MASTER

The effects of retail lighting on atmosphere perception

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Preface

This is the Master's Thesis of my graduation project, which is part of the Master's program in Human Technology Interaction of Eindhoven Technical University. In cooperation with Philips Lighting, I studied the effects of retail environments on atmosphere perception. Thanks to this project I gained experience in conducting and reporting scientific research. Additionally, it expanded my knowledge regarding the impact of retail environments and particularly lighting on perceived atmosphere.

I would like to express my gratitude to my supervisors of Eindhoven Technical University, Yvonne de Kort and Wijnand IJsselsteijn, and my supervisor of Philips Lighting, Marike de Kruiff, for their valuable and inspiring support and feedback. Furthermore I would like to thank my colleagues of Philips Lighting for providing a nice working atmosphere and my fellow students for having a great time during my period at the university. Lastly, I would like to thank my parents, other family members, and my friends for their advice and unconditional support.

Pieter Custers
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Summary

Shop environments have the potency to influence consumers in numerous ways. The shop environment may influence the store's image and purpose to its customers, it can evoke emotional reactions with its customers and it can even have an impact on the amount of money and time spent in the store. It turns out that the atmosphere perceived by the customers is very important for shop owners.

Perceived atmosphere can be described as the appraisal of an environment with respect to the potential affective effect. Providing the right atmosphere can be achieved by means of numerous environmental variables, with lighting being one of them. For companies like Philips Lighting it would be very useful to know to what extent lighting influences the perceived atmosphere. This study investigates the role that lighting plays among the extensive set of environmental variables in evoking a desired atmosphere. Furthermore it investigates the effects of individual context and lighting variables on perceived atmosphere. A field study was conducted in 57 retail fashion shops. In these retail settings the three concepts 'context', 'lighting' and 'perceived atmosphere' were assessed and quantified.

The context variables were assessed and quantified by means of a card-sorting experiment. In that experiment pictures of the interior of the shops were used as cards. Participants were asked to choose an environmental variable that was important for them while shopping. Additionally they were asked to sort the pile of pictures into five piles (ranging from *totally not applicable* to *totally applicable*), based on the chosen variable. The 59 obtained divisions and related analyses gave insights into which interior qualities are important to people. Furthermore it provided a two-dimensional context score, by which it became possible to relate the context to the lighting and perceived atmosphere.

For measuring the subjective lighting impression of the shops, in cooperation with lighting experts of Philips Lighting, a questionnaire was developed. This questionnaire proved to be able to distinguish between six different lighting attributes. Furthermore it provided for each shop a score on each of these lighting attributes.

For quantifying atmosphere perception Vogels' (2008) methodology was used. This questionnaire provided for each shop a score on the four atmosphere dimensions *coziness*, *liveliness*, *tenseness* and *detachment*. The scores for the shops on these four dimensions were used as criteria (i.e. dependent variables) in four different Multiple Regression Analyses; one for each atmosphere dimension. The models predicted these criteria based on the predictors, which were formed by the six lighting variables and the two context variables.

The results indicate that lighting does have a significant contribution to the prediction of perceived atmosphere, even if controlled for context effects. Furthermore the results prove several effects of lighting attributes and context variables on atmosphere perception: a brighter store evokes an atmosphere that is perceived as less cozy and more tense; more glare and sparkle in a shop evokes a perceived atmosphere that is more lively; and a more legible interior is perceived as less lively and more detached.

The present study provided new measurements to quantify interior qualities and lighting attributes and proved them to be feasible. Together with the atmosphere measurement developed by Vogels (2008) the present study successfully related interior qualities and lighting attributes to atmosphere perception and proved a significant contribution of retail lighting to the prediction of perceived atmosphere, even if controlled for context effects.

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1. Introduction

A store environment can influence consumers in numerous ways. It may be very influential in communicating the store's image and purpose to its customers (Bitner, 1992), it can evoke emotional reactions with its customers (Donovan & Rossiter, 1982), it can have an impact on the customers ultimate satisfaction with the service (Bitner, 1990), and it can even affect the money and time spend in the store (Donovan, Rossiter, Marcoolyn, & Nesdale, 1994). From this it turns out that providing the right environmental setting is very important for shop owners.

Although the environmental effects on appraisal, preference and affective states are studied heavily (for a review: Turley & Miliman, 2000), hardly any study has investigated the effects of retail environments on perceived atmosphere. Perceived atmosphere is not an affective state, but the appraisal of an environment with respect to the potential affective effect. Since a persons affective state can be evoked by many other variables than just the environment, it might be better to investigate the perceived atmosphere. For quantifying an environment's perceived atmosphere, a questionnaire, was developed by Vogels (2008). Furthermore, Vogels revealed by means of factor analysis that perceived atmosphere could be expressed in four dimensions: coziness, liveliness, tenseness and detachment.

Kotler (1973) was the first to use the term 'atmospherics', as the 'conscious planning of atmospheres to contribute to the buyers' purchasing propensity'. Providing a particular atmosphere can be achieved by means of an extensive set of atmospheric variables. Turley & Miliman (2000) conducted a literature review and counted 43 environmental cues inside a store that have the potency to affect consumer evaluations and behaviors. Examples are design cues, like the colors and materials used for the walls, ceiling, floor, racks, and shelves; social cues, like crowdedness; and ambient cues like music, scent and lighting.

Lighting is just one of the numerous environmental cues that have the potency to affect perceived atmosphere. Recent studies investigated the effects of lighting on environmental impressions (e.g. spaciousness), on emotions, mood and cognition (Flynn, 1992; Fleischer, Krueger, & Schierz, 2001; Knez, 1995). However, there is a surprising lack of empirical research addressing the effects of lighting on perceived atmosphere in retail settings.

De Vries & Vogels (2007) used the instrument of Vogels (2008) to demonstrate an effect of lighting on perceived atmosphere. However, in this study the lighting was not systematically varied. Van Erp (2008) was the first to investigate the effects of particular lighting attributes on atmosphere perception. However, Van Erp's (2008) research was conducted in an empty experimental room with the context (i.e. other environmental cues) held constant for every lighting setting. Hence, no answers could be given to the question about the contribution of lighting attributes upon all the other environmental cues.

The present study aims at answering that question and therefore its main objective is to investigate the role that lighting plays among the extensive set of environmental cues in evoking a desired atmosphere. From this follows the research question of this study:

- Does retail lighting contribute significantly to the prediction of perceived atmosphere if controlled for context effects?

In order to answer this question, a field study is conducted in 57 retail fashion shops. With the aim to prevent the stores from having big differences in 'sold products' and thereby reducing the risk of 'sold products' having an effect on the perceived atmosphere, only fashion shops were selected. Furthermore, low- and high-end shops were avoided for the same reason. Nonetheless, even when only mid-range fashion shops are selected, the interiors between the shops can differ substantially and can overrule potential lighting effects.

In all the 57 stores the three concepts ‘context’, ‘lighting’ and ‘perceived atmosphere’ are assessed and quantified. For measuring perceived atmosphere Vogels’ (2008) instrument is used. For assessing and quantifying the lighting in the shops, in cooperation with lighting experts, a questionnaire was developed that probed the relative contribution of the different types of lighting (general, accent, architectural, decorative) and six lighting variables brightness, contrast, glare & sparkle, color temperature, modeling, and the lighting installation. For assessing and quantifying the context of the shops, a card-sorting experiment was developed. Eventually, the measurements of the present study were developed to answer the following sub questions:

- *What are the effects of retail lighting attributes on perceived atmosphere?*
- *What are the effects of retail context on perceived atmosphere?*

By answering these questions this study will provide better understanding about the impact of light in a retail setting on perceived atmosphere. Furthermore, effects of individual lighting attributes on perceived atmosphere are discussed, providing designers with guidelines for creating desired atmospheres.

Chapter Two presents a literature review on topics that are relevant for the present study. Chapter Three, Four and Five explain the construction of the context variables, the lighting variables, and the atmosphere variables, respectively. Chapter Six presents the multiple regression analysis, which is performed in order to construct the regression model that predicts atmosphere perception. In chapter Seven, the obtained results are discussed and suggestions for further research are made.

2. Literature review

Literature about the effects of lighting on perceived atmosphere in a retail environment is scarce. However, several studies have investigated the appraisal of retail environments and lighting systems. Relevant literature for the present study, together with the scarce literature regarding atmosphere perception, is discussed in this chapter. It starts with an overview of emotion (measurements) and perceived atmosphere (measurement). Subsequently, this chapter provides an overview about the effects of retail environments on emotion and behavior, and continues with discussing lighting and its impact on emotions and perceived atmosphere.

2.1. Emotions

This section describes the concept emotion and emotion measurements. According to Lararus (1991) emotions are affective states that are the outcome of a cognitive appraisal, which is a person's evaluation of the meaning of the current situation. This situation can be for instance an interaction with another person, with one self (e.g. thoughts), or an environment. If this situation is evaluated as important an emotion is experienced. Depending on the valence and importance of the situation a certain type of emotion with a certain intensity is experienced (Lazarus, 1991).

People's emotions can be measured in different ways based on for instance behavioral responses or facial expressions, but also by means of physiological or cognitive variables. There are several methods available to describe emotions, of which the dimensional approach is the most commonly used. According to this approach, emotions can be described by a number of underlying dimensions. One example of a dimensional approach is the PANAS model, proposed by Watson, Clark & Tellegen (1988). This model describes emotions using the two dimensions positive affect (PA) and negative affect (NA). The positive affect dimension represents the extent to which a person feels alert, active and enthusiastic, while the negative affect dimension represents the extent to which a person feels distress, anger, guilt and fear. The PA & NA dimensions can be measured using ten emotion terms for the PA dimensions and ten emotion terms for the NA dimension (Watson et al. 1988).

A second multi-dimensional approach for describing emotions is the PAD model proposed by Mehrabian & Russel (1974). This model describes emotions by means of the three dimensions pleasure (P), arousal (A) and dominance (D). The first dimension, pleasure, refers to the valence (positive-negative) of an emotion, arousal refers to the mental and/or physical activity level, and dominance refers to the (lack of) control over others or situations. The PAD dimensions can be measured using different methods. Together with the PAD model, Mehrabian & Russell (1974) provided a semantic differential scale, consisting of 18 bipolar mood adjectives. To make assessing emotions a lot quicker, Russell, Weiss & Mendelsohn (1989) proposed a single item scale to measure pleasure and arousal: the affect grid. This is a two-dimensional grid, with one axis indicating the experienced (un)pleasant feeling and the other axes indicating the experienced arousal or sleepiness. Another simplification was proposed by Bradley & Lang (1994). They proposed SAM: the self assessment manikin. SAM is a nonverbal, graphic depiction of various points along each of the pleasure, arousal, and dimension scales. Although the affect grid of Russell et al. (1989) is compacter because of using only one scale instead of three, SAM includes all three major affective dimensions, against only two used with the affect grid of Russell et al. (1989).

Mehrabian (1997) compared the PANAS and PAD models and found that the positive affect (PA) and negative affect (NA) dimensions correspond to the diagonals of the pleasure (P) and arousal (A) axes.

2.2. Atmosphere perception

Atmosphere perception is related to experienced emotions. However, both concepts differ in the sense that ‘perceived atmosphere’ is not an affective state, but the appraisal of an environment with respect to a potential affective effect (Vogels, 2008). Vogels (2008) suggests that, although perceived atmosphere has the potency to change people’s emotions, it does not necessarily give rise to a particular feeling. To give an example: persons can feel very stressed in a relaxed environment if they think about all of their problems. On the other hand they will have a hard time feeling relaxed in a stressful environment.

Consequently, the effect of an environment on one’s emotions will depend, amongst others, on one’s initial affective state. To the contrary, Vogels (2008) claims that the effect of environmental variables on perceived atmosphere is expected to be independent from people’s emotions. As perceived atmosphere and emotions differ, emotion measurements are inappropriate for measuring perceived atmosphere in an environment.

To overcome this problem, Vogels (2008) developed a tool to quantify perceived atmosphere. She constructed an atmosphere questionnaire comprising of atmosphere terms forming 38 semantic differential scales. Additionally was demonstrated that the atmosphere questionnaire can discriminate between the atmospheres of different environments and that perceived atmosphere can be described in terms of the two dimensions *coziness* and *liveliness*. These dimensions are comparable to the *pleasure* and *arousal* dimensions found by Mehrabian & Russell (1974).

In a follow-up study, De Vries & Vogels (2007) investigated the ability of Vogels’ (2008) atmosphere questionnaire to distinguish between different lighting settings. In an empty experimental room, participants were asked to rate four different lighting settings using the atmosphere questionnaire. De Vries & Vogels (2007) found the atmosphere questionnaire (Vogels, 2008) being able to discriminate between different lighting settings. Additionally, in line with Vogels (2008), was demonstrated that perceived atmosphere can be expressed using the two dimensions pleasure and arousal. Furthermore, by means of a Varimax rotation they revealed two other factors, which could be interpreted as tenseness and liveliness.

In the most recent study Van Erp (2008) investigated the relation between light and perceived atmosphere. In an empty experimental room, intensity, color temperature and spatial distribution of the lighting was varied. Participants were asked to rate perceived atmosphere by means of the atmosphere questionnaire of Vogels (2008). Van Erp’s (2008) data was pooled with the data obtained by Vogels (2008) and De Vries & Vogels (2007), resulting in a data set consisting of 524 cases in 27 locations, obtained with 85 participants. This data set was used to perform a factor analysis (for explanation see Appendix A). Van Erp (2008) demonstrated that atmosphere can be expressed in the four dimensions *coziness*, *liveliness*, *tenseness* and *detachment*. Since this study used a much greater sample size than previous research, Van Erp’s (2008) factor analysis provided more stable and complete factors (i.e. dimensions) than the ones of Vogels (2008) and De Vries & Vogels (2007).

2.3. Effects of retail environment on emotions and behavior

Shopping environments can evoke emotional responses in costumers (Machleit & Eroglu, 2000) and may even influence the shopper's ultimate satisfaction with the service provided (Bitner, 1990). Emotions, in turn, have an effect on shopping behaviors (Donovan & Rossiter, 1982; Donovan, Rossiter, Marcoolyn & Nesdale, 1994; Spies, Hesse & Loesch, 1997). For instance Spies et al. (1997) found that customers in a pleasant store spontaneously spent more money on articles they simply liked.

Mehrabian & Russell (1974) propose an environmental psychology model (M-R model), which suggest that individuals react to environments with two general, and opposite, forms of behavior: approach and avoidance. Furthermore they propose that the three basic emotional states, pleasure-arousal-dominance, mediate the effect of environmental stimuli on behavior. This effect is based on the Stimulus-Organism-Response (S-O-R) paradigm, relating features of the environment (S) to approach-avoidance behaviors (R) within the environment, mediated by a person's emotional states (O) evoked by the environment.

Donovan & Rossiter (1982) introduced the M-R model into the store atmosphere literature. They measured eight store-relevant approach-avoidance behaviors, and found that respondents' ratings of their emotions using the PAD instrument significantly predicted approach-avoidance measures like willingness to spend time in the store and willingness to explore the environment. As predicted by the M-R model, they demonstrated that pleasure was significantly related to approach-avoidance measures overall, and that arousal was positively related to approach behaviors in pleasant environments. They also hypothesized that arousal would be negatively related to approach behaviors in unpleasant environments. However, there were insufficient unpleasant environments to adequately test this hypothesis. In line with Greenland & McGoldrick (1994), Donovan & Rossiter (1982) found no significant relation between the dominance-dimension and any of the approach-avoidance measures.

In a follow-up study, Donovan et al. (1994) left out the dominance factor and concentrated on the pleasure and arousal dimension. They demonstrated that emotional states of people in the shop predict not just intentions, but also actual purchase behavior. More specifically, Donovan et al. found (1994) that pleasure experienced in a shop has a strong effect on customers spending more money than intended and spending extra time in the shop. The latter is important as well, as Underhill (1999) found that people spending more time in a store, purchase more products. Overall, the results of Donovan et al. (1994) reinforce the conclusion drawn by Donovan & Rossiter (1982), that the M-R model (in its modified form using only the pleasure and arousal dimensions) can be used for the study of store behavior.

2.3.1 Environmental variables

The previous section described that retail environments affect human emotion and behavior. This section elaborates on the different environmental characteristics of a retail environment that are responsible for evoking those emotions and behavior.

A retail environment consists of a lot of different environmental cues. Turley & Milliman (2000) performed a literature review and counted 57 different environmental characteristics that can influence shopping costumers' emotions and behavior. In order to make it easier to study the effects caused by all these different environmental cues, several researchers provided categorizations (Bitner, 1992; Berman & Evans, 1995; Turley & Milliman, 2000; Baker et al., 2002).

Bitner (1992) studied the impact of the physical surroundings on customers and employees and identified, based on a review of diverse literature, three composite categories of environmental cues being particularly relevant: *ambient conditions*, *spatial layout and functionality*, and *signs, symbols and artifacts*. *Ambient conditions* included characteristics such as lighting, music, temperature, noise and scent. *Spatial layout* referred to the arrangement of the furnishing, equipment and machinery, and the size, shape and spatial relationship among those items. *Functionality* refers to the ability of those items to facilitate performance and to accomplish goals. Signs, symbols and artifacts included for example labels (e.g. company name), directional purposes (e.g. exits), or rules of behavior (e.g. wait behind the line).

Berman & Evans (1995) included the exterior of the shops and grouped atmospheric elements into four categories: the *general interior, the layout and design, the point-of-purchase and decoration,* and *the exterior of the shop*. Turley & Milliman (2000), on their turn, added a fifth category: human variables. Turley & Milliman conducted a literature review and found 57 atmospheric variables, which were grouped into the five mentioned categories. Examples of *general interior variables* were the flooring and carpeting, color schemes, paint and wallpaper, lighting, music, merchandise, etc. *Layout and design variables* included placement of furniture, merchandise, equipment, racks and cases. *Point-of-purchase and decoration variables* referred to for instance point-of-purchase displays, signs and cards, pictures and artwork. Examples of *human variables* were employee characteristics, customer characteristics and crowding. *External variables* included entrances, height and size of building, surrounding area, etc.

In their research on how store environment cues influence customers' store choice decision criteria, Baker et al. (2002) proposed a model in which the environmental cues were divided into three categories: design, ambient, and social variables. Except for the external variables, these categories are comprised by the same type of environmental cues as the categories of Turley & Milliman (2000).

All these individual environmental cues have been investigated on their potential influence on emotions and/or behavior (for a review see Turley & Miliman, 2000). Since environments include such an extensive variety of stimuli, Russell & Mehrabian (1976) proclaimed that it is essential to seek general variables as descriptors that grasp the main influence of the environment. Mattila & Wirtz (2001) add that consumers perceive a retail environment holistically and that their responses to physical environments depend on a combination of effects.

2.3.2 Generalized environmental variables

The previous section described why it is necessary to form general variables in studying the environment. This section presents literature that aimed at forming such general variables.

Kaplan (1987) studied the affective assessment of outdoor environments and concluded that preference for an environment can be predicted by three environmental dimensions: complexity, mystery, coherence and legibility. Coherence (e.g. order, clarity) was found to enhance positive evaluation, whereas complexity (e.g. visual richness, decoration, information rate) was found to enhance emotional arousal (Nasar, 1989).

With the M-R model, Mehrabian & Russel (1974) proposed a general measure to characterize the environment: *information rate*. Information rate is defined as the degree of perceived complexity and novelty. Complexity implies the number of elements and changes in an environment. Novelty refers to the unfamiliar, the unexpected and the surprising. More novel and complex environments possess a higher information rate.

The information rate scale of Mehrabian & Russel (1974) was based on Berlyne (1971), who initiated using complexity as a discriminative quality in a series of studies in which complexity was manipulated in drawings, ornamentation and scribbles. Later Berlyne's ideas were used by other scholars (e.g. Mehrabian & Russell, 1974), who used the term 'complexity' to characterize exteriors (Nasar, 2000).

Complexity refers to visual richness, ornamentation, information rate, diversity and variety in an environment (Nasar, 2000). Berlyne (1971) investigated the impact of complexity on interest and preference. He found a linear relationship between complexity and interest and a curvilinear (inverted U) relationship between complexity and preference, meaning that moderate levels of complexity were mostly preferred. Environmental studies have confirmed these relationships to pleasure (preference) and arousal (interest) (Ulrich, 1983; Nasar, 2000).

Another important environmental dimensions is order (Berlyne, 1971), which is related to the extent of coherence, legibility, organization, and clarity of an environment (Nasar, 2000). In studies of urban environment (as summarized by Nasar, 1997) order has been shown to have a positive impact on pleasantness and a negative impact on arousal.

Gilboa & Rafaeli (2003) studied the effects of *complexity* and *order* in a retail environment. Their study investigated the relation between 'complexity and order' and the three emotion dimensions (Pleasure, Arousal and Dominance) mediating approach-avoidance behaviors. Thereto participants were asked to rate pictures of retail environments on their degree of complexity and order, emotions, and approach-avoidance tendencies. The results showed that the relationships between complexity and order and reported pleasantness and arousal were consistent with the findings (of the earlier mentioned studies) regarding external environments. As expected, *Order* of the store environment had a positive effect on pleasantness and a negative effect on arousal. *Complexity* was found to have a negative effect on arousal. However the inverted 'U' relationship with pleasantness could not be shown. Nonetheless, the three emotional dimensions mediated an inverted 'U' relationship between *complexity* and intended approach behavior. *Order* had a positive correlation with intended approach behavior.

2.4. Lighting

Lighting is one of the many environmental cues that can have an effect on emotions and perceived atmosphere (Knezz, 1995; Van Erp, 2008). This section first explains of what attributes retail lighting systems commonly are comprised. Secondly, it presents an overview of other studies involving effects of lighting on emotions and perceived atmosphere.

2.4.1 Lighting Attributes

This paragraph provides an overview of the lighting attributes *brightness, contrast, color temperature, color rendering, glare & sparkle*, and *modeling*. Most retail lighting systems can be described in terms of these lighting attributes. Other attributes, such as *daylight* and *dynamic lighting* are hardly used in present retail settings, hence are not relevant for the present study and therefore not involved in this overview.

Brightness

Brightness is the subjective amount of light a source appears to emit. The objective amount of emitted light can be expressed in terms of illuminance and luminance (see Figure 2.1 on the next page). Illuminance is defined as the amount of light that falls on a given surface, expressed in lux. Luminance is defined as the amount of light emitted by a surface in a given direction, expressed in candelas per square meter.

Some examples of typical illuminance levels are displayed in Figure 2.2. Stevens (1961) was the first who was able to show a consistent relationship between luminance and brightness impression.

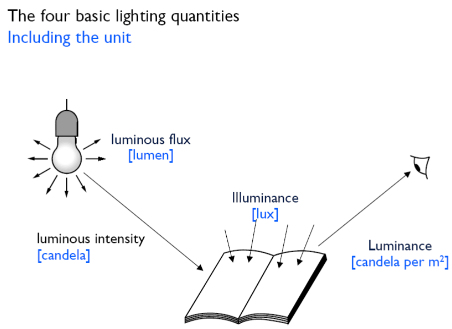


Figure 2.1. Lighting quantities

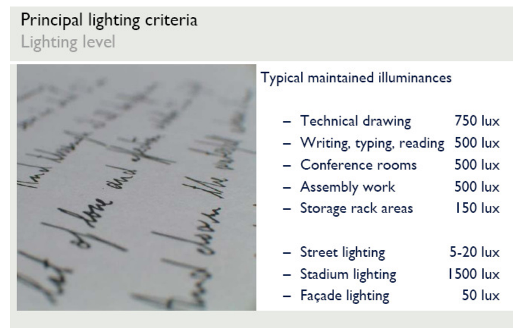


Figure 2.2. Typical illuminance levels

However, the subjective brightness is not only affected by the luminance, but also by the spatial distribution of the luminance (Tiller & Veitch, 1995; Loe, Mansfield & Rowlands, 1994). Tiller & Veitch (1995) described an experiment wherein they found that a room with a non-uniform luminance distribution required less illuminance to match the subjective brightness impression of a room with a uniform luminance distribution. In other words, keeping illumination values equal, a non-uniformly illuminated room is perceived brighter than a uniformly illuminated room. Loe et al. (1994) studied the impact of 18 different light distribution settings on perceived room brightness in a conference room. They concluded that brightness perception was not only determined by the luminances present, but also by the location of those luminances.

Research has shown that higher brightness levels attract the attention of people, which is called 'phototropism' (Hopkinson & Longmore, 1959). In retail settings this is frequently used by applying high brightness levels on a particular area of a shop to make sure that section receives extra attention. Often this area is located in the back of the shop to lead customers along as many products as possible.

Contrast

Contrast quantifies the visibility of a target relative to its immediate background. A higher contrast makes it easier to detect the target. In other words contrast is the difference in brightness of an object that makes that object distinguishable from other objects. Two different definitions of contrast are Michelson contrast: $C = \frac{L\max - L\min}{L\max + L\min}$ (with Lmax and Lmin the maximum and minimum luminance, respectively) and Weber contrast: $C = \frac{L - Lb}{Lb}$ (with L and Lb the luminance of the concerned object and the background, respectively).

Color Temperature

The color of the light emitted by a light source can be characterized by the color temperature (CT) or the correlated color temperature (CCT). This measure is based on the fact that a black body's spectral emission is defined by Planck's radiation law. Consequently, the chromaticity coordinates of a black body are a function of its temperature. Figure 2.3 displays a section of the CIE 1931 chromaticity diagram with the Planckian locus shown. The black body locus is the curved line joining the chromaticity coordinates of a black body at different temperatures. When the chromaticity coordinates of a light source lie exactly on the locus, the emitted color of that light source can be expressed by the (color) temperature of a black body having the same chromaticity coordinates.

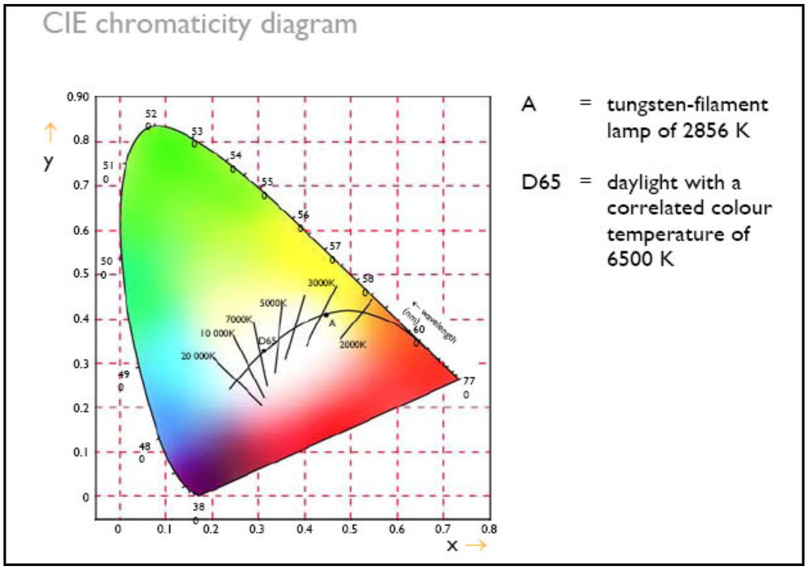


Figure 2.3. Chromaticity diagram with black body locus

The lines running across the locus are iso-temperature lines. All colors on an iso-temperature line have the same correlated color temperature. This means that for light sources that have chromaticity coordinates that lie close to, but not exactly on the locus, their color appearance is quantified as the CCT, i.e. the temperature of the iso-temperature line closest to the chromaticity coordinates of the light source. CT and CCT are usually given in Kelvin [K]. Low temperature light sources, such as an incandescent lamp, will have a yellowish color appearance, which is described as 'warm'(e.g. 2700 K), while high temperature light sources, such as some types of fluorescent lamps, will have a bluish appearance, which is described as 'cool' (e.g. 6300 K and higher).

Color rendering

The color rendering index (CRI) is a quantitative measure that represents the ability of a light source to render a set of standard test colors compared to the rendering under a reference light source with the same CCT. A score of 100 indicates perfect agreement. A light source with a CRI above 80 will tend to produce more saturated colors and greater brightness perception and a light source with a CRI below 60 will create an unattractive rendering of skin tones and a non-white color appearance of the lighting.

Glare & Sparkle

Glare refers to having difficulty seeing caused by bright light. Vos (1999) suggested eight different types of glare, most of them occurring outside, thus evidently not in a retail fashion setting. However, two of these types, disability glare and discomfort glare, can be expected inside shops. Disability glare to some extent disables the visual system. This type of glare can be divided in glare caused by point sources (e.g. facing an oncoming vehicle on the road at night) or large area sources (e.g. a bright sky visible through a window). According to Boyce (2003) discomfort glare is not well understood, but the term is used when people complain about visual discomfort caused by bright light sources, luminaries, or windows. Glare used in a positive, (just) acceptable way, is called sparkle.

Modeling

Modeling is the name for the phenomenon of light revealing the three dimensional form of a subject. Modeling is frequently related to the amount of three-dimensional information of a human face that is revealed by the lighting. Figure 2.4 on the left shows a lighting situation with a lot of modeling, whereas on the right side a lighting situation is shown with almost no modeling.

A lot of modeling *No modeling*

Figure 2.4 Modeling effect

2.4.2 Effects of lighting on emotion and atmosphere

This section presents former research involving lighting. First is explained how other researchers quantified lighting conditions and how different lighting attributes affect people's impressions. Additionally, literature involving effects of lighting on emotion and atmosphere is discussed.

Quantifying lighting conditions and effect of lighting on impression.

Flynn, Hendrick, Spencer & Martyniuk (1973) were one of the first researchers who studied lighting effects using a real interior. They used the context of a conference room and asked 50 participants to rate six different lighting conditions by means of 34 semantic differential (SD) scales. Factor analysis revealed five independent dimensions on which the impressions of the room under the six lighting conditions were based. The five dimensions were identified as perceptual clarity (e.g. clear – hazy), evaluative (e.g. pleasant – unpleasant), spaciousness (e.g. large – small), spatial complexity (e.g. simple – complex), formality (e.g. rounded – angular). However, additional examination of the results revealed that only three dimensions showed much separation between the different lighting conditions. These three were the evaluative impression, perceptual clarity impression, and spaciousness impression dimensions.

In addition, Flynn et al. (1973) asked another 46 participants to rate the difference between each of the (same) six lighting conditions. Multi-dimensional scaling (MDS) was used to reveal three dimensions that accounted for the variance in the data. These three dimensions were identified as: bright/dim, uniform/non-uniform, and overhead/peripheral.

Additional analysis made Flynn et al. (1973) conclude that evaluative dimensions was correlated with the overhead/peripheral MDS dimension, that the perceptual clarity dimension correlated with the bright/dim MDS dimension and that the spaciousness dimension was correlated with the uniform/non-uniform MDS dimension.

This research, together with several follow-up studies, summarized by Flynn (1992), suggest that in the North American society and culture, there are at least six broad categories of human impression that can be influenced (cued) or modified by the lighting design: perceptual clarity, spaciousness, relaxation and tension, public versus private space, pleasantness, spatial complexity (sometimes liveliness). Furthermore that lighting systems can be subjectively categorized by three major modes of lighting, being bright – dim, overhead – peripheral, and uniform – non-uniform.

After relating the lighting modes to the impression dimensions, Flynn (1992) suggested several design guidelines: Firstly, if an impression of *perceptual clarity* is desired, the designer has to stress ‘bright’ and ‘peripheral’ lighting. Secondly, an impression of *spaciousness* (i.e. large) is achieved when stressing ‘uniform’ and ‘peripheral’ lighting. Furthermore, when impressions of *pleasantness* and *relaxation* are of concern, the designer has to stress ‘peripheral’ and ‘non-uniform’ lighting. And lastly, to establish a ‘private’ impression, the designer has to stress ‘non-uniform’ and ‘dimmed’ lighting.

Hawkes, Loe & Rowlands (1979) conducted a similar study as Flynn (1973) and evaluated 18 lighting conditions provided in a small rectangular window-less office. Factor analysis revealed two (instead of three with Flynn) independent dimensions, which were identified as brightness (e.g. bright – dim scale strongly related) and interest (e.g. interesting – uninteresting scale strongly related). Additional analysis showed that brightness was clearly related to the amount of light in the room and that interest was related to the uniformity of the light in the room.

The sample sizes used by Flynn et al (1973) and Hawkes et al. (1979) both were too small for a robust factor analysis. Veitch & Newham (1998) tackled this problem and asked 292 participants to rate the appearance of an open-plan office lit by one of nine different lighting installations, using 27 SD scales. Factor analysis revealed three dimensions, which could be identified as brightness, visual attraction, and complexity.

Flynn, Spencer, Martynikuk & Hendrick (1975) demonstrated the consistency of the lighting-cue effects by evaluating five different lighting installations in three different sized rooms, and additionally also with different contexts. The results suggested that lighting provides a number of cues that people use to interpret a space and that these cues are at least partly independent of the room that is being experienced (Flynn, 1977).

Houser, Tiller, Bernecker & Mistrick (2002) investigated human subjective responses to eleven different lighting conditions, varying in direct/indirect lighting ratio. Rea (1982) and Tiller & Rea (1992) concluded that SD scales may be used inconsistently if they are not clearly defined. To counter that problem, Houser et al. (2002) explicitly associated each scale with an attribute of the visual environment. The subjective categories of impression that were evaluated by Houser et al. were ‘subjective brightness of the room’, ‘preferred modeling of objects’, ‘perception of visual comfort’, ‘perceived uniformity of the light distribution’, ‘impressions of spaciousness’, ‘overall preference’. The scales for measuring the subjective brightness and the perceived uniformity of the room lighting, five scales were included: ceiling, desktop, walls, floor, and room overall. Important findings included that 1) the walls and ceiling contributed to the perception of overall brightness when the work plane illuminance was held constant, 2) the room appeared more spacious when more light was supplied indirectly, and 3) light settings where the indirect component had a horizontal illuminance contribution of 60% or more were favored.

Effect of lighting on emotions and perceived atmosphere

Until now not much is known about the effects of retail lighting on perceived atmosphere. However, few studies have investigated the effects of lighting on atmosphere perception in laboratory settings. Furthermore, a number of studies are conducted to investigate topics that are strongly related to perceived atmosphere. First, some examples of such literature are discussed. Secondly, perceived atmosphere related research is presented.

Knez (1995) investigated the effects of indoor lighting and used Watson et al.'s (1988) PANAS scales to measure emotions, whereas the room light evaluations of the participants were assessed by means of seven unipolar adjectives: glaring, dim, soft, bright, warm, intense, and cool. No significant results were found regarding positive mood. Nonetheless, for negative mood a significant interaction between color temperature and gender was obtained. Males' negative mood increased dramatically in the 'warm' compared to the 'cool' condition. Females' negative mood, on the contrary, decreased in the 'warm' and increased in the 'cool' white light condition. Knez (1995) found no significant effects of illuminance on affect, which was reinforced by the findings of Hygge and Knez (2001).

Fleisher, Krueger & Schierz (2001) investigated the effect of intensity, color temperature and direct/indirect lighting ratio on emotions. The PAD instrument of (Mehrabian & Russell, 1974) was used for evaluating participants' emotions. A high intensity, compared to a low intensity, was found more pleasant. High color temperature lighting ('cool' white light) was found more arousing compared to low color temperature lighting ('warm' white light). Furthermore, Fleisher et al. (2001) demonstrated that high illuminance levels in combination with an indirect component of 50% lead to a feeling of dominance. On the other hand, lower illuminance levels, especially with direct light, lead to a feeling of weakness.

De Vries & Vogels (2007) confirmed the ability of Vogels' (2008) atmosphere questionnaire to distinguish between different lighting settings. However, lighting settings were not systematically varied; hence no conclusions could be drawn about effects of particular lighting attributes on perceived atmosphere.

To date the only study that related different lighting attributes to atmosphere perception is Van Erp (2008). In an empty experimental room, the effect of intensity (low vs. high), color temperature (cool vs. warm) and spatial distribution (diffuse vs. directional) on perceived atmosphere was determined. The perceived atmosphere was measured by means of Vogels' (2008) atmosphere questionnaire. Van Erp (2008) demonstrated that atmosphere can be expressed in terms of the four dimensions *coziness*, *liveliness*, *tenseness* and *detachment*. Furthermore, several significant effects of different lighting attributes on atmosphere perception were found. Compared to a low intensity, a high intensity was found less *cozy*, less *tense*, more *lively* and more *detached*. Additionally they found that compared to diffuse lighting, directional lighting was perceived as more *cozy*, more *lively* and less *tense*.

3. Construction of the context variables

To control perceived atmosphere for potential context effects, this context had to be evaluated and quantified. In this sense 'context' refers to the environmental characteristics of retail environments. Turley & Miliman (2000) counted the environmental cues that have the potency to influence customers' emotions and behavior and reached 57. Except for the external variables, Baker et al (2002) grouped these environmental cues into three categories: design, ambient, and social cues. The present study focuses on the design variables and on one ambient variable: lighting. The other ambient variables (e.g. odor and music) are not included because of feasibility reasons. Social cues (e.g. crowdedness) were not measured for the same reasons. However, a large impact of social cues was not expected, as this research was conducted at times that very few customers were present. With the social and ambient variables excluded, still 33 environmental cues remain (Turley & Miliman, 2000).

To investigate the main influence of the environment, it is essential to seek general variables (Russell & Mehrabian, 1976). Order and complexity are important general variables for evaluating external environments (Ulrich, 1983; Nasar, 1997; Nasar, 2000). Gilboa & Rafaeli (2003) evaluated retail environments using pictures that had to be rated on five point scales for their degree on order and complexity.

However, as the general variables 'complexity' and 'order' were found in urban and natural environments, and this study focuses on retail environments, the present study used a method that made it possible for participants to suggest also other environmental characteristics, which were found important while shopping.

In order to assess and quantify these (general) interior qualities a card-sorting experiment (e.g. Akerelrea & Zimmerman, 2002; Kuniavsky, 2003; Maurer & Warfel, 2004) was designed and conducted. Card-sorting is a task that involves sorting a deck of cards into groups that make sense to the participants. By sorting the cards in categories that are meaningful to them, participants provide insights into their mental models and into how they judge and group certain content. In the present study the cards represented pictures of the shops. Participants were asked to come up with an interior quality, which could be used as a base for sorting the pictures into five groups according to their applicability to that particular quality (e.g. legible). The exact procedure is further explained in the upcoming paragraphs. After the method of the experiment, the obtained results are presented and discussed. The experiment resulted in a two-dimensional context score for each shop, which was used in chapter 6 to control the atmosphere perception for context effects.

3.1. Method

This section presents the method of the card-sorting experiment that was used to assess and quantify the context variables of the shops. Participants, settings and materials, procedure and measurement are presented in this order.

3.1.1 Participants

Twenty participants were recruited from a participant database made available by the Eindhoven Technical University. All of them were native Dutch, ten male and ten female, all living in or near Eindhoven (NL) and ranging in age between 19 and 44, with an average of 28 years. The participants were (formerly) enrolled in Vocational Educations (3 participants), University of Professional Education (4 participants) and University of Science (13 participants) studies. None of the participants had disabled eye vision or was involved in lighting- or shop design. The maximum number of shops that seemed familiar to a participant was four.

3.1.2 Settings & materials

To conduct the present study, cooperation of retail shop owners was a prerequisite. 77 Shops were selected, which were all located in the city centre of Eindhoven. As the lighting variables and the atmosphere variables were rated by participants visiting the shops and filling in questionnaires, to keep the present study feasible, the selected shops were all located within a radius of 200 meters. To get their permission, all 77 shops owners were approached, of which 57 were willing to cooperate.

Pictures of all the shops were used to perform the card-sorting experiment. To validly relate the context variables to the lighting and atmosphere variables, all three assessments had to be made from the same position in the shop with the same gaze direction. Since the lighting and atmosphere variables were measured using questionnaires to be filled in by participants really present at the shops, the pictures had to be taken at a position wherefrom it would be possible for participants to fill in the questionnaires. Additionally, standing at this position the participants should not cause any inconvenience for costumers or employees. A position as close to the entrance as possible was chosen to prevent the participants from perceiving different lighting or atmosphere settings while walking to the designated position. Last requirement was that daylight would not interfere with the shop lighting.

For most of the shops two pictures were needed to sufficiently represent the sight that people would have when really standing in the shops. However, for 14 of the 57 shops one picture was enough to cover the whole sight. Every single picture was printed on A5 thick photo paper resulting in a set of 100 cards with on each a picture of the interior of one of the shops. Although Dearholt et al. (1986) describe a card-sorting experiment using 219 cards, a pilot study showed that the card-sorting task was hard to perform using a set as large as 100 cards. The same pilot showed that of the 43 shops, which initially needed two cards to be included in the set, both pictures of thirteen shops kept ending up into the same pile, indicating that those pictures presented the same interior qualities. Hence another thirteen shops only needed one card, leading to a set containing 87 cards with pictures of 57 different shops.

3.1.3 Procedure

There is still debate on the required number of participants for a card sorting task in the literature. However, most of the time a number between fifteen (Maurer & Warfel, 2004) and twenty (Hahsler & Simon, 2001) is sufficient. In the present study twenty participants performed the experiment individually to assure independence of grouping strategies (Kidwell & Martin, 2001). The experiment was performed at the Eindhoven University of Technology. After entering the room, the participants were asked to sit down in front of a table and were provided with the set of 87 cards (arranged randomly). The participants received a short briefing about the procedure and were asked to go trough the set of cards to get familiar with the content. Then they were asked to think of a discriminating quality they felt could serve as a base for sorting the shops. It was emphasized that the decision of what quality to choose was totally free as long as this quality was related to the content of the card. For instance print quality was not allowed as a discriminating quality. Another remark was that during the whole experiment it was allowed to change cards to different piles and that there was no right or wrong division. Final remark was that the task did not imply that pictures of the same shop had to end up in the same pile.

After deciding what quality they would use, the participants sorted the pictures into five piles, ranging from *quality is not applicable* to *neutral* to *quality is applicable*. Although a division over five piles was desired, the participants were asked to first create three piles, each pile referring to one of the three conditions *quality is not applicable*, *neutral* or *quality is applicable*. After three piles were created, participants were asked to divide the neutral pile again in three piles, each representing *quality less applicable*, *neutral* or *quality more applicable*. This procedure was followed because the 'neutral' category often was significantly bigger than the extremes.
After the participants had finished the task they could take a short break. Then the procedure was repeated, only this time with another quality. The experiment stopped after 60 minutes. Participants received a credit note worth 10 Euros for their time. The results of the card sorting task were analyzed using data-analysis tool SPSS 16.0.

3.1.4 Measurements

Together, the twenty participants produced 59 divisions with accompanying discriminating qualities. After each sorting session each card was scored according to its categorization, ranging from '1' for the *quality not applicable* pile to '5' for the *quality applicable* pile. Additionally the participant was questioned to explain the connection between each quality and the specific underlying elements of the picture leading to the particular classification (e.g. color organized products make the shop having a clear overview). This would help the researcher interpreting the name of the chosen quality.

3.2. Results

This paragraph presents the results obtained with the card-sorting experiment. According to the categorization the cards received a score ranging from one to five. The scores resulted in a table with in every row one of the 87 cards and the columns representing the 59 qualities.

To make the data more comprehensible and better interpretable, a Multiple Correspondence Analysis (MCA) was performed. MCA (e.g. Abdi & Valentin, 2007; Greenacre & Blasius, 1994, 2006) is an exploratory technique that reduces the data into a lower dimensional representation. It is an extension of Correspondence Analysis (CA), with the difference that MCA is used when the relation between more than two categorical variables is of interest. MCA can also be compared to Principal Component Analysis (PCA), only with the difference that MCA is used for categorical data.

The scoring data, consisting of 59 card divisions, was made intelligible by MCA. By means of this analysis the data was transformed into a data set that describes all the cards on two general dimensions. These two dimensions explained 50% of the total variance of the data. The graphical output of the MCA is displayed in Figure 3.1 and is explained in the following paragraphs.

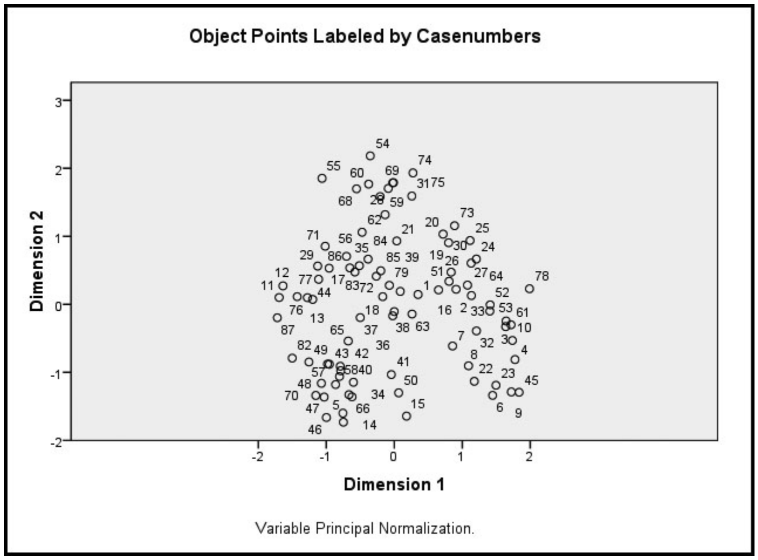


Figure 3.1. Graphical Output of MCA

Dimension 1

The first dimension accounted for 31% of the variance and is presented on the horizontal axes in figure 3.1. The discrimination measures (Appendix B) of the qualities show which qualities had most impact in determining the orientation of the dimension. Qualities with a high discrimination measure on a particular dimension are well described by that dimension. The discrimination measures indicate that dimension one is related to the extent of how much the cards present a view that is *legible, orderly, expensive* and *traditional*. This means that the more a card scores positive on dimension one, the more the card is judged as giving the impression of being orderly, expensive and traditional. On the other hand this implies that the more a card scores negative on dimension one, the more the card is judged as giving the impression of being chaotic, cheap and trendy.

Dimension 2

The second dimension accounted for 19% and is presented on the vertical axis in figure 3.1. The discrimination measures (Appendix B) indicate that this dimension is related to the extent of how much the cards present a view that is *warm*, *old-fashioned* and *cozy*. This means that the more a card scores positive on dimension two, the more the card is judged as giving the impression of being warm, old-fashioned and cozy. Again on the other hand this implies that the more a card scores negative on dimension two, the more the card is judged as giving the impression of being cold, modern and uncomfortable.

The correlation between the two context variables was determined by calculating Cronbach's Alpha between the sores of the shops for each of the two variables (see Table 3.1).

Table 3.1 Correlations between context dimensions (Cronbach's Alpha's)

Inter-dimensional correlation matrix		
	Legibility	Warm
Legibility	1.000	-.006
Warm		1.000

Scores

By means of the MCA the scores of the cards were represented by a two-dimensional score. This means that each card involved in the card-sorting experiment received a score on the two abovementioned dimensions that corresponds with the location of the card-number in Figure 3.1. The cards with pictures of the same shop were averaged to determine scores for each of the shops. Both card scores and shop scores can be found in Appendix C.

3.3. Discussion

A card-sorting experiment was performed to assess and quantify the interior qualities of the shops. A wide variety of interior qualities was used to sort the pictures and provide each picture with a score. This resulted in an extensive and complex data set that consisted of 59 card divisions, based on a wide variety of interior qualities. By means of a multiple correspondence analysis, this unpractical data set was transformed into a more feasible dataset. This analysis revealed two underlying dimensions, which together explained 50% of the variance of the data. After that, instead of using 59 dimensions, the interior qualities could be represented by just two dimensions, which were identified as ‘legibility’ and ‘warm’. This reduction made it possible to investigate the effects of the context variables on perceived atmosphere (Chapter 6). The relation of these findings with other literature is discussed in Chapter 7.

4. Construction of the lighting variables

The main goal of the present study is to demonstrate a significant contribution of retail lighting to the perceived atmosphere, if controlled for context effects. To do this, context, lighting, and perceived atmosphere had to be quantified. The previous chapter described quantifying the context variables. This chapter will explain how the lighting attributes were quantified.

Research has found different lighting attributes to be important when evaluating a lighting setting. Flynn (1973, 1979) found the three dimensions brightness, uniformity and overhead/peripheral ratio, whereas Hawkes et al. (2002) found only brightness and uniformity. Knez (1995) investigated the effect of color temperature, which was measured by rating the setting for a ‘cool’ or ‘warm’ impression. Houser et al. (2002) suggested a measure in which the lighting attributes brightness, uniformity, modeling and glare were quantified using a seven point scale. Furthermore, Houser et al. suggested that to prevent ambiguity brightness and uniformity of the ceiling, walls, floor, the desktop, and overall room had to be rated separately.

A lighting questionnaire was developed in conjunction with lighting experts of Philips Lighting. The development of the questionnaire is presented in paragraph 4.1.4, after which the procedure is explained for conducting the questionnaire. Then paragraph 4.2 presents the results and how these results were analyzed and transformed into data that made it possible to investigate the effect of the lighting variables on perceived atmosphere as explained in Chapter 6.

4.1. Method

This section explains the way the lighting variables are quantified. The first part explains why a subjective method was preferred over objective metrics. Thereafter the participants, settings and materials are described. As there was no ready to use questionnaire available, one had to be developed for this study. The process of development is explained in the paragraph ‘measurements’. Lastly, the procedure of measuring the lighting attributes is explained.

4.1.1 Subjective vs. objective measurements

To measure the lighting attributes present at the shops a lighting attributes questionnaire was developed. There are numerous metrics available to characterize 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 (Boyce, 2003). Adaptation is one of those problems. People unconsciously adapt to the brightness and even to the colors of an environment (Boyce, 2003). Brightness adaption helps humans to see in highly illuminated situations (e.g. bright daylight) and very low illuminated situations (e.g. moonlight). Chromatic adaption means that the human visual system (again unconsciously) adapts to the most present color and, in the absence of clues to the contrary, tends to perceive that color as white.

Above mentioned problems imply that measuring the lighting characteristics using objective metrics could lead to discrepancies between the objective and the subjective realities. Another important reason for choosing a subjective measurement was the feasibility of objective measurements. Some of the lighting attributes are really hard to measure using objective measurements. So instead of measuring the lighting characteristics by means of technical equipment, an expert observation based method, to be specific a questionnaire that had to filled in by lighting questionnaires, was chosen. As participants, experts were preferred over 'normal people', because people without a background in lighting normally are not able to classify retail shop lighting. They are not intimately familiar with the constraints, jargon and established frame of relevance to assess retail lighting systems. This was the reason for developing a questionnaire with lighting experts forming the target group. These experts were lighting designers employed at the Lighting Design and Application Center (LiDAC) of Philips Lighting.

4.1.2 Participants

Seven lighting experts of the LiDAC (Lighting Design and Application Center) and GOAL (Global Application Lighting) departments of Philips Lighting participated in the lighting questionnaire. All experts were higher educated (bachelor or master's degree), two were Italian and five were Dutch. Two were female and five male. Their ages ranged between 29 and 58, with an average of 46.

4.1.3 Setting and materials

The experts rated all the shops, which were identical to the set used in the entire study. The pictures obtained from the context experiment were used to make sure the experts filled in the questionnaires from the same position and with the same gaze direction as participants rating the context and atmosphere variables.

4.1.4 Measurements

Three lighting experts were involved in the development of the lighting questionnaire. They listed relevant lighting attributes and suggested possible ways in which these attributes could be rated. Next to the established lighting attributes brightness, contrast (i.e. uniformity), color temperature, glare & sparkle, and modeling, the experts suggested other lighting attributes to include in the questionnaire. These being four items to assess the relative contribution of the different types of lighting (general, accent, architectural, decorative) and four items to evaluate the lighting installation. These characteristics were included because they were expected to have a potential impact of the impression of the lighting setting. What is precisely meant with the terms 'type of lighting' and 'lighting installation' is explained in the following paragraphs. Color rendering was found too difficult to indicate and hence was not included in the questionnaire. The experts reviewed subsequent versions of the scales, which led to the lighting attributes questionnaire that can be found in Appendix D.

Type of lighting

Lighting specialist tend to think in terms of four types of lighting: general lighting, accent lighting, architectural lighting and decorative lighting. Within the Philips organization definitions for these different types of lighting are:

- General lighting provides the required horizontal illuminance over the total area with a certain degree of uniformity.
- Accent lighting is directional lighting to emphasize a particular object or to draw attention to a part of the field of view.
- Architectural lighting is lighting to form or underline the architecture of the space. It has a close correlation with the architecture of the interior, which it seeks to draw attention to in one way or another.
- Decorative lighting refers to attractive luminaires or lamps to provide a point of interest or an attractive feature in an interior. Here it is the light itself that provides the interest, and not the illuminated object.

The experts were asked to estimate the contribution of each type of lighting in percentages, implying that the scores together had to add up to 100%.

The items concerning brightness, color temperature, glare, sparkle, modeling, contrast and the lighting installation all had to be rated relative to an average shop lighting situation.

Brightness

In line with Houser et al. (2002) the brightness rating was separated for the different environmental elements ceiling (C), sidewalls (S), back wall (B), horizontal products (H; e.g. products laid out on tables), floor (F) and overall room. This division is illustrated in Figure 4.1. The separation of the back and side walls is done to account for the fact that the back wall is often provided with a higher illumination to attract people towards that position.

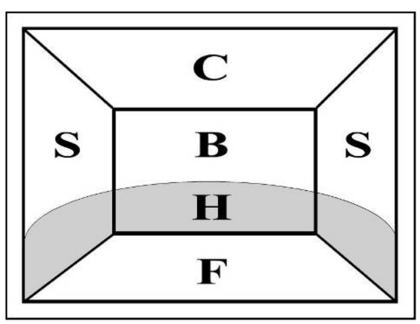


Figure 4.1 Space division

The measure consisted of two scales. First the experts were asked to rate the position of the highest brightness by simply marking the matching letter (e.g. B, S, etc.). Secondly the brightness of the individual elements and the total space relative to an average shop had to be rated on a seven-point scale, ranging from *low brightness impression* to *high brightness impression*.

Color Temperature

The third section of the questionnaire probed color temperature of the light and of the space illuminated by that light, using a seven-point scale, ranging from *low color temperature* to *high color temperature.*

Glare, sparkle and modeling

The following section probed glare, sparkle and modeling. For each one item was included that had to be scored on a seven-point scale ranging from *no glare* to *a lot of glare*, from *dull* to *sparkly* and from *little modeling* to *a lot of modeling*, respectively.

Contrast

In line with Houser et al. (2002), the contrast rating was separated for the different environmental elements ceiling (C), sidewalls (S), back wall (B), horizontal products (H; e.g. products laid out on tables), floor (F) and overall room. Furthermore, contrast items were divided into two sub concepts, luminance changes and luminance contrast ratio. 'Luminance changes' refers to the number of changes from high brightness to low brightness. 'Luminance contrast ratio' refers to the ratio between the high brightness and the low brightness, which often is defined as: $C = \frac{L\max - L\min}{L\max + L\min}$.

Because a seven-point scale was found too large and was expected to cause confusion, a five-point scale was chosen. The 'luminance changes' scale ranged from *a few* to *many*, while the 'luminance ratio' scale ranged from *just noticeable difference* to *theatrical* to *dramatic*. Because the experts thought this still could be slightly ambiguous, illustrations (Figure 4.2) were added to the contrast items of the questionnaire.

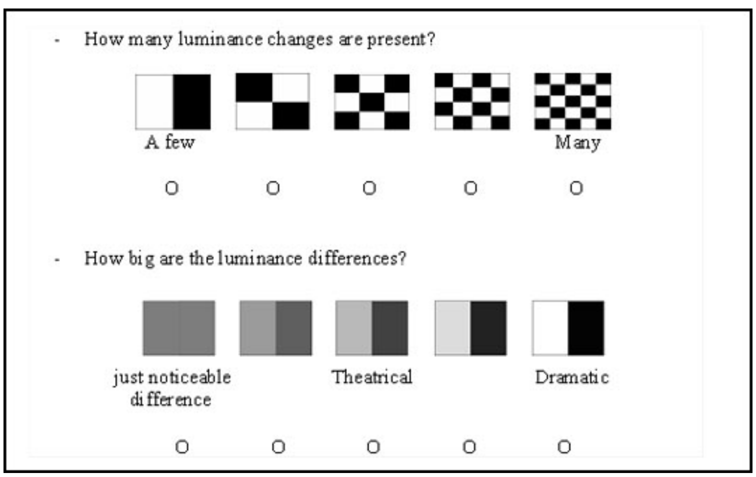


Figure 4.2. Illustrations used with contrast scales

The lighting installation

The final section of the lighting attributes questionnaire probed items related to the lighting installation. The four items had to be rated on a seven-point scale, ranging from *inconspicuous* to *conspicuous*, from *no pattern* to *structured pattern*, from *few different lighting fittings* to *many different lighting fittings* and *from few lighting fittings* to *many lighting fittings*.

4.1.5 Procedure

Seven experts visited all 57 shops and rated the lighting attributes present employing the questionnaire described above. Before visiting the shops the experts received a short briefing in which they were asked to read through the questionnaire to check if everything was clear. Furthermore it was requested not to communicate with each other regarding lighting during the whole experiment.

The surveys were performed on Tuesdays, Wednesdays, Thursdays and Fridays from 10.00 AM (opening time) till 12.30 PM, because in the afternoon the shops tend to be a lot busier. As visiting all the shops would take around five hours, the tour was divided in two sessions of two and a half hours. The first morning the experts were guided round the first 29 shops, the second morning round the remaining 28. In every shop the experts were asked to stand on a designated location and to look in a designated direction. The guide also prevented the experts from being distracted by curious employees and customers.

To control for learning and tiring effects, three experts completed the list of shops forwards, while four experts did the same backwards. At most three experts were involved in the same session to prevent large deviations between their standing positions and thereby discrepancies in their visual inputs. The visits were performed in three successive weeks to prevent the shops from changing between the different visits. To control for these changes pictures were used as reference material and shop owners were asked to report any changes. The results of the lighting attributes questionnaire were analyzed using data-analysis tool SPSS 16.0.

4.2. Results

Shop number 18 was excluded from the data because, for an unknown reason, it closed down during the experiment. Shop number 50 was excluded because the shop owner changed the color of the ceiling from black to white, giving the shop a much brighter appearance. Except for the item about the positioning of the highest brightness, which was a categorical variable, all data were converted to a five point scale. The resulting datasheet had a row for each shop and a column for each rating of each expert.

4.1.6 Inter-rater reliability

An inter-rater reliability analysis was performed to determine the level of agreement among the experts. This was done by determining Cronbach's Alpha between experts' scores for each individual item. Table 4.1 shows the results per item of the lighting attributes questionnaire, ranging from .635 to .940, with an average of .804.

Table 4.1. Inter-rater reliabilities

Item	Cronbach's Alpha
General Lighting	,940
Accent Lighting	,942
Decorative Lighting	,805
Architectural Lighting	,933
Brightness Backwall	,870
Brightness Ceiling	,820
Brightness Floor	,819
Brightness Hor. Products	,823
Brightness Side walls	,892
Brightness Total	,915
Color Temperature Light	,759
Color Temperature Total space	,813
Glare	,889
Sparkle	,822
Modeling	,865
Lum changes Backwall	,691
Lum ratio Backwall	,789
Lum changes Ceiling	,677
Lum ratio Ceiling	,635
Lum changes Floor	,638
Lum ratio Floor	,765
Lum changes Hor. Products	,719
Lum ratio Hor. Products	,825
Lum changes Side Walls	,775
Lum ratio Side Walls	,816
Lum changes Total	,773
Lum ratio total	,766
Conspicuous	,628
Pattern	,778
Different fittings	,841
Amount of fittings	,906
Mean	,804

4.1.7 Principal Component Analysis

To make the data more compact and thereby suitable to relate to the atmosphere variables, a principal component analysis (PCA) was performed. By means of this PCA the extensive data was transformed into a data set consisting of a few underlying dimensions. The scores for indicating the position of the highest brightness were categorical and hence not allowed to be included in the PCA. Consequently this item was removed. To perform the PCA the data set was transformed such that every expert's rating of a shop was a case (i.e. row) and every item was a column.

In order to simplify the interpretation of the factor structure a Varimax (Kaiser) rotation was used. This is an orthogonal rotation of the data, which simplifies the factor structure and consequently makes its interpretation easier and more reliable (Abdi, 2003). What basically happens is that the data is rotated through which the axes are placed in a position in which the sum of variances of the loadings is the maximum possible. A consequence is that the number of variables that have high loadings on more than one factor is minimized. In the following paragraphs first determining the number of factors is explained. The second paragraph describes the obtained factor loadings. The third paragraph continues with explaining the interpretation of the factors. The last paragraph discusses how the scores for each of the underlying factors are determined.

Determining number of factors

There are several criteria to determine the right number of extracted factors. In Table 4.2 the eigenvalues of all the factors are displayed together with their relative explained variance, expressed in percentages. One method to determine the number of factors is to take all factors with eigenvalues higher than 1.00. As can be seen in Table 4.2 this method would suggest a solution with nine factors.

Table 4.2. Eigenvalues of the factors

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7,713	24,881	24,881	7,713	24,881	24,881	5,423	17,493	17,493
2	3,012	9,715	34,596	3,012	9,715	34,596	4,186	13,503	30,996
3	2,513	8,107	42,703	2,513	8,107	42,703	3,035	9,790	40,786
4	1,945	6,273	48,977	1,945	6,273	48,977	1,938	6,253	47,039
5	1,585	5,114	54,091	1,585	5,114	54,091	1,914	6,175	53,214
6	1,439	4,641	58,731	1,439	4,641	58,731	1,710	5,517	58,731
7	1,355	4,371	63,102						
8	1,240	4,001	67,103						
9	1,131	3,648	70,751						
10	,970	3,128	73,879						
11	,852	2,748	76,627						
12	,793	2,558	79,185						
13	,710	2,289	81,474						
14	,636	2,053	83,527						
15	,598	1,930	85,457						
16	,514	1,659	87,116						
17	,457	1,473	88,589						
18	,416	1,341	89,930						
19	,409	1,318	91,248						
20	,378	1,221	92,468						
21	,372	1,201	93,669						
22	,320	1,031	94,700						
23	,277	,892	95,592						
24	,255	,823	96,415						
25	,223	,718	97,133						
26	,207	,667	97,801						
27	,189	,609	98,410						
28	,176	,567	98,977						
29	,159	,513	99,489						
30	,156	,503	99,993						
31	,002	,007	100,000						

Extraction Method: Principal Component Analysis.

Another method is to take all the factors before 'the elbow' of the curve in the scree plot (see Figure 4.3). This method would result in a solution with four factors. A third method that is used frequently is taking all the factors that together explain 90% of the variance, which would result in a solution with eighteen factors. However, maybe the most important criterion of all is the researcher's interpretation of the factor structure.

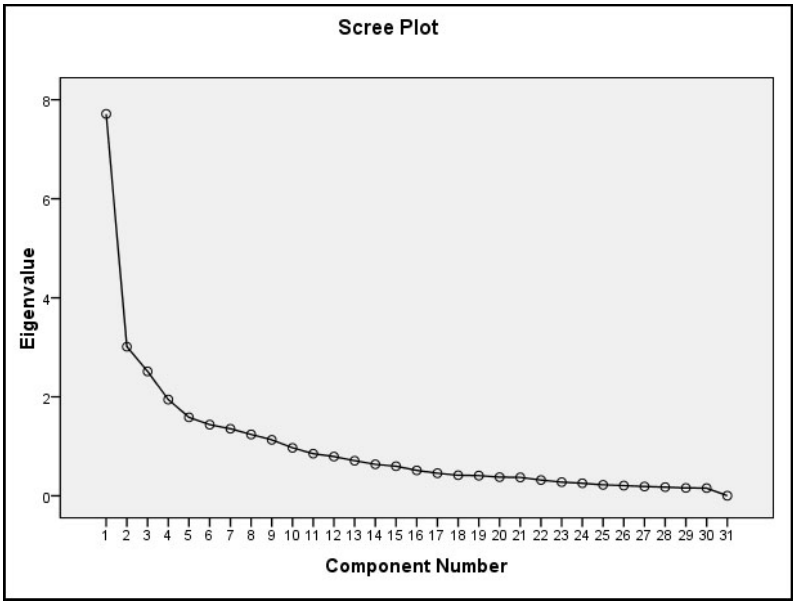


Figure 4.3. Factor/component numbers plotted against the eigenvalues

The aim of the PCA was to reduce the extensive data set into a data set consisting of a minimal number of factors containing a maximum amount of information. A solution with more than nine factors would make it too complex to relate the lighting attributes to the atmosphere perception and context qualities. And since the established methods to determine the number of factors produced the numbers four, nine and eighteen, all possible solutions having a number of factors between four and nine were explored. Hereby the distribution of the items over the different factors was observed. The six factor solution was the solution using as few factors as possible while having an item distribution that made most sense. This six factor solution was chosen to represent the lighting attributes data.

Factor loadings

The output of the factor analysis provided factor loadings for all the items. Items with a high loading on a factor contribute strongly to that particular factor. Based on the factor loadings seven items were removed from the dataset. The item for general lighting was removed because it had approximately the same factor loading as the item for accent lighting; only for general lighting the factor loading was negative. It was not possible to reverse the scores for 'general lighting', as the scores for the items concerning the different sorts of lighting are relative quantifications, indicated in percentages. Hence the scores add up to 100% and the higher the contribution of one type of lighting, the lower the contribution of the other ones. This interaction effect holds for the items 'general-' and 'accent lighting' and for the items 'architectural-' and 'decorative lighting'. General and accent lighting both function as task lighting. Hence one can imagine that in shops with a high level of general lighting, accent lighting is not very useful. On the other hand in shops with a low level of general lighting, there is need for more accent lighting to reach a sufficient lighting level. A comparable interaction effect is visible by the two items 'decorative-' and 'architectural lighting'. Hence 'architectural lighting' was removed. The item 'luminance ratio on the floor' was removed for not loading (< .350) on any of the factors. The items for color temperature, 'modeling', 'different fittings' and 'amount of fittings' were removed for loading on more than two factors. The factor loadings of the remaining 23 items are shown in Table 4.3. Loadings lower than .350 can be neglected and therefore are not shown.

Although the three items for the luminance ratio of the horizontal products, of the sidewalls, and of the total space did not load solely on factor one, it was decided that it was better for all three items to contribute to factor one. This for the fact that the loadings on factor one were higher and that the other items in factor one were contrast related as well. The same goes for the two items for the brightness of the sidewalls and of the ceiling. They were chosen to contribute to factor two, in which all the brightness items were placed. Sparkle loaded on two factors as well, but had a high loading on factor three and could better be related to 'glare' and 'accent'. This because sparkle is a type of glare, which is often caused by accent lighting.

Table 4.3. Factor loadings

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
lumChanges_S	,826					
lumChanges_total	,822					
lumChanges_B	,778					
lumChanges_H	,747					
lumRatio_H	,587		,363			
lumRatio_total	,554					,513
lumRatio_S	,553					,359
lumChanges_F	,551					
lumRatio_B	,549					
Brightness_total		,884				
Brightness_H		,722				
Brightness_F		,712				
Brightness_S		,683	,380			
Brightness_B		,655				
Brightness_C		,621		,445		
Glare			,796			
Accent			,618			
Sparkle		,420	,582			
lumChanges_C				,820		
lumRatio_C				,796		
Pattern					,763	
conspicious					,739	
Decorative						,704

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

Table 4.4. Eigenvalues of the factors after rotation and items removed

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6,580	28,608	28,608	6,580	28,608	28,608	4,590	19,958	19,958
2	2,504	10,885	39,493	2,504	10,885	39,493	3,653	15,883	35,841
3	1,845	8,020	47,513	1,845	8,020	47,513	2,177	9,467	45,308
4	1,587	6,901	54,414	1,587	6,901	54,414	1,820	7,913	53,221
5	1,400	6,085	60,499	1,400	6,085	60,499	1,448	6,295	59,516
6	1,197	5,203	65,702	1,197	5,203	65,702	1,423	6,186	65,702
7	1,029	4,474	70,176						
8	,894	3,885	74,061						
9	,766	3,331	77,392						
10	,711	3,093	80,485						
11	,616	2,680	83,165						
12	,518	2,251	85,416						
13	,489	2,125	87,541						
14	,425	1,850	89,391						
15	,402	1,749	91,140						
16	,381	1,658	92,797						
17	,363	1,579	94,376						
18	,300	1,305	95,681						
19	,249	1,081	96,762						
20	,211	,916	97,678						
21	,186	,808	98,487						
22	,182	,792	99,278						
23	,166	,722	100,000						

Extraction Method: Principal Component Analysis.

The six factor solution explained 58.7 % of the variance of the dataset. After removing the above mentioned items and repeating the PCA, the explained variance increased to 65.7 % (see Table 4.4).

Interpretation of the factors

In the following paragraphs the interpretation of the factors is explained, in the order from most important to least important.

Factor one: Contrast

Factor one was responsible for explaining 20.0 % of the variance of the data and described items that considered luminance changes and the luminance ratio of those changes in the shops. In other words factor one can be interpreted as the contrast of the lighting in the shops. Concerning contrast, all planes (back wall, floor, etc.) loaded on factor one except for the items considering the contrast of the ceiling. These items loaded higher on factor four. For each of the seven participants the reliability was determined by calculating Cronbach's Alpha's, which ranged from .585 to .888 with an average of .793.

Factor two: Brightness

Factor two explained 15.9 % of the total variance of the data set and described the shops' brightness. Every single brightness item had a high factor loading on factor two, which means that factor two can be interpreted by the brightness of the lighting in the shops. For each of the seven participants the reliability was determined by calculating Cronbach's Alpha's, which ranged from .736 to .888 with an average of .827.

Factor three: Glare & Sparkle

Factor three explained 9.5 % of the total variance of the data and can be interpreted as the factor glare & sparkle. In fact sparkle is a desired and pleasant form of glare, which often is created using accent lighting. So also these three items fit nicely together in one factor. For each of the seven participants the reliability was determined by calculating Cronbach's Alpha's, which ranged from .537 to .768 with an average of .653.

Factor four: Ceiling

As already mentioned while explaining factor one, factor four consisted of the two contrast items of the ceiling (luminance changes and luminance ratio of the ceiling). This factor explained 7.9 % of the total variance of the data. For each of the seven participants the reliability was determined by calculating Cronbach's Alpha's, which ranged from .547 to .847 with an average of .718.

Factor five: Lighting installation

Factor five describes two items related to the lighting installation: the lighting installation being patterned and the lighting installation being conspicuous. This factor explained 6.3 % of the total variance of the data. For each of the seven participants, the reliability was determined by calculating Cronbach's Alpha's, which ranged from .236 to .873 with an average of .529.

Factor six: Decorative lighting

The sixth and final factor describes only one single item, namely the item for the amount of decorative lighting, and explains 6.2 % of the total variance. Since this factor contains one item, no reliability could be determined.

4.1.8 Scores for the lighting variables

After the PCA was performed the lighting of the shops could be represented by a 6 dimensional score, i.e. six scores for the dimensions contrast, brightness, glare, ceiling, lighting installation and decorative. The score for each of the dimensions was determined by averaging the scores of the items contributing to that particular dimension or factor. For instance the score for the factor *glare* was calculated by averaging the scores for *accent lighting*, *glare* and *sparkle*. The same procedure has been applied for all six factors for all 55 shops. The table presenting the six scores for all the 55 shops can be found in Appendix E. Correlations between the six factors were determined by calculating Cronbach's Alpha's (Table 4.5).

Table 4.5 Correlations between scores on lighting factors (Cronbach's Alpha's)

Inter factor correlation matrix						
	Contrast	Brightness	Glare & Sparkle	Contrast of Ceiling	Lighting installation	Decorative lighting
Contrast	1.000	.402	.620	-.056	-.092	.089
Brightness		1.000	.399	.165	.206	-.198
Glare & Sparkle			1.000	-.051	.041	.047
Contrast of ceiling				1.000	.202	-.111
Lighting installation					1.000	.043
Decorative lighting	.					1.000

4.3. Discussion

The goal of the lighting attributes questionnaire was to quantify the lighting attributes of the shops, in order to make it possible to relate the lighting to the perceived atmosphere. In each shop seven lighting experts rated 31 items concerning the lighting attributes. The inter-rater reliability analysis for scoring these items provided Cronbach's Alpha's ranging from .635 to .940 with a mean of .804. Since Cronbach's Alpha's higher than .650 are considered as being acceptable, these inter-rater reliabilities are considered high. This means that there was a high level of agreement amongst the experts in scoring the lighting attributes of the shops, which implies that the results are reliable, that the design of the questionnaire is satisfactory and that the results are reproducible.

The lighting attributes were described using 31 items or variables. The performed PCA revealed six underlying factors, which can be used to represent the lighting attributes data. The six factors each represented one of the lighting attributes *contrast*, *brightness*, *glare & sparkle*, *ceiling contrast*, *the lighting installation* and *decorative lighting*. The first factor can be interpreted as the contrast of the lighting of the shops. However, the 'luminance ratio-' and 'luminance changes' of the ceiling were placed in another factor. This indicates that the contrast of the ceiling is not strongly related to the contrast of the rest of the shop, which is something that can be understood based on the fact that most of the times the lighting sources are located in the ceiling, hence providing more luminance changes and higher luminance ratios.

From the six constructed factors, only the factor for the lighting installation showed low average reliability. For the rest of the factors the reliabilities were acceptable (>.60) to good (>.80), which means that the items forming a particular factor were strongly correlated. This implies that for instance a high brightness on the back wall most of the times means a high brightness on the other planes of the space as well.

In short it is proved that the lighting attributes questionnaire is able to distinguish six lighting attributes. At the same time it produced scores representing these six lighting attributes for each of the 55 shops. By being able to characterize the lighting of the shops by means of these six scores, it became possible to relate the lighting to perceived atmosphere. How this is done is explained in chapter 6. The relation of these findings with other literature is discussed in Chapter 7.

5. Construction of the atmosphere variables

The aim of the present study is to relate the context and lighting attributes of the shops to the atmosphere perception in those shops. The former chapters presented how the context and lighting attributes were quantified. To relate these two concepts to the perceived atmosphere in the shops, the latter had to be quantified as well.

This chapter presents the procedure for measuring the atmosphere variables, which are used to represent the perceived atmosphere in the shops. It starts with presenting the methodology of quantifying the atmosphere variables, after which the obtained results are presented and discussed. The results are used in chapter 6 for relating the atmosphere scores to the context variables and the lighting attributes of the shops.

5.1. Atmosphere questionnaire

This section describes the way the perceived atmosphere in the shops is measured. Thereto it first presents the method and continues with describing recruiting the participants. Subsequently, the settings and the exact measurements and procedure are explained.

5.2. Method

For constructing the atmosphere variables, a reliable measure had to be developed, which could be used to measure the perceived atmosphere of participants in 57 shops. As was demonstrated by Vogels (2008), De Vries & Vogels (2007) and Van Erp et al. (2008), Vogels' atmosphere questionnaire was a reliable method to discriminate between different lighting settings. In an earlier study Van Erp et al. (2008) proved that perceived atmosphere could be described by the four factors *coziness, tenseness, liveliness*, and *detachment*. Therefore, in cooperation with Vogels, based on their factors loadings in the study of Van Erp (2008), several words were chosen to represent the four atmosphere factors. Atmosphere words that loaded high on one particular factor and low on the other three were chosen to represent that particular factor. For the atmosphere factors *coziness* and *tenseness* five words were chosen that met this criterion. For the other two factors *liveliness* and *detachment* only four atmosphere words were chosen. The atmosphere terms representing the four atmosphere factors are displayed in table 5.1.

Table 5.1. Selected atmosphere words (Translations can be found in Appendix F)

factors	*Coziness*	*Liveliness*	*Tenseness*	*detachment*
items	Geborgen Intiem Knus Gemoedelijk Behaaglijk	Stimulerend Levendig Inspirerend vrolijk	Bedreigend Beangstigend Beklemmend Gespannen Ongemakkelijk	Zakelijk Formeel Koud Kil

These words were used to construct an atmosphere questionnaire, which can be found in Appendix G. This questionnaire is used to measure the perceived atmosphere in the shops.

5.1.1 Participants

Six participants were recruited from a participant database made available by the Eindhoven Technical University. All of them were native Dutch, three of them were male and three were female. Their ages ranged between 22 and 29, with an average of 24.5 years. For six shops, three participants indicated that they had visited them before. All participants were enrolled in an academic education, none of the participants had disabled eye vision, and none of them was a lighting expert. They participated for two mornings from 9.45 AM until 12.30 AM, for which they received a credit note worth 40 Euros.

5.1.2 Settings / Shops

The same 57 shops were used as with constructing the lighting variables and the context variables. Again, the pictures obtained from the context experiment were used to make sure the participants had the right standing position and gaze direction while filling in the questionnaire.

5.1.3 Measurements

To measure the perceived atmosphere in the shops the method designed by Vogels (2008) was used. Several changes were implemented to make the questionnaire practical to use in the present study. In the end this led to the atmosphere questionnaire as can be found in Appendix G, which consists of eight-teen atmosphere words that had to be scored on seven-point bipolar Likert scales. Since all participants were native Dutch, the atmosphere words as well as the scores of the scale were labeled in Dutch. The labels can be translated in English as ‘absolutely not applicable’, ‘hardly applicable’, ‘not really applicable’, ‘neutral’, ‘slightly applicable’, ‘well applicable’, and ‘very well applicable’. The translations of the atmosphere words can be found in Appendix F.

5.1.4 Procedure

Six participants visited all 57 shops and rated 18 atmosphere words for their applicability to the shops. Before the start participants received a short briefing in which they were notified that they were going to visit 28 or 29 shops, but that the walking distances would be very short. Additionally they were requested not to communicate with each other regarding the experiment.

Since the results from this questionnaire later on would be related to the results of the lighting attributes, the procedure and period of performing the atmosphere questionnaire was the same as with the lighting attributes questionnaire. Again, visiting all shops was divided over two sessions, each involving at most three participants. To control for learning and tiring effects, half of the participants completed the list of shops forwards, while the other half did the same backwards. Pictures were used to check for any changes to the shop. The obtained data was analyzed using the data-analysis tool SPSS 16.0.

5.3. Atmosphere results

As was also the case for the lighting attributes experiment, shop number 18 and 50 were excluded from the data set for closing down and changing the color of the ceiling, respectively. The data resulted in a table with in every row one of the 55 shops and the 126 columns representing the scores of the six participants on the 21 items.

Internal consistencies

Each of the four atmosphere factors was represented by four or five atmosphere words. The internal consistencies of the four atmosphere factors were calculated with a Cronbach's Alpha for each of the six participants, which are shown in Table 5.2.

Table 5.2. Internal consistencies of the atmosphere scales

Atmosphere factor	Internal consistencies (Cronbach's α)	
	6 participants	Average
Coziness	.66 - .70 - .86 - .89 - .93 - .93	.83
Liveliness	.52 - .72 - .76 - .80 - .89 - .93	.77
Tenseness	.58 - .68 - .84 - .85 - .86 - .90	.79
Detachment	.00 - .36 - .61 - .87 - .88 - .93	.61

The average Cronbach's Alpha's indicate acceptable (>.60) to good (>.80) internal consistencies, which means that the scores for the different items can be averaged to obtain for every shop one score per factor per participant.

Inter-rater reliabilities

Inter-rater reliabilities indicate the amount of agreement among the participants while rating the perceived atmosphere. The same as with determining the internal consistencies, for the inter-rater reliability again Cronbach's Alpha's were calculated. For the inter-rater reliabilities the scores of the six participants for the atmosphere terms in each factor were included in the analysis, leading to one Alpha per atmosphere factor. The resulting Alpha's are displayed in Table 5.3.

Table 5.3. Inter-rater reliability for each of the atmosphere scales

Atmopshere factor	Inter-rater reliability
Coziness	.65
Liveliness	.76
Tenseness	.42
Detachment	.84

Atmosphere scores

After averaging the scores of the six participants a four dimensional score for every shop remained. The correlations between the scores on the different atmosphere factors are displayed in Table 5.4. The numerical values as well as graphical representations of the scores can be found in Appendix H. In addition Appendix H gives an indication for each shop whether it scored higher or lower than the average shop. The average scores of all the shops for the different atmosphere factors *coziness, liveliness, tenseness* and *detachment* were -0.17, 0.09, -1.64 and -0.95 respectively. The resulting scores for the atmosphere factors *coziness* and *liveliness* show a nice spread around zero, while the scores for the atmosphere factors *tenseness* and *detachment* apparently are mainly below zero. This can be intuitively understood, since tense and detached atmospheres are usually not desired for shop owners. On the other hand everyone can think of a shop that is perceived as cozy, uncomfortable (i.e. not cozy), lively or dull (i.e. not lively), so a good spread of the scores on *coziness* and *liveliness* was expected. Figure 5.1 – 5.4 display pictures of shops scoring extremely high or low on the four atmosphere scales.

Table 5.4 Correlations between scores on atmosphere factors (Cronbach's Alpha)

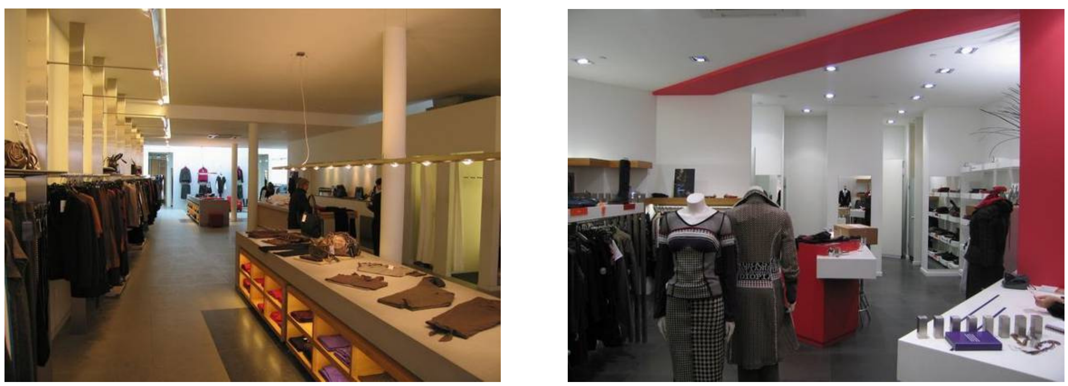
Inter-factor correlation matrix				
	Coziness	Liveliness	Tenseness	Detachment
Coziness	1.000	.330	-.613	-.309
Liveliness		1.000	-.340	-.789
Tenseness			1.000	.310
Detachment				1.000

Low **high**

Figure 5.1. Shops scoring extreme on factor coziness

Low **high**

Figure 5.2. Shops scoring extreme on atmosphere factor liveliness



Low **high**

Figure 5.3. Shops scoring extreme on atmosphere factor tenseness

Low **high**

Figure 5.4. Shops scoring extreme on atmosphere factor detachment

5.4. Discussion

To quantify the atmosphere perception of the shops, six participants visited 57 shops and rated 18 atmosphere terms for their applicability to the atmosphere of the shops.

The results showed acceptable to good internal consistencies for three of the four atmosphere factors. Only the *detachment* scale got a low score for two participants. This indicates that their ratings for the different atmosphere terms of the *detachment* scale did not correlate, implying that for these participants the atmosphere terms forming the atmosphere factor *detachment* did not have similar meanings. However, the scale structure is based on the extensive data from earlier studies, which have demonstrated these scale structures to be reliable. Except for the two low scores for the detachment scale, the internal consistencies of the atmosphere scales indeed indicated that the used atmosphere words are suitable for measuring the perceived atmosphere in a retail environment.

The inter-rater reliabilities indicated agreement among participants while scoring the atmosphere terms of three of the four atmosphere factors, implying that for the atmosphere terms of the factor *coziness*, *liveliness* and *detachment* the meaning were similar. Only for the factor *tenseness* a low inter-rater reliability emerged, implying that for these words the interpretation of participants differed. Once again the remark must be made that earlier studies used a much larger sample and demonstrated the atmosphere terms to be reliable items to measure perceived atmosphere.

The good internal consistencies and inter-rater reliability indicate that the atmosphere questionnaire is a reliable method to measure the perceived atmosphere of a space. By means of the atmosphere questionnaire for every shop a four-dimensional atmosphere score was produced. Chapter 6 presents how these scores were used to relate the perceived atmosphere to the lighting and context qualities of the shops.

6. Effects of lighting and context on atmosphere

The main goal of the present study was to demonstrate a significant effect of retail lighting on perceived atmosphere, if controlled for context effects. The previous chapters describes how the context, lighting and perceived atmosphere variables were quantified. This chapter will combine these variables and perform Multiple Regression Analyses (MRA). This analysis calculates a model for predicting perceived atmosphere with context and lighting being the predictors. Based on the multiple regression analyses we can conclude whether lighting does significantly contribute to perceived atmosphere in retail environments. This chapter firstly explains some background information about MRA and will continue with presenting and discussing the obtained results.

6.1. Multiple regression analysis explained

Multiple Regression Analysis (MRA) is a statistical technique that provides a model that predicts a score of the dependent variable based on the independent variables. In the present study a model is determined that will predict the score of perceived atmosphere, based on the scores for the context qualities and the lighting attributes. When referring to MRA the independent variables are called predictors, which in this case are the two context variables and the six lighting variables. The dependent variable is called the criterion, which in this case is the perceived atmosphere. The multiple regression model describes the effect of the predictors on the criterion. As is known from chapter 5, the criterion of the present study (i.e. perceived atmosphere) consists of the four atmosphere dimensions *coziness, liveliness, tenseness* and *detachment.* Since there are four different criteria, four different multiple regression analyses had to be performed, each with the same predictors.

A MRA provides a model for predicting the criterion. The correlation between the observed and predicted values of the criterion is expressed by R. R Square (R^2) indicates the proportion of variance of the criterion variable that is accounted for by the regression model. Furthermore the MRA provides a beta value for every predictor. This beta value is a measure of how great the impact is of the predictor on the criterion variable. Thus, the higher the beta, the stronger the influence on the criterion variable.

Multiple regression requires a number of cases that substantially exceeds the number of predictor variables used in the regression. The minimum is that there are five times as many cases as predictors (Brace, Kemp & Snelgar, 2003, p.208). The present study meets this requirement by having approximately seven times more cases than predictors. The Multiple regression analyses were performed using data-analysis tool SPSS 16.0.

6.2. Results

To test for relations between the lighting and the context qualities of the shops on the perceived atmosphere in those shops, for each atmosphere factor a Multiple Regression Analysis (MRA) was performed. This section presents the results obtained from these analyses. Four hierarchical multiple regressions were performed to predict the four atmosphere perception scores. In every multiple regression the two context variables were inserted in the first block as predictors. In the second block the six lighting variables were added. Following this procedure we can determine whether the lighting predictors add value to the model while controlling for context effects. This is the case if after including the lighting variables the explained variance increases significantly. The following paragraphs present the results per atmosphere factor.

Coziness

The results for the atmosphere factor coziness are displayed in Table 6.1 and are explained further on.

Table 6.1. Hierarchical regression predicting coziness

Criterion: Coziness	**β coefficients Step 1**	**Step 2**	**R²**	**R² change**
Block 1 (context)			.105	
Legibility	-.158	-.132		
Warm	.281 *	.246		
Block 2 (lighting)			.384**	.279 **
Contrast		.058		
Brightness		-.499 **		
Glare & Sparkle		-.007		
Contrast of the ceiling		-.206		
Lighting installation		.039		
Decorative lighting		-.153		

Note: * coefficient is significant for p<.05
** coefficient is significant for p<.01
*** coefficient is significant for p<.001

The model with solely the context predictors included was not able to account for a significant amount of variance of the criterion *coziness* [$F_{(2,52)} = 3{,}036$; $p = .057$]. Despite this, the predictor *warm* emerged as a significant ($\beta = .281$; $p < .05$) predictor for the criterion. The positive beta value of *warm* indicates that an interior, which is judged as warmer, evokes an atmosphere perception that is cozier.

After adding the lighting predictors, the model became significant [$F_{(8,46)} = 3{,}581$; $p < .01$] and accounted for 38% ($p < .01$) of the variance of the data. This means that the lighting of the shops contributes significantly to the prediction of coziness, while controlling for context effect. The lighting attribute *brightness* emerged as a significant ($\beta = -.499$; $p < .01$) predictor for *coziness*. The negative beta value for *brightness* indicates that a brighter shop leads to a less cozy perceived atmosphere. With adding the lighting attributes the significant effect of context variable *warm* disappeared ($p = .088$).

Liveliness

The results for the criterion *liveliness* are displayed in Table 6.2. With only the context variables included, the model was significant [$F_{(2,52)}$ = 17,849; p < .000]. The context variables accounted for 41% of the variance of *liveliness*, with both *legibility* (β = -.590; p < .000) and *warm* (β = -.247; p < .05) emerging as significant predictors. The negative beta values for both the context variables indicate that the more the interior of a shop is judged as legible or warm, the less the atmosphere of the shop is perceived as lively.

The second model, which included the context variables and the lighting variables, was significant [$F_{(8,46)}$ = 6,270; p < .000] as well. Although the change was not significant (p = .113), the explained variance of the model increased to 52%. The significant effect of context predictor *warm* (p = .245) disappeared. On the other hand *glare & sparkle* (β = .293; p < .05) was added to the variables that emerged as a significant predictor. Like in the first step, in the second step *legibility* (β = -.496; p < .000) emerged as a significant predictor for liveliness as well. The results indicated that the more an interior is judged as legible, the less the atmosphere of the shop is perceived as lively. Furthermore that the more the lighting provides more *glare & sparkle*, the more the atmosphere of a shop is perceived as lively.

Table 6.2. Hierarchical regression predicting liveliness

Criterion: 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		

Note: * coefficient is significant for p<.05
** coefficient is significant for p<.01
*** coefficient is significant for p<.001

Tenseness

The results for the criterion *tenseness* are displayed in Table 6.3. The first model, with just the context variables included was not significant [$F_{(2,52)}$ = 1,635; p = .205]. After adding the lighting variables to the model, it still was not significant [$F_{(2,52)}$ = 1,343; p = .247]. Nonetheless, lighting attribute *brightness* emerged as a significant predictor (β = .445; p < .14) for the criterion *tenseness*. The positive beta value indicates that shops with brighter lighting evoke an atmosphere that is perceived as more tense.

Table 6.3. Hierarchical regression predicting tenseness

Criterion: Tenseness	β coefficients Step 1	Step 2	R^2	R^2 change
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: * coefficient is significant for p<.05
** coefficient is significant for p<.01
*** coefficient is significant for p<.001

Detachment

The results for the criterion *detachment* are displayed in Table 6.4. At step one, with only the context variables included, the regression model was significant ($F_{(2,52)}$ = 48,644; p < .000] and accounted for 65% of the variance. Context variable *legibility* emerged as a significant (β = .806; p < .000) predictor for the criterion *detachment*. The beta value indicates that the more a shop is judged as legible, the more the atmosphere of the shop is perceived as detached.

The second model, which included the context and the lighting variables, was significant [$F_{(8,46)}$ = 12.337; p < .000] as well. The change was not significant (p = .625), the explained proportion of the variance of the criterion increased only minimally to 68% after adding the lighting predictors. None of the lighting predictors emerged as a significant predictor for the criterion, leaving *legibility* (β = .765; p < .000) as the only one.

Table 6.4. Hierarchical regression predicting detachment

Criterion: Tenseness	β coefficients Step 1	Step 2	R^2	R^2 change
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		

Note: * coefficient is significant for p<.05
** coefficient is significant for p<.01
*** coefficient is significant for p<.001

Uncontrolled regression analysis

Additionally the multiple regression analyses were repeated with only the lighting variables included as predictors. This would probably reveal additional effects of lighting attributes on perceived atmosphere, which would provide an indication of the direction of the effects on atmosphere perception. Next to the effects already found by means of the abovementioned analyses, these analyses revealed additional significant effects of lighting attributes on perceived atmosphere (Table 6.5). Brightness was found to emerge as a significant predictor for *coziness* ($\beta = -.588$; $p < .000$), for *tenseness* ($\beta = .484$; $p < .05$), and for *detachment* ($\beta = .354$; $p < .05$). In other words a shop with brighter lighting is perceived as less cozy, more tense and more detached. Furthermore contrast emerged as a significant predictor for tenseness ($\beta = -.362$; $p < .05$), indicating that a shop with more contrast used in the lighting evokes an atmosphere that is perceived as less tense. Lastly, *glare & Sparkle* emerged as a significant predictor for *liveliness* ($\beta = .469$; $p < .01$) and for *detachment* ($\beta = -.382$; $p < .05$), indicating that more glare and sparkle in a store evokes an atmosphere that is perceived as more *lively* and less *detached.*

Table 6.5. Significant beta coefficients of the regression analyses

Environmental cues	Controlled for context effects				Not controlled for context effects			
	Cozy	Lively	Tense	Detached	Cozy	Lively	Tense	Detached
Lighting								
Brightness	-.499**		.445*		-.588***		.484*	.354*
Contrast							.362*	
Glare & Sparkle		.293*				.469**		-.382*
Context								
Legibility		-.496***		.765***				
Warm								

Note: * coefficient is significant for p<.05
** coefficient is significant for p<.01
*** coefficient is significant for p<.001

7. Discussion

The main goal of the present study was investigating whether retail lighting has a significant effect on perceived atmosphere, while controlling for context effects. Furthermore was aimed to show significant effects of context variables and lighting attributes on perceived atmosphere. To reach these goals a field study was conducted in 57 retail fashion shops. The results show that that lighting does have a significant effect on perceived atmosphere; even if this interaction is controlled for effects caused by other environmental characteristics (i.e. context). Additionally several effects of context variables and lighting attributes were revealed.

Perceived atmosphere assessment

For measuring the atmosphere perception an adapted version of the instrument of Vogels (2008) was used. This measurement consisted of a questionnaire that was filled in by participants visiting each shop. The questionnaire resulted in a score for each shop on each of the four atmosphere dimensions *coziness*, *liveliness*, *tenseness* and *detachment*. Representing the perceived atmosphere by means of the scores on these four dimensions made it possible to relate the atmosphere perception to the context and lighting of the shops.

Context assessment

To quantify the environmental characteristics (i.e. context) of the shops, a card-sorting experiment was designed. This experiment revealed that a substantial part of the interior of a shop can be represented using two underlying dimensions. One dimension was identified as 'legibility', because it was strongly related to environmental characteristics such as 'legible', 'orderly', and 'expensive'. The second dimension was identified as 'warm', because it was strongly related to environmental characteristics such as 'warm' and 'cozy'. The results of the card-sorting experiment consisted of a score for each shop on only two dimensions. This reduction in number of predictors made it possible to relate the context variables to the perceived atmosphere of the shops.

That 'legibility' and 'warm' were revealed as most important environmental characteristics is partly in line with other research (Ulrich, 1983; Nasar, 2000), which suggests 'order' to be an important dimension with evaluating environments. In the present study the 'legibility' dimension was strongly related to environmental characteristics such as legible, orderly and messy. However, the other important environmental characteristic suggested by Ulrich (1983) and Nasar (2000), 'complexity', was not revealed in the present study. This might be caused by the fact that Ulrich (1983) and Nasar (2000) did not use a retail fashion environment as a reference. They found important dimensions for evaluating environments in general and the present study specifically asked for important environmental characteristics for shops.

Lighting assessment

For characterizing the lighting, a questionnaire was developed. In a retail environment this questionnaire, filled in by experts, reliably measured six lighting attributes: contrast, brightness, glare & sparkle, contrast of the ceiling, lighting installation, and decorative lighting. The results consisted of a score for each shop on those six lighting attributes. This reduction of the number of predictors made it possible to relate the lighting to the perceived atmosphere of the shops.

The revealed lighting dimensions are partly in line with the findings of other research (Flynn et al., 1973; Flynn, 1992; Hawkes et al., 1979), who found three basic dimensions for evaluating a lighting setting. These dimensions were identified as bright/dim, uniform/non-uniform, and overhead/peripheral. The 'bright' and 'uniform' (i.e. contrast) dimensions were also revealed in the present study. However, an overhead/peripheral dimension was not found. On the other hand, the present study found four other dimensions that were important in explaining the variance of the data.

This is probably caused by the fact that the other research (Flynn et al., 1973; Flynn, 1994; Hawkes et al., 1979) used an experimental room, in which not all possible lighting attributes were varied (e.g. contribution of decorative lighting). Furthermore, their rating scales did not include items for assessing glare & sparkle or the lighting installation, and did not provide separate items for assessing the lighting characteristics for the ceiling, walls, etc.. Hence, these characteristics could not be revealed as separate important lighting dimensions. On the contrary, in the present study, a peripheral/overhead lighting rating was not included in the lighting questionnaire, hence could not be revealed as an important lighting dimension as was done by Flynn (1973) and Flynn et al. (1994).

Regression analysis

After the context variables, lighting variables, and perceived atmosphere variable were quantified, multiple regression analyses were performed to calculate regression models to predict 'perceived atmosphere' with 'context' and 'lighting' being the predictors. Four different regression analyses were performed; one for each atmosphere dimension. A hierarchical procedure was chosen, with the context variables comprising the first block and de lighting variables the second block. Following this procedure made it possible to determine whether retail lighting had a significant contribution to the prediction of perceived atmosphere if controlled for context effects.

The models revealed that after adding the lighting variables, the predictability of each of the four models increased. Although this improvement was only significant for the atmosphere dimension *coziness*, this implies that lighting attributes did contribute significantly to the model, which demonstrates that among the enormous set of visual environmental cues that are present in a retail environment (e.g. colors and materials of the walls, ceiling, racks, shelves, etc.), lighting plays a significant role in evoking atmospheres.

For the atmosphere factors *coziness*, *liveliness* and *detachment* models were constructed that predicted a significant proportion of the atmosphere factor. Only for the atmosphere factor *tenseness* no significant model emerged.

Effects of context variables

Of the two context variables, *legibility* was found to have a significant effect on perceived atmosphere as well. A more *legible* interior is perceived as less *lively* and more *detached*. Bear in mind that the counterpart of a legible shop was a messy shop. Consequently a messy shop evokes an atmosphere that is perceived as more *lively* and less *detached*. The other context variable *warm* did not emerge as a significant predictor for the atmosphere factors.

Order, investigated in urban environments (as summarized by Nasar, 1997) was found to have a positive impact on pleasantness and a negative impact on arousal. Gilboa & Rafaeli (2003) confirmed these findings in a retail environment. As mentioned earlier, the 'legibility' dimension of the present study was strongly related to impressions of 'order'. The present study found a negative effect of 'order' on arousal. If the emotional dimension 'arousal' and the perceived atmosphere dimension 'liveliness' are assumed to be similar, then these findings are in line with the previous findings of Gilboa & Rafali and Nasar.

Effects of lighting attributes

The regression models revealed several effects of lighting attributes on perceived atmosphere: a brighter shop evokes an atmosphere that is perceived as less *cozy* and more *tense*. Another lighting attribute that emerged as a significant predictor was *glare & sparkle*. More *glare & sparkle* in a shop evokes an atmosphere that is perceived as more *lively*. Only for the atmosphere factor *detachment* no lighting attribute emerged as a significant predictor.

The results of the uncontrolled regression analyses show an increase of the impact of the lighting attributes, if context variables are excluded from the analysis. Furthermore, three additional significant effects emerged compared to the controlled condition ('contrast' on *tense*, 'brightness' and 'glare & sparkle' on *detached*). These additional effects could not be revealed in the controlled condition. However, they do provide an indication of the direction of the effects of the lighting attributes on perceived atmosphere.

These results are partially in line with Van Erp (2008), who found a higher brightness to be perceived as less cozy and less tense, meaning that the effect on tense was reversed. Probably the main reason for this difference is the difference in research setting. Van Erp (2008) provided different lighting settings in an experimental room without any context. The present study was a field study performed in real life shops. Providing such context evokes a whole other mind set with people, which can be a cause for the difference between the findings of Van Erp and the present study. Anyhow, the different findings show the importance of field studies, even considering the complexity and drawbacks.

Knez (1995) and Hygge & Knez (2001) did not find significant effects of illuminance on emotions and Fleischer et al. (2001) found a higher intensity to be more pleasant. If the 'pleasant' emotion dimension is compared with the 'cozy' atmosphere dimension (both strongly related to feelings of pleasure: pleasant, cozy, comfortable), these findings do not match the findings of the present study. This shows the benefits in measuring perceived atmosphere instead of emotions and reinforces the claim of Vogels (2008) that perceived atmosphere is a better measurement tool than emotion measurements, since an environment does not necessarily affect human's emotions (Lazarus, 1991). Furthermore, Knez (1995) did find some complex interaction effects between gender and color temperature on emotions. Fleischer as well found a color temperature effect. However, both color temperature as well as gender was not included in the present study's analyses; hence these findings could not be compared.

An additional note has to be made about the probable underestimation of the impact of the lighting variables on perceived atmosphere. This is caused by the fact that the context variables are comprised of among others the lighting variables. To overcome this problem, the best solution would be if the context variables would be measured using the same lighting condition for every shop.

To summarize, the present study demonstrated measurements for quantifying environmental characteristics, lighting attributes and perceived atmosphere of shops. By means of these measurements, effects of context variables and lighting attributes on perceived atmosphere were shown. However, perhaps the most important aspect of the present study is that in the enormous set of visual environmental cues that are present in retail environments (e.g. colors and materials of the walls, ceiling, racks, shelves, etc.), lighting plays a significant role in evoking atmospheres.

Suggestions for further research

The present study provides the first insights into how retail lighting and the interior qualities of shops are related to the perceived atmosphere in shops. However, some limitations and suggestions for further research have to be mentioned.

Investigating the effects of retail lighting on perceived atmosphere in a real-life environment is difficult because all of the other variables that have the potency to influence the atmosphere perception. The best solution would be to keep those other variables constant, but this is an impossible one. Doing a repeated measures experiment in the same shop would keep a lot of variables constant (e.g. interior qualities, sold products, employees), but still a number of variables would vary (e.g. sound, crowdedness). In the present study as well a few shops slightly changed their interior for instance by placing advertisement banners and displaying other cloths at other positions.

Another solution is to measure all the variables and control for effects caused by these variables. The present study controlled for effects caused by interior qualities. However, sound, crowdedness, (price of) products sold and employees present are a few examples of variables that have the potency to influence perceived atmosphere. It would be interesting to control for these effects as well.

The present study used a card-sorting experiment to quantify the interior qualities of the shops. While assessing these interior qualities, participants were allowed to sort the pictures of the shops based on whatever discriminating quality they could think of. The experiment revealed important interior qualities for evaluating retail fashion shops. In further research this knowledge can be used to develop a questionnaire and assess these interior qualities while really visiting the shops.

The developed lighting questionnaire was able to distinguish between six different lighting attributes. However, it was not possible to include the important lighting attributes *color temperature* and *modeling* in the analyses. This was probably because of the lack of sufficient variance between the shops according to these variables. It would be interesting to develop a measure that would make it possible to include all the lighting attributes in the analyses.

The atmosphere perception and the lighting attributes questionnaire were filled in by participants really standing in the shops. In most of the times, a least two participants performed the questionnaire at the same time. Those people could never have exactly the same standing position and hence experience other visual inputs. In the present study this could be the reason for not all inter-rater reliabilities being satisfactory. This problem could be solved by performing the questionnaire with only one participant at a time.

Since the questionnaires had to be filled in at a position close to the entrance, the participants only had about ten seconds for adaptation. As most shops are approached from the street, the amount of daylight can play an important role. When walking from the street into the shop, on a sunny day that shop can be experienced a lot darker than the same shop on a rainy day. A solution would be to measure the amount of daylight at the moment of approaching the shop.

The participants sample used for measuring the atmosphere perception was homogeneous in age, educational level and nationality. It would be interesting to investigate whether differences in these variables would result in an effect on atmosphere perception.

Lastly, it would be interesting to include an evaluative assessment when performing further research. This would make it possible to find what perceived atmosphere are preferred with customers.

References

Abdi, H. (2003). Factor rotations in factor analyses. In Lewis-Beck, M., Bryman, A, Futing. T. (Ed.): *Encyclopedia for research methods for the social sciences* (pp. 978-982). Thousand Oaks (CA): Sage.

Abdi, H. & Valentin, D. (2007). Multiple Correspondence Analysis. In N.J. Salkind (Ed.): Encyclopedia of measurement and statistics (pp. 651-657). Thousand Oaks (CA): Sage.

Akerelrea, C. & Zimmerman, D. (2002). A group card sorting methodology for developing informational web sites. In *Proceedings of the 2002 IEEE Professional Communication Conference.* 437 – 445.

Baker, J., Parasuraman, A., Grewal, D., & Vos, G.B. (2002). The Influence of Multiple Store Environment Cues on Perceived Merchandise Value and Patronage Intentions. *Journal of Marketing*, 66, 120 – 141.

Berlyne, D.E. (1971). *Aesthetics and Psychobiology*, New York: Appleton-Century-Crofts.

Berman, B. & Evans, J.R. (1995). *Retail Management: A Strategic Approach (6th Ed)*, NJ: Prentice Hall International.

Bitner, M.J. (1990). Evaluating Service Encounters: The Effects of Physical Surroundings and Employee Responses. *Journal of Marketing*, 54, 69–82.

Bitner, M.J. (1992). Servicescapes: The Impact of Physical Surroundings on Customers and Employees. *Journal of Marketing,* 56, 57–71.

Boyce, P.R. (2003). *Human factors in lighting* (2^{nd} ed.). London: Taylor & Francis.

Brace, N., Kemp, R., & Snelgar, R. (2003). *SPSS for psychologists: a guide to data analysis using SPSS for windows*. Mahwah (NJ): Lawrence Erlbaum Associates.

Bradley M.M. & Lang, P.J. (1994). Measuring emotion; the self assessment manikin and the semantic differential. *Journal of behavioral therapy & experimental psychiatry*, 25(1), 49-59.

Dearholt, D., McDonald, J., Paap, K., & Schvaneveldt, W. (1986). A formal interface design methodology based on user knowledge. In *Proceeding of the 1986 SIGCHI Conference on Human Factors in Computing Systems* (285-290). Boston: ACM Press

Deaton, M. (2002). *Sorting techniques for user-centered information design.* Retrieved March 30, 2005 from http://www.mmdeaton.com/-sortingtechniquesforinformationdesign.doc

Donovan, R.J. & Rossiter, J.R. (1982). Store atmosphere: An experimental psychology approach. *Journal of Retailing*, 58, 34-57.

Donovan, R. J., Rossiter, J.R., Marcoolyn, G., & Nesdale, A. (1994). Store Atmosphere and Purchasing Behavior. *Journal of Retailing,* 70, 283–294.

Fleischer, S., Krueger, H., & Schierz C. (2001). Effect of brightness distribution and light colours on office staff, *The 9th European Lighting Conference Proceeding Book of Lux Europa*, 76-80, Reykjavik.

Flynn, J.E. (1977). A study of subjective responses to low energy and non-uniform lighting systems, *Lighting Design & Application*, 7, 6 – 15.

Flynn, J.E. (1992). Lighting-design decisions as interventions in human visual space. In J.L. Nasar (Eds.), *Environmental aesthetics: theory, research and applications* (pp 156-170). New York: Cambridge University Press.

Flynn, J.E., Hendrick, C., Spencer, T.J., & Martyniuk, O. (1973). Interim study of procedures for investigating the effect of light on impressoion and behavior. *Journal of the Illuminating Engineering Society, 3, 87 – 94.*

Flynn, J.E., Spencer, T.J., Martyniuk, O., and Hendrick, C. (1975) The effect of light on human judgment and behavior, IERI Project 92, Interim Report to the Illuminating Engineering Research Institute, New York: IERI.

Gilboa S., & Rafaeli, A. (2003), Store environment, emotions and approach behavior: applying environmental aesthetics to retailing. *The International Review of Retail, Distribution and Consumer Research*, 13:2, 195 – 211.

Greenacre, M. & Blasius, J. (1994) (Eds.). *Correspondence analysis in the social sciences. Recent developments and applications. London*: Academic Press.

Greenacre M. (2006). From simple to multiple correspondence analysis. In: Greenacre, M. & Blasius, J. (Eds.), *Multiple correspondence analysis and related methods* (41 – 75). London: Chapman & Hall/CRC

Greenland, S.J. and McGoldrick, P.J. (1994). Atmospherics, attitudes, and behavior: modeling the impact of designed space. *International Review of Retail, Distribution, and Consumer Research*, 4: 1–16.

Hahsler, M. & Simon, B. (2001). User-centered navigation re-design for web-based information systems. Retrieved April 21, 2008 from http://www.wu-wien.ac.at/usr/wi/bsimon/publikationen/navigation_re-design_amcis.pdf

Hawkes, R. J., Loe, D. L., & Rowlands, E. (1979). A note towards the understanding of lighting quality. *Journal of the Illuminating Engineering Society*, 8, 111-120.

Hopkinson, R. G., & Longmore, J. (1959). Attention and distraction in the lighting of work-places. *Ergonomics*, 2, 321-334.

Houser, K.W., Tiller, D.K., Bernecker, C.A., & Mistrick, R.G. (2002). The subjective response to linear fluorescent direct/indirect lighting systems. *Lighting Research and Technoogy,* 34. 243–264.

Hygge, S., & Knez, I. (2001). Effects of noise, heat and indoor lighting on affect and cognitive performance. *Journal of Environmental Psychology*, 21, 291-299.

Kaplan, S. (1987). Aesthetics, Affect, and Cognition. *Environment and Behavior*, 19, 3 – 32.

Kidwell, D. & & Martin, S. (2001). A case study in cluster analysis for intranet organization. *Engineering Management for Applied Technology*. August 2001. 57-64.

Knez, I. (1995). Effects of indoor lighting on mood and cognition. *Journal of Environmental Psychology*, 15, 39-51.

Kotler, P., (1973). Atmosphere as a Marketing Tool. *Journal of Retailing*, vol. 49, 48-64.

Kuniavsky, M. (2003). *Observing the user experience: a practioner's guide for user research.* San Francisco: Morgan Kauffman.

Lazarus, R. S. (1991). *Emotion and adaptation*. New York: Oxford University Press.

Loe, D. L., Mansfield, K. P. & Rowlands, E. (1994). Appearance of lit environment and its relevance in lighting design: experimental study. *Lighting Research and Technology*, 26, 119-133.

Machleit, K. A., Eroglu, S.A. (2000). Describing and Measuring Emotional Response to shopping experience. *Journal of Business Research*, 49, 101–111.

Mattila, A.S. and Wirtz, J. (2001). Congruency of scent and music as a driver of in-store evaluations and behavior, *Journal of Retailing*, 77, 273–89.

Maurer, D. & Warfel, T. (2004). *Card sorting: A definitive guide.* Retrieved April 8, 2008 from http://www.boxesandarrows.com/archives/card_sorting_a_definitive_guide.php

Mehrabian, A. (1997). Comparison of the PAD and PANAS as models for describing Emotions and for differentiating anxiety for depression. *Journal of psychopathology and behavioral assessment*, *19*(4), 331-353.

Mehrebian, A. & Russel, J.A. (1974). *An appraoch to environmental psychology.* Cambridge, MA: MIT Press.

Murdoch, J, Caughey, C. (2004). Psychological effects of lighting: The work of Professor John Flynn. *Lighting Design and Application, 34,* 8, 69-73

Nasar, J.L. (1989). Perceptions, cognition, and evaluation of urban places. In: I. Altman & E.H. Zube (Eds.), *Public Places and Spaces*. New York: Plenum Press, 31 – 56.

Nasar, J.L. (1997). New developments in aesthetics for urban design. In G.T. Moore & R.W. Marans (Eds.), *Advance in Environment, Behavior and Design*, 4, New York: Plenum Press.

Nasar, J.L. (2000). The evaluative image of places. In W.B. Walsh, K.H. Craik, & R.H. Price (Eds.), *Person-Environment Psychology (2nd ed.)*, Mahwah, NJ: Lawrence Erlbaum Associates.

Rea, M.S. (1982) Calibration of subjective scaling responses. *Lighting Research and Technology*, 14, 121-129.

Rowlands, E., Loe, D. L., McIntosh, R. M., & Mansfield, K. P. (1985). Lighting adequacy and quality in office interiors by consideration of subjective assessment and physical measurement*.* *CIE Journal*, 4, 23-37.

Russell, J.A., & Mehrabian, A. (1976). Environmental variables in consumer research, *Journal of Consumer Research*, 3, 62–3.

Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). The affect grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology*, 57, 493–502.

Spies, K., Hesse, F., & Loesch, K. (1997). Store atmosphere, mood and purchasing behavior. *International Journal of Research in Marketing*, 14. 1 – 17.

Stevens, S.S. (1961) The psychophysics of sensory function, in W.A. Rosenblith (Eds.) *Sensory Communication*, Cambrigde, MA: MIT Press.

Tiller, D.K., & Rea, M.S. (1992). Semantic differential scaling: prospects in lighting research. *Lighting Research and Technology,* 24: 43-52.

Tiller, D. K., & Veitch, J. A. (1995). Perceived room brightness: Pilot study on the effect of luminance distribution. *Lighting Research and Technology*, 27, 93-101.

Turley, L.W. & Miliman, R.E. (2000). Atmospherics effects on shopping behavior: a review of the experimental evidence, *Journal of Business Research*, 49, 193–211.

Ulrich, R.S. (1983). Aesthetics and affective response to natural environment. In I. Altman & J.F. Wohlwill (eds). *Behavior and the Natural Environment: Human Behavior and the Environment, Advances in Theory and Research*, 6, New York: Plenum.

Underhill, P., (1999). *Why We Buy: The Science of Shopping,* New York: Simon & Schuster.

Van Erp, T.A.M. (2008). The effects of lighting characteristics on atmosphere perception. Unpublished Master thesis for the Master's degree program Human Technology Interaction, department of Eindhoven University of Technology. Available online: http://alexandria.tue.nl/extra2/afstversl/tm/Erp%202008.pdf

Veitch, J.A. (2001). Psychological processes influencing lighting quality. *Journal of the Illuminating Engineering Society*, 30(1), 124-140.

Vogels, I.M.L.C. (2008). Atmospheric Metrics: Development of a tool to quantify experienced atmosphere. In: J.H.D.H. Westerink, M. Ouwerkerk, T.J.M. Overbeek, W.F. Pasveer, & B. Ruyter (Eds.), *Probing Experiences: From Assessment of User Emotions and Behavior to Development of Products* (25 – 41). Dordrecht: Springer.

Veitch, J. A., & Newsham, G. R. (1998). Lighting quality and energy-efficiency effects on task performance, mood, health, satisfaction and comfort. *Journal of the Illuminating Engineering Society,* 27, 107-129.

Watson, D., Clark, L.A, & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The Panas scales. *Journal of personality and social psychology*, 54, 1063-1070.

Whyte, W.H. (1980). *The social life of small urban spaces*. Washington, DC: The Conservation Foundation.

Appendix A Explanation of PCA/factor analysis

Principal component analysis is a factor analysis, which determines the underlying structures of the data in order to find out whether the 31 items could be described in terms of a few underlying dimensions. A PCA provides linear transformations of the independent variables, in other words factors, which together explain 100% of the variance of the data. The number of factors it provides is the same as the number of items, which in this case is 31. Thereby the first factor accounts for the highest explained variance and the explained variance of each of the following factors is lower than the previous one. The importance of each factor is expressed by its eigenvalue. The eigenvalue of a factor is the explained variance of that factor divided by the average explained variance of all factors. There are several methods to determine the best number of factors to represent the data. An often used method is to choose the factors with an eigenvalue higher than 1.00. Another method is to plot the eigenvalues in a scree plot and choose all the factors before 'the elbow' of the curve, i.e. before the first big angle in the curve. A third method that is frequently used is to take all the factors explaining 90% of the variance of the data. Besides the eigenvalues of each factor, PCA also produces a list of factor loadings, which represent the contribution of the items to each of the factors. If an item has a high factor loading for a particular factor, the item is closely related to that factor. Using factor loadings interpretations of the underlying factors can be found.

Appendix B Output of MCA (context experiment)

Discrimination measures of the Multiple Correspondence Analysis performed as part of the procedure to construct the context variables.

Table B.1. Discrimination Measures of the MCA

Discrimination Measures

	Dimension				Dimension		
	1	2	Mean		1	2	Mean
Q1_Overzichtelijk	,327	,052	,190	Q31_Chic	,605	,031	,318
Q2_Overzichtelijk	,445	,070	,257	Q32_Duur	,725	,077	,401
Q3_Overzichtelijk	,193	,281	,237	Q33_Duur	,501	,067	,284
Q4_Overzichtelijk	,631	,046	,338	Q34_Duur	,161	,158	,159
Q5_Overzichtelijk	,324	,084	,204	Q35_Uitnodigend	,163	,296	,230
Q6_Overzichtelijk	,277	,076	,176	Q36_Uitnodigend	,025	,063	,044
Q7_overzichtelijk	,644	,084	,364	Q37_Kindvriendelijk	,115	,024	,070
Q8_Ruimtelijk	,411	,035	,223	Q38_Welkom	,117	,406	,262
Q9_Ruimtelijk	,549	,119	,334	Q39_klantvriendelijk	,124	,128	,126
Q10_Manouvreerbaar	,144	,054	,099	Q40_Warm	,091	,384	,237
Q11_Rommelig	,387	,034	,211	Q41_Warm	,083	,398	,241
Q12_Rommelig	,623	,058	,340	Q42_Warm	,011	,604	,307
Q13_Rommelig	,381	,029	,205	Q43_houtvloer	,120	,218	,169
Q14_Rommelig	,154	,057	,106	Q44_Houtgebruik	,100	,165	,133
Q15_chaotisch	,465	,044	,255	Q45_Gezellig	,210	,682	,446
Q16_chaotisch	,274	,134	,204	Q46_Huiselijk	,113	,468	,291
Q17_Druk	,783	,202	,493	Q47_jong	,147	,109	,128
Q18_drukte	,411	,131	,271	Q48_Jeugdig_00	,678	,205	,442
Q19_Vol	,500	,169	,335	Q49_Zakelijk	,689	,378	,533
Q20_Gevuldheid	,375	,117	,246	Q50_Zakelijk	,609	,118	,364
Q21_Net	,508	,098	,303	Q51_Presentatie	,063	,091	,077
Q22_Modern	,015	,522	,269	Q52_Keuze	,102	,211	,156
Q23_Modern	,066	,484	,275	Q53_Saai	,324	,279	,302
Q24_Modern	,050	,448	,249	Q54_TL	,105	,053	,079
Q25_Modern	,042	,529	,286	Q55_aantrek_verlicht	,071	,153	,112
Q26_Strak	,486	,073	,280	Q56_Plafond_en_verlicht	,351	,170	,260
Q27_Trendy	,639	,101	,370	Q57_Helder	,028	,158	,093
Q28_Industrieel	,317	,503	,410	Q58_Paspoppen	,079	,048	,063
Q29_klassiek	,629	,188	,408	Q59_Pers	,174	,019	,096
Q30_Chic	,524	,060	,292	Active Total	18,259	11,049	14,654

Appendix C Shops context scores

Context scores on the two dimensions revealed by the MCA. Table C.1 displays the scores for each of the cards. In Table C.2 the scores of the cards with pictures of the same shop were averaged to determine scores for each of the shops.

Table C.1. Card scores

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Object Scores

Case Number	Dimension 1	Dimension 2
1	,349	,145
2	1,134	,130
3	1,639	-,327
4	1,776	-,811
5	-,749	-1,731
6	1,447	-1,337
7	,857	-,611
8	1,092	-,903
9	1,723	-1,287
10	1,737	-,530
11	-1,695	,101
12	-1,639	,272
13	-1,279	,099
14	-,756	-1,599
15	,179	-1,642
16	,909	,222
17	-,959	,532
18	-,171	,113
19	,799	,906
20	,718	1,032
21	,035	,932
22	1,176	-1,131
23	1,495	-1,189
24	1,208	,666
25	1,114	,939
26	,836	,473
27	1,077	,283
28	-,089	1,704
29	-1,127	,563
30	1,130	,606
31	,258	1,592
32	1,209	-,390
33	1,406	-,100
34	-,667	-1,327
35	-,514	,568
36	-,001	-,106
37	-,501	-,194
38	-,023	-,169
39	,088	,190
40	-,601	-1,145
41	-,044	-1,032
42	-,795	-,909
43	-,956	-,880
44	-1,201	,074
45	1,836	-1,293
46	-,999	-1,663
47	-1,032	-1,362
48	-1,073	-1,160
49	-1,256	-,847
50	,064	-1,300
51	,650	,213
52	1,410	-,006
53	1,645	-,245
54	-,354	2,183
55	-1,063	1,853
56	-,704	,707
57	-,864	-1,178
58	-,807	-1,060
59	-,136	1,319
60	-,378	1,768
61	1,717	-,300
62	-,474	1,060
63	,261	-,142
64	,806	,339
65	-,678	-,539
66	-,622	-1,359
67	-,789	-,975
68	-,556	1,699
69	-,023	1,787
70	-1,156	-1,338
71	-1,017	,854
72	-,266	,413
73	,887	1,156
74	,274	1,933
75	-,013	1,790
76	-1,429	,114
77	-1,114	,369
78	1,990	,230
79	-,073	,280
80	-,209	1,584
81	-,982	-,876
82	-1,502	-,790
83	-,581	,475
84	-,386	,665
85	-,199	,494
86	-,654	,537
87	-1,722	-,196

Variable Principal Normalization.

Table C.2. . Shop scores

Shop	Dimension 1	Dimension 2
1	-1,073	-1,160
2	1,527	-0,125
3	-0,483	0,570
4	0,035	0,932
5	-0,982	-0,876
6	-0,089	1,704
7	0,857	-0,611
8	-0,835	-1,119
9	1,336	-1,160
10	-0,266	0,413
11	-0,322	-1,088
12	0,032	0,011
13	-0,596	-1,073
14	-0,289	1,743
15	-1,502	-0,790
16	1,717	-0,300
17	-1,459	0,185
18	-0,289	-1,621
19	0,956	0,378
20	-0,209	1,584
21	-0,251	-0,150
22	-0,650	-0,949
23	-0,749	-1,731
24	1,737	-0,530
25	-0,073	0,280
26	-0,789	-0,975
27	-1,695	0,101
28	1,407	-1,095
29	0,887	1,156
30	1,707	-0,569
31	1,836	-1,293
32	0,533	0,098
33	1,990	0,230
34	-1,127	0,563
35	1,161	0,803
36	0,131	1,861
37	0,909	0,222
38	1,307	-0,245
39	-0,257	1,544
40	0,742	0,138
41	-1,156	-1,338
42	0,694	1,099
43	1,447	-1,337
44	-1,017	0,854
45	-0,709	2,018
46	-1,271	0,241
47	-0,591	-0,379
48	-1,722	-0,196
49	-0,704	0,707
50	-1,201	0,074
51	-0,565	0,322
52	-0,875	-0,895
53	-0,474	1,060
54	0,758	0,969
55	0,650	0,213
56	-1,016	-1,513
57	-0,427	0,515

Appendix D Lighting attributes questionnaire

1. Indicate the proportional (percentage) amount of lighting:

- General ….. %
- Accent ….. %
- Decorative ….. %
- Architectural ….. %

2. Brightness:

In this context we are talking about the luminance (and not the illuminance) of the space.

Spatial distribution of the brightness

Figure 1 shows a schematic representation of a space. ‘B’ stands for the Back wall, ‘C’ for the Ceiling, ‘F’ for the Floor, ‘H’ for the space from eyelevel to the flour (Horizontal products) and ‘S’ for the Side walls. What letter indicates the surface with the highest luminance?

O B O C O F O H O S

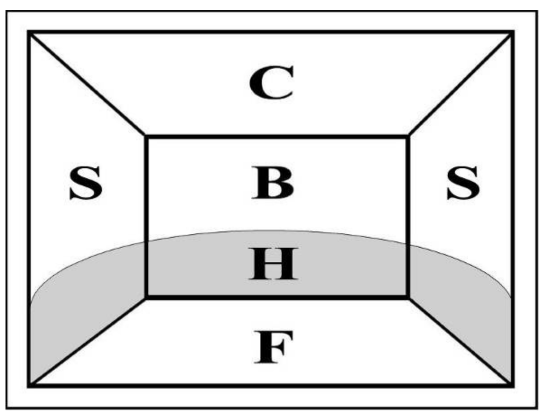


Figure 1. A space divided into 5 elements

Subjective brightness impression

Please score this shop using the scales as stated below. Take into account that the mid-score is the score for a typical high street retail outlet.

B. The subjective brightness impression on the vertical products (back wall)

Low Brightness O O O O O O O High brightness

Appendix D Continuation of lighting attributes questionnaire

C. The subjective brightness impression on the ceiling.

Low brightness O O O O O O O High brightness

F. The subjective brightness impression on the floor.

Low brightness O O O O O O O High brightness

H. The subjective brightness impression on the horizontal products

Low brightness O O O O O O O High brightness

S. The subjective brightness impression on the vertical products (side walls)

Low brightness O O O O O O O High brightness

The subjective brightness impression of the total space

Low brightness O O O O O O O High brightness

3. Color temperature

Please score this shop using the scales as stated below. Again take into account that the mid-score is the score for a typical high street retail outlet.

Subjective color temperature impression of the lighting.

Low cT O O O O O O O High cT

Subjective color temperature impression of the total space.

Low cT O O O O O O O High cT

Appendix D Continuation of lighting attributes questionnaire

4. Glare

No glare	O	O	O	O	O	O	O	A lot of glare

5. Sparkle

Dull	O	O	O	O	O	O	O	Sparkling

6. Modeling

Modeling is the term used to describe the ability of light to emphasize the three-dimensional nature of objects. Modeling is an interpretation of perceived contrasts. So please consider people's faces or other 3D objects that can help you give an indication of the amount of modeling.

Little modeling	O	O	O	O	O	O	O	A lot of modeling

Appendix D Continuation of lighting attributes questionnaire

7. Spatial Distribution (contrast)

Here again is meant the ratio between the luminance differences (and not the illuminance differences). Figure 2 again shows the division of a space. ‘B’ stands for the Back wall, ‘C’ for the Ceiling, ‘F’ for the Floor, ‘H’ for the space from eyelevel to the flour (Horizontal products) and ‘S’ for the Side walls.

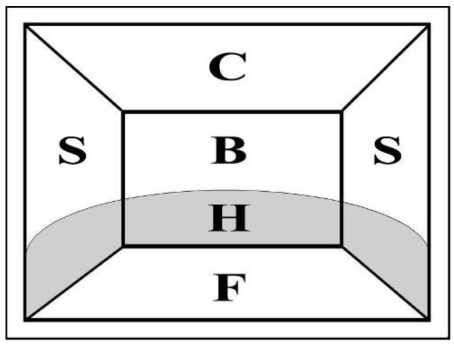
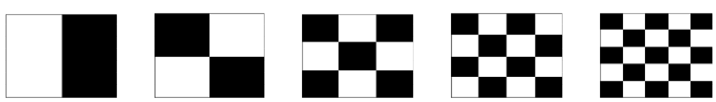


Figure 2. A space divided into 5 elements

Please score the different elements of this shop using the scales as stated below. Again take into account that the mid-score is the score for a typical high street retail outlet.

B. Contrast on the back wall

- How many luminance changes are present?



A few Many

O O O O O

- How big are the luminance differences?

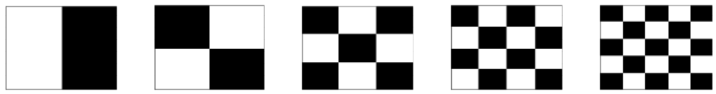
just noticeable difference Theatrical Dramatic

O O O O O

Appendix D Continuation of lighting attributes questionnaire

C. Contrast on the ceiling

- How many luminance changes are present?



A few Many

O O O O O

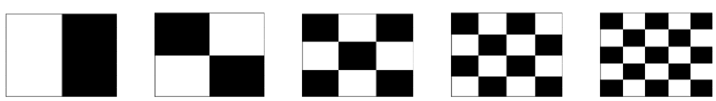
- How big are the luminance differences?

just noticeable difference Theatrical Dramatic

O O O O O

F. Contrast on the floor

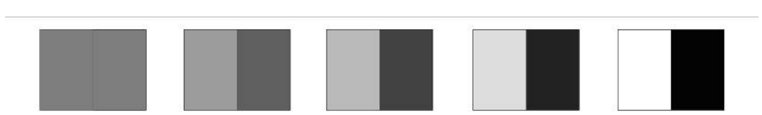
- How many luminance changes are present?



A few Many

O O O O O

- How big are the luminance differences?



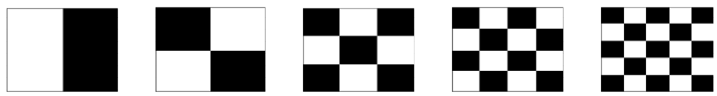
just noticeable difference Theatrical Dramatic

O O O O O

Appendix D Continuation of lighting attributes questionnaire

H. Contrast on the horizontal products

- How many luminance changes are present?



A few Many

O O O O O

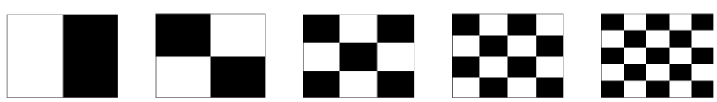
- How big are the luminance differences?

just noticeable difference Theatrical Dramatic

O O O O O

S. Contrast on the side wall

- How many luminance changes are present?



A few Many

O O O O O

- How big are the luminance differences?

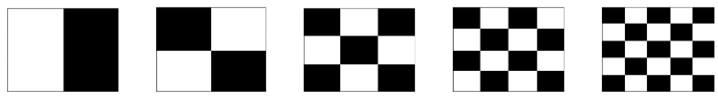
just noticeable difference Theatrical Dramatic

O O O O O

Appendix D Continuation of lighting attributes questionnaire

Contrast of the total space

- How many luminance changes are present?



A few — Many

O O O O O

- How big are the luminance differences?

just noticeable difference — Theatrical — Dramatic

O O O O O

8. Esthetics of the lighting installation

This question is about the applied armatures or other light emitting elements.

Inconspicuous	O	O	O	O	O	O	O	Conspicuous
No pattern	O	O	O	O	O	O	O	Structured pattern
Little amount of different lighting fittings	O	O	O	O	O	O	O	Many different lighting fittings
Little amount of lighting fittings	O	O	O	O	O	O	O	Many lighting fittings

Appendix E Shop scores on the 6 lighting attributes factors

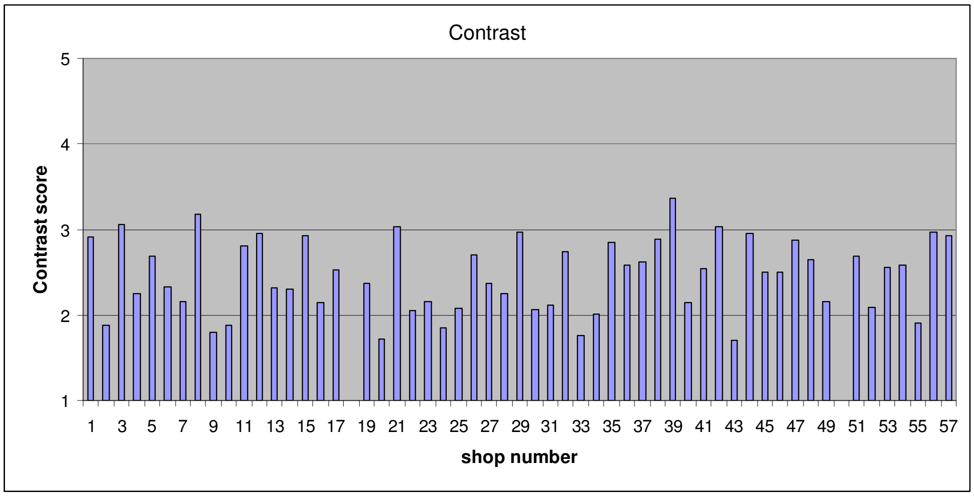
In this appendix the lighting attributes factor scores for all the shops averaged for the 7 participants/lighting experts are displayed. Firstly, the numerical scores are given in a table, where after the scores are graphically displayed in diagrams. The scores are standardized to a five point scale, ranging from 1 to 5. Thereby bear in mind that the score for the sixth factor, decorative is a representation of the relative contribution of decorative lighting in the shops. Since the main types of lighting applied most of the times are general lighting and accent lighting, these scores range between 1 and 2.03.

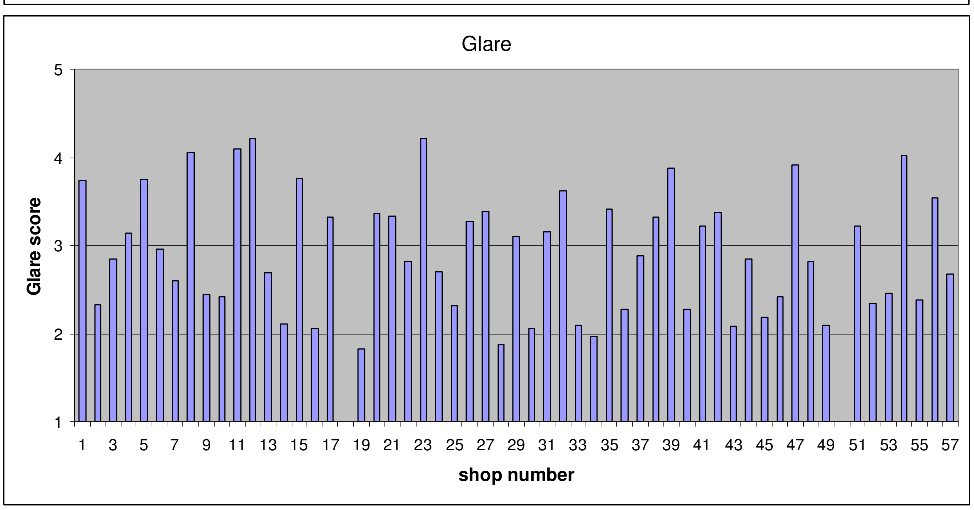
	Contrast	Brightness	Glare	Ceiling	Installation	Decorative
1	2,92	2,71	3,74	2,14	3,24	1,49
2	1,87	3,35	2,32	2,50	3,24	1,06
3	3,06	2,71	2,84	1,86	3,52	1,46
4	2,25	2,68	3,14	3,50	3,81	1,49
5	2,68	3,40	3,75	2,36	3,52	1,00
6	2,33	1,89	2,96	2,36	2,62	1,66
7	2,16	2,52	2,61	2,07	4,62	1,26
8	3,18	3,27	4,06	2,14	2,86	1,37
9	1,79	2,29	2,44	2,00	3,38	1,26
10	1,87	1,89	2,42	2,71	2,76	1,06
11	2,81	3,11	4,09	2,43	3,71	1,14
12	2,95	3,32	4,22	2,50	3,67	1,29
13	2,32	2,68	2,69	2,86	3,52	1,29
14	2,30	1,79	2,11	1,93	3,10	1,26
15	2,92	3,29	3,76	2,21	3,05	1,00
16	2,14	3,37	2,06	3,29	3,52	1,00
17	2,52	3,22	3,32	2,79	3,05	1,14
19	2,37	3,16	1,83	3,00	3,71	1,20
20	1,71	1,98	3,36	2,50	3,14	1,00
21	3,03	3,16	3,33	1,43	3,43	1,43
22	2,05	3,70	2,81	2,64	4,00	1,34
23	2,16	3,08	4,21	2,21	3,81	1,11
24	1,86	2,51	2,70	1,64	4,00	1,34
25	2,08	2,22	2,31	2,50	3,00	1,17
26	2,70	3,27	3,27	3,29	3,90	1,26
27	2,37	3,41	3,39	2,93	2,90	1,20
28	2,25	2,75	1,88	2,50	3,67	1,23
29	2,97	3,13	3,10	2,14	2,86	1,14
30	2,06	2,49	2,06	2,43	3,57	1,20
31	2,11	3,22	3,16	1,50	3,81	1,14
32	2,75	3,57	3,62	2,79	3,00	1,03
33	1,76	2,56	2,09	3,57	3,10	1,69
34	2,02	2,16	1,97	2,21	3,10	1,00
35	2,84	3,84	3,41	2,00	2,29	1,06
36	2,59	2,24	2,28	3,71	3,86	1,00
37	2,62	2,76	2,89	1,86	3,00	1,06

Appendix E Contin. of scores for the shops on the 6 lighting attributes factors

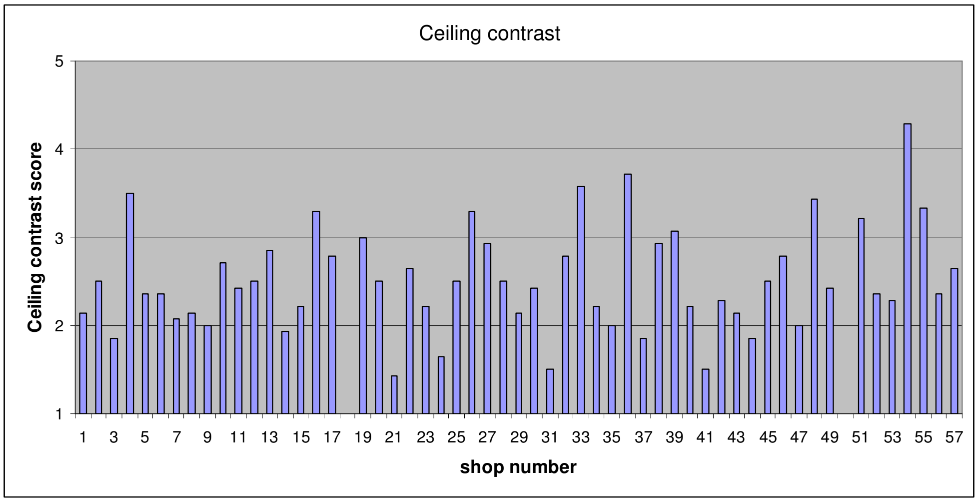
	Contrast	Brightess	Glare	Ceiling	Installation	Decorative
38	2,89	3,11	3,32	2,93	3,43	1,11
39	3,37	3,71	3,88	3,07	3,67	1,40
40	2,14	2,89	2,28	2,21	3,62	2,03
41	2,54	1,98	3,22	1,50	2,52	1,49
42	3,03	3,29	3,37	2,29	3,38	1,20
43	1,70	3,00	2,09	2,14	3,24	1,00
44	2,95	3,03	2,85	1,86	2,00	1,11
45	2,51	2,94	2,19	2,50	2,52	1,00
46	2,51	2,72	2,43	2,79	2,71	1,26
47	2,87	3,19	3,91	2,00	3,57	1,29
48	2,65	3,63	2,82	3,43	3,71	1,09
49	2,16	2,48	2,10	2,43	2,67	1,00
51	2,68	2,95	3,22	3,21	3,19	1,11
52	2,10	2,30	2,34	2,36	2,86	1,14
53	2,56	2,65	2,46	2,29	2,86	1,29
54	2,59	2,89	4,01	4,29	3,19	1,20
55	1,91	3,32	2,39	3,33	3,62	1,00
56	2,97	2,25	3,54	2,36	2,48	1,63
57	2,92	2,78	2,68	2,64	3,81	1,23

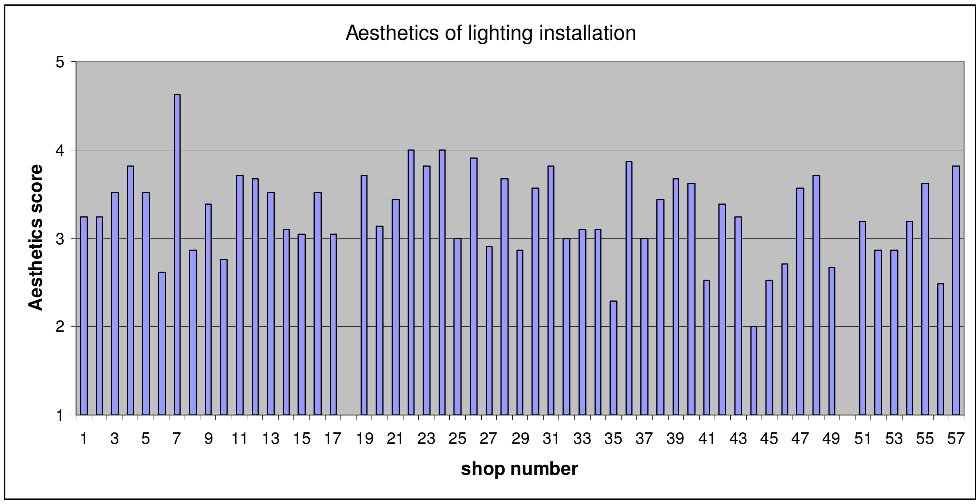
Appendix E Contin. of scores for the shops on the 6 lighting attributes factors

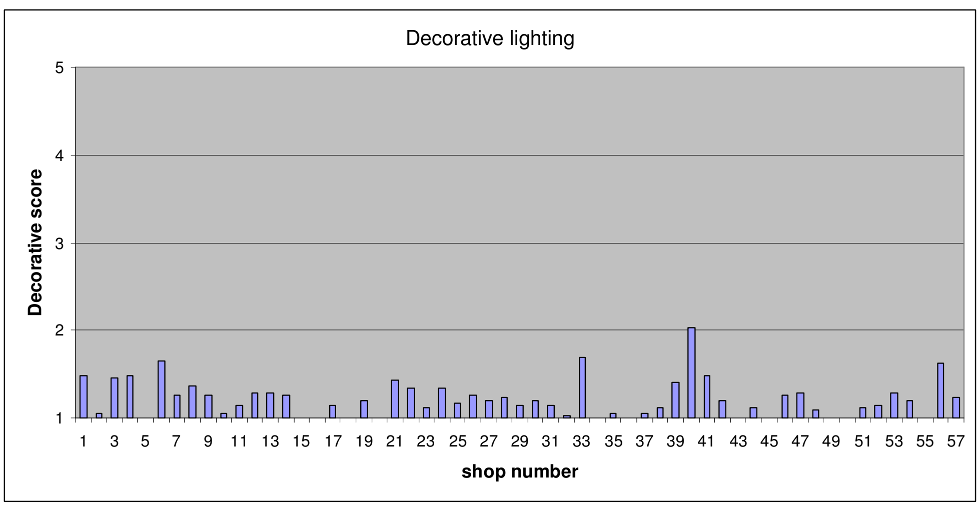




Appendix E Contin. of scores for the shops on the 6 lighting attributes factors







Appendix F Atmosphere terms and their translations

In table F.1 are displayed the atmosphere terms that were used by Vogels (2008), De Vries & Vogels (2007) and Van Erp et al. (2008) to quantify perceived atmosphere. Next to each word one can read the English translation. Please bear in mind that it is not always possible to find translations containing the exact same meaning. Therefore, these English translations should only be used as an indication of the meaning of the atmosphere words and certainly not for developing an English version of the atmosphere questionnaire.

Table F1. Atmosphere terms together with their English translations.

Atmosphere term	*Translation*	*Atmosphere term*	*Translation*
afstandelijk	*detached*	levendig	*lively*
beangstigend	*terrifying*	luxueus	*luxurious*
bedompt	*musty*	mysterieus	*mysterious*
bedreigend	*threatening*	ongedwongen	*uninhibited*
behaaglijk	*cosy*	ongemakkelijk	*uncomfortable*
beklemmend	*oppressive*	onrustig	*restless*
deprimerend	*depressed*	ontspannen	*relaxed*
enerverend	*exciting*	persoonlijk	*personal*
formeel	*formal*	romantisch	*romantic*
gastvrij	*hospitable*	ruimtelijk	*spatial*
geborgen	*safe*	rustgevend	*tranquil*
gemoedelijk	*pleasant*	saai	*boring*
gespannen	*tense*	sloom	*lethargic*
gezellig	*pleasant*	stimulerend	*stimulating*
inspirerend	*inspiring*	toegankelijk	*accessible*
intiem	*intimate*	vijandig	*hostile*
kil	*chilly*	vrolijk	*cheerful*
knus	*cosy*	warm	*warm*
koud	*cool*	zakelijk	*business*

Appendix G Atmosphere questionnaire

Figure G.1 displays the atmosphere questionnaire as it is used in the present study. The English translations of the scales from left to right are: 'absolutely not applicable', hardly applicable', 'not really applicable', 'neutral', 'slightly applicable', 'well applicable' and 'very well applicable'. The English translations of the atmosphere words can be found in Appendix F.

	Absoluut niet van toepassing	Nauwelijks van toepassing	Niet zo van toepassing	**Neutraal**	Enigszins van toepassing	Goed van toepassing	**Zeer goed** van toepassing
	-3	-2	-1	0	1	2	3
behaaglijk	0	0	0	0	0	0	0
beangstigend	0	0	0	0	0	0	0
kil	0	0	0	0	0	0	0
inspirerend	0	0	0	0	0	0	0
gemoedelijk	0	0	0	0	0	0	0
bedreigend	0	0	0	0	0	0	0
koud	0	0	0	0	0	0	0
levendig	0	0	0	0	0	0	0
geborgen	0	0	0	0	0	0	0
beklemmend	0	0	0	0	0	0	0
formeel	0	0	0	0	0	0	0
stimulerend	0	0	0	0	0	0	0
knus	0	0	0	0	0	0	0
gespannen	0	0	0	0	0	0	0
zakelijk	0	0	0	0	0	0	0
vrolijk	0	0	0	0	0	0	0
intiem	0	0	0	0	0	0	0
ongemakkelijk	0	0	0	0	0	0	0

Figure G.1. The atmosphere questionnaire as it is used in the present study

Appendix H Shops atmosphere scores

These tables provide for each shop an atmosphere factor score, which means that each number is the average score of the four or five atmosphere words (i.e. items) representing one of the four factors (i.e. F1, F2, F3 or F4), averaged over six participants.

F1: Coziness F2: Liveliness F3: Tenseness F3: Detachment

Shop	F1	F2	F3	F4
1	-0,67	1,25	-1,80	-1,83
2	-0,47	-0,38	-1,97	0,04
3	0,00	0,38	-1,97	-1,00
4	-0,33	0,50	-1,83	-1,29
5	-0,20	0,79	-2,13	-1,67
6	1,20	-0,46	-1,73	-0,96
7	0,47	0,96	-2,33	-1,96
8	-0,33	0,50	-2,13	-1,71
9	0,07	0,04	-1,83	0,04
10	-0,10	-0,08	-1,67	-1,08
11	-0,43	0,50	-1,27	-1,58
12	0,43	1,42	-2,03	-2,04
13	-0,10	0,79	-1,40	-1,63
14	1,00	-0,46	-1,50	-0,21
15	0,33	0,75	-1,80	-1,63
16	0,53	-0,46	-1,20	0,21
17	-0,77	0,63	-0,83	-1,96
19	-0,90	-1,00	-0,83	0,42
20	1,50	0,46	-2,13	-1,67
21	-0,80	0,21	-0,83	-1,00
22	-0,60	0,42	-1,43	-1,08
23	-1,33	0,50	-0,23	-1,88
24	0,40	0,25	-2,50	-0,17
25	-0,63	-1,17	-1,30	-0,67
26	-0,53	0,50	-2,10	-1,17
27	-0,70	0,75	-1,20	-1,88
28	0,13	-0,67	-2,00	-0,38
29	-0,53	-0,71	-1,47	-0,38

Shop	F1	F2	F3	F4
30	-0,13	-0,71	-1,67	0,38
31	-0,63	-0,33	-1,27	0,83
32	-0,60	-0,58	-1,63	0,00
33	-1,03	-1,58	-1,43	-0,29
34	-0,03	-0,08	-2,17	-2,13
35	-0,83	-0,21	-1,37	-0,25
36	-0,17	0,17	-2,20	-1,50
37	0,50	1,29	-1,83	-1,17
38	-0,73	-1,21	-1,20	0,21
39	-0,77	0,58	-1,60	-1,38
40	-0,57	-0,63	-1,30	0,17
41	0,57	0,79	-1,97	-1,67
42	-0,70	-0,75	-1,60	0,46
43	-1,30	-1,13	0,00	0,88
44	0,83	1,04	-1,53	-2,21
45	0,27	0,08	-2,20	-1,58
46	0,47	1,08	-2,20	-2,13
47	-0,40	0,50	-1,30	-1,71
48	-0,43	0,21	-1,37	-1,88
49	-0,23	-0,79	-1,83	-0,75
51	0,67	1,13	-2,53	-1,92
52	0,17	0,04	-1,90	-1,88
53	0,40	-0,75	-1,70	-0,79
54	-0,77	-0,71	-1,67	0,29
55	-0,23	-0,42	-1,60	0,04
56	-0,10	1,67	-1,70	-2,00
57	0,00	-0,08	-1,93	-0,13

On the following page for each shop an indication is given whether it scored below or above average.

Appendix H Continuation of shops atmosphere scores

This table displays the scores of the shops relative to the average score of all shops.

Criteria:

- '-' means the shop scores below average
- '+' means the shop scores higher than Average

  - F1: Cozy
  - F2: Liveliness
  - F3: Tenseness
  - F4: Detachment

Shop	F1	F2	F3	F4
1	-	+	-	-
2	-	-	-	+
3	+	+	-	-
4	-	+	-	-
5	-	+	-	-
6	+	-	-	-
7	+	+	-	-
8	-	+	-	-
9	+	-	-	+
10	+	-	-	-
11	-	+	+	-
12	+	+	-	-
13	+	+	+	-
14	+	-	+	+
15	+	+	-	-
16	+	-	+	+
17	-	+	+	-
19	-	-	+	+
20	+	+	-	-
21	-	+	+	-
22	-	+	+	-
23	-	+	+	-
24	+	+	-	+
25	-	-	+	+
26	-	+	-	-
27	-	+	+	-
28	+	-	-	+
29	-	-	+	+

Shop	F1	F2	F3	F4
30	+	-	-	+
31	-	-	+	+
32	-	-	-	+
33	-	-	+	+
34	+	-	-	-
35	-	-	+	+
36	+	+	-	-
37	+	+	-	-
38	-	-	+	+
39	-	+	+	-
40	-	-	+	+
41	+	+	-	-
42	-	-	+	+
43	-	-	+	+
44	+	+	+	-
45	+	+	-	-
46	+	+	-	-
47	-	+	+	-
48	-	+	+	-
49	-	-	-	+
51	+	+	-	-
52	+	-	-	-
53	+	-	-	+
54	-	-	-	+
55	-	-	+	+
56	+	+	-	-
57	+	-	-	+

Appendix H Continuation of shops atmosphere scores