

3.5.3. Analysis

Internal consistencies of the atmosphere dimensions were determined by calculating Cronbach's alpha for each of the six participants (Table 4). Averaged values indicated acceptable (>0.60) to good (>0.80) reliabilities. The level of agreement between participants was determined by calculating inter-rater reliabilities (Cronbach's alpha) per dimension. Again, these were acceptable to good, except for the tenseness dimension, which showed only a modest inter-rater reliability. The values are reported in Table 4. Correlations between the scores on the different atmosphere factors are displayed in Table 5.

4. Results

After scores on the dependent (perceived atmosphere) and independent variables (context and lighting attributes) had been gathered and computed as described above, multiple regression analyses were performed. Multiple regression can establish that our set of independent variables – the lighting attributes and the context variables – explain a proportion of the variance in each of the four dependent atmosphere components. The beta weights reported in the analyses are an indication of the relative predictive importance of the respective variables. In four separate regression analyses, the four perceived atmosphere dimensions (cosiness, liveliness, tenseness and detachment) were predicted with the two context variables (legibility and warmth) and the six lighting attributes (contrast, brightness, glare and sparkle, contrast on the ceiling, aesthetics of the lighting installation and decorative lighting) as predictors. Note that in these analyses, the 57 shops were the cases (they made up the rows in the statistical database).

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 6. Brightness contributed significantly to three atmosphere dimensions as follows: cosiness (negatively), tenseness and detachment. Contrast significantly decreased perceived tenseness. Glare and sparkle contributed significantly to liveliness and negatively to detachment. The proportions of explained variance of the four atmosphere variables (indicated by R^2 values in Table 6) are moderate, ranging between 0.18 and 0.34.

We then repeated the analyses, this time controlling for contextual variables. We could thus determine the effects of lighting on

Table 7 Beta coefficients of regression analyses with context variables

	Cosiness $R^2 = 0.348$ β	Tenseness $R^2 = 0.189$ β	Liveliness $R^2 = 0.522$ β	Detachment $R^2 = 0.682$ β
Context				
Legibility	−0.132	0.051	−0.496***	0.765***
Warmth	0.246	−0.116	−0.146	0.033
Lighting				
Contrast	0.058	−0.298	0.093	0.013
Brightness	−0.499**	0.445*	−0.128	0.170
Glare and sparkle	−0.007	0.043	0.293*	−0.175
Contrast of ceiling	−0.206	−0.059	−0.123	−0.003
Lighting installation	0.039	−0.157	0.158	−0.064
Decorative lighting	−0.153	0.102	−0.026	0.033

Results of four separate regression analyses, with the four atmosphere dimensions as respective dependent variables, $N = 57$.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

perceived atmosphere while controlling for context effects. Table 7 shows the results of the four analyses. 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. The proportions of explained variance of the four atmosphere variables in this analysis ranged from moderate to substantial (0.19–0.68).

5. 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 specific lighting attributes. The analyses indicate that indeed lighting contributes a measurable part to atmosphere assessments, although the contribution was generally modest.

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. Liveliness was positively related to glare and sparkle; tenseness was positively related to brightness and negatively to contrast; cosiness was inversely related to brightness, and detachment was positively related to brightness and inversely to glare and sparkle.

In the second set of regression analyses, context variables were entered first before entering the lighting attributes. This minimised the chance of confounds caused by naturally occurring relationships between interior design and lighting attributes, which might otherwise lead us to under- or overestimate lighting's contribution to atmosphere perception. In fact, since the lighting in the shops was also partly reflected in the photographs used for the context quantifications (although we tried to avoid shooting ceilings and luminaires as much as possible), 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, or to Dutch culture, 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.

Measuring light's contribution in naturalistic settings proved to be quite a complex exercise. For a start, 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 this. 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 naturalistic 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 was controlled by selecting time slots that avoided the busier 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. This still left us with a huge range of different interiors – for example, cluttered to spacious, old-fashioned to trendy, warm wooden furniture to cool metal racks and stands. A card-sorting technique was therefore employed to characterise and quantify the diversity of these interior styles. The data enabled us to characterise all 57 shops by their location in a two-dimensional space stretching from orderly/legible to disorderly and from warm to cold. Noise and background music were not controlled, neither were shops' exterior designs.

A third challenge in the present research was measuring ambiance or atmosphere. Atmosphere, it was argued, is not an affective state of an observer resulting from an environment. Rather, it is a quality perceived by observers, relating to affective connotations the setting may have. The typical two- or three-dimensional components (evaluation, arousal and potency) often found in environmental assessment, reflecting the dimensional structure behind emotions,[18,33] were therefore considered unsuitable in the current study. We selected Vogels' measure[35] instead, since it was specifically targeted to atmosphere perception, and its dimensions appeared closer to what we intended to measure. The 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. For instance, Küller's proposed scale[34] consists of eight components and may therefore be considered more detailed and informative. Also, it would 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.[8] However, it was felt that the current measure was closer to the 'atmosphere' concept, and a limitation of the number of items was desirable since each participant would have to fill out the questionnaire 57 times – one for every shop.

The selected sample of 57 shops created a large enough range to guarantee a good variance in our core dependent and independent variables – lighting attributes and atmospheres, and to perform the multiple regression analyses on. The fact that this many shops were willing to participate potentially also illustrates the interest of these shops' owners in the role that lighting plays in the success of their business.

5.1. 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. The amounts of variance predicted for each of the dimensions of atmosphere are generally modest, and when controlling for interior design, typically only one of the lighting attributes had a significant individual contribution per atmosphere dimension. However, considering the wide variety of shop interiors, clothing collections, music played, etc., the findings should nonetheless be considered encouraging for lighting designers and researchers. Even with the enormous set of visual environmental cues present in retail environments, lighting does play a significant role in creating an ambiance.

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