Light and the Perception of Safety, Cleanliness and Ambience at Train Stations

Final thesis report

Martijn Vos – April 2015

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For quality of life

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Abstract

Service oriented companies, such as railway operators, are becoming more aware of the importance of customer experience. Customer experience is for railway operators, such as Netherlands Railways, becoming an important element of the evaluation of their performance. Light turned out to be an environmental characteristic which influences the customer experience on train stations. Therefore, this study focusses on the relation between light and the experience of travellers on train stations. Light was measured by the concepts illuminance (lux) and light colour temperature (kelvin). Customer experience was defined as the perception safety, cleanliness and ambience. In addition, the concepts goal- orientedness (commuting versus social recreational) and density were included as variables with a possible intervening effect. The relation between light and the perception of safety, cleanliness and ambience was investigated by a literature study and an experiment. The experiment was executed on a virtual replication of the train station of Amersfoort. 280 persons participated in the experiment by executing an assignment and filling out a questionnaire. Evidence collected from literature was used to formulate hypotheses which were tested by performing experiments on the virtual train station. It turned out that the concepts perceived safety and cleanliness were significantly influenced by the illuminance level, whereas light colour temperature had a significant effect on the perception of ambience. In addition, gender and familiarity with the train station were also found to be significantly related to the perception of safety, cleanliness and ambience. The concepts goal- orientedness and density turned out to have no significant intervening effect. The general conclusion is that railway operators should make a distinction between functional and ambient lighting in relation to areas in which people move (e.g. station hall, stairs) and in which people stay (platform). Moreover, it is important to mention that railway operators need to take into account the possible (social) implications of lighting (e.g. lighting vs. cleaning budgets).

Keywords: customer experience, train stations, railway operators, light, illuminance, light colour temperature, safety, cleanliness and ambience.

Summary

Service oriented companies, such as railway operators, are becoming more aware of the importance of customer experience. Customer experience is for railway operators, such as Netherlands Railways, becoming an important element of the evaluation of their performance. Light turned out to be an environmental characteristic which influences the customer experience on train stations. Therefore, this study focusses on the relation between light and the experience of travellers on train stations. Light was measured by the concepts illuminance (lux) and light colour temperature (kelvin). Customer experience was defined as the perception safety, cleanliness and ambience. In addition, the concepts goal- orientedness (commuting versus social recreational) and density were included as variables with a possible intervening effect. The following research question was formulated: ‘’what is the relation between illuminance and light colour temperature on the one hand and perceived safety, cleanliness and ambience by travellers on train stations on the other?’’.

Methods

Evidence collected from literature was used to formulate hypotheses which were tested by performing experiments on the virtual train station. Three illuminance levels (75, 150 and 225 lux) and two light colour temperatures (3000K and 5000K) were tested. The participants (N = 280) were asked to open the virtual train station on their PC and fulfil an assignment (e.g. catch the train to Amsterdam). The sample was mainly consisting of students of which 44.9% were male and 55.1% female. The average age was 20.63 years (SD = 5.78, minimum 16, maximum 62 years). The data gathered at the virtual train station was analysed with analyses of descriptive statistics, analysis of variance (ANOVA) and multiple analysis of (co)variance (MAN(C)OVA).

Literature

Based on literature the conclusion was drawn that a higher illuminance level leads to a more positive perception of safety and cleanliness. A place will be experienced as more ambient when a low illuminance level is employed. It seems that the illuminance level of light has a comparable effect on the perception of safety and cleanliness. A more positive perception of ambience can be created by employing a lower illuminance level. Based on literature the conclusion was drawn that a lower light colour temperature (cold) leads to a more positive perception of safety and cleanliness. Whereas a higher (warm) light colour temperature leads to a more positive perception of ambience. The concept of goal- orientedness was translated into the concept of must (utilitarian) and lust travellers (hedonic). Based on literature the assumption is made that must travellers perceive the train station as safer and less clean. The train station will, in addition to that, be perceived as more ambient by lust travellers. According to literature are lust travellers more receptive for environmental stimuli. Based on this literature study the assumption was made that a higher density level leads to a more negative perception of the perception of safety. There was no evidence available in literature on the relation between density and the perception of cleanliness. However, the assumption was made that a high density level is positively influencing the perception of cleanliness. In addition, the assumption was made that a high density level leads to a negative perception of ambience. Whereas high density (to a certain extent) in for example restaurants or a disco is perceived as ambient, will a comparable density level be perceived as non- ambient on a train station.

Results

It turned out that, as found in literature, comparable results were found for safety and cleanliness. The perception of safety and cleanliness can be influenced positively by employing a high illuminance level on the train station. A warm light colour temperature can be used to influence the perception of ambience in a positive way. In addition, light colour temperature turned out to be also significantly related to the general score of the train station. Warm light colour temperature lead to a higher general score. Finally, there were no significant intervening effects found for the variables goal- orientedness and density.

Conclusions and recommendations

The main conclusion is that there is no unique light setting (e.g. warm light colour temperature, combined with a high light intensity) which is able to positively influence the perception of safety, cleanliness and ambience as a whole. Illuminance is related to safety and cleanliness and light colour temperature to ambience. In addition, gender and familiarity with the train station where also found to have important impact on the perception of safety, cleanliness and ambience. Based on this conclusions, railway operators should make a distinction between functional and ambient lighting in relation to areas in which people move (e.g. station hall, stairs) and in which people stay (platform). Finally, railway operators also need to take in account the possible social implications of lighting (e.g. lighting versus cleaning budgets).

Samenvatting (Dutch)

Service gerichte bedrijven, zoals spoorwegmaatschappijen, worden zich steeds meer bewust van het belang van beleving. De rol van beleving in de beoordeling van spoorwegmaatschappijen, zoals de Nederlandse Spoorwegen (NS), wordt steeds groter. Licht is een belangrijk aspect van de ruimtelijke omgeving die een grote invloed kan hebben op de beleving van reizigers op het treinstation. Om deze reden, richt dit onderzoek zich op de relatie tussen licht en beleving op het trein station. Licht is gemeten met behulp van de concepten lichtsterkte (lux) en licht kleur temperatuur (kelvin). Beleving is gedefinieerd als de perceptie van veiligheid, reinheid en ambiance. Daarnaast, zijn de variabelen motivationele oriëntatie (forens versus sociaal recreatief) en drukte meegenomen als variabelen met een mogelijk interveniërend effect. De volgende onderzoeksvraag is geformuleerd: ‘’wat is de relatie tussen lichtsterkte en licht kleur temperatuur aan de ene kant en de perceptie van veiligheid, reinheid en ambiance aan de andere kant?’’.

Methoden

De resultaten van de literatuurstudie is gebruikt om een aantal hypothesen te formuleren. De hypothesen zijn getest met behulp van experimenten op een virtueel treinstation. Drie lichtsterktes (75, 150 en 225 lux) en twee licht kleur temperaturen (3000K en 5000K) zijn getest. De deelnemers (N = 280) werden gevraagd om het virtuele station te openen op een computer en een opdracht uit te voeren (bijvoorbeeld: pak de trein naar Amsterdam). De steekproef bestond voornamelijk uit studenten (44.9% man en 55.1% vrouw). De gemiddelde leeftijd was 20.63 jaar (SD = 5.78, minimum 16, maximum 62 jaar). De data verzameld op het virtuele treinstation is geanalyseerd met behulp van analyse van descriptive statistics, analysis of variance (ANOVA) en multiple analysis of (co)variance (MAN(C)OVA).

Literatuur

Op basis van literatuur is de conclusie getrokken dat een hogere lichtintensiteit leidt tot een positievere perceptie van veiligheid en reinheid. Daarnaast kan de perceptie van ambiance positief worden beïnvloed door een lagere lichtintensiteit. Het is gebleken dat er in de literatuur vergelijkbare effecten worden beschreven voor de perceptie van veiligheid en reinheid. Voor licht kleur temperatuur is de conclusie getrokken dat een koude licht kleur temperatuur leidt toe een positievere perceptie van veiligheid en reinheid. Waar een warme licht kleur temperatuur leidt tot een positievere perceptie van ambiance. Het concept motivationele oriëntatie is vertaald naar het concept van must (utilitair) en lust (hedonisch) reizigers. Op basis van literatuur is de aanname gedaan dat must reizigers het treinstation over het algemeen als veiliger en minder schoon ervaren. Waar lust reizigers een positievere perceptie van ambiance hebben op het treinstation. Tenslotte is op basis van de literatuur de aanname gedaan dat meer drukte leidt tot een negatieve perceptie van veiligheid. Er was onvoldoende bewijs in de literatuur voor een relatie tussen drukte en reinheid. Daarom is de aanname gedaan dat meer drukte leidt tot een positievere perceptie van reinheid, simpelweg omdat vuil niet wordt opgemerkt. De perceptie van ambiance wordt negatief beïnvloed door meer drukte. Belangrijk om daarbij op te merken is dat voor drukte geldt dat het effect sterk afhankelijk is van de setting. Waar een hoge drukte in een restaurant of disco een positief effect heeft op de perceptie van ambiance, is het tegenover van toepassing op het treinstation.

Resultaten

Het is gebleken dat, als beschreven in de literatuur, vergelijkbare resultaten zijn gevonden voor veiligheid en reinheid. De perceptie van veiligheid en reinheid kan positief worden beïnvloed door toepassing van een hoge lichtintensiteit op het treinstation. Een warme licht kleur temperatuur kan worden gebruikt om de perceptie van ambiance positief te beïnvloedden. Daarnaast is gebleken dat licht kleur temperatuur ook een significante relatie heeft met het algemene oordeel over het treinstation. Een warme licht kleur temperatuur leidt tot een hogere score. Tenslotte, zijn er geen interveniërende effecten gevonden voor de variabelen motivationele oriëntatie en drukte.

Conclusies en aanbevelingen

De algemene conclusie van deze studie is, dat er niet iets bestaat als een unieke licht instelling (bijvoorbeeld: warme licht kleur temperatuur gecombineerd met een hoge lichtintensiteit) die de perceptie van zowel veiligheid als reinheid en ambiance kan beïnvloedden. Lichtintensiteit kan worden gebruikt om de perceptie van reinheid en veiligheid te beïnvloedden. Licht kleur temperatuur kan worden gebruikt om ambiance te beïnvloedden. Daarnaast is gebleken dat geslacht en bekendheid met het station ook een belangrijke relatie hebben met de perceptie van veiligheid, reinheid en ambiance Op basis van deze bevindingen wordt spoorwegmaatschappijen aanbevolen om een onderscheid te maken tussen functionele en ambiance verlichting. Het onderscheid moet worden gemaakt in relatie tot gebieden waar mensen zich verplaatsen (bijvoorbeeld: stationshal, trappen) en waar mensen verblijven (perron). Tenslotte, is het belangrijk dat spoorwegmaatschappijen zich bewust zijn van de mogelijke sociale gevolgen van licht (bijvoorbeeld: licht versus schoonmaakbudgeten).

Foreword

L.S.,

This journey started on Friday 20 september 2013 with a guest lecture of Mark about his work at Netherlands Railways as part of a course at Wageningen University. A few months later I started orientating on possible thesis subjects. I knew that I wanted to learn more about the way in which behaviour of people can be influenced and shaped by space. After orientating at different organisations and thesis topics I ended up at Mark, NS (Netherlands Railways) and more specific the department MOA (Marktonderzoek en Advies – Marketresearch and consulting) doing this thesis research project! As a student in the field of facility management (FM) I was used to look at space from a rather managerial perspective. During the past few months at NS I have learned that the way in which people behave and perform is also determined by less hard qualities such as experience and comfort. In my opinion, most facility managers are aware of this, but they do not have the experience or skills to influence the soft aspects of space. With this thesis project I hope to contribute to a further development of the understanding of space in its broadest sense.

I would like to thank a couple of persons who contributed to the establishment of this thesis project. First of all I would like to thank Mark, my first supervisor of NS, for his support, humorous approach and the trust and freedom he granted me in the past few months. I would like to thank my second supervisor of NS, Sacha, for her enthusiasm and support. In addition to that I would like to thank my first supervisor of the WUR, Mark, for his critical view, encouragement and nice talks about many different topics. I would also like to thank Herman, my second supervisor of the WUR, for his infectious enthusiasm and feedback on my empirical work. Thanks guys, I enjoyed working with you. Without you I would not have been able to reach this result!

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Despite some minor setbacks during the empirical phase, I am really proud of the final product! Enjoy reading and feel free to contact me anytime for any questions regarding this project.

Best regards,

Martijn Vos
Wageningen, March 31st

Reading guide

This thesis consists of six chapters. The first one addresses the introduction of this study by describing the background and research design. The second chapter contains the theoretical framework, in which every paragraph is dedicated to one of the concepts (e.g. illuminance, safety and density). The third and fourth chapter contain the methods and results of the empirical phase. The conclusions and recommendations will be discussed in chapter five and the discussion is addressed in final chapter six.

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1. Introduction

NS (Nederlandse Spoorwegen- Netherlands Railways) is the principal passenger railway operator in the Netherlands, daily handling more than a million passengers. The annual turnover of NS is approximately 4.6 billion euro. NS consists of several independent subsidiaries, among which are NS Reizigers and NS Stations. NS Reizigers is mainly responsible for the domestic transport of passengers. The train stations and its environment are owned and maintained by NS Stations. This thesis is commissioned by NS Reizigers and more specifically the department MOA (Marktonderzoek en Advies – Marketresearch and consulting). MOA is a customer focused multimodal European service provider that focuses on the areas, strategic concept development, transport research and consumer research. Besides NS reizigers and NS in general, MOA is working for external clients, including the Dutch Ministry of Infrastructure and Environment. This study focusses on the use of lighting on train stations in order to influence perceived safety, cleanliness and ambience of travellers. The empirical part of the study will be performed on a train station that is simulated in virtual reality.

1.1 Background

This first paragraph is used to describe the background and relevance of this thesis project. In addition to that, the different concepts related to light and the traveller experience will be introduced.

1.1.1 Traveller experience

In the past few decades customer oriented companies are becoming more aware of the importance of the customer experience. This is in line with the development of the experience economy, often shortened to Exponomy (Pine & Gilmore, 1998), which is described as the next economy following the service, industrial and agricultural economy. Pine and Gilmore (1998) argue that businesses should offer memorable events to their customers that will become a product or service itself. The concept of the Exponomy is originally born in the field of business and has spread to health care, tourism and urban planning. Also for the rail sector, the Exponomy is becoming more important. The experience of the customers can be defined by the pyramid of customers need (Van Hagen, 2011).

Van Hagen, Peek and Kieft (2000) developed the pyramid of customer needs (figure 1), in which they divided the customer needs into five different dimensions. Safety and reliability are preconditions for the train station and are a foundation of the pyramid of customer needs. Safety refers to social safety and is an absolute prerequisite for the functioning of the train station as a public space. Reliability refers to the extent in which travellers receive what they expect to receive from the railway operator. Speed is the most important customer need. In general customers would like to get from A to B as quick as possible. If this need is fulfilled, the transfer needs to be easy and the train station needs to have a good overview and adequate signage. After that, the customers expect that there is enough physical comfort, such as

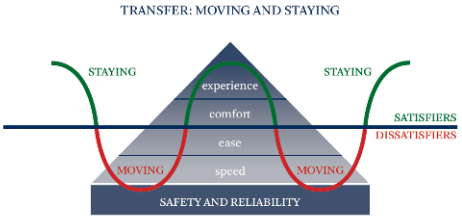

Figure 1: Pyramid of customer needs (Van Hagen, 2011)

facilities but also sheltered waiting- and sitting areas. Finally, the customers wants to have a pleasant experience. Experience is a broad concept. In this context it refers to the visual aspects, such as design, neatness and colours. But also the less tangible environmental variables such as light, odour and music are able to contribute to the pleasantness of the experience. It is possible to divide the customer needs into dissatisfiers and satisfiers (Herzberg, Mausner and Snyderman, 1959). Safety, reliability, speed and ease are dissatisfiers, which means that they negatively influence the customer satisfaction when they are insufficient or not present. Since the dissatisfiers are preconditions for the functioning of a public place, they will not positively influence the customer satisfaction when they are present. Travellers expect a train station to be safe, therefore will a safe train station not lead to a more positive evaluation. Comfort and experience are satisfiers. They will positively influence the customer satisfaction when they are present. Absence of the satisfiers will not lead to a more negative evaluation of the train station. Satisfiers are generic, which means that they apply to all travellers to the same extent and it is not possible to segment the travellers based on those quality aspects. The pyramid of customer needs (figure 1) applies in reverse when travellers stay on the train platform. Safety and reliability are still basic requirements but comfort and experience are becoming more important. In general, travellers appreciate the aspects speed and ease as more important than the experience and comfort of the trip. Based on the model we can assume that travellers appreciate a safe and fast trip more than a luxurious but slow trip. However it should be noted that the model uses average figures. In practice it is possible to make a distinction between travellers based on their motivational orientation. Van Hagen (2011) developed the concept of must and lust travellers, which is based on the theory of utilitarian and hedonic consumers (Batra & Ahtola, 1990). Must travellers are often commuters who travel to their work or school. This group of travellers is goal oriented and attach more value to a quick and easy trip than lust travellers. Lust travellers are travellers with a social recreational motive, who travel about 1 to 3 days per month. Lust travellers find comfort and experience in general more important. Besides the distinction between goal- oriented and less goal oriented travellers, density can influence the experience of travellers at train stations as well (Vos, 2013; Peters, 2008; Van Hagen, 2011). The concepts goal- orientedness and density will be discussed more extensively in chapter 2.3 and 2.4. The concept light, in relation to human behaviour, will be introduced in the following paragraph.

Railway operators are aware of the effects that the environment can have on their customers. Several studies are performed in order to evaluate the use of colour & light, music, advertising & infotainment at train platforms and stations in general (Van Hagen, Pruyn, Galetzka & Kramer, 2009; Van Hagen, Pruyn, Galetzka & Sauren, 2010; Van Hagen 2011; Boes, 2007; Vos, 2013). Light turned out to have an important effect on the level of arousal of travellers. In general travellers experience too many light stimuli as negative and have a preference for dimmed light while waiting on the platform (Berlyne, 1971). It is however again important to make a distinction between must and lust travellers. Must travellers prefer a higher light intensity than lust travellers. Since must travellers are making up the majority during peak hours, Van Hagen (2011) proposes to use a high light intensity during peak hour in order to keep must travellers alert while getting on and off the train. A lower light intensity level can be applied during off-peak hours, when the lust travellers make up the majority on the platform. The relation between light and human behaviour is not only relevant for the rail sector, in many other sectors similar research is performed, for example in health care (Dalke et al., 2006), education (Wessolowski, Koenig, Schulte-Markwort & Barkmann, 2014) and an office environment (Ne'eman, Sweitzer & Vine, 1984). One of the main conclusions is that

light is essential and therefore needs to be taken in account when designing and creating space. In the following paragraph, the concept light will be unravelled and a deliberate choice will be made for multiple concepts that define and measure light.

1.1.2 Defining light

Light is the part of the spectrum visible for the human eye, with a wavelength that is approximately situated between 380 and 780 nanometre (Webb, 2006). In relation to the environment, light is considered to be an ambient environmental element. Galetzka, de Vries, Hulshof and Koeman (2012) describe ambient environmental elements as: ‘’*The effects that the use of colour, music, lighting, and sound has on consumer behaviour. Atmospherics is a concept from the environmental psychology and refers to environmental factors that can influence consumer evaluations and behaviours”.* There are different concept that can be used to define and measure light. In the following paragraphs the use and purpose of lumen, lux, candela, kelvin and the colour rendering index (Boyce, 2003).

1. Lumen

One of the ways to measure and express the illuminance of a light source is by using lumen (lm). Lumen expresses the amount of light radiated by a light source per unit of time. Since there is a difference between the amounts of light perceived and the amount of light radiated by a light source, the unit lumen is not really useful to study the influence of light on human behaviour. The unit lux solves this issue.

2. Lux

Lux (lx) is a second and most common method to express the illuminance of a light source (Peters, 2008). In contrast to lumen, lux measures the amount of incident light per square meter. This is the amount of light that is actually perceived. The units’ lux and lumen are related: one lux equals one lumen per square meter.

3. Candela

Candela (cd) means candle in Latin and corresponds to the illuminance level of a regular candle. The unit candela expresses the lux level of a light source on a distance of one meter. Candela does not refer to the amount of light that is radiated by a light source. In order to illustrate, the candela level of a lamp will increase when a reflector or lens is used. By using a reflector or lens, the illuminance level will increase because the light is bundled.

4. Kelvin

Kelvin (K) is used to express the colour temperature of a light source. The colour temperature spectrum consists of two extremes, namely, warm red light with long wavelengths on one side and cold blue light with short wavelengths on the other side. White daylight is situated in the middle of the spectrum. A high kelvin value refers to a blue and cool light colour temperature, warmer light that tends to the red colours on the spectrum have a lower kelvin value. The temperature of light usually varies between 3000K (warm) and 6000K (cold). In order to illustrate, a candle has a kelvin value of 1200K, a fluorescent lamp has a value of 4000K and daylight reaches up to 5500K.

5. Colour Rendering Index (CRI)

Whereas kelvin only measures the light colour temperature which is radiated by a light source, the colour rendering index (CRI) measures the way in which the colours of an object appear influenced by light (Hebert, Peek & Kang 2013). A colourful painting will look different when it is lit with an incandescent lamp than when it is lit with a fluorescent lamp. Daylight has a CRI of 100 and is used as a standard for comparison with other light sources, the higher the CRI (based on a scale of 0 to 100), the more natural the colours appear to be. An incandescent lamp scores 97 to 100 on the CRI whereas the score of a fluorescent lamp ranges between 52 and 90 on the CRI.

Since not all concepts can be applied in virtual reality, it is necessary to make a deliberated choice for one or multiple light concepts that will be employed in this study. There are three international metric units that measure illuminance, namely, lumen, lux and candela (Boyce, 2003). The unit lumen is not really useful for studies that assess the relation between light and human behaviour. The lumen level is not depending on its surroundings since it is only measuring the amount of light that is radiated by a light source. Measurability of lumen is the major drawback of the concept. When for example 100 lumen is used, it is hard and probably not possible to determine which illuminance level is perceived by the participants. The concept lux solves this issue by measuring the amount of light that is radiated on a certain surface or object (Wulfinghoff, 1999). The concepts lumen and lux are related. One lux equals one lumen per square meter, the lux level decreases when the distance from the light source increases. Candela, the third concept, is a rather complex concept that is hard to measure in the virtual environment. Candela is measuring the distance that light from a certain luminaire travels through the space. The concept candela will not be used since it is not measurable in the virtual environment in relation to human behaviour. It is possible to simulate a certain light colour temperature by using the concepts kelvin and the colour rendering index. Studies that focus on light are often assessing the illuminance as well as the light colour temperature of light (for example Deguch & Stato, 1992; Quartier, Vanrie & Cleempoel, 2014), since the concepts are closely related to each other. Whereas kelvin measures the colour temperature of a light source, the colour rendering index focusses on the appearance of objects influenced by light, for example a painting or a screen with travel information. Since this study focusses on the perception of travellers who are visiting a train station, is it much more convenient to use the unit kelvin that measures the colour temperature of a light source instead of the influence that light has on the colours of a single object. Summarized, the concepts lumen, candela and colour rendering index will not be used during this study due to reasons related to measurability and visibility. The concepts that will be used are lux (described as illuminance) and kelvin (described as light colour temperature). The concept lux is chosen since it measures the actual amount of light that is radiated on a certain surface, instead of the total amount radiated (lumen) or the distance that light travels through space (candela). Besides that, lux is the most convenient to measure in virtual reality. The concept kelvin is used because of its measurability in virtual reality. In contrast to the concept colour rendering index, kelvin is measuring the actual colour temperature of light instead of the way in which the colours of an objects appear under the influence of light. This line of arguments was confirmed by Wessolowski et al. (2014), who described illuminance (lux) and light colour temperature (kelvin) as the most important features of light when it comes to human perception.

1.1.3 Light and virtual reality

The empirical part of this study consists of a number of experiments in virtual reality. A valid question that one can ask is whether the results obtained in the virtual environment are applicable to the physical environment. The main advantage of executing experiments on a virtual instead of a real station is that it is possible to collect a lot of data in a relatively short period of time. The ecological validity of virtual environments is shown by several studies (Blasovich et al., 2002; Van Hagen, 2011; Kardes, 1996). Van Hagen (2011) performed experiments in a virtual environment as well as in the field. It turned out that the manipulations in the virtual environment were successful in order to allow effects with colour, light, density and time pressure. The following paragraph is dedicated to the relation between light and the traveller experience.

1.1.4 Light and the traveller experience

Light is seen as a basic requirement for human beings that for an important part determines health, wellbeing and alertness (Van Bommel & Van den Beld, 2004; Fleischer, Krueger & Schierz, 2001). In addition to that, Custers, De Kort, IJsselsteijn and Kruiff (2010) found that light is able to influence spatial impressions and perceived atmosphere. One of the goals of NS (2012), is: *'to transport more passengers safely, on time and comfortably via appealing railway stations every year''*. The extent to which a railway station is appealing or not, is largely determined by spatial impressions and more specifically the lighting conditions which are employed on the railway station (Summers & Hebert, 1999). The attractiveness of the NS railway stations is evaluated on a regular basis. The spatial impression and experience of travellers is one of the measured items. De Bruyn and De Vries performed in 2009 a factor analysis (N=4157) in 2009, in order to define the traveller experience. It turned out that the experience of travellers can be divided into two parts. The first part is a basic experience that focuses on safety and cleanliness, the second part focuses on facilities and a pleasant environment. Kotler (1973) describes a pleasant environment as a physical surrounding that is having ambience. The experience of travellers on train stations is in this study is therefore defined as the perception of safety, cleanliness and ambience. It is essential for a rail operator like NS that the customer experience is translated into an environment that suits the needs and expectations of all travellers, although not every consumer has the same needs during the consumption of a service (Van Hagen, 2011). As mentioned earlier is it possible to make a distinction between travellers by using the concept of must and lust travellers. Must travellers are mostly commuters who regularly travel by train. For them, time and goal- orientedness are essential. Lust travellers on the other hand incidentally travel by train and attach more value to comfort and convenience of the trip. Since these needs of those two customer groups are significantly different, it is needed to make a distinction between them during this study. In addition to goal- orientednes, density is also influencing the experience of travellers. Density is often referred to as the perception of crowding. This is described as the psychological frame of mind in which demand for space is greater than available space (Stokols, 1972). In contrast to goal- orientedness and the perception of safety, cleanliness and ambience, density is not a behavioural characteristic but a rather spatial one. The different variables described in this paragraph will be treated more extensively in chapter two. The conceptual and technical research design will be discussed in paragraph 1.2 and 1.3.

1.2 Conceptual research design

The second paragraph of this chapter will provide a description of the broad context of the research area and how this relates to the research objective. The chapter consists of three subparagraphs that describe the problem statement, research objective and research questions.

1.2.1 Problem statement

The following problem statement is formulated: *the Dutch rail sector has no empirical evidence that underlines the relation between light on the one hand and perceived safety, cleanliness and ambience on the other hand*. The empirical evidence will be used to apply interventions on train stations in order to improve the perceived safety, cleanliness and ambience. In addition to that it will be useful to measure the effects of the interventions in a real life situation. Perceived safety and cleanliness are currently measured in the annual customer satisfaction survey of NS (2012). In 2012, 56% of the travellers' evaluated cleanliness higher than seven, on a scale from zero to ten, safety was evaluated higher than seven by 78% of the travellers. Ambience is described in the annual customer survey as general customer experience, 74% of the travellers evaluated the customer experience higher than seven. The perceived safety, cleanliness and ambience might be improved by adjusting the illuminance and light colour temperature.

1.2.2 Research objective

The main purpose of this master thesis is *to gain insights into the influence of light on the perceived safety, cleanliness and ambience of travellers on train stations. In addition to that the role of goal- orientedness and density will be assessed.* When building and renovating train stations, NS uses walking and colour plans. There are however no standard sound or light plans available. Therefore, the second main goal of this thesis is to create a standard light plan that can be used by Dutch rail companies when building and renovating train stations. The broader purpose of this research project is to contribute to the development of attractive train stations with customer services that positively contribute to the customer satisfaction.

1.2.3 Research questions

Based on the problem analysis and the research objective the following research question is formulated: *What is the relation between illuminance and light colour temperature on the one hand and perceived safety, cleanliness and ambience by travellers on train stations on the other?*

The research question can be divided into several sub-questions that address the dependent factors perceived safety, cleanliness and ambience. The sub-questions will be answered by studying literature and performing experiments and contribute to the conclusion of the main research question. Based on the central research question above, the following sub-questions are formulated:

Safety:

- What is the relation between illuminance and light colour temperature on the one hand and perceived safety by travellers at train stations on the other?

- What is the relation between density and perceived safety by travellers at train stations?
- What is the relation between goal- orientedness and perceived safety by travellers at train stations?

Cleanliness:

- What is the relation between illuminance and light colour temperature on the one hand and perceived cleanliness by travellers at train stations on the other?
- What is the relation between density and perceived cleanliness by travellers at train stations?
- What is the relation between goal- orientedness and perceived cleanliness by travellers at train stations?

Ambience:

- What is the relation between illuminance and light colour temperature on the one hand and perceived ambience by travellers at train stations on the other?
- What is the relation between density and perceived ambience by travellers at train stations?
- What is the relation between goal- orientedness and perceived ambience by travellers at train stations?

1.3 Hypotheses

In the third paragraph the hypotheses will be presented and substantiated by using scientific literature. The substantiation of the hypotheses is short, a more extensive literature review can be found in chapter two. This paragraph is created in order to give an impression of the hypotheses that are going to be assessed in the empirical part of this study. The different hypotheses and relationships were visualized, below in figure 2. Hypothesis 11 (grey line, figure 2) is not supported sufficiently by literature. Therefore assumptions are made, these assumptions will be tested in the empirical phase of this study. The black lines represent relationships and hypotheses that are fully substantiated by literature. The dotted lines represent the relationships that are expected to be intervening. More evidence for confirmation of this assumption will be collected by performing statistical analysis.

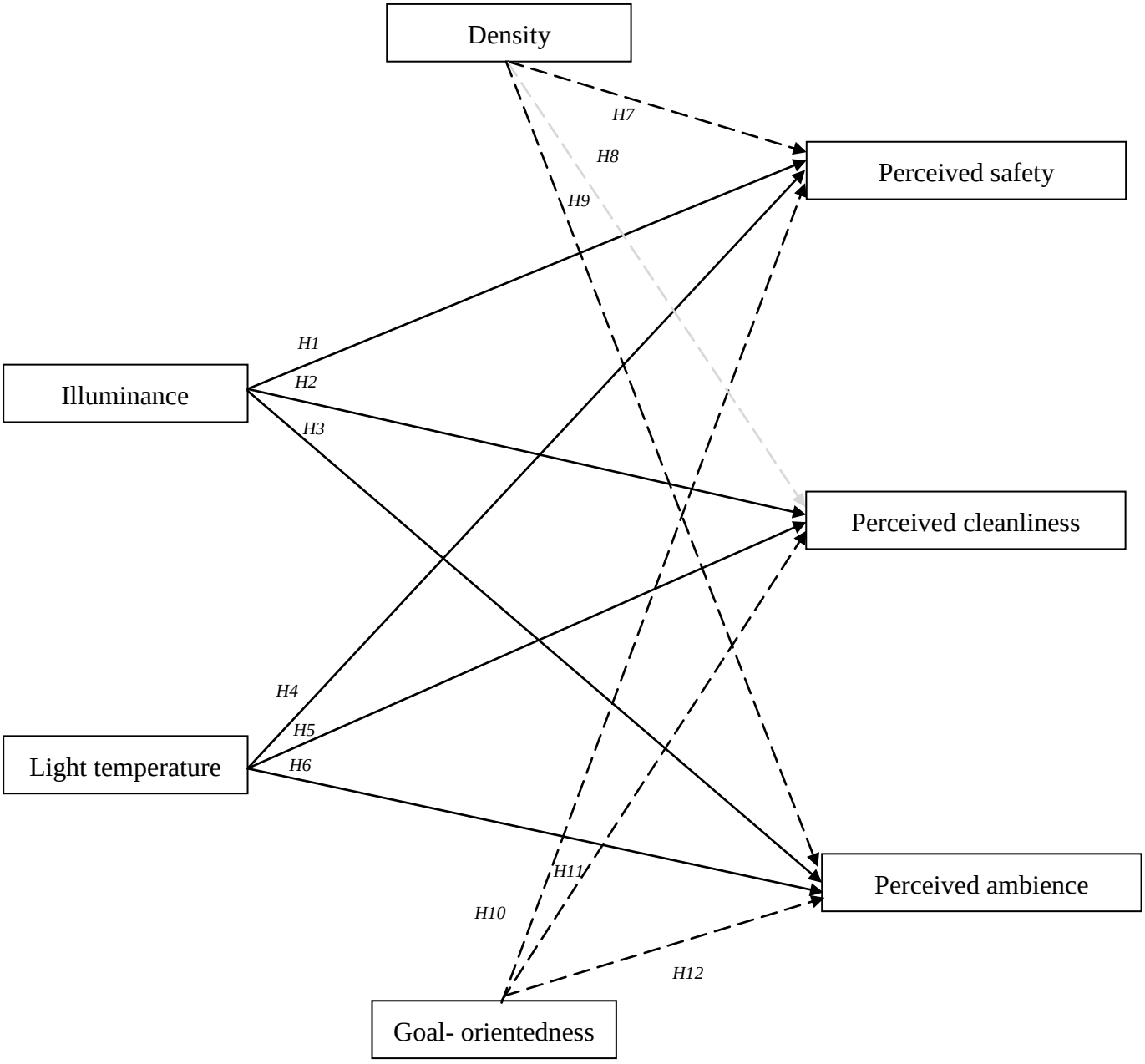

Figure 2: Visualization of hypotheses

1.3.1 Illuminance

Below, three different hypotheses will be discussed that are related to illuminance on the one hand and perceived safety, cleanliness and ambience on the other.

Hypothesis 1 (H1: Illuminance and perceived safety)

Places that have a higher illuminance level are according to Antonakaki (2006) perceived as safer. In addition to that, Johansson et al. (2011) showed that travellers feel most safe on train stations when the lighting is bright and evenly distributed. Based on these findings in literature the following hypothesis was formulated: *a higher illuminance level leads to a higher perceived safety by travellers at train stations.*

Hypothesis 2 (H2: Illuminance and perceived cleanliness)

Based on common sense most people would say that a lower illuminance level leads to an environment that is perceived as cleaner, since the cleanliness of the floor or objects in space are less visible. Surprisingly, Molenaar and Hu (2013) found, by performing experiments in a metro coupe that the perception of cleanliness of a littered place significantly increases when the illuminance level is high in the littered spot, compared to an evenly lit situation. According to Molenaar and Hu (2013), there are several possible explanations for this outcome, for example the feeling that 'something is going to be done soon about the situation', in addition to that, it enhances the clean feel of the remaining part of the metro coupe. Applying a lower illuminance level to the same place had no significant impact on how people perceived the cleanliness of the environment compared to an evenly lit situation. Therefore, the following hypothesis was stated: *a higher illuminance level leads to a higher perceived cleanliness by travellers at train stations.*

Hypothesis 3 (H3: Illuminance and perceived ambience)

Custers et al. (2010) performed a study in the retail sector and found that an environment is perceived as less ambient when the illuminance level is high. It is important to mention that this study will be performed on a train station instead of a retail environment. Since there are no studies available that measure the relation between illuminance and ambience at train stations, this evidence will be used as a starting point. In line with this, the following hypothesis was formulated: *a lower illuminance level leads to a higher perceived ambience by travellers at train stations.*

1.3.2 Light colour temperature

Below, three different hypotheses will be discussed that are related to light colour temperature on the one hand and perceived safety, cleanliness and ambience on the other.

Hypothesis 4 (H4: Light colour temperature and perceived safety)

According to Quartier et al. (2014) warmer lighting is associated with an increased perception of cosiness. Quartier et al. (2014) describes cosines with the feelings pleasantness, safety, quaintness and intimateness. Since safety is contributing to the cosines of a certain environment, the assumption is made that a higher light colour temperature positively contributes to the perceived safety. Therefore the following hypothesis was formulated: *a*

lower light colour temperature leads to a higher perceived safety by travellers at train stations.

Hypothesis 5 (H5: Light colour temperature and perceived cleanliness)

Pijls and Groen (2012) performed a research that looked into the measures that influence the perception of cleanliness by patients of a hospital. It turned out that the participants associated cooler light colours with cleanliness, while the warmer light colours where associated with uncleanliness. Since there is no evidence available in literature for a relation between the light colour temperature and perceived cleanliness on train stations, this hospital case was used. This has resulted in the following hypothesis: *a higher light colour temperature leads to a higher perceived cleanliness by travellers at train stations.*

Hypothesis 6 (H6: Light colour temperature and perceived ambience)

According to Quartier et al. (2014) and Custers et al. (2010) evokes warm lighting significantly more pleasurable feelings caused by an increased perceived cosiness and liveliness of the environment. In line with this, the following hypothesis was formulated: *a higher light colour temperature leads to a higher perceived ambience by traveller at train stations.*

1.3.3 Goal- orientedness

Below, three different hypotheses will be discussed that are related to goal- orientedness on the one hand and perceived safety, cleanliness and ambience on the other. Based on literature (Van Hagen, 2011), the first assumption is made that goal- orientedness has an intervening effect on the relation between the independent variables (illuminance level and light colour temperature) and the dependent variables (perceived safety, cleanliness and ambience).

Hypothesis 7 (H7: Goal- orientedness and perceived safety)

According to Vos (2013) are must passengers reporting lower feelings of social safety than lust passengers, especially in conditions where the illuminance level is low. Therefore the proposed hypothesis was: *lust travellers perceive train stations as safer than must travellers do.*

Hypothesis 8 (H8: Goal- orientedness and perceived cleanliness)

Vos (2013) found that must passengers are quicker irritated by a littered station environment than lust passengers are. The associated hypothesis was: *lust travellers perceive train stations as cleaner than must travellers do.*

Hypothesis 9 (H9: Goal- orientedness and perceived ambience)

According to Van Hagen (2011) hedonic customers, referred to as lust travellers, are paying less attention to the time and are more receptive to environmental stimuli than must travellers. This phenomenon can be described by making a distinction between travellers who are in a paratelic and telic state. In general, lust travellers are in a paratelic state and the telic state belongs to must travellers. Travellers who are in a paratelic state are arousal seeking, less goal oriented and need more stimuli, travellers who are in a telic state are looking for places with little arousal, are more serious and goal- oriented. Since lust travellers generally receive more

environmental stimuli and are less goal oriented than must travellers, the following hypothesis was formulated: *lust travellers perceive train stations as more ambient than must travellers.*

1.3.4 Density

Below, three different hypotheses will be discussed that are related to density on the one hand and perceived safety, cleanliness and ambience on the other. As for goal- orientedness, in the previous paragraph, is the assumption made that density has an intervening effect on the relation between the independent variables (illuminance level and light colour temperature) and the dependent variables (perceived safety, cleanliness and ambience).

Hypothesis 10 (H10: Density and perceived safety)

According to Cox, Houdmont and Griffiths (2006) density can evoke negative feelings such as stress and reduced social safety. Social safety and density are related, Cox et al. (2006) argue that specific types of crime, such as pick pocketing and physical abuse, are more likely to take place in crowded places. These finding led to the following hypothesis: *higher density at train stations negatively influences the perceived safety of passengers.*

Hypothesis 11 (H11: Density and perceived cleanliness)

There is no evidence available in literature for the relation between density and perceived cleanliness. The assumption is made that travellers pay less attention to the cleanliness of the environment when the density is high. Whether this assumption is true, needs to be assessed during the literature study. It is important to mention that travellers will probably not notice an unclean environment when safety is compromised on the train station. Based on this assumption the following hypothesis was stated: *higher density at train stations positively influences the perceived cleanliness of travellers.*

Hypothesis 12 (H12: Density and perceived ambience)

Turley and Milliman (2000) found that density is an atmospheric variable that is rather difficult to understand and control. Harrel, Hutt and Anderson (1980) found in addition to that, that a higher density can influence the shopping satisfaction and evaluation of the shop by consumers negatively. Based on this findings the following hypothesis was formulated: *higher density at train stations negatively influences the perceived ambience of travellers.*

To sum it all up, the following hypotheses are formulated based on literature:

- A higher illuminance level leads to a higher perceived safety by travellers at train stations;
- A higher illuminance level leads to a higher perceived cleanliness by travellers at train stations;
- A lower illuminance level leads to a higher perceived ambience by travellers at train stations;
- A lower light colour temperature leads to a higher perceived safety by travellers at train stations;
- A higher light colour temperature leads to a higher perceived cleanliness by travellers at train stations;

- A higher light colour temperature leads to a higher perceived ambience by traveller at train stations;
- Lust travellers perceive train stations as safer than must travellers do;
- Lust travellers perceive train stations as cleaner than must travellers do;
- Lust travellers perceive train stations as more ambient than must travellers;
- Higher density at train stations negatively influences the perceived safety of passengers;
- Higher density at train stations positively influences the perceived cleanliness of travellers;
- Higher density at train stations negatively influences the perceived ambience of travellers.

The hypotheses are used as guiding lines for the empirical research process. More details about the empirical part of this study will be elaborated on in the following paragraph.

1.4 Technical research design

The fourth paragraph of this first chapter consists of a description of the technical research design. The chapter comprises two paragraphs that describe the research materials and the research strategy.

1.4.1 Research materials

- Scientific literature (library, digital sources): scientific literature will be used in order to create the theoretical framework. Journals in the field of marketing, retailing, facility management, environment and behaviour, environmental psychology, motivation and emotion, ergonomics and urban planning will be used.
- Grey literature: are used as a complement to the scientific literature. Examples of these documents are annual reports and customer satisfaction reports of NS. Documents will be used as input for the theoretical framework.
- Virtual environment: Since experiments in the real world are to complex, the experiments will be carried out in a virtual environment.

1.4.2 Research strategy

The most crucial part of the technical research design is the choice and substantiation of the research strategy. Verschuren, Doorewaard, Poper and Mellion (2005) define a research strategy as: *"the coherent body of decisions about the way which you are going to carry out your research project"*. Literature and experiments are the main sources of information for this explanatory research project.

Literature study

The literature study serves as a base for this research project and is essential for the establishment of a theoretical framework and formulation of hypotheses. The journals that are used are related to the field of marketing, retailing, facility management, environment and behaviour, environmental psychology, motivation and emotion, ergonomics and urban planning. The hypotheses are formulated based on the literature study. The hypotheses are the linking pin between the literature and empirical study. The stimulus-organism-response (SOR) model of Mehrabian and Russel (1974) will be used as a guideline for the formulation of the conceptual model. The three aspects stimulus, organism and response are used to describe the relation between light and the experience of the environment. In this case the stimulus is light, the organism is the human being who perceives a certain level of safety and cleanliness and the response is the corresponding behaviour. In order to visualize the different variables, the following research model (figure 3) is drawn:

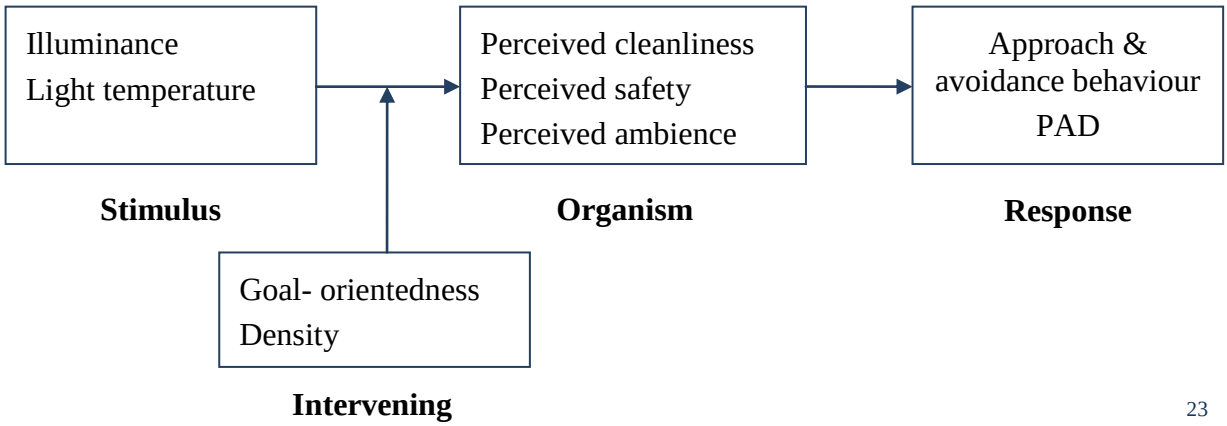

Figure 3: Research model

The specific relationships between the different variables will be assessed by performing a literature study. Based on literature study different hypotheses are formulated in the previous paragraph 1.3. During the proposal phase of this study the assumption was made that the variables goal- orientedness and density were independent variables with a possible intervening effect. Based on literature (Van Hagen, 2011) the assumption is made that goal-orientedness as well as density were having an intervening effect on the relationship between illuminance and light colour temperature on the one hand and safety, cleanliness and ambience on the other. This was visualised in figure 3 (research model).

Pre-test experiments

A pre-test is performed in order to evaluate the internal validity of the independent variables (illuminance, light colour temperature, goal- orientedness and density) by performing manipulation checks. The goal of performing manipulation checks is to determine whether the performed interventions are successful. An intervention is successful if participant X, who is exposed to the high density level condition, is indeed perceiving this condition as busier than participant Y who is exposed to the low density level. The manipulation check was not included to verify if the independent variables caused variation in the dependent variables.

Three different *illuminance levels* were tested in the pre- test and the final experiment. The illuminance levels are based on the unit lux and are based on the illuminance levels of ProRail, the company responsible for the Dutch rail infrastructure (Prorail, 2009). The illuminance levels of ProRail are based on several guidelines such as NEN 6702, CIE 68 and NSvV OV 311. The illuminance levels are established based on safety concerns, the experience of travellers were not taking into consideration. The average illuminance level that is used on train stations is 150 lux, the lower and upper bound are 75 and 225 lux. The illuminance levels that will be tested in this study are therefore: 75, 150 and 225 lux. Scientific literature is inconclusive about the use of certain illuminance levels, most studies use national or international guidelines and standards to determine the illuminance level that suits their study best. Subsequently the *light colour temperature* was tested. The light colour temperature consists of two different measurement levels expressed in kelvin (K), namely, 3000K and 5000K. This is first of all based on the guidelines of Prorail (2009) who stated 3000K as minimal light colour temperature on train stations. In addition to that a study of Park et al. (2007) tested the effect of lighting on consumers' emotions and behavioural intentions and used 3000K as lower bound and 5000K as upper bound. Observability of the different conditions is essential, especially because the participants perform and perceive the experiments on their own personal computer, the screen settings of individual participants might deviate. For this reason an upper bound of 5000K instead of 4000K was chosen in order to ensure that the difference between the conditions was visible. Besides the illuminance level and light colour temperature, goal orientedness and perceived density is tested in the pre- test. *Goal- orientedness* is measured by assigning the participants to one of the two roles, either the role of must or lust traveller. In total two different levels of *density* are used, a train station with a low density and a train station with a high density. The general rule of thumb for sample size in experimental pre- tests is to minimally include 150 participants (Cozby & Bates, 2011). Since this study contains many different conditions 600 persons are invited. The expectation was made that 30% of invited people were participating in the experiment. This means that the pre- test will be completed by at least 180 respondents. After finalising the experiment, the respondents will be asked to fill out a short questionnaire. If the results of the

pre-test experiment are satisfactory, the post-test experiment will be performed in exactly the same way, obviously only the number of respondents differs.

Post-test experiments

Before the post-test experiment will be performed there is the possiblity to make small changes to the experimental design based on the results of the pre-test. The main purpose of the post-test experiments within this project is to investigate the effect of light, defined as illuminance and light colour temperature on perceived safety, cleanliness and ambience of travellers on a train station. The hypotheses that are formulated based on literature are tested by performing the experiments. Since it is expensive and time consuming to perform the experiments in the real world, the experiments will be performed in a virtual train station environment. This experimental design is often referred to as 'game simulation' or 'gaming' (Verschuren et al., 2005). The participants are able to take part in the experiment by visiting a website at their personal computer. The virtual environment (figure 4) will be built by an external engineering company. The train station which was simulated is Amersfoort. This train station does have average passenger flows (38.500 travellers) compared to the other Dutch train stations. The train station of Amersfoort does furthermore contain all the elements that a train station can have, except for a tunnel. To make the model even more representative a tunnel will be built in. The people who are participating in the experiment will be guided through two phases, the station hall or tunnel and finally the platform. People will automatically allocated to either the station hall or tunnel, the participants will not be guided through all the phases since this costs too much time. After completion of each phase, participant will be asked to fill out a part of the questionnaire. It is important that the participant is not able to see the environment or go back to the environment when finishing the certain phase. Participants are able to 'walk' around freely in the virtual environment. It is possible for the participants to move from the platform back to the station hall. In order to structure the data analysis, participants will be exposed to one and the same condition during the two phases. So, when participant X starts with the experiment he or she will automatically be allocated to a condition with for example a low (75 lux) illuminance level, high kelvin level (3000K), a must travellers goal orientation and a platform that has a high density level.

Figure 4: Screenshot virtual environment (3000K)

Independent variables

The independent variables that define light in this study are illuminance and light colour temperature, in addition to that goal- orientedness and density are included. It is not in all cases common to measure the independent variables (Sigall and Mills, 1998). For this study the measurement of the independent variables is useful, for example to demonstrate that the scenario belonging to either the must or lust condition is perceived as such by the participants. The constructs that are presented in this paragraph are used in the pre- test as well as in the actual experiment. The three different *illuminance* levels (75, 150 and 225 lux) are measured by using a construct which is developed for this study. The main purpose of the measurement of the illuminance level is to be sure that the different illuminance levels are perceived as such by the participants. The construct that was used to measure the way in which illuminance is

perceived consists of four items. The first item is: ‘to which extent do you agree on a scale reaching from strongly disagree to strongly agree with the following statement: I have perceived the light during my stay at the train station as intense’. The two different *light colour temperatures* (3000K and 5000K), were measured by using the construct that is partly adopted from Peters (2008). The construct consists of four items, for example: ‘the lighting on this railway station platform was: quite dark - quite light’.

In the proposal phase of this study, the variables goal- orientedness and density were defined as independent variables that are based on literature assumed to have an intervening effect on the relationship between the independent and dependent variables. The participants were randomly assigned to the role of must traveller (goal oriented) or the role of the lust traveller (less goal oriented), representing the level of *goal- orientedness*. The must travellers were told that they were in a hurry and needed to catch the first train to Amsterdam. Participant who were classified as being a lust traveller were told that they had to take the train to Amsterdam but had plenty of time. The construct used is adopted from Sauren (2010). The construct consists of four items that will be measured by using a seven point Likert scale ranging from ‘totally disagree’ to ‘totally agree’. An example of an item is: ‘’during the time spent on this train station, I wanted to have fun’’. *Density* was tested by allocating the participants to a train station with a high or low density (number of people). To measure the perception of density, the construct of Sauren (2010) was used. The scale consisted of four items that consist of a seven point Likert scale ranging from ‘totally disagree’ to ‘totally agree’. One of the items was: ‘’the train station seemed very crowded to me’’.

Dependent variables

The dependent variables are perceived safety, perceived cleanliness and perceived ambience. The three dependent variables were measured by using three different constructs that consist of a seven point Likert scale ranging from ‘totally disagree’ to ‘totally agree’. The dependent variable, *perceived safety* was measured by five items. The construct was adopted from Taylor (1994) and Vos (2014). One of the items within this construct is: ‘’on this railway station I feel calm’’. An example of an item that measured *perceived cleanliness* is: ‘’the train station is messy’’. The construct is put together for this study and consists of five items. *Perceived ambience* is the third and final dependent variable. Ambience was measured by five items adopted from StationBelevingsMonitor (SBM, 2013) which evaluates the attractiveness of train stations. An example of one of these items is: ‘’the train station has a warm gleam to it’’. Besides the perceived safety, cleanliness and ambience it is useful to measure pleasure, arousal, dominance (primary emotional reactions) and approach & avoidance behaviours (Mehrabian and Russel, 1974). This variables will provide additional insights concerning the relation between the perception of safety, cleanliness, ambience and light. An overview of the different constructs and corresponding items can be found in appendix A.

Statistical analysis

The independent variables that were tested in this study are illuminance, light colour temperature, goal orientedness and density. The dependent variables are perceived safety, cleanliness and ambience, and in addition to that, pleasure, arousal, dominance and approach & avoidance behaviour were tested. The hypotheses which were proposed (paragraph 1.3) were tested with a 3 (illuminance levels: 75, 150 and 225 lux) x2 (light colour temperature: 3000K and 5000K) x2 (type of passenger: must passenger versus lust passenger) x2 (type of density: low density versus high density) between subjects MANOVA. MANOVA

(multivariate analysis of variance) is an extension of the ANOVA (univariate analysis of variance) test technique and can be used in studies with multiple dependent variables. It is possible and not unusual to conduct several ANOVA tests in order to study the relation between the independent and each dependent variable. There are however some drawbacks attached to this method. The more tests that are conducted on the same data, the more the chance on a type I error will increase. A type I error refers to a null hypothesis that is falsely rejected, which means that the assumption is made that there is a difference between two interventions, whereas this is not the case in reality. An example of a type I error that could be made in this study is the assumption that the null hypothesis 'H_0: illuminance is not influencing the perception of safety' is rejected and the alternative hypothesis 'H_A: Illuminance influences the perception of safety' accepted while this is not the case in reality. The risk of facing a type I error can be adjusted by choosing a lower significance level (p-value). This is in most cases 5%, but the risk can be minimalized by for example using a significance level of 1%. In addition to that multiple ANOVA tests ignore any possible relationships between the dependent variables. This is obviously not desirable. The possible intervening effect of goal- orientedness and density will be tested by running a MANCOVA test. The purpose of performing a MANCOVA (Multivariate Analysis of Covariance) test is to include goal- orientedness and density as covariate variables and find out if the variables are influencing the relation between illuminance and light colour temperature on the one hand and safety, cleanliness and ambience on the other. All constructs that measure one of the variables are using a seven point scale.

Sample

NS owns a database, called 'NS panel', this database consists of approximately 110.000 persons who are willing to participate in research projects of NS. The members of NS panel are approached four or five times a year for various studies, they receive no fixed compensation but with each study a number of book tokens are randomly divided among the respondents. The initial plan was to recruit 2.400 participants by inviting 8.000 participants. It however turned out that the virtual train station could not be opened by a large amount of the NS panel members due to technical problems (e.g. minimal requirements, installation of a plugin). Therefore, the decision was made to recruit participants in a different way. First and second year university students of the 'Hanze Hogeschool in Groningen' were required to participate in this research project. A total of 280 students have participated. A couple of day passes were randomly divided among the participants.

2. Theoretical framework

This theoretical framework will discuss the literature findings with regard to the influence of lighting, described as illuminance and light colour temperature, on the perception of safety, cleanliness and ambience of travellers at train stations. The relation between the intervening variables (goal- orientedness and density) and the environmental variables (perceived safety, cleanliness and ambience) will also be reviewed by using literature. The visualisation of the hypothesis (figure 2) earlier in this report will be used as a guiding line for the structure of the theoretical framework. In the first two paragraphs of this chapter, illuminance (2.1) and light colour temperature (2.2) will be discussed in relation to the environmental factors, safety, cleanliness and ambience. In the paragraph 2.3 and 2.4, the relation between density and goal-orientedness on the one hand and perceived safety, cleanliness and ambience on the other will be treated. Finally, in the paragraphs 2.5, 2.6 and 2.7 the concepts perceived safety, cleanliness and ambience will be discussed in relation to the earlier mentioned concepts illuminance, light colour temperature, density and goal- orientedness. Final paragraph 2.8 is used to summarize the results of the theoretical framework.

2.1 Illuminance

In this paragraph illuminance will be discussed in relation to the variables, perceived safety, cleanliness and ambience. Illuminance is in this study defined by the unit lux (lx), lux is the most common way to quantify the illuminance of a light source (Peters, 2008). In contrast to lumen that measures the illuminance of a light source is lux measuring the amount of incident light per square meter. The units lux and lumen are related, one lux equals one lumen per square meter. Mehrabian (1976) found that the PAD (pleasure, arousal and dominance) factors can influences people's behaviour in a certain environment. One of his main believes was that lighting has a significant impact on individuals, because: *''brightly lit rooms are more arousing than dimly lit ones''*. Mehrabian (1976) described this phenomenon by using the classical inverted-U relationship, which visualises the relation between approach & avoidance behaviour and arousal. The main believe is that people in general would like to stay in an environment that is both pleasant and arousing. In the following paragraph (2.6.1), illuminance will be discussed in relation to the environmental factor perceived safety.

2.1.1 Illuminance and perceived safety

Safety seems to be closely related to the illuminance level that is used in a certain environment. Especially crime reduction is a topic that is often mentioned in research related to illuminance and safety (Painter, 1996). Therefore, this paragraph is split up into a part that is dedicated to illuminance in relation to the perception of safety and a second part that focusses on crime reduction.

Perceptions of safety

Research suggests that the three cues: darkness, disorder and finding oneself alone or in the presence of others who are perceived to be threatening, can negatively influences perceptions of safety (Painter, 1996). Especially the first one, darkness, is relevant and interesting for this study, why do people feel less safe when it is dark in an environment? An obvious explanation is that people unsafe because of the possible risk to become surprisingly

victimized. This findings are in line with the prospect refuge theory of Appleton (1975), which says that the ability to see (prospect) but not be seen (refuge) is basic to many biological needs. Perceived safety will increase when the ability to see without being seen increases. Loewen, Steel and Suedfeld (1993) tested various aspects of the prospect refuge theory, and looked into environmental features that were relevant to perceived safety. Light was the most frequent mentioned feature, followed by open space and unambiguous refuge. This means that the prospect refuge theory not only involves landscape features, the degree of illuminance also seems to be relevant (Loewen et al., 1993). A nationwide experiment in the U.K. assessed the impact of improved lighting on crime and fear of crime (Herbert & Davidson, 1994). Although it was hard find empirical evidence for crime reduction, the researchers found that the fear for crime significantly decreased with a higher illuminance level. As mentioned in the introduction of this paragraph, is the following part dedicated to the relation between illuminance and crime reduction.

Crime reduction

Crime reduction is a popular topic among light researchers, there seems to be a general consensus nowadays that lighting can reduce crime rates in public space (Haans & Kort, 2012; Keane, 1998; Welsh & Farrington, 2004; e.g.). Tiffany and Ketchel (1970) found for example that robbers are more likely to target banks which employ a lower illuminance level, because of a poorer visibility inside as well as from the street. This is probably also the reason why crimes against individuals most often occur in places where the chance of being seen is low (Newman, 1980). The research of Tiffany and Ketchel (1970) was performed a view decades ago, although, the results are still useful. Painter (1996) tried to explain the mechanisms that are related to illuminance and crime reduction. Lighting is according to Painter (1996) not a straightforward solution to crime, lighting and more specific illuminance, seems to be a psychological deterrent to offenders through multiple mechanisms. The most important mechanisms are visibility, recognition and an increased use of the depending environment. According to Painter (1996) encourages a higher illuminance level people to use a certain area, such as a street or train station after dark. Increased density caused by traffic and pedestrians, increases the natural surveillance. Natural surveillance increases the risk for offenders of being seen and caught. Based on this insights, the following hypothesis was formulated:

H1: A higher illuminance level leads to a higher perceived safety by travellers at train stations.

In addition to safety, it also possible to use illuminance in order to influence the perception of cleanliness. The following sub paragraph will focus on this topic.

2.1.2 Illuminance and perceived cleanliness

The perception of cleanliness can be influenced by using different lighting conditions. In addition, it is possible to influence littering behaviour by using different lighting conditions. Littering behaviour and more specific the relation between illuminance and cleanliness will be treated in paragraph 2.6. It is first of all important to mention that there is a low correlation between actual and perceived cleanliness (Robin et al., 2007). This means that there are other factors besides actual cleanliness that make up the general perception of cleanliness. Molenaar

and Hu (2013) performed experiments in a metro coupe and found that people perceive an environment as cleaner when the attention is drawn to the litter by using a high illuminance level. Based on common sense most people would say that an environment is perceived as cleaner when the illuminance level is low, since the cleanliness of the floor or objects in space are less visible. Molenaar and Hu (2013) have several explanations for this outcome, according to them, does the littered place enhances the clean feel of the remaining part of the depending environment. Another plausible explanation is that people have the feeling that soon something is going to be done about the situation when the illuminance level on the littered spot is high. As noted by Molenaar and Hu (2013), there is not much literature available on this topic. In order to build up a decent theoretical framework, paragraph 2.6 will focus on concepts that are related to perceived cleanliness, such as: littering behaviour, place attachment and cleanliness in general. Based on the findings in this paragraph, the following hypothesis was formulated:

H2: A higher illuminance level leads to a higher perceived cleanliness by travellers at train stations.

Since a safe and clean train station will not necessarily be a place where people would like to be, the concept ambience is included. The following sub paragraph is dedicated to the relation between illuminance and the perception of ambience.

2.1.3 Illuminance and perceived ambience

Any lighting designer, lighting researcher or architect would agree that lighting, and more specific illuminance, is directly related to the extent of ambience of a place. According to literature is there a relation between the illuminance level and ambience on the one hand and emotions, mood and cognition on the other (Fleischer et al., 2001; Custers et al., 2010). The study of Fleischer et al. (2001) reported more pleasant emotions and an increased level of dominance when the illuminance level is higher. Custers (2010) found that a high illuminance level significantly contributed to three atmosphere dimensions: cosiness (negatively related), tenseness and detachment. Besides these rather theoretical examples, there is also a lot of empirical evidence available for the relation between illuminance and ambience in practice. Such as the study of Markin, Nilis and Narayana (1976). They suggest that retailers who would like to peruse more of their merchandise and create an ambient environment should employ a low illuminance level in order to lower the level of arousal. Customers will peruse more products because of the lower walking pace by which they move through the store. This means that retailers can influence the time customers spend in their store by adjusting the illuminance level. The study of Markin et al. (1976) is performed in a retail setting, there are off course differences between the retail and railing sector. Perception of time is according to Van Hagen (2011) one of the most important differences. Travellers waiting for their train are more aware of time than people who are for example looking for a new pair of shoes.The following hypothesis was formulated for the relation between illuminance and ambience:

H3: A lower illuminance level leads to a higher perceived ambience by travellers at train stations.

2.1.4 Conclusion illuminance

The purpose of this sub paragraph is to summarize the most important findings in literature regarding illuminance in relation to the perception of safety, cleanliness and ambience. Illuminance was measured by using the unit lux (lx). Based on literature the conclusion is drawn that a higher illuminance level leads to a more positive perception of safety and cleanliness. A place will be experienced as more ambient when a low illuminance level is employed. It seems that the illuminance level of light has a comparable effect on the perception of safety and cleanliness. A more positive perception of ambience can be created by employing a lower illuminance level, which leads to lower arousal levels and more relaxation among travellers. Light can be measured in many different ways, as mentioned earlier will light in study be defined by the concepts illuminance and light colour temperature. Light colour temperature will be treated in the next paragraph.

2.2 Light colour temperature

Everyone recognizes the activating effects and the positive moods caused by the light on a sunny summer day and the calming effect of a fireplace, candlelight or sunset. Light colour temperature can have an impact on the wellbeing and behaviour of people. According to Wessolowski et al. (2014), is light colour temperature together with illuminance (treated in paragraph 2.1) the most important component of the concept light. An alternative designation for the concept light colour temperature, is the term correlated colour temperature. Since there is no significant difference between the two terms, light colour temperature will be used in this study. Light colour temperature is measured in degrees of kelvin (K) (Wessolowski et al., 2014) and varies between 3000K (warm) and 6000K (cold). High light colour temperatures appear as cold colours, such as white and blue, low light colour temperatures appear as warm colour impressions such as red and yellow (Rea, 2000). Exposure to light and more specific light colour temperature is essential for synchronisation of our circadian rhythm (Sinoo, Van Hoof & Kort, 2011). Despite the fact that this relation is not necessarily relevant for this study, it is useful to demonstrate the importance of light and more specific light colour temperature. The purpose of this paragraph is to study the relation between light colour temperature on the one hand and the perception of safety (2.2.1), cleanliness (2.2.2) and ambience (2.2.3) on the other. The available literature on the concept light colour temperature is in contrast to the available literature on illuminance scarce. The most studies concerning light colour temperature focus on wellbeing, concentration and productivity. Although a decent framework was set up. The first sub paragraph focusses on the relation between light colour temperature and the perception of safety.

2.2.1 Light colour temperature and perceived safety

The evidence for the relation between light colour temperature and perceived safety is scarce, it is however possible to make some assumptions based on the available research. Quartier (2014) found that a lower light colour temperature (3000K, warm) is leading to a more positive perception of cosiness and comfort. Cosiness is according to Bille (2014) intrinsically connected with the concepts safety and secureness. Therefore the assumption is made that a lower light colour temperature positively influences the perception of safety. Based on the available literature it is possible to state that a higher as well as a lower light colour temperature positively can influence the perception of safety. A high light colour temperature (cold light) is often associated with efficient passenger flows and overview of public space (Van Hagen, 2011). The following hypothesis was formulated on the previous assumptions.

H4: A lower light colour temperature leads to a higher perceived safety by travellers at train stations.

As with illuminance, light colour temperature is expected to influence the perception of cleanliness. The following paragraph will focus on the relation between those two concepts.

2.2.2 Light colour temperature and perceived cleanliness

As for the relation between light colour temperature and perceived safety. It is important to mention that the evidence for the relation between light colour temperature and perceived

cleanliness is scarce as well. In general, higher light colour temperatures are (cool) associated with cleanliness. Pijls and Groen (2012) evaluated the measures which influence the perception of cleanliness of hospital patients. The patients associated high light colour temperatures with cleanliness and low light colour temperatures (warm) with uncleanliness. Based on these findings, the following hypothesis was formulated:

H5: A higher light colour temperature leads to a higher perceived cleanliness by travellers at train stations.

The following paragraph focusses on the relation between light colour temperature and the perception of ambience.

2.2.3 Light colour temperature and perceived ambience

As mentioned in the introduction will probably everyone agree that the mood of people and the ambience of a place is significantly influenced by the light on a sunny day in for example July or August. Custers et al. (2010) indicated that a high light colour temperature influences the perception of ambience negatively. A high light colour temperature is often described as less arousing compared to low light colour temperatures (Custers et al., 2010). The assumption is made that a low light colour temperature (warm) positively influences the perception of ambience. This assumption is confirmed by the curve (figure 5) of Kruithof (1941), which displays the relation between light colour temperature and illuminance in relation to ambience (Sinoo et al., 2011). According to Kruithof (1941) is the appearance of light colour temperature influenced by the illuminance level of light. As mentioned before there are three different illuminance levels (75, 150 and 225 lux) and two different kelvin levels (3000K and 5000K) light colour temperature levels evaluated in this study. According to the curve of Kruithof (1941) two of the six lighting combinations are in general assessed as pleasing (3000K * 150lx and 3000K * 225lx), none of the higher light colour temperatures are perceived as pleasant. Based on these findings in literature, the following hypothesis was formulated:

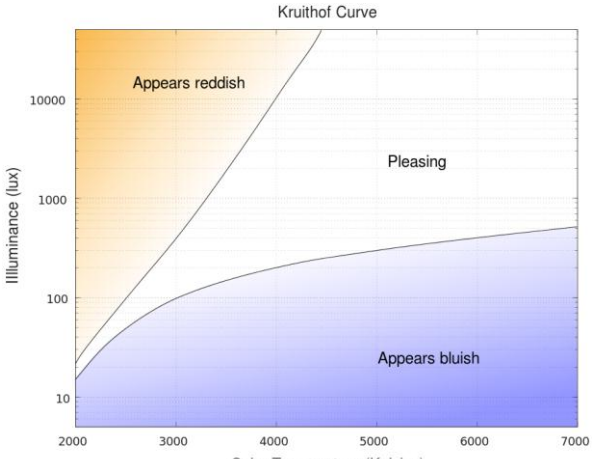

Figure 5: Kruithof Curve (Kruithof, 1941)

H6: A lower light colour temperature leads to a higher perceived ambience by travellers at train stations.

2.2.4 Conclusion light colour temperature

The purpose of this sub paragraph is to summarize the most important findings in literature regarding light colour temperature in relation to the perception of safety, cleanliness and ambience. In this study, light colour temperature was measured by using the concept kelvin. Based on literature the conclusion is drawn that a lower light colour temperature (cold) leads

to a more positive perception of safety and cleanliness. Whereas a higher (warm) light colour temperature leads to a more positive perception of ambience. The findings for the perception of safety and cleanliness were based on a couple of assumptions. The evidence for a possible relation between warm light colour temperatures and a positive perception of ambience is a rather strong one. Based on the findings in this sub paragraph and sub paragraph 2.1.4 the assumption is made that the perception of safety and cleanliness are related, since they are 'behaving' in the same way under the influence of light. This assumption will be tested in the empirical phase of this study. The following two paragraphs are dedicated to the variables goal- orientedness and density.

2.3 Goal- orientedness

Goal- orientedness is often referred to in literature as the motivational orientation of people, whereas motivation is defined as the intensity, persistence, and direction of effort allocation (Vieira & Torres, 2014). It is possible to make a distinction between utilitarian and hedonic motivations. Consumers with utilitarian motivations are looking for products or services that can be bought in a deliberate and efficient manner. The hedonic motivations are in contrast to the utilitarian motivations focussing on the potential entertainment and emotional value of a product or service (Batra & Ahtola, 1990). Vieira and Torres (2014) have performed a study in which they proved that motivational orientation moderates the relation between arousal and response. In addition to that, Vieira and Torres (2014) found that the motivational orientation is also moderating the relation between arousal on the one hand and satisfaction (Mattila & Wirtz, 2000), loyalty (Ridgway, Dawson & Block, 1990), impulse (Donovan, Rossiter, Marcoolyn & Nesdale, 1994), products bought, minutes and money spent in the service environment (Sherman, Mathur & Smith, 1997; Babin & Darden, 1995). The major part of research done on motivational orientation is performed in a retail setting, there is however also empirical evidence on motivational orientation in the rail sector. Van Hagen (2011) refers to train stations as complex environments, this statement is based on the theory of Bitner (1992). This complex environment needs to suit the needs of different consumers. According to Van Hagen (2011) is not every consumer having the same needs during the consumption of a service. A common distinction between consumers that is often made in the retail sector, is the distinction between utilitarian and hedonic consumers (Batra & Ahtola, 1990). Utilitarian consumers are more goal oriented than hedonic consumers, who see shopping as an activity itself. NS translated this concept of utilitarian and hedonic consumers into the concept of must and lust travellers (Van Hagen, 2011). Must travellers are goal oriented and most of the time commuters who travel by train a couple of times a week. Lust travellers are recreational travellers who find comfort and convenience more important than a fast trip (SENTA, 2005). Must and lust travellers are significantly different and will therefore be included in this study (Van Hagen, 2011). In the following three paragraphs, goal orientedness will be discussed in relation to the concepts perceived safety, cleanliness and ambience.

2.3.1 Goal- orientedness and perceived safety

This sub paragraph is focussing on the way in which must and lust travellers perceive the safety of an environment. According to Blokland (2009) is the perception of safety increasing when people are familiar with an environment. Blokland defines public familiarity as the concept of people knowing the surroundings and people in a certain environment. Public familiarity contributes to the extent to which people are able to predict the circumstances of a public environment. And in addition to that, it makes people feel more at ease and thereby contribute to a more positive perception of safety. Since a train station is a public environment this theory can also be applied to a train station and its surroundings. The assumption is made that must travellers, who are travelling more often, will be more familiar. Must travellers will therefore perceive train stations as more safe, since they are in general more familiar with the station environment (Blokland, 2009). This lead to the following hypothesis:

H7: Must travellers perceive train stations as safer than lust travellers do.

The relation between goal- orientedness and the perception of cleanliness will be discussed in the following paragraph.

2.3.2 Goal- orientedness and perceived cleanliness

This sub paragraph is focussing on the way in which must and lust travellers perceive the cleanliness of an environment. According to Machleit et al. (2000) are must travellers found to be more quickly irritated and discounted than lust travellers because of unexpected findings at train stations. The cleanliness of an environment is often referred to as a dissatisifer (Herzberg et al., 1959). This means that the cleanliness of an environment is only influencing the customer satisfaction of an environment when the evaluation of the cleanliness is negative. Therefore uncleanliness of a train station can be described as an unexpected finding, since most travellers will expect a clean train station. Must travellers will note irregularities quicker than lust travellers, since they are in general more familiar with a train station. Based on these findings, the following hypothesis was formulated:

H8: Lust travellers perceive train stations as cleaner than must travellers do.

The relation between goal- orientedness and the perception of ambience will be discussed in the following paragraph.

2.3.3 Goal- orientedness and perceived ambience

This final sub paragraph of paragraph 2.3 is focussing on the way in which must and lust travellers perceive the ambience of an environment. Based on common sense it seems to be pretty straightforward that lust travellers are more receptive for environmental. This was also backed by scientific literature (Van Hagen, 2011). Must passengers find the aspects privacy, peace, waiting alone, spending time usefully and a fast flow significantly more important than lust passengers do. Lust passengers on the other hand find facilities, service, comfortable seating and a warm atmosphere more important. Therefore the assumption was made that lust travellers will perceive a train station as more ambient than must travellers do. In line with this finding, the following hypothesis was formulated:

H9: Lust travellers perceive train stations as more ambient than must travellers.

2.3.4 Conclusion goal- orientedness

The purpose of this sub paragraph is to summarize the most important findings in literature regarding goal- orientedness in relation to the perception of safety, cleanliness and ambience. Goal- orientedness deals with the distinction between utilitarian and hedonic motivations. The concept of goal- orientedness is translated into the concept of must (utilitarian) and lust travellers (hedonic). Based on literature the assumption is made that must travellers perceive the train station as safer, this has to do with familiarity. Travellers who are more familiar with an environment perceive it as more safe, since they know better what to expect. The train station is in general perceived as less clean by must travellers. Must travellers will detect irregularities quicker than lust travellers, since they are in general more familiar with the depending train station. The train station will, in addition to that, be perceived as more ambient by lust travellers. According to literature are lust travellers more receptive for environmental stimuli. The relation between goal- orientedness and the perception of safety, cleanliness and ambience is discussed in this paragraph. The following paragraph will focus on the concept density.

2.4 Density

In addition to the context factor goal- orientedness, is the context factor density also able to influence the way in which an environment perceived and assessed. For rail operators density is an important topic, since they need to balance between density on the one hand and economical and energy efficiency on the other (Vuchich, 1981). In addition to that, Vuchich (1981), stresses that density affects the behaviour of travellers and the dwelling time of trains, which affects the line capacity. The dwelling time of trains and line capacity is crucial, but not relevant for this study. Before we dig deeper into the concept of density it is useful to make the distinction between three interrelated terms, namely, (1) density, (2) perceived density and (3) perceived crowding (Rapoport, 1975; Stokols, 1972). In many studies, these concepts are used interchangeably despite of the fact that they are significantly different. Before the three different concepts will be treated, it is important to pinpoint the difference between density and crowding. Density is referred to as a physical state involving limitation. Whereas crowding is defined to the restrictive nature of space as perceived by individuals (Mehta, 2013). According to McGrew (1970) there are two kinds of (1) density, namely, social and spatial density. Social density refers to the actual number of people in a certain space. Spatial density refers to the amount of space that is available per person. In contrast to density, is the concept (2) perceived density referred to as subjective estimate of the space available, and the number of people present (Rapoport, 1975). Perceived crowding is referred to as the subjective experience of different density levels. The concept of perceived crowding is the most difficult to define and measure, since the same density or perceived density level may or may not result in the same response among individuals. The differences between density and crowding will be treated in more detail in the following paragraphs.

Actual and perceived density

There is a big discrepancy between actual density and the way in which it is perceived by travellers. According to Mohd Mahudin et al. (2012) only a few attempts have been made to make a distinction between physical density and the subjective evaluations of density in a rail setting (Cox et al., 2006; Turner, Corbett, O'Hara & White, 2004). As mentioned, can the same density or perceived density level lead to different individual responses. A person can perceive a train station as dense while another person perceives the opposite. This is according to Mehta (2013) depending on a couple of factors, such as, (1) personal- (Machleit et al., 2000), (2) situational- (Eroglu & Mantel, 1990; Machleit et al., 2000) and (3) cultural variables (Pons et al., 2006). There are many different (1) personal factors, Machleit et al. (2000) indicate that perceptions of crowding are individual in nature. Two different travellers can perceive the same density level in a different way. This is largely depending on individual characteristics, such as for example the distinction between introverts and extroverts. An example of a (2) situational factor is the presence of other travellers. Evans and Wener (2007) found that the close presence of other travellers has more impact on perceived density than the influence of the actual density in the train. And last but not least, (3) culture can have a big impact on the perception of density. Pons, Laroche and Mourali (2006) found that individuals from Middle Eastern countries perceived a lower density level and appreciate dense situations more than people who live in North America. A possible reason for the different perceptions is due to the fact that people from North America are used to live in sparsely populated areas. The discrepancy between actual and perceived density does also apply to a railing sector, Lam, Chueng and Lam (1999) found that the journey time of travellers is influencing the way in which density is perceived. It turned out that travellers are less sensitive to a higher density when they have a short travel time. According to Lam et al. (1999) are this conclusions not

applicable to the train station, a shorter waiting time on the train station does not influence the way in which density is perceived. The concept density will be used in this study, since the concept crowding is more difficult to measure.

Density and the experience of travellers

In general, a lower density level reduces stress and can be achieved when the persons involved are able to adapt to the environment and when there is more space available (Harrell et al., 1980). Besides stress reduction there are many more factors that are influenced by density. Especially for people who travel by public transport, the concept density is one of the most important factors when it comes to the traveller experience. First of all Cantwell, Caulfield and O'Mahony (2009) indicated that density is a significant source of dissatisfaction for travellers. Cheng (2010) found that density is the factor that causes the most anxiety among rail commuters in Taiwan. In addition to that, density can lead to stress and feelings of exhaustion (Lundberg, 1976; Mohd Mahudin et al., 2012). Density can also lead to perceptions of risk to personal safety and security (Cox et al., 2006), feelings of invasion of privacy (Wardman & Whelan, 2011; Tirachini, Hensher & Rose, 2013). And also increased chance to arrive late at work and a possible loss in productivity for travellers are found to be related to density (Fickling, Gunn, Kirby, Bradley & Heywood, 2008). Lundberg (1976) performed an empirical study in which he measured the rate of catecholamine excretion. Catecholamine is a substance which indicates the stress level of a person. Urine was taken from rail commuters in Sweden, and it turned out that feelings of discomfort grew more intense as the number of train passengers increased. Mohd Mahudin et al. (2012) tried to explain the relationship between density and possible negative outcomes. It turned out that the evaluations of the psychosocial aspects of density and of its ambient environment significantly predicts the affective reactions of travellers to the density situation. Mohd Mahudin et al. (2012) concluded that the relationship between density and possible negative outcomes is not a simple, direct relationship, but a relationship which is mediated by affective feelings related to density. The following paragraphs will, just as in the previous paragraphs, focus on the perception of safety, cleanliness and ambience in relation to density.

2.4.1 Density and perceived safety

This sub paragraph is focussing on the way in which density can influence the perception of safety of an environment. As mentioned in the paragraph about illuminance (2.1.1) will a higher illuminance level lead to a higher level of natural surveillance. A higher level of natural surveillance will increase the chance for possible offenders to be caught. This means that a higher actual density is positively related to actual safety. Cox et al. (2006) performed a literature review and found that density and more specific feelings of crowding at train stations have a negative impact on people and can lead to stress and a diminished perception of safety. In addition to density, the passengers flow and spaciousness of train stations are also of great importance for the perception of safety (Galetzka et al., 2012). In most cases travellers spend their time on the train station near the entrances, stairs and exits. This can cause obstruction and hinder the passengers flow at the train station. According to Vos (2013) and Lee, Lam and Wong (2001) can obstruction together with density have a negative impact on feelings of comfort, frustration and the perception of safety at the train station. Based on these findings in literature the assumption is made that increased density negatively influences the perception of safety at train stations. This lead to the following hypothesis:

H10: Higher density at train stations negatively influences the perceived safety of passengers.

The relation between density and the perception of cleanliness will be discussed in the following paragraph.

2.4.2 Density and perceived cleanliness

This sub paragraph is focussing on the way in which density can influence the perception of cleanliness of an environment. There is no scientific evidence available for the relation between density and perceived cleanliness. The empirical phase of this study needs to demonstrate if there is a relationship between density and perceived cleanliness. Based on common sense the assumption is made that a higher density level will have a positive influence on the perception of cleanliness at train stations. When the density level in a certain environment is higher, people will probably not be able to fully perceive the level of cleanliness of the environment. Therefore the following hypothesis was formulated:

H11: Higher density at train stations positively influences the perceived cleanliness of travellers.

The relation between density and the perception of ambience will be discussed in the following paragraph.

2.4.3 Density and perceived ambience

This final sub paragraph of paragraph 2.4 is focussing on the way in which density can influence the perception of ambience of an environment and more specific a train station. Baker (1986) and Turley and Milliman (2000) found that the concept density is an important element of the ambience of a place. Density can have a negative as well as a positive impact on the perception of ambience in a service environment. According to Harrel et al. (1980) is an increased density level having a negative effect on satisfaction and evaluation of the service environment. On the other hand can density also have a positive effect on the perception of ambience, this is largely depending on the context of the service environment. Hedonic settings (pleasure) with a high density, such as a disco or restaurant will probably lead to a positive perception of ambience while places with a utilitarian setting (utility) such as grocery stores, book stores and banks evoke the opposite effect (Mehta, 2013). The main conclusion for the relation between density and perceived ambience is that there is a relationship between the two concepts. The way in which density is influencing the perception of ambience is largely depending on the context. Density has a positive effect on perceived ambience in a hedonic setting and negative in a utilitarian setting. Since a train station in general is seen as a utilitarian setting will a higher density level negatively influence the perception of ambience. Based on this findings, the following hypothesis was formulated:

H12: Higher density at train stations negatively influences the perceived ambience of travellers.

2.4.4 Conclusion density

The purpose of this sub paragraph is to summarize the most important findings in literature regarding density in relation to the perception of safety, cleanliness and ambience. Density refers to the actual number of people in a certain space, which is in some cases referred to as social density. Based on this literature study the assumption is made that a higher density level leads to a more negative perception of the perception of safety. There is no evidence available in literature on the relation between density and the perception of cleanliness. However, the assumption is made that a high density level is positively influencing the perception of cleanliness. When the density level is high travellers will not be able to fully perceive the level of cleanliness of the environment. Finally, the assumption is made that a high density level leads to a negative perception of ambience. Whereas high density (to a certain extent) in for example restaurants or a disco is perceived as ambient, will a comparable density level be perceived as non- ambient on a train station. The above mentioned hypotheses are the final hypotheses of this study. The following paragraphs (2.5, 2.6 & 2.7) are focussing on the environmental concepts, perceived safety, cleanliness and ambience. There were no additional hypotheses formulated for the concepts, perceived safety, cleanliness and ambience. The outlines and hypotheses for this concepts were already formulated in the previous paragraphs.

2.5 Perceived safety

The purpose of this paragraph is to describe the different aspects of the concept safety by assessing literature. Safety is often referred to as social or personal safety which is defined as a general cognitive response that expresses a persons' sense of security and absence of anxiety of becoming victimized when travelling through public space (Boomsma & Steg, 2013; Haans et al. 2012). According to Bruyn and De Vries (2009) safety is part of the basic experience of travellers on train stations, it makes passengers feel comfortable during their wait (Van Hagen, 2011). Most studies which focus on safety (Cho, Rodríguez & Khattak, 2009) make a distinction between actual and perceived safety, the main differences between these two concepts will be described in this paragraph.

Actual safety

As mentioned previously is actual safety referring to objective safety, which can be defined as quantitative safety, such as the number of physical or social abuses. Important to mention is that an environment with a low actual safety does not necessarily have to be perceived as unsafe. The risk of getting injured because of the physical environment (falling of the platform, getting injured by using the escalator e.g.) is really small and probably negligible. Especially misbehaviour of other travellers is a relevant threat to the actual safety at train stations (Salomonsom & Felleson, 2014). Examples of these threats to the actual safety of travellers are, according to Salomonsom and Felleson (2014): physical violence, verbal threats and abuse, drunkenness, the harassment of other passengers, unreasonable demands being placed on staff and fare evasion. It is possible to oppose misbehaviour of travellers by using social strategies or apply interventions to the physical environment. Social strategies are for example referring to the appearance of the train conductors and the interaction techniques which are used by the employees of the railway operator (Salomonson & Felleson, 2014). Interventions to the physical environment are in most cases preventive measures, such as, creating a safe physical environment that supports the train conductors when they have to deal with an aberrant customer (Cozens, Neale, Whiteaker & Hillier, 2002; Salomonson & Felleson, 2014; Cascetta & Carteni, 2014). The psychical environment is becoming more important in the reduction of crime in the rail sector and this awareness is increasing. Instead of focussing on the offender, the crime site is becoming more important (Cozens et al., 2002). Cozens et al. (2002) uses the approach 'crime prevention through environmental design', (CPTED). The CPTED approach asserts that the physical environment can encourage or discourage opportunities for crime by applying specific design and management of the environment. Basic elements of the theory that underpin CPTED are, optimizing opportunities for surveillance and clearly defining boundaries including preferred use (Cozens et al., 2002). The CPTED approach assumes that potential offenders are discouraged by the commission of an offense when they are visible for law-abiding. According to Salomonson and Felleson (2014) is public transport tending to facilitate crime when the density on the train stations is high. Examples of by-products of high density on the train station are pick pocketing, mugging, unpaid fares, vandalism and graffiti. One of the most important problems when it comes to actual safety in the rail sector is that crime is significantly underreported. There are several reasons why travellers do not report accidents. For example reluctance to delay the journey, a lack of confidence that the offender will be apprehended and the absence of someone to report to are examples of non-reporting behaviour (Cozens et al., 2002). As a result of this non-reporting behaviour the reported crime on train stations is low, however, the perception of crime is according to traveller surveys significantly higher. This is in line with the theory of Jacobs (1961), she states that fear for crime in the residential area can result in

avoidance of a certain area and therefore a reduction of crucial eyes on the street. Since measuring the impact of fear of crime on non-use of the railways is really difficult it remains largely unexplored. Carr and Spring (1993) developed a graph (figure 5) which visualizes the relation between the impact of fear on the number of people travelling. Carr and Spring (1993) state that the impact of the fear of crime is significantly related to the number of travellers. Fear of crime is according to Carr and Spring (1993) maintaining itself. The cycle of fear represents an area where actual and perceived safety meet since the perception of safety and the corresponding behaviour is to a great extent caused by the actual safety of a place (Blöbaum and Hunecke, 2005). In the following sub paragraph, the concept perceived safety will be substantiated by describing a couple of theories.

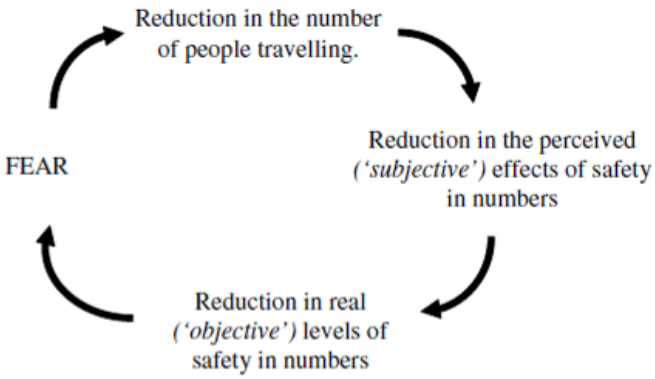

Figure 5: Cycle of fear (Carr et al., 1993)

Perceived safety

Despite of the fact that perceived and actual safety are closely related to each other (Carr & Spring, 1993), they are not exactly the same. Therefore it is important to make a distinction between them. The perception of safety refers to the extent to which travellers experience the environment as safe. Actual safety can be measured by for example counting the number of reported safety related accidents, like pick pocketing, social and physical abuse. There is a lot of research available in the area of perceived safety, the theories regarding the prospect and refuge theory, social and physical cues and the broken windows theory are considered as most relevant for this study. A classic theory in the field of perceived safety is *the prospect and refuge theory* (Appleton, 1975). Appleton (1975) states that people prefer environments that contain prospect and enclosure, in order to see the enemy without being seen themselves. The prospect refuge theory builds on the habitat theory which is initially proposed by Darwin (1958). The habitat theory assumes that the relationship between human beings and the perceived environment is comparable to the relationship between a creature and its habitat. Appleton (1975) added an aesthetic dimension to the habitat theory and states that contemplation of the landscape stems from the spontaneous perception of landscape. Shapes, colours, spatial arrangements and other visible attributes such as illuminance act as an indication for favourable or unfavourable environments. The prospect and refuge theory is often referred to as the environment where creatures have the ability to see (prospect) but not be seen (refuge). Our far ancestors would not have been able to hunt when they could not see the prey, in addition to that they would not survive if there was no possibility to hide or escape from predators. Despite the fact that our environment drastically changed due to technological advancements, the preference is innate and is reflecting the genes and biological needs of our far ancestors (Appleton, 1975). The findings of Appleton (1975) are tested in many other studies that where focussing on the perception of safety in urban environment (Nasar, Julian, Buchman, Humphreys & Mrohaly, 1983; Hudson, 1992; Loewen et al. 1993; Hagerhall, 2000). An environment where people have the ability to see without being seen is not necessarily an environment that is perceived as safe, there are many small social and physical cues that can influence this perception. When it comes to the perception of safety and more specific personal safety it is according to Van 't Hof (2008) possible to make a

distinction between *social and physical cues*. Social cues are surveillance, crowdedness, emptiness and social incivilities. The concept surveillance can be divided into formal surveillance, such as: police, security and guard and informal surveillance (other people who are walking by). Crowding (paragraph 2.4) can be divided into human and spatial density, whereas spatial density is a physical cue. Crowdedness in a social context refers to the levels of human density, high levels of human density can evoke negative as well as positive affect. Van 't Hof (2008) uses the example of a bar where large numbers of people are desirable, since making contact with other people is a reason to visit a bar. Whereas large numbers of people on a train station can lead to frustrate task achievement. The opposite of crowdedness, emptiness is also seen as a cause for people to feel unsafe. The absence of other people may evoke feelings of unsafety as well. Social incivilities refer to disorder in the social environment. Examples of factors that lead to neighbourhood instability are public drinking, corner gangs, street harassment and noisy pollution. The physical cues are: overview, entrapment and physical incivilities. The concept overview deals with the possibility for individuals to scan their surroundings for potential danger. Objects or characteristics that hinder the visibility reduce the extent to which individuals are able to control their surroundings. This is known as visual obstruction. According to RMO (2004) can visual obstruction be minimalized and perceived safety increased by for example removal of bushes that impair visibility. Other factors which can improve overview are: elimination of dead angles and non-visible corners and the improvement of lighting. There are many studies available which mention the relation between light and the perceived safety (Loewen et al., 1993; Herbert & Davidson, 1994). The concept light will be treated more extensively in the subparagraphs 2.5.1 and 2.5.2. Entrapment was defined as the possibility for people to leave or escape their surroundings freely. Blöbaum and Hunecke (2005) conducted a field experiment and found that perceived danger is strongly affected by the opportunity to escape. To summarize, *social incivilities* refer to inappropriate behaviour that increase feelings of unsafety. And *physical incivilities* are referring to physical traces of vandalism in an environment. Another theory in this field is the Broken Windows Theory (BWT) of Wilson and Kelling (1982). The researchers found that places with poor maintenance and cleanliness eventually will get into a process of ongoing deterioration. According to Thompson, Offler, Hirsch, Every, Thomas and Dawson (2012) do people have the desire to say 'I've been here', such attempts are constituted by using graffiti and vandalism. The BWT focusses on the physical environment and its impact on human behaviours. The BWT proposes that maintaining and monitoring of a well ordered environment may stop further vandalism and escalation into more serious types of crime. A disordered environment normalises and encourages people to contribute to further decay of the environment. The principle of the BWT is in line with the theories of Armitage (2002) and Skogan (1990) who state that a clean and well maintained environment creates and promotes order and cleanliness. The BWT is therefore referring to perceived as well as actual safety, when an environment is perceived as less ordered it will in most cases lead to an increase of petty criminal behaviour and thereby the actual (and measureable) safety of a place. The BWT is very popular but it lacks empirical support and the available studies have provided mixed results. However Keizer, Lindenberg and Steg (2008) performed a study in which they assessed the BWT by performing six different experiments. The results of the experiments are backing the BWT. It turned out that, when people observe that others violated a social norm or legitimate rule, they are more likely to violate other norms or rules. This phenomenon is referred to as the cross- norm inhibition effect. One of the experiments assessed whether people were more likely to litter in an environment in which the walls were painted with graffiti. It turned out that 33% of the participants littered in an environment without graffiti and 69% in an environment with

graffiti. The difference between the condition with and without graffiti was found to be highly significant. The additional experiments were providing the same results and evidence for the effect of the cross- norm inhibition in practise. The BWT together with the prospect and refuge theory is mainly focussing on the relation between the physical environment as a whole and the perception of safety. The following two sub-paragraphs are more specific and focussing on the relationship between lighting. Lighting was defined by the concepts illuminance and light colour temperature.

2.5.1 Perceived safety and illuminance

This sub paragraph is focussing on the way in which the illuminance level can influence the perception of safety of an environment. As mentioned is lighting considered as one of the many physical cues that can influence the perception of safety. This sub paragraph is focussing on the way in which illuminance is able to influence the perception of safety. The illuminance level used in a certain environment seems to be closely related to the perception of safety. As mentioned earlier (paragraph 2.1.1.) are crime reduction and human behaviour concepts which are often related to the illuminance level in a certain environment. The perception of safety in relation was treated earlier (paragraph 2.1.1.) and will therefore be briefly discussed in this paragraph. The most crimes against individuals occur in places where the chance of being caught is small (Newman, 1980). Criminals have the smallest change of being caught in an environment where the illuminance level is low, as demonstrated by Tiffany and Ketchel (1970). When the illuminance level is higher, more people are making use of the depending environment and the visibility and recognition are increasing (Painter, 1996). Lighting therefore seems to be one of the most common suggestions for crime prevention by design (Lab, 1997). The perception of safety is, in addition to the level of criminal activity, also related to the illuminance level applied in a certain environment. Painter (1996) suggests in addition to that, that the three cues darkness, disorder and finding one alone or in the presence of others who are perceived to be threatening can negatively influence the perception of safety.

2.5.2 Perceived safety and light colour temperature

This sub paragraph is focussing on the way in which the light colour temperature can influence the perception of safety of an environment. As mentioned earlier in paragraph 2.1.2 is the evidence for the relation between light colour temperature and perceived safety scarce. It is however possible to make some well-founded assumptions based on literature. The main findings of paragraph 2.1.2 are that a higher light colour temperature (cold) as well as a lower light colour temperature (warm) can influence the perception of safety. Wei et al. (2014) found that the arousal and visual clarity increased when people were exposed to a higher light colour temperature. The lower light colour temperature seems to be positively related to a higher level of cosiness, cosiness is intrinsically related to the concepts safety and secureness (Bille, 2014). Therefore the second assumption is made that a lower light colour temperature can also positively influence the perception of safety. If the assumptions are true needs to become clear in the empirical phase of this study.

2.5.3 Conclusion perceived safety

The purpose of this sub paragraph is to summarize the most important findings in literature regarding perceived safety, and the relation of perceived safety with illuminance and light colour temperature. Safety is often referred to as social or personal safety, which is defined as a general cognitive response that expresses a persons' sense of security and absence of anxiety of becoming victimized when travelling through public space (Boomsma & Steg, 2013; Haans et al. 2012). A distinction is often made between actual and perceived safety. Actual safety refers to the objective or quantitative safety, such as the annual number of physical or social abuses on a train station. The perception of safety refers to the extent to which people experience an environment as safe. The perception of safety is defined earlier in this paragraph by using the prospect and refuge theory, social and physical cues and the broken windows theory. Although the concepts actual and perceived safety are related to each other, they are quite different, an environment with a low actual safety (e.g. many violence related incidents) does not necessarily need to be perceived as such. The assumption is made that other factors such as light are influencing the way in which safety is perceived. Light is in this study defined by the concepts illuminance and light colour temperature. The assumption is made that a higher illuminance level is positively influencing the perception of safety, a higher illuminance level leads to a higher visibility and recognition of others. In line with this the assumption is made that a lower light colour temperature also positively influences the perception of safety. The following paragraph will focus on the relation between cleanliness and the lighting variables illuminance and light colour temperature.

2.6 Perceived cleanliness

Cleanliness of railway stations and public space in general is seen as an important aspect of the basic experience of travellers on train stations (De Bruyn & De Vries, 2009). Moreover, cleanliness is essential to the perception of safety at stations by passengers. According to The Greater London Authority (2006) poor maintenance and uncleanliness can negatively influence the perception of fear. As with safety, it is also with cleanliness possible to make a distinction between actual and perceived cleanliness. According to Robin, Matheau-Police and Couty (2007) (cited by Molenaar & Hu 2013) there is a low correlation between actual and perceived cleanliness. This means that there are other factors which influence the perception of cleanliness. Actual and perceived cleanliness will therefore be treated in the following two paragraphs.

Actual cleanliness

Actual cleanliness refers to human activities in public space that create litter such as cigarette butts, plastic bottles and newspapers (Becherucci & Seco Pon 2014). Clean railway stations are according to Baggerman, Van Zee, Van ‘t Rot (2008) one of the most important features to contribute to a positive waiting evaluation. This is in line with a study of De Bruyn and De Vries (2009) who concluded that cleanliness together with safety and facilities are factors which are able to create a pleasant environment. The cleanliness of an environment mainly depends on littering behaviour of human beings and natural sources (Sevilla, Rodriguez, Garcia-Maraver and Zamorano, 2013). Since littering by natural sources is less relevant for this study, only human littering behaviour will be treated. Terpstra et al. (1979) defined litter as forms of garbage that originate by people throwing away objects in places that are not designated for such a purpose. Behaviour related to pollution of an environment is often referred to as littering behaviour (Armitage et al., 2000). Littering behaviour is largely depending on the time of the day, location, type of item being littered and whether the depending person is alone or in a group. Moreover, there are three subcategories by which litter can be defined, namely: packaging and disposals, information carriers and product remains (Wever, Van Onselen, Silvester & Boks, 2010).

Before the possible interventions, which counteract litter in public space will be discussed, it is interesting to look at the reasons for people to litter. Krauss, Freedman and Whitcup (1976) do appeal to individual differences, which can partly be explained by normative rules. The rules (Krauss et al., 1976) are in line with the theory of planned behaviour, as formulated by Ajzen (1991). This theory assumes that the attitude towards a certain behaviour, subjective norms and the perceived behavioural control are affecting the intentions to perform behaviour of a certain kind. According to Krauss et al. (1976) it is possible to make a distinction between three different kinds of normative rules:

1. Normative rules whose violation has immediate consequences for others, examples are theft or murder. This kind of normative rules are non-arbitrary since they specify what most members of a group agree upon as being necessary. Violation of these rules usually results in severe sanctions.
2. Normative rules that have equally serious consequences for others when being violated. Rules regulating the traffic are an example of this normative rules, as long as all people adhere to the same rules there is no problem. It will for example to the most

people not matter whether the stop signal is red or green, but if one person adheres to green as the stop signal instead of red, the consequences will be disastrous.

3. Normative rule that are non-arbitrary and the consequences of the violation are not serious. Examples of these violations are noise pollution and littering. When the rules are violated, sanctions are seldom applied or they tend to be informal and mild, violation can become a serious problem when lots of people are involved.

The third type (Krauss et al., 1976) is relevant for this study since it is focussing on littering behaviour and more general cleanliness of an environment. According to Krauss et al. (1976) there are three conditions that need to be met for individual littering behaviour to be affected by social norms. First, the individual must have learned the social norms. Second, the individual needs to perceive the meaningfulness of the norm in relation to the particular environment. Finally, the individual needs to be affected by the sanctions associated with rule violation. If one of the conditions does not apply to a person there is a big chance that he or she consistently will violate the norm. Therefore, one would expect a child to violate normative rules more often, for example because they do not understand the rule or are not able to oversee the consequences of a violation. If the three conditions are met, there are still other situational factors that influence the strength and the meaningfulness of the norm and thereby littering behaviour. A rather extreme example of situational factors is for example a fire, physical or social violence. Krauss et al. (1976) give the example of people who are more likely to litter a candy wrapper when they flee an office fire than when they take a walk through the park. Another explanation for people to litter is based on the theory that people are more likely to litter when other people are littering. This behaviour can be linked to the concept of social conformity. According to Zhou, Horrey and Yu (2009) is social conformity a personality trait that is about the willingness or tendency to follow the ideas, values and behaviours of other people. This concept is in line with the broken windows theory and more specific the study of Keizer et al. (2008), which will be discussed in the following sub paragraph ‘perceived cleanliness’.

There are several strategies available which influence littering behaviour and thereby minimize litter in public space. According to Huffman, Grossnickle, Cope and Huffman (1995), it is possible to make a distinction between antecedent and consequence strategies. Antecedent strategies try to influence littering behaviour before the generation of litter, whereas consequence strategies aim to influence people after the act of littering. Examples of antecedent strategies are written signs and verbal prompts (Geller, Witmer & Orebaugh, 1976), community involvement (Krauss et al., 1976) and removing litter since littering is more likely to occur in a littered environment (Finnie, 1973). Another antecedent strategy concerns the design, design can be used to facilitates and encourage positive behaviour by for example the presence of waste bins and ashtrays (O’Neill, Blanck & Joyner, 1980). Consequence strategies are often based on the principle of reward and penalty. Rewards increase the likelihood that positive behaviour will occur again, whereas penalties obviously will decrease the likelihood that negative behaviour occurs again (Huffman et al., 1995). As mentioned in the introduction of this paragraph is it possible to make the distinction between actual and perceived cleanliness. Actual cleanliness and littering behaviour were defined in this sub paragraph. The concept perceived cleanliness will be introduced in the following sub paragraph.

Perceived cleanliness

Perceived cleanliness is not only based on the actual amount of litter, instead of that secondary factors come into play. According to Molenaar and Hu (2013) are lighting and weather conditions examples of factors that contribute to the perceived cleanliness of an environment. The extent to which people perceive an environment as clean is also depending on the more general concept of place attachment (Bonaiuto, Fornara & Bonnes, 2013). Place attachment is defined by Brown and Perkins (1992) as positive affect, cognitive and behavioural bonds that people have with a social or physical environment. This implies that the perception of cleanliness is largely depending on the extent to which people feel attached to an environment. People who are in an environment that is perceived as clean, will start to behave more appropriately (Welsh & Farrington 2004). In contrast, people will litter more in an environment which is perceived as unclean and the number of criminal activities is higher (Molenaar and Hu, 2013). That means that the actual cleanliness of an environment can be enhanced by optimizing the perception of cleanliness. Due to its relevant relation with perceived cleanliness, the concept of place attachment will be treated more extensively. Since the concept of place attachment seems to be closely related to the perception of cleanliness of a place, it will be explored more extensively. The theory of *place attachment* is built upon the essence of the *social interdependence theory* and *theories of attraction* (Loureiro, 2014). The key of the social interdependence theory is that people communicate with each other to become closer to one another (Kelley & Thibaut, 1978). An ideal relationship is, according to the theory, characterized by high levels of reward and low levels of costs. Theories of attraction are used in many contexts, most of the time to describe interpersonal attraction (Krueger & Avshalom, 1992; Aron & Lewandowski, 2001) but also to describe the attractiveness of organisations (Ellegaard, 2012).

According to different authors is it possible to divide the concept *place attachment* into the concepts *place identity* and *place dependence* (Bricker & Kerstetter, 2000; Backlund & Williams, 2003; Loureiro, 2014). Place identity is referred to as the symbolic or affective attachment to a place or environment (Backlund & Williams, 2003). Prohansky (1978) suggest that the development of place identity is related to an increase in positive valence emotions, often referred to as intrinsic attractiveness. According to Zajonc (2001) is place identity formed on the basis of repeated exposure to a certain place, it does not matter if the exposure to a certain place is based on an actual experience or only reading or hearing about it. This phenomenon is called the mere- exposure effect by which people tend to develop a preference for a certain place because they are familiar with it. In addition to the concept place identity, is the concept of place dependence suggesting that people evaluate places based on the availability of functional needs (Backlund & Williams, 2003). Over time people develop a frame of references, based on this frame of references people evaluate how well places meet their functional needs. Whereas place identity is referring to symbolic or affective attachment to a place, is place dependence more pragmatic by focussing on the functionality of a place. The concepts of place identity and place dependence define the extent to which people are attached to a place. In addition, place attachment seems also to be determined by environmental conditions such as the overall feel, lighting and weather conditions. Place attachment is seen as an important factor when it comes to the perception of cleanliness.

Perceived cleanliness can also be linked to the Broken Windows Theory (BWT) of Wilson and Kelling (1982). According to Armitage (2002) and Skogan (1990) creates and promotes a clean and well maintained environment order and cleanliness. People are, in addition to that,

behaving more appropriate when the environment is perceived as cleaner (Welsh & Farrington, 2004). According to Molenaar and Hu (2013) is more appropriate behaviour leading to environments that feels cleaner and safer on the short term as well as on the longer term. Keizer et al. (2008) performed a study in which the BWT was tested in a series of field experiments. It turned out that when people are observing other people who are violating social norms or legitimate rules, they are more likely to violate other norms or rules. An example of this phenomenon is that people are significantly more likely to litter and even steal when the environment is perceived as less clean. This process is defined by the authors as the cross- norm inhibition effect and is caused by a conflict between injunctive and descriptive norms. Injunctive norms are described by Keizer et al. (2008) as the perception of behaviours that are typically approved or disapproved in an environment. Descriptive norms refer to the perception of the behaviour which are typically performed and are seen as normal in that depending environment. Based on this, the conclusion might be drawn that people are more likely to litter or commit other 'crimes' when they perceive that other people have littered the environment.

2.6.1 Perceived cleanliness and illuminance

This sub paragraph is focussing on the way in which illuminance can influence the perception of cleanliness of an environment. Molenaar and Hu (2013) performed experiments in a metro coupe in which they were assessing the relation between different illuminance levels and the perception of cleanliness. The researchers found that people perceive an environment as more clean when the attention is drawn to the litter by using a higher illuminance level. As mentioned in sub paragraph 2.1.2, there are several explanations for this outcome. A first explanation is that the littered place enhances the clean feel of the remaining part of the depending environment. Another plausible explanation is that people have the feeling that soon something is going to be done about the situation when the illuminance level on the littered spot is higher. The empirical evidence on the relation between illuminance and perceived cleanliness is scarce, the empirical phase of this study is therefore crucial to gain additional insights.

2.6.2 Perceived cleanliness and light colour temperature

This sub paragraph is focussing on the way in which light colour temperature can influence the perception of cleanliness of an environment. As mentioned in sub paragraph 2.2.2, is the evidence in academic literature for a relation between light colour temperature and the perception of cleanliness scarce. The only evidence comes from a study performed by Pijls and Groen (2012), who looked into the measures that influence the perception of cleanliness of hospital patients. The higher light colour temperatures (5000K, cool) where associated with cleanliness, whereas the lower light colour temperatures (3000K, warm) where associated with uncleanliness.

2.6.3 Conclusion perceived cleanliness

The purpose of this sub paragraph is to summarize the most important findings in literature regarding perceived cleanliness and the relation between perceived cleanliness on the one hand, and illuminance and light colour temperature on the other. Cleanliness of railway stations and public space in general is seen as an important aspect of the basic experience of

travellers on train stations (De Bruyn & De Vries, 2009). Cleanliness is essential to the perception of safety at stations by passengers. As with safety, a distinction is made between actual and perceived cleanliness. Actual cleanliness refers to human activities in public space that create litter such as cigarette butts, plastic bottles and newspapers (Becherucci & Seco Pon 2014). Whereas perceived cleanliness is not only based on the actual amount of litter, instead of that secondary factors come into play. The perception of cleanliness is partly determined by the concept place attachment. Place attachment is defined by Brown and Perkins (1992) as positive affect, cognitive and behavioural bonds that people have with a social or physical environment. In addition to that it is possible to relate the perception of cleanliness to the broken windows theory (BWT). The BWT says that a clean environment creates and promotes cleanliness. People are, in addition, behaving more appropriate when the environment is perceived as clean. Although there is not much literature available on this topic, there seems to be a relation between light and the perception of cleanliness. The assumption is made that a high illuminance level and a cold light colour temperature is leading to a more positive perception of cleanliness. The following paragraph will focus on the relation between ambience and the lighting variables illuminance and light colour temperature.

2.7 Perceived ambience

In literature is often referred to ambience as being the atmosphere of a place and vice versa. The meaning of ambience and atmosphere are roughly the same, the two concepts are used interchangeably. Since both terms are used in literature it is important to be consistent and use one of the two, in this study ambience will be used. Ambience is defined as the effort to develop a service environment which evokes specific emotional effects and positively contributes to the evaluation of the provided service (partly adopted from Kotler, 1973). In this paragraph, three components of the concept ambience will be discussed. First, the difference between intended and perceived ambience. Secondly the different dimensions of ambience and finally the relation between perceived ambience and human behaviour.

Intended and perceived ambience

Ambience is in contrast to the concepts of safety and cleanliness an affective evaluation of a certain environment (Vogel, 2008). It is not possible to measure the amount of ambience or rank train stations based on their ambience in an objective way. In contrast to the concepts safety and cleanliness which are more abstract and easier to measure. It is possible to make a distinction between intended and perceived ambience. The intended ambience is described by Kotler (1972) as the set of sensory qualities that a designer of the environment tries to convey to the space. Kotler (1972) uses the example of an Israeli airline who described their core values as being: cheerful, warm and friendly. Their core values are transmitted to the travellers by using an appropriate colour scheme and lighting. Kotler (1972) stresses that the perceived ambience may vary for different people. One's reaction to for example colours, sounds, noises and temperatures are partly learned and may largely depend on one's culture. People of different cultures have especially different thoughts about colour, for example colours used during a funeral. In western countries (e.g. United States, Europe) the colour black is common, whereas the colour white is most common in Eastern (e.g. Afghanistan, Iraq). In the following part of this paragraph, the concept ambience will be divided into different dimensions.

Ambience divided into different dimensions

Kotler (1973) found that a place and more specific the ambience is more influential than the product in the experience of the consumer. Whereas sight, sound, scent and touch are the most important sensory channels to convey ambience. According to Kotler (1973), it is possible to divide the concept ambience into four different dimensions, namely: visual, aural, olfactory and tactile dimension. The *visual dimension*, is defined as the colour, brightness of light, size and shape of an environment. The *aural dimension* of ambience refers to the pitch, in most cases type of music, and the volume of this sound. The *olfactory dimension* deals with the scent and freshness of an environment and finally the *tactile dimension* refers to the softness, cleanliness and temperature of an environment. Especially the visual dimension is relevant for this study, since it is referring to the lighting conditions of an environment. Cleanliness, another variable in this study is also mentioned as being part of the concept ambience. Therefore, the concepts ambience and cleanliness will possibly be correlating in the empirical phase of this study. In line with the study of Kotler (1973) many other studies to the effect of atmosphere where carried out, based on these studies it is possible to make a distinction between different elements that define atmosphere. They are, colour and lighting (Bellizzi, Crowly & Hastey, 1983), social factors (Baker, Grewal & Levy, 1992), ambient factors such as music (Kellaris & Mantel, 1996) and the number of people present (Eroglu & Machleit,

1983; Hui & Bateson, 1991). There are small differences between the elements defined by Kotler (1973) and the elements that were defined by other researchers. The most notable difference is the addition of the social factor, which is not explicitly described in the study of Kotler. Kotler (1973) is focussing on spatial characteristics which can be associated with the concept ambience. Whereas other researchers also have included human elements such as the social factors and number of people present in an environment. So far, it has become clear what ambience means and of which dimensions ambience is consisting, the final paragraph will be used to describe how ambience can influence the behaviour of human beings.

Ambience and human behaviour

Ambience and human behaviour are related to each other. According to Heung and Tianming (2012) are customer satisfaction and behaviourial intentions influenced by ambience. More specific, the intentions return, spread positive word-of-mouth and their willingness to pay more. Since the literature available about ambience in the rail sector is scarce, studies performed in a retail or hospitality setting were used. Retail, hospitality and the rail sector have in common that they are inextricably linked with an environment in which a service (combined with a product or not) is provided, this environment is often referred to as a service environment (Bitner, 1992). Kotler (1973) assessed the relation between the ambience of a place and the probability that a person will buy a product or service. He visualised this relation in the so called 'causal chain that connects atmosphere and purchase probability' (figure 6). The first step of the model refers to the sensory qualities of a space in which a service or product is offered. The second incorporates the fact that potential buyers not perceive all sensory qualities of a space. This is due to the fact that people's perception is influenced by selective attention, distortion and retention. If the sensory qualities are perceived by the depending person (step 3) it can possibly have an effect on the information and affective state. Finally, the purchase probability might be increased by the modified information and affective state. According to Kotler (1973) can ambience influence purchase behaviour in three different ways, namely as an attention-creating, message- creating or affect-creating medium.

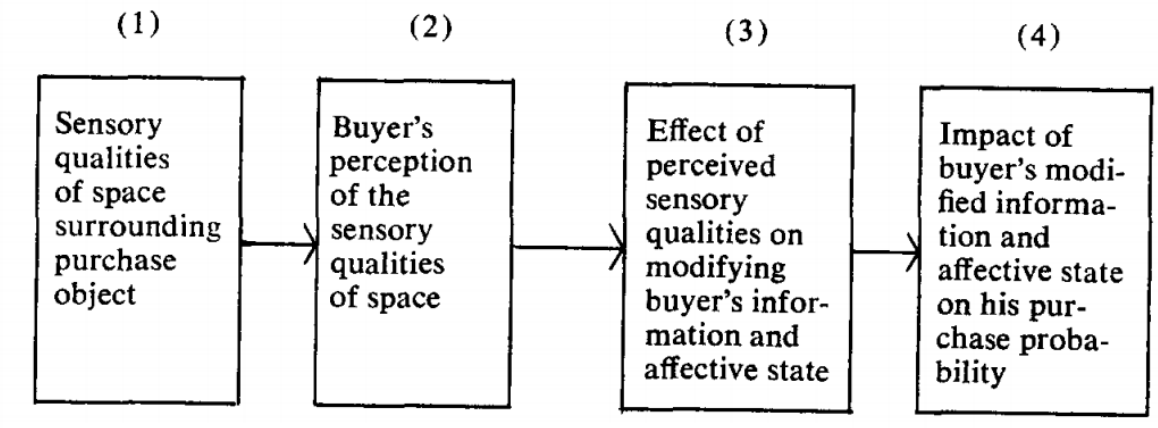

Figure 6: The causal chain connecting ambience and purchase probability (Kotler, 1973).

This is quite in line with the findings of Vogels (2008), who argues that ambience is, compared to mood, considered to be a fairly stable concept. This is due to the fact that ambience is an affective evaluation of the environment, a subjective impression, rather than an affective state or feeling itself. The way in which ambience is perceived is therefore more strongly linked to the expected than the actual emotion effect of the environment. To illustrate, a traveller can evaluate a train station as 'relaxing' while feeling pretty stressed. For this reason Vogels (2008) argues to use the perception of ambience to evaluate the psychological effect of the environment instead of using the concept mood. Kotler (1973) describes in a pragmatic way in which way ambience can influence the behaviour of people in the service industry, he uses the airline business as an example. Many people are despite of the low air fatality statistics afraid of flying, airlines have to deal with this issue indirectly. Airlines can gain confidence by making use of the concept of ambience, this was done in different ways. Air terminals often appear to be very modern, bustling and efficient, in addition to that, is the design sturdily and attractive (especially on longer flights). Finally the social factor is really important for airline businesses, employees need to look confident and pilots are for example often tall, handsome and experienced looking. In this case, the costume of airline employees needs to contribute to the overall ambience of the flight.

Summarizing, ambience is defined as the effort to develop a service environment which evokes specific emotional effects and positively contributes to the evaluation of the provided service (Kotler, 1973). Instead of the concepts safety and cleanliness is ambience an affective evaluation of the environment (Vogel, 2008). This means that it is not possible to measure the amount of ambience in a certain place or compare the amount of ambience at the train station of Utrecht with the amount of ambience at the train station of Amersfoort. For this reason it is much more convenient to make a distinction between intended and perceived ambience. Furthermore, it is possible to divide the concept ambience into four different dimensions, namely, visual aural, olfactory and tactile dimension (Kotler, 1973). Heung and Tianming (2012) found that ambience can influence customer satisfaction and behavioural intentions, more specific, the intentions return, spread positive word-of-mouth and their willingness to pay more.

2.7.1 Perceived ambience and illuminance

Any lighting designer, lighting researcher or architect agree with the statement that the level of illuminance is directly related to the extent of perceived ambience of a place. According to literature is there a relation between the illuminance level and ambience on the one hand and emotions, mood and cognition on the other (Fleischer et al., 2001; Custers et al., 2010). As mentioned earlier (paragraph 2.1.3.) is a higher illuminance level leading to more pleasant emotions and increased level of dominance. In addition to that, Custers (2010) found that the illuminance level contributes significantly to the three atmosphere dimensions: cosiness (negatively related), tenseness and detachment. The general consensus in practise is, as mentioned earlier, that service companies like retailers should employ a low illuminance level in order to lower the level of arousal for customers. Customers will peruse more products because of the lower walking pace by which customers move through the store (Markin et al., 1976). The concept light colour temperature will be treated in the following sub paragraph.

2.7.2 Perceived ambience and light colour temperature

This sub paragraph is focussing on the way in which light colour temperature can influence the perception of ambience of an environment. As mentioned in previous paragraphs (2.2.3 and 2.7.1) is it straightforward that the perception of ambience is related to the type of lighting in an environment. Especially the illuminance level and light colour temperature seems to be relevant. Custers et al. (2010) found that cool white light, or a higher light colour temperature negatively influences the perceived ambience of a place. A warm light colour temperature can be used to enhance the perception of ambience of a place.

2.7.3 Conclusion perceived ambience

The purpose of this sub paragraph is to summarize the most important findings in literature regarding perceived ambience and the relation between perceived cleanliness on the one hand, and illuminance and light colour temperature on the other. Ambience is defined as the effort to develop a service environment which evokes specific emotional effects and positively contributes to the evaluation of the provided service (partly adopted from Kotler, 1973). Ambience is in contrast to the concepts of safety and cleanliness an affective evaluation of a certain environment (Vogel, 2008). It is not possible to measure the amount of ambience or rank train stations based on their ambience in an objective way, this in contrast to the concepts of safety and cleanliness which are more abstract and measurable concepts. Therefore, a distinction is made between intended and perceived ambience. The intended ambience is described by Kotler (1972) as the set of sensory qualities that a designer of the environment tries to convey to the space. Kotler (1972) stresses that the perceived ambience may vary for different people, one's reaction to for example colours, sounds, noises and temperatures are partly learned and may largely depend on one's culture. Based on literature, there is a robust relation between ambience and light. The assumption is made that a low light illuminance level and a warm light colour temperature are leading to a more positive perception of ambience. The conclusions of the theoretical framework will be summarized in the following paragraph.

2.8 Conclusions theoretical framework

The goal of this paragraph is to sum up the results and draw the conclusions of this theoretical framework. The paragraph is split up into three different sub paragraph. Each environmental variable (perception of safety, cleanliness and ambience) will be discussed in a separate sub paragraph.

2.8.1 Safety

It has become clear in the previous paragraphs that the perception of safety can be influenced in a positive way by using light. A higher illuminance level and a lower light colour temperature positively influence the perception of safety. In the field of safety, illuminance is often related to crime reduction. In general people prefer a place with a high illuminance level more than a place with a lower illuminance level. Since people prefer places with a higher illuminance level, there are in most cases more people present in these places. When there are more people present in a place, the perception of safety increases and crime rates drop. Research performed in the area of density in public spaces indicated that people feel less safe in abandoned places and very busy places. According to literature is light colour temperature in addition to illuminance also able to influence the perception of safety of a place. The general conclusion is that travellers evaluate a place as more safe when the lighting is warm, warm light represents a low light colour temperature. Travellers prefer warmer light since it is associated with cosiness and comfort. Finally it is useful to mention that safety is perceived differently by different kind of travellers. Travellers who are familiar with a certain train station, such as commuters, perceive the environment as more safe, since they know there way around. More recreational travellers on the other hand, will perceive the same train station as less safe since they are less familiar with that depending area.

In conclusion, higher light intensities and warm light colour temperatures can positively influence the perception of safety. The concepts goal- orientedness and density turned out to mediate the relationship between light and the perception of safety.

2.8.2 Cleanliness

It has become clear that cleanliness can be influenced by using light. It turned out that even littering behaviour, which largely determines the cleanliness of an area can be influence by using light. A higher illuminance level and a higher light colour temperature are positively influencing the perception of cleanliness. A higher illuminance level in an unclean space will give people the impression that soon something will be done about the uncleanliness. In addition to that are cool colours (high light colour temperature) also able to influence the perception of cleanliness. It is possible to make a distinction between travellers based on the way in which they perceive cleanliness. Commuters are for example quicker irritated because of unexpected findings, such as an unclean train station than recreational travellers. There is no direct evidence available for the mediating effect of density on the relation between light and cleanliness. Based on common sense, the assumption is made that a higher density will lead to a more positive perception of cleanliness.

Based on literature the conclusion is drawn that high light intensities and warm light colour temperatures can positively influence the perception of cleanliness by travellers. The concept goal- orientedness is mediating this relationship, the evidence for the mediating concept density is scarce.

2.8.3 Ambience

It is proven by using scientific literature that the perceived ambience of a place can be influenced by using light. A lower illuminance level and a lower light colour temperature will positively influence the perception of ambience of a place. A lower illuminance level causes less stress and gives travellers a feeling of cosiness and relaxation. The stress level of traveller's decreases and the mood improves when the lighting is warmer. Again, it is possible to make a distinction between commuters and recreational travellers. Travellers with a recreational purpose find service, comfortable seating and a warm atmosphere important while commuters find the aspects privacy, peace and a fast flow important. In addition to that are recreational travellers more receptive for the environment, they will therefore in general perceive a station as more ambient than commuters. The second mediating variable density can also have an important effect, a high density level negatively influences the perception of ambience. It is however important to make a distinction between environments that focus on pleasure and environments that are more functional. In for example bars or restaurants, density can enhance the perception of ambience. Whereas, density in more functional settings, such as a supermarket, has a more negative effect on the perception of ambience.

Based on literature the conclusion is drawn that a low light intensity and warm light colour temperatures can positively influence the perception of ambience by travellers. The concepts goal- orientedness and density are mediating this relationship. The role of density is largely determined by the purpose (pleasure or functional) of the environment.

3. Methods

In the third chapter of this report, the methods employed in the empirical phase of this study were be described. The technical research design was already formulated in the introduction of this report (paragraph 1.4). This paragraph contains more specific information about the participants and the design of the research (3.1). The actual procedures employed in the empirical phase of this study (3.2). And the constructs which were described briefly in paragraph 1.4 will be described more extensive in paragraph 3.3.

3.1 Sample and design

The purpose of this paragraph is to describe the sample. In addition to that the design of this project will again be illustrated in order to make it easier for the reader to understand paragraph 3.2 and 3.3. Students of two different universities were approached for this study. In total 280 students participated (44.9% were male, 55.1% female). The average age of those members was 20.63 years (SD = 5.78, minimum 16, maximum 62 years). In a 3 (illuminance: high vs middle vs low level) x 2 (light colour temperature: warm vs cold) x 2 (goal orientedness: must vs lust) x 2 (density: high vs low) between subjects design the influence of lighting on the perception of safety, cleanliness and ambience of travellers on train stations was tested.

3.2 Procedures

The effect of the illuminance level and the light colour temperature was measured by providing the participants an exercise on the virtual station of Amersfoort. The participants had to catch the train to Amsterdam. While loading the virtual train station, the individual participants were randomly assigned to an illuminance level (75, 150 or 225 lux), light colour temperature (3000 or 5000 kelvin), a density level (low or high) and finally a motivational orientation (must or lust). Screenshots of the different lighting and density conditions can be found in appendix B The illuminance level, light colour temperature and density level are pretty straightforward, the motivational orientation, referred to as goal- orientedness in this report needs additional explanation. The participants were randomly assigned to either a must or lust scenario. The must traveller scenario was: ‘you are hurried’ and the lust traveller scenario was: ‘you have plenty of time’ (see appendix C for the complete scenarios). This is in line with the studies of Wirtz, Mattila and Tan (2000) and Van Hagen (2011) in which the different scenarios were employed successfully. The participants were starting in the tunnel or in the station hall. After the participants were through the tunnel or station hall, they were asked to fill out a questionnaire about that depending part of the train station. After filling out the questionnaire, the participants were led back to the virtual model in which they were able to catch their virtual train. After they ‘stepped’ onto the train, they were asked to fill out a final questionnaire about the platform of the train station. The questionnaire was concluding constructs that were questioning their emotion, perception of the train station and perception of the employed lighting. In the following paragraph 3.3 the different constructs will be discussed.

3.3 Constructs

The different constructs that were used will be described in this paragraph. In addition will, the corresponding statistical reliability of the constructs will be evaluated by describing the Cronbach's alpha. All items (except for the general attitude towards the tunnel, station hall and platform) were measured by using a seven points Likert scale, whereas one represents 'totally disagree' and seven 'totally agree'. In each of the following sub paragraphs a construct is discussed that was used in this study. The complete list of the constructs and corresponding items can be found in appendix A. Important to note is that the questionnaire was conducted in Dutch. The different items described in this paragraph were translated from English to Dutch, this might have led to some small differences.

3.3.1 Perceived illuminance

The perception of illuminance was measured by using a construct which was developed for this study. The construct is consisting of four items (α = .87) which were measured by using a seven points Likert scale, ranging from totally disagree to totally agree. One of the items is: *''the lighting at the station was: very weak - very bright''.*

3.3.2 Perceived light colour temperature

The perception of light colour temperature is measured by using a construct which was developed by Peters (2008). The construct is consisting of three items (α = .74) which were measured by using a seven points Likert scale, ranging from totally disagree to totally agree. One of the items is: *''the lighting in the station was: very cool - very warm''.*

3.3.3 Perceived goal- orientedness

Since it is important that the participants experience the motivational orientation which was allocated to them, four items (α = .82) (Sauren, 2010) were used to measure the perception of goal orientedness. One of the items is: *''on the train station I wanted to focus on my task''*, as mentioned in the introduction, the items were measured by using a seven points Likert scale, ranging from totally disagree to totally agree. The fourth item of this construct was omitted. By omitting this item the internal consistency (α) of the scale increased from .46 to .82.

3.3.4 Perceived density

In order to measure to which extent the participants experience the allocated density as such, five items (Sauren, 2010) were used to measure the perception of density. One of the items within this construct (α = .83) is: *''there are many travellers at the train station''*, the items were measured by using a seven points Likert scale, ranging from totally disagree to totally agree.

3.3.5 Perceived safety

The perception of safety was measured by using the construct of Taylor (1994) and Vos (2014). The construct is consisting of five items (α = .81) which were measured by using a

seven points Likert scale, ranging from totally disagree to totally agree. One of the items is: *''during the time spent on the train station I felt safe''*.

3.3.6 Perceived cleanliness

The perception of cleanliness was measured by using a construct which was developed for this study. The construct is consisting of four items (α = .83) which were measured by using a seven points Likert scale, ranging from totally disagree to totally agree. One of the items is*: '' the train station is well maintained*''.

3.3.7 Perceived ambience

The perception of ambience was measured by using the Station Belevings Monitor SBM (2013), a tool which was developed by NS Stations. The construct is consisting of four items (α = .83) which were measured by using a seven points Likert scale, ranging from totally disagree to totally agree. One of the items is: *''I think that the station is atmospheric''*.

3.3.8 Approach & avoidance behaviour

Approach & avoidance behaviours were measured by using the construct of Mehrabian et al. (1974). The construct is consisting of five items (α = .440) which were measured by using a seven points Likert scale, ranging from totally disagree to totally agree. One of the items is: *''I would explore the train station''*. The Cronbach alpha of this construct was too low to use the gathered data in the next phases of this study. Even by separately testing the questions which were focussing on approach behaviour (α = .51) and avoidance behaviour (α = .62), the reliability of the scale was too low. This means that the different items were not measuring the same concept based on pairwise correlations between the items.

3.3.9 PAD emotions (pleasure, arousal and dominance)

The PAD emotions (pleasure, arousal and dominance) were measured by using bipolar concepts on a seven point Likert scale (Russel and Mehrabian, 1974). Such as: *''indicate how you felt during the time spend in the tunnel: unhappy – happy''*. Pleasure was measured by using four items: unhappy – happy, irritated – happy, unsatisfied – satisfied and unpleasant – pleasant (α = .89). Arousal was measured by the following four items: relax – agitated, calm – excited, apathetic – stressed and quit – agitated (α = .69). Since the Cronbach alpha of arousal was initially .51, item 3 and item 4 were omitted in order to increase the reliability of the construct. Finally, the concept dominance was measured by using four concepts, namely: impressionable – influential, docile – leading, insecure – in control and submissive – dominant (α = .74).

3.3.10 General questions

Finally, the questionnaire was concluded with four general questions, which were developed for this study. The first one was about the general attitude towards the train station, based on a ranking from 0 (lowest score) to 10 (highest score). The second question was about the departure station, in order to see if the size of the station matters. In line, the third question

was about the recognition of the virtual train station and the fourth question was used to find out whether the participants had comments of any kind.

4. Results

The results of the empirical phase of this study will be discussed in this chapter, whereas paragraph 4.1 focusses on the results of the pre- test and more specific the outcomes of the manipulation checks. Paragraph 4.2 focusses on the outcomes of the post- test. Due to practical reasons the same dataset is used in the pre- test phase as the post - test phase. Since the outcomes of the pre-test are positive, there is no need to recruit additional participants for the post- test. Of the 280 participants who participated in this study, 44.9% were male and 55.1% female. The average age was 20.63 years (SD = 5.78, minimum 16, maximum 62 years). The average age is relatively low since the major part of the sample was consisting of students. The possible consequences of this on the reliability of this study will be described in chapter 6.

4.1 Results of the pre- test

As mentioned in paragraph 1.4 of this report is the main purposes of the pre- test to perform a set of manipulation checks. The goal of performing manipulation checks is to determine whether the performed interventions were successful. This test is not intended to verify if the independent variables caused variation in the dependent variables. The test was merely used to see if for example the high density scenario was indeed perceived as denser than the low density scenario. Manipulation checks were performed for the different illuminance and light colour temperature levels, goal- orientedness and the different density levels. The results of this manipulation checks were discussed in the following four sub paragraphs.

4.1.1 Preparation dataset

Out of totally 643 responses (tunnel, station hall and platform) a set of 73 outliers were omitted. The major part of these outliers were referring to participants who filled out the questionnaire as part of a large group of participants. Due to this were the instructions (e.g. take your time, read the introduction carefully) probably not received or understood.

4.1.2 Manipulation check illuminance

Totally four items of the questionnaire (α = .87) were used to measure the perception of illuminance in the tunnel, station hall and at the platform of the train station. The participants were randomly exposed to one of the different illuminance levels, the levels were, 75 lux (low), 150 lux (medium) and 225 lux (high). The participants were starting in the tunnel (N = 173) or station hall (N = 142), after that all participants were placed on the platform (N = 255) of the virtual train station. An ANOVA test showed that the lowest illuminance level was indeed perceived as the least intense (M = 3.79, SD = 1.10) after that the medium level (M = 3.80, SD = 1.16) and the highest illuminance level (225 lux) was finally perceived as most intense (M = 3.88, SD = 1.24), F (2, 640) = .458, p = .689). There were no significant differences found for the three different parts of the train station. The result of the manipulation check did not change when the medium level light intensity was omitted (F (2, 640) = .458, p = .547). There is a possible explanation for this result. The differences between the three illuminance levels were quiet small (75, 150 and 225 lux), research indicates that people are not able to consciously perceive the illuminance level of a certain space. This

process is an unconscious process, which means that people are not able to note the differences between the illuminance levels in different spaces. If person X for example is put in room A with an illuminance level of 75 lux, subsequently is placed in room B with an illuminance level of 150 lux and thereafter is asked which room was brighter is probably not able to give the right answer. When the range is extended to 20 and 500 lux, participants will be able to detect differences, these values are however no realistic replication of reality. In this study significant effects were found which confirm conclusions drawn in previous light studies. Therefore the assumption was made that the illuminance level is indeed perceived unconsciously and therefore cannot be confirmed neither rejected by using the manipulation checks. Therefore, the assumption is made that the concept illuminance was measured in a reliable way and can be included in the post- test analysis.

4.1.3 Manipulation check light colour temperature

Totally three items of the questionnaire ($\alpha = .74$) were used to measure the perception of light colour temperature in the tunnel, station hall and at the platform of the train station. The participants were randomly exposed to one of the different illuminance levels, the levels were, 3000K (warm) and 5000K (cold). The participants were starting in the tunnel (N = 173) or station hall (N = 142), after that all participants were placed on the platform (N = 255) of the virtual train station. An ANOVA test showed that the participants who were exposed to the light colour temperature of 3000K (M = 3.54, SD = 0.98) were indeed perceiving this condition as warmer. The participants exposed to the light colour temperature of 5000K were perceiving the lighting as colder (M = 3.29, SD = 1.02), $F (1, 567) = 8.660$, $p = .003$. No significant differences were found for the three different parts of the train station. The main conclusion of this sub paragraph is, that the concept light colour temperature is measured in a reliable way and can be included in the post- test analysis.

4.1.4 Manipulation check goal- orientedness

Totally four items of the questionnaire ($\alpha = .82$) were used to measure the perception of goal-orientedness in the tunnel, station hall and at the platform of the train station. The fourth item of the goal- orientedness scale ‘On the station I have experienced stress’ was omitted. By omitting this item the internal consistency (α) of the scale increased from .461 to .815. This is probably due to the differences between the first three items and the fourth one. The first three items were more specific focused on goal- orientedness by asking questions about the urgency of people to focus on their task. The fourth item rather focussed on an effect, namely stress, which can be a result of people needing to focus on their task. The participants were randomly allocated to a must (utilitarian) or lust travellers (hedonic) scenario. The participants were starting in the tunnel (N = 173) or station hall (N = 142), after that all participants were placed on the platform (N = 255) of the virtual train station. An ANOVA test showed that the participants who were exposed to the must travellers (M = 6.32, SD = 0.78) scenario were more goal oriented than lust travellers (M = 6.17, SD = 0.90), $F (1, 568) = 4.111$, $p = .043$). There were no significant differences found for the three different parts of the train station. The main conclusion of this sub paragraph is, that the concept light colour temperature is measured in a reliable way and can be included in the post- test analysis.

4.1.5 Manipulation check density

Totally five items of the questionnaire (α = .83) were used to measure the perception of density in the tunnel, station hall and at the platform of the train station. The participants were randomly allocated to a low or high density level and they were starting in the tunnel (N = 173) or station hall (N = 142), after that all participants were placed on the platform (N = 255) of the virtual train station. An ANOVA test showed that the participants who were exposed to the high density scenario (M = 3.23, SD = 1.34) were perceiving the environment as more dense than people who were exposed to the low density level (M = 2.96, SD = 1.37). F (1, 568) = 6.947, p = .009. There were no significant differences found for the three different parts of the train station. The main conclusion of this sub paragraph is, that the concept light colour temperature is measured in a reliable way and can be included in the post- test analysis.

4.1.6 Conclusion pre- test

The main conclusion of this paragraph about the results of the pre- test, is that all the different interventions were perceived as such by the participants. Besides the removal of one item of the goal- orientedness scale there is no need to make any adjustments to the questionnaire or virtual train station. This means that the dataset is reliable and can be used for further analysis in the following paragraph (4.2).

4.2 Results of the post- test

The results of the post- test were described in this paragraph. The results were described, based on figure 2 in paragraph 1.3, which represented the expected relations between the independent and dependent variables. This paragraph is divided into seven different sub paragraphs. The normality assumptions for the statistical analysis were tested in sub paragraph 4.2.1. In the subsequent sub paragraph the relation between the independent variables (illuminance and light colour temperature) and dependent variables (perception of safety, cleanliness and ambience) was treated by using a MANOVA. After that, the intervening effect of the variables goal- orientedness and density was be tested in sub paragraph 4.2.3 by using a MANCOVA. Sub paragraph 4.2.4 focusses on the interaction effects between the different variables. The sub paragraphs 4.2.5, 4.2.6 and 4.2.7 focus on the dependent variables safety, cleanliness and ambience by using ANOVA's. Sub paragraph 4.2.8 contains additional results which are not directly used to support the hypothesis but are useful for the final conclusions of this study. Final sub paragraph 4.2.9 contains the general conclusion for the post- test. As mentioned in paragraph 1.4.2, a distinction was made between the tunnel, station hall and platform of the virtual train station. Participants started at the tunnel or station hall, after filling out the questionnaire for this parts of the train station, they were 'placed' at the platform of the train station. Due to the relatively small amount of participants, it was not possible to draw conclusions from the datasets for the tunnel and station hall.

4.2.1 Normality assumptions

Before any statistical test is performed, it is essential to check if the normality assumptions are met. Prior to conducting the MANOVA, a correlation analysis were performed between the dependent variables, to check if the dependent variables correlate with each other in an

acceptable range. As can be seen in table 1, are the dependent variables correlating in a moderate way, suggesting the appropriateness of a MANOVA. A Box's M test was performed to test if the covariance matrices between the groups are equal. The Box's M value of 40.373 was associated with a non- significant p-value of .108. Which means that the covariance matrices between the groups were assumed to be equal. In addition to the homogeneity of variance assumption was tested for the three dependent variables by using Levene's F test. It turned out that the Levene's F Tests for the perception of safety (F (5, 563) = 1.277, p = .272), cleanliness (F (5, 563) = 1.458, p = .193) and ambience (F (5, 563) = 1.058, p = .383) were non- significant. This indicates that the homogeneity of variance assumption was considered satisfied, suggesting that the ANOVA would be robust.

	Perception of safety	Perception of cleanliness	Perception of ambience
Perception of safety		R (570) = .377, p = .000	R (570) = .221, p = .000
Perception of cleanliness	R (570) = .377, p = .000		R (570) = .183, p = .000
Perception of ambience	R (570) = .221, p = .000	R (570) = .183, p = .000	

Table 1: Pearson correlation coefficient for the dependent variables

4.2.2 General effect of light

This sub paragraph contains the results for the relation between light (illuminance and light colour temperature) and the perception of safety, cleanliness and ambience. The results were summarized in table 2. A one-way multivariate analysis of variance (MANOVA) was conducted to test the hypothesis that there would be one or more mean differences between the perception of safety, cleanliness and ambience under the influence of different illuminance levels. A statistically significant MANOVA effect was obtained, Wilks' Lambda = .976, F (6, 1122) = 2.329, p = .031. This means that the traveller experience, defined by the perception of safety, cleanliness and ambience, is significantly depending on the illuminance level employed at the train station. The multivariate effect size for illuminance was estimated at .012, which implies that 1.2% of the variance in the set of dependent variables was accounted for by the illuminance level employed. The same MANOVA was conducted to test the hypothesis that there would be one or more mean differences between the perception of safety, cleanliness and ambience under the influence of different light colour temperatures. A statistically significant MANOVA effect was obtained, Wilks' Lambda = .981, F (3, 561) = 3.556, p = .014. This means that the traveller experience, defined by the perception of safety, cleanliness and ambience, is significantly depending on the light colour temperatures employed at the train station. The multivariate effect size for light colour temperature was estimated at .019, which implies that 1.9% of the variance in the set of dependent variables was accounted for by the light colour temperature employed. In addition to the individual effect of illuminance and light colour temperature, a MANOVA was performed to test the combined effect of illuminance and light colour temperature on the perception of safety, cleanliness and ambience. A significant effect was obtained for the combined effect of illuminance and light colour temperature (Wilks' Lambda = .979, F (6, 1120) = 1.965, p = .068). It is however important to note that this relation is less significant than the single effects of illuminance and light colour temperature. The significance level needs to be adjusted from 95% to 90% to become significant. The multivariate effect size for illuminance and light colour temperature together was estimated at .010, which implies that 1.0% of the variance in the set of dependent variables was accounted for by illuminance and light colour

temperature combined. This is slightly lower than the individual effects of the lighting variables. The interaction effects will be discussed in more detail in paragraph 4.2.4 and the individual results for the perception of safety, cleanliness and ambience will be discussed in the sub paragraphs 4.2.5, 4.2.6 and 4.2.7. The possible intervening effect of the variables goal- orientedness and density will be discussed in the following sub paragraph.

	Wilk's lambda	**F**	**p**	**Partial eta squared**
Illuminance	.976	2.329	.031	.012
Light colour temperature	.981	3.556	.014	.019
Illuminance * light colour temperature	.979	1.965	.068	.010

Table 2: MANOVA for light in relation to the perception of safety, cleanliness and ambience

4.2.3 General effect of goal- orientedness and density

This sub paragraph contains the results for the relation between goal- orientedness and density on the one hand and the perception of safety, cleanliness and ambience on the other. The results were summarized in table 3. As mentioned earlier in sub paragraph 1.4.2 were the variables goal- orientedness and density for first instance treated as independent variables with a possible intervening effect. A one-way multivariate analysis of covariance (MANCOVA) was performed to test the hypothesis that goal- orientedness and density are having an intervening effect. Furthermore the hypothesis was tested that there would be one or more mean differences between the perception of safety, cleanliness and ambience under the influence of goal- orientedness and density. It turned out that goal- orientedness (Wilks' Lambda = .998, F (3, 559) = .450, p = .717) and density (Wilks' Lambda = .997, F (3, 559) = .507, p = .678) were not having an intervening effect on the relation between the independent variables (illuminance and light colour temperature) and the dependent variables (perception of safety, cleanliness and ambience). Even if the variables were treated as independent variables they were not having a significant effect on the mean differences between the perception of safety, cleanliness and ambience. This means that the traveller experience, defined by the perception of safety, cleanliness and ambience, is not significantly depending on goal- orientedness and density. The conclusion of this sub paragraph is that goal- orientedness and density are not directly influencing the perception of safety, cleanliness and ambience. There were however indications that there are more complex interaction effects in which goal- orientedness and density are involved. Since the variables goal- orientedness and density were not having an intervening effect, they are from now on treated as independent variables. These interaction effects will be discussed in the following sub paragraph.

	Wilk's lambda	**F**	**p**	**Partial eta squared**
Treated as intervening variable				
Goal- orientedness	.998	.450	.717	.002
Density	.997	.507	.678	.003
Treated as independent variable				
Goal- orientedness	.996	.688	.559	.004
Density	.998	.422	.738	.002

Table 3: MANOVA for goal- orientedness and density in relation to the perception of safety, cleanliness and ambience

4.2.4 Interaction effects

In addition to the MANOVA's which assessed the individual effect of the independent variables, a couple of interaction effects between the independent variables were detected (table 4). Besides the earlier mentioned interaction effect between illuminance and light colour temperature (paragraph 4.2.2), there were two additional interaction effects found. A two way interaction was found between illuminance and goal- orientedness on the perception of safety, cleanliness and ambience (Wilks' Lambda = .977, F (6, 1088) = 2.142, p = .046). This means that the traveller experience, defined by the perception of safety, cleanliness and ambience, is significantly depending on the illuminance level combined with the goal-orientedness of travellers. The multivariate effect size was estimated at .012, which implies that 1.2% of the variance in the set of dependent variables was accounted for by the illuminance level combined with the goal- orientedness of travellers. In addition to that, a three way interaction between illuminance, light colour temperature and density was found on the perception of safety, cleanliness and ambience (Wilks' Lambda = .975, F (6, 1088) = 2.301, *p* = .033). This means that the traveller experience, defined by the perception of safety, cleanliness and ambience, is significantly depending on the illuminance level, light colour temperature and density level. The multivariate effect size was estimated at .013, which implies that 1.3% of the variance in the set of dependent variables was accounted for by a combination of the illuminance level, light colour temperature and density. As mentioned earlier will the following paragraph focus on the individual results for the perception of safety, cleanliness and ambience in relation to light.

	Wilk's lambda	**F**	**p**	**Partial eta squared**
Illuminance * goal orientedness	.977	2.142	.046	.012
Illuminance * light colour temperature * density	.975	2.301	.033	.013

Table 4: MANOVA for interaction effects in relation to the perception of safety, cleanliness and ambience

4.2.5 Results for perception of safety

In addition to the results which were presented in the previous paragraphs, this sub paragraph will focus on the results which were found for the perception of safety. A one-way ANOVA's on the dependent variable, perception of safety, was conducted as a follow-up tests to the MANOVA. As can be seen in Table 5, none of the ANOVA's were statistically significant.

	F	**p**	**Partial eta squared**
Illuminance	.942	.332	.002
Light colour temperature	.542	.582	.002
Illuminance * light colour temperature	.637	.529	.002

Table 5: ANOVA's for light in relation to the perception of safety

Although no significant results were found for the relation between the light and the perception of safety, there are three interaction effects found. First of all an interaction effect between density and temperature on the perception of safety (90% significance level), F (1) = 3.266, *p* = .073. Furthermore a significant two way interaction effect was found for the relation between the illuminance level and goal- orientedness on the perception of safety (F (2) = 4.775, *p* = .017). Finally a three way interaction was found for the independent variables

illuminance, light colour temperature and density on the perception of safety ((F (2) = 5.681, p = .004).

4.2.6 Results for perception of cleanliness

In addition to the results which were presented in the previous paragraphs, this sub paragraph will focus on the results for the perception of safety. A one-way ANOVA's on the dependent variable, perception of cleanliness, was conducted as a follow-up tests to the MANOVA. As can be seen in Table 6, the ANOVA for illuminance in relation to cleanliness turned out to be significant. A higher illuminance level leads to a more positive perception of cleanliness. Important to note is that the significance level needs to be adjusted from 95% to 90% for the ANOVA to become significant.

	F	**p**	**Partial eta squared**
Illuminance	2.945	.053	.010
Light colour temperature	2.011	.157	.004
Illuminance * light colour temperature	1.520	.220	.005

Table 6: ANOVA's for light in relation to the perception of cleanliness

No additional interaction effects were found for the relation between the independent variables and cleanliness.

4.2.7 Results for perception of ambience

In addition to the results which were presented in the previous paragraphs, this sub paragraph will focus on the results for the perception of safety. A one-way ANOVA's on the dependent variable, perception of ambience, was conducted as a follow-up tests to the MANOVA. As can be seen in Table 7, are the ANOVA's for light colour temperature and the two way interaction between illuminance and light colour temperature significant at a significance level of 95%. Whereas illuminance is significant at a significance level of 90%. It turned out that a high illuminance level combined with a warm light colour temperature leads to a more positive perception of ambience.

	F	**p**	**Partial eta squared**
Illuminance	2.500	.083	.009
Light colour temperature	5.626	.018	.010
Illuminance * light colour temperature	5.183	.006	.018

Table 7: ANOVA's for light in relation to the perception of ambience

In addition to the direct relations which were found for ambience, a two way interaction was found for goal- orientedness and density on the perception of ambience (F (2) = 4.147, p = .042).

4.2.8 Additional results

In addition to the results which were described in the previous sub paragraphs there are some additional results. In addition to the concepts perceived safety, cleanliness and ambience, the additional concepts pleasure, arousal, dominance and the general score of the train station were measured. But first of all some interesting results were found for the perception of safety, cleanliness and ambience in relation to gender.

Gender

Despite the fact that differences related to gender are no part of this study, some interesting results were found on this topic. A one-way multivariate analysis of variance (MANOVA) was conducted to test the hypothesis that there would be one or more mean differences between the perception of safety, cleanliness and ambience under the influence of gender. A statistically significant MANOVA effect was obtained, Wilks' Lambda = .953, F (3, 566) = 9.203, p = .00. This means that the traveller experience, defined by the perception of safety, cleanliness and ambience, is significantly depending on the gender of the participant. The multivariate effect size for illuminance was estimated at .047, which implies that 4.7% of the variance in the set of dependent variables was accounted for by gender. In addition to that, a one-way ANOVA's on the dependent variables (perception of safety, cleanliness and ambience), was conducted as a follow-up tests to the MANOVA. As can be seen in Table 8, all the ANOVA's were statistically significant. It turned out that male participants perceived the train station as safer, cleaner and more ambient than female participants. In addition to that, it turned out that gender is having a significant intervening effect on the relation between illuminance and light colour temperature on the one hand and the perception of safety, cleanliness and ambience on the other.

	F	**p**	**Partial eta squared**
Perception of safety	13.908	.000	.024
Perception of cleanliness	5.308	.000	.008
Perception of ambience	23.944	.000	.032

Table 8: ANOVA's for gender in relation to the perception of safety, cleanliness and ambience

Familiarity with the train station

In addition to their gender, the participants were asked to fill out if they recognized the virtual train station. The virtual train station was a simulation of the train station of Amersfoort. 13% of the participants recognized the train station, the remaining 87% did not know that is was station Amersfoort. This makes sense since the majority of the participants live and study in Groningen, which is 180 kilometres from Amersfoort. A one-way ANOVA's on the dependent variables (perception of safety, cleanliness and ambience) in relation to the familiarity with the train station was conducted. Interesting differences were found for participants who were familiar with the train station and participants who were not. As can be seen in Table 9, the ANOVA's for the perception of safety and cleanliness were statistically significant (at a 90% and 95% significance level). It turned out that participants who were familiar with the train station, experienced the train station as safer (mean: 4.71 versus 5.06) and cleaner (mean: 4.86 versus 5.29). Familiarity and more specific public familiarity was discussed earlier, in paragraph 2.3.1. Familiarity contributes to the extent to which people are able to predict the circumstances of a public environment and make people feel more at ease

and thereby contribute to a more positive perception of safety (Blokland, 2009). This finding was confirmed by statistics, the perception of safety and cleanliness (correlating concepts) were significantly related to the familiarity of travellers.

	F	p	Partial eta squared
Perception of safety	3.513	.062	.013
Perception of cleanliness	5.720	.017	.022
Perception of ambience	.076	.784	.000

Table 9: ANOVA's for familiarity in relation to the perception of safety, cleanliness and ambience

General score train station

After filling out the questionnaire the participants were asked to give a score to the train station (0 to 10). It turned out that the general score of the train station is significantly related to the light colour temperature employed at the train station (F (1) = 11.005, p = .001). A warm light colour temperature lead to a higher general score of the train station. The univariate effect size for the general score of the train station was estimated at .019, which implies that 1.9% of the variance in the set of dependent variables was accounted for by the light colour temperature. The following sub paragraph will focus on the results for the dependent variables pleasure, arousal and dominance.

Pleasure, arousal and dominance (PAD)

In addition to the perception of safety, cleanliness and ambience, the dependent variables pleasure, arousal and dominance (PAD) were included and tested in relation to illuminance and light colour temperature. First of all a Box's M test was performed to test if the covariances matrices between the groups are equal. The Box's M value of 59.569 was associated with a significant p-value of .001. Which means that the covariance matrices between the groups were not assumed to be equal. This means that it is not desirable to perform a MANOVA on the PAD variables. Therefore multiple ANOVA's were performed, the Levene's F test for pleasure (F (5, 563) = 1.025, p = .402), arousal (F (5, 563) = 1.120, p = .349) and dominance (F (5, 563) = 1.105, p = .357) turned out to be non-significant. This indicates that the homogeneity of variance assumption was considered satisfied, suggesting that the ANOVA would be robust. One significant relation was found for light colour temperature on pleasure (F (1) = 3.406, p = .073), participants experienced more pleasure when exposed to a warm light colour temperature. Which is in line with the relation between warm light colour temperature and a positive perception of ambience (sub paragraph 4.2.7).

4.2.9 General conclusion post- test

The results described in the previous paragraphs will be summarized in the following research model (figure 7), which serves as a prelude to the following chapter, which covers the conclusions and recommendations. The model contains relations between the independent (illuminance and light colour temperature) and dependent variables (perception of safety, cleanliness and ambience). In addition to that the independent variables gender and familiarity (with the train station) were included in the model due to the amount of variance of the dependent variables which they are accounting for. Since the variables gender and familiarity were initially not included in the research model, they are marked with dotted lines.

Furthermore it might be striking that the independent variables goal- orientedness and density are not included. This is because they have no direct relation with the dependent variables. Variance is presented by using the statistical concept 'partial eta squared', which is abbreviated as (η_p^2).

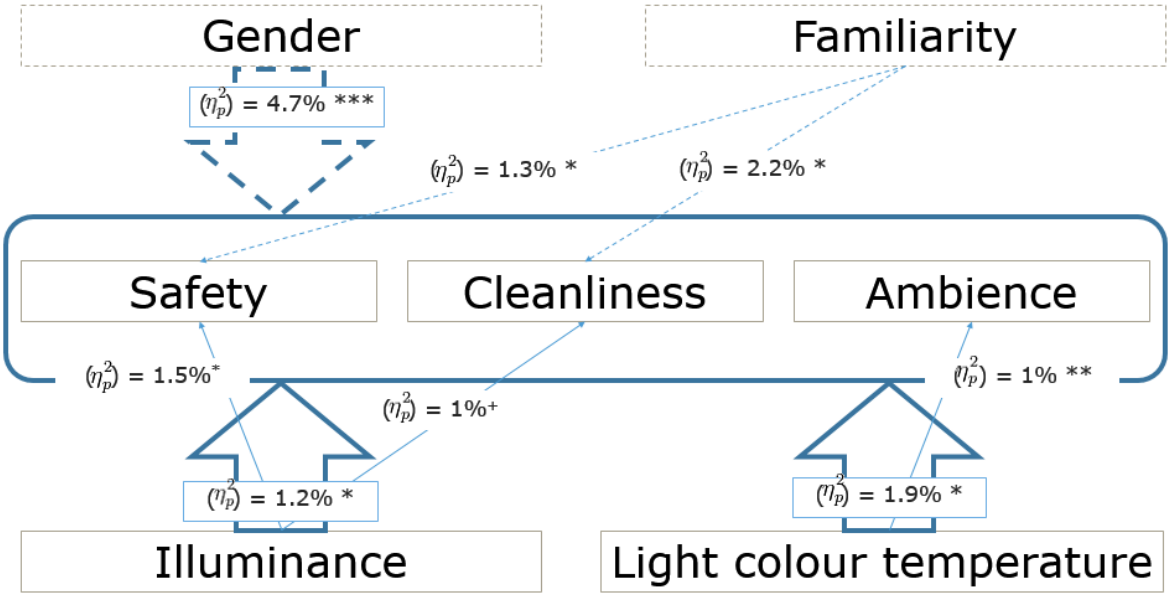

Figure 7: Concluding research model, explaining variance by using partial eta squared (η_p^2)
*Note: + p < .1; * p < .05; ** p < .01; *** p < .001*

5. Conclusions and recommendations

The conclusions of this study will be discussed in this fifth chapter. In the first paragraph (5.1) the hypotheses, which were formulated by studying literature, will either be confirmed or rejected. In the paragraphs 5.2, 5.3, 5.4 and 5.5 the conclusions were drawn for the variables illuminance, light colour temperature, density and goal- orientedness in relation to the perception of safety, cleanliness and ambience. The conclusions were drawn based on the research questions which were formulated in sub paragraph 1.2.3. The hypotheses as mentioned earlier, will be discussed in the following paragraph.

5.1 Hypotheses

In this first paragraph of chapter five will the results as discussed in the previous chapter be discussed and used to accept or reject the different hypotheses. The results of this can be found in table 6. It is important to note that the hypotheses need to be seen as the leading thread in this study. The hypotheses are not offering a lot of details when it comes to drawing the conclusions. The hypotheses offer the first conclusions which will be elaborated on in the remaining paragraphs of this chapter.

Nr.	Hypothesis	Result
1.	A higher illuminance level leads to a higher perceived safety by travellers at train stations.	**Rejected**
2.	A higher illuminance level leads to a higher perceived cleanliness by travellers at train stations.	**Accepted**$^{+}$
3.	A lower illuminance level leads to a higher perceived ambience by travellers at train stations.	**Rejected**
4.	A lower light colour temperature leads to a higher perceived safety by travellers at train stations.	**Rejected**
5.	A higher light colour temperature leads to a higher perceived cleanliness by travellers at train stations.	**Rejected** (differences between means)
6.	A lower light colour temperature leads to a higher perceived ambience by travellers at train stations.	**Accepted***
7.	Must travellers perceive train stations as safer than lust travellers do	**Rejected** (differences between means)
8.	Lust travellers perceive train stations as cleaner than must travellers do.	**Rejected** (differences between means)
9.	Lust travellers perceive train stations as more ambient than must travellers.	**Rejected**
10.	Higher density at train stations negatively influences the perceived safety of passengers.	**Rejected**
11.	Higher density at train stations positively influences the perceived cleanliness of travellers.	**Rejected** (differences between means)
12.	Higher density at train stations negatively influences the perceived ambience of travellers.	**Rejected**

Table 10: conclusion hypotheses

*Note: + p < .1; * p < .05; ** p < .01; *** p < .001*

5.2 Illuminance and light colour temperature

The conclusions regarding illuminance and colour temperature in relation to the perception of safety, cleanliness and ambience were discussed in this paragraph. A significant relation was found between illuminance and colour temperature on the one hand and the perception of safety, cleanliness and ambience on the other. In addition, density seems to influence the relation between illuminance and light colour temperature. An environment with a low density level was assessed as more positive by travellers when light with a warm light colour temperature was applied. A train station with a high density level was assessed as positive and travellers experience more pleasure when a cold light colour temperature was applied. A possible explanation for this finding is that travellers are able to handle a certain amount of stimuli. As found by Custers et al. (2010) (described in paragraph 2.2.3) a warm light colour temperature is more arousing than a cold light colour temperature. Therefore travellers might prefer a warm and more arousing light colour temperature in the quiet moments, and a cold (less arousing) light colour temperature in the busier moments. As a result of this, travellers experience more pleasure when the light colour temperature is 'in line' with the density at the train station. Furthermore, it turned out that travellers give a significantly higher score (on a ten point scale), to a train station with a warm light colour temperature (M = 6.21, SD = 1.449) than a train station with a cold light colour temperature (M = 5.77, SD = 1.692). So, it is possible to conclude that light is influencing the way in which a train station is perceived by travellers. It is interesting to take a look at the relation between light and the individual environmental variables. This will be done in the following sub paragraphs. The research questions which were formulated in paragraph 1.2.3 are used as the leading thread. The conclusions for the perception of safety in relation to light were discussed in the following sub paragraph.

5.2.1 Perception of safety

The following research question was answered in this sub paragraph: *''what is the relation between illuminance and light colour temperature on the one hand and perceived safety by travellers at train stations on the other?''*. It turned out that there is no direct relation between light and the perception of safety, the relation seems to be influenced by the goal-orientedness of the travellers and density at the train station. First of all a difference was found for the way in which safety is perceived by must and lust travellers under influence of the illuminance level. The train station is perceived as more safe by lust travellers when the illuminance level is low or medium. Whereas must travellers experience a train station as safer when the illuminance level is high. This is line with the findings of Van Hagen (2011), who found lust travellers attach the most value to a warm atmosphere, whereas must travellers find fast passenger flows more important. Why a low or medium illuminance level is associated with a warm atmosphere seems to be pretty straightforward. High illuminance in relation to fast passenger flows needs some additional explanation. A higher illuminance level offers a better overview of the train station and might therefore explain why must travellers feel safer. In line with the findings regarding the perception of safety are lust travellers reporting a higher level of dominance when exposed to a low illuminance level. Must travellers are experiencing a higher level of dominance when exposed to a medium or high illuminance level. This confirms that lust travellers feel safer and more in control when they are exposed to a lower illuminance level, the same applies to must travellers when exposed to a higher illuminance level. In addition to that density, was also found to be an important factor when it comes to the perception of safety at the train station. Travellers perceive a train

station as more safe in the quiet moments with a warm light colour temperature than with a cold light colour temperature. The opposite applies to the busier moments. This is in line with the earlier findings for illuminance and light colour temperature in relation to the environmental variables. As found by Custers et al. (2010) (described in paragraph 2.2.3) is a warm light colour temperature more arousing than a cold light colour temperature. Therefore travellers might prefer a warm and more arousing light colour temperature in the quiet moments, and a cold (less arousing) light colour temperature in the busier moments. When travellers feel more at ease, because they are exposed to the right amount of arousal, they will feel safer. This is backed by the optimal arousal theory of Berlyne (1971). Which assumes that people strive for an optimal pleasure level, which is influenced by arousal. Therefore people prefer a warm light colour temperature in the quiet moments. A quiet train station is evoking not much stimuli, since travellers strive for an optimal arousal level, they prefer a warm (and more arousing) light colour temperature. The conclusions for the perception of cleanliness in relation to light were discussed in the following sub paragraph.

5.2.2 Perception of cleanliness

The following research question was answered in this sub paragraph: *''what is the relation between illuminance and light colour temperature on the one hand and perceived cleanliness by travellers at train stations on the other?''*. As expected are travellers perceiving the train station as cleaner when the illuminance level is high, compared to the low and medium conditions. This is in line with the theory of Molenaar and Hu (2013), who performed experiments in a metro coupe and found the same results. According to Molenaar and Hu (2013), there are several possible explanations for this outcome, for example the feeling that 'something is going to be done soon about the situation', in addition to that, it enhances the clean feel of the remaining part of the train station. Important to note is that the research design of Molenaar and Hu (2013) differs from the one of this study. Whereas Molenaar and Hu (2013) tested different cleanliness levels (littered or not), the cleanliness level was held constant in this study. It is therefore not possible to attribute the differences for the perception of cleanliness to the actual cleanliness of the train station. As described and expected in paragraph 2.6 are there other factors, such as place attachment, which determine the way in which cleanliness is perceived. A possible explanation for the significant relation between a high illuminance level and a more positive perception of cleanliness is that a higher illuminance level leads to a higher level of place attachment. Another explanation might be that travellers associate cool colours (blue, white e.g.) with cleanliness and warmer colours (yellow, red e.g.) with uncleanliness (Pijls and Groen, 2012). Whereas high illuminance levels are perceived as cooler than low illuminance levels, which were perceived as reddish. Finally, light colour temperature turned out to have no effect on the perception of cleanliness. The conclusions for the perception of ambience in relation to light will be discussed in the following sub paragraph.

5.2.3 Perception of ambience

The following research question was answered in this sub paragraph: *''what is the relation between illuminance and light colour temperature on the one hand and perceived ambience by travellers at train stations on the other?''*. It turned out that illuminance, but especially light colour temperature is influencing the perception of ambience of travellers at the train station. The combined effect of illuminance and light colour temperature turned out to even

have a highly significant effect on the extent to which travellers perceive a train station as ambient (or not). Especially the light colour temperature of light is influencing the way in which the ambience of a train station is perceived. A warm light colour temperature is leading to a more positive perception of ambience, whereas a cold light colour temperature has a negative effect on the perception of ambience. The effect is even stronger when combined with a medium or high illuminance level. The following paragraph will entirely focus on the relation between goal- orientedness and the environmental variables.

5.3 Goal- orientedness

The conclusions regarding goal- orientedness in relation to perceived safety, cleanliness and ambience were discussed in this paragraph. As described in paragraph 2.3 is goal-orientedness often referred to in literature as the motivational orientation of people, whereas motivation is defined as the intensity, persistence, and direction of effort allocation. NS is currently making a distinction between must and lust travellers, must travellers are goal oriented and most of the time commuters who travel by train a couple of times a week. Lust travellers are recreational travellers who find comfort and convenience more important than a fast trip (SENTA, 2005). It turned out that lust travellers feel more dominant when exposed to a low illuminance level, while the opposite applies to must travellers, who feel more dominant on a train station with a high illuminance level. This is in line with the theory of Blokland (2009), described in paragraph 2.3.1 which says that people who are more familiar with the train station (must travellers) will feel more dominant. The relation between goal-orientedness and the environmental variables safety, cleanliness and ambience was be discussed in the following three sub paragraphs.

5.3.1 Perception of safety

The following research question was answered in this sub paragraph: *''what is the relation between goal- orientedness and perceived safety by travellers at train stations?''*. The actual question is if safety is perceived in a different way by must and lust travellers. It turned out that there are no direct relations between safety and goal orientedness. There are however some indications which offer insights in the specific characteristics of must and lust travellers. As already mentioned in sub paragraph 5.2.1, a difference was found for the way in which safety is perceived by must and lust and lust travellers under influence of different illuminance levels. Lust travellers perceive the train station as more safe when the illuminance level is low or medium, whereas must traveller prefer a high illuminance level. As mentioned in paragraph 5.2.1 has this preference to do with the fact that lust passengers attach more value to an ambient station. Whereas must travellers would like to get from A to B as fast as possible (Van Hagen, 2011).

5.3.2 Perception of cleanliness

The following research question was answered in this sub paragraph: *''what is the relation between goal- orientedness and perceived cleanliness by travellers at train stations?''*. The actual question is if cleanliness is perceived in a different way by must and lust travellers. It turned out that there are no direct relations between cleanliness and goal orientedness. No additional, more complex relations were found for cleanliness.

5.3.3 Perception of ambience

The following research question was answered in this sub paragraph: *''what is the relation between goal- orientedness and perceived ambience by travellers at train stations?''*. The actual question is if ambience is perceived in a different way by must and lust travellers. It turned out that there are no direct relations between ambience and goal orientedness. There are however some indications which offer insights in the specific characteristics of must and lust travellers. It turned out that ambience was perceived differently by must and lust travellers influenced by density. Lust travellers perceive the train station as more ambient in the quiet moments, whereas must travellers experience more ambience when it is busy. This outcome is not immediately making sense, the expectation (paragraph 5.1, hypotheses) was that lust travellers in general perceive the train station as more ambient. This expectation was based on the findings of Van Hagen (2011), who concluded that lust travellers are more receptive for environmental stimuli than must travellers. Must travellers find the aspects privacy, peace, waiting alone and fast flows significantly more important than lust travellers. This is not in line with the findings of this study. A possible explanation could be that must travellers are more familiar with the train station, and therefore are able to handle higher density levels and experience more ambience in the busier moments. Whereas lust travellers are in most cases not familiar with the depending train station and experience more ambience when they can easily look around without bumping into other travellers.

5.4 Density

The conclusions regarding density in relation to perceived safety, cleanliness and ambience was discussed in this paragraph. Density is an important topic for rail operators, since they need to find a balance between density on the one hand and economical and energy efficiency on the other (Vuchich, 1981). Two different density levels were tested in this study, to be more precise, a low and a high density level. It is interesting to take a look at the relation between density and the dependent variables (perception of safety, cleanliness and ambience). This was done in the following sub paragraphs. The research questions which were formulated in paragraph 1.2.3 are used as the leading thread.

5.4.1 Perception of safety

The following research question was answered in this sub paragraph: *''what is the relation between density and perceived safety by travellers at train stations?''*. The actual question is if safety is perceived in a different way when travellers are exposed to different density levels? It turned out that there is no direct relation between the perception of safety and density. There is however a relation between the perception of safety and density, illuminance and the light colour temperature. Travellers the train station as more safe when it is quiet at the train station under influence of a warm light colour temperature. In the busy moments the train station was perceived as more safe when a cold light colour temperature was employed. The illuminance level is also influencing this relation, the medium condition turned out to lead to the most positive perception of safety at the train station. In the following paragraph the results for density in relation to the perception of cleanliness will be discussed.

5.4.2 Perception of cleanliness

The following research question was answered in this sub paragraph: *''what is the relation between goal- orientedness and perceived cleanliness by travellers at train stations?''*. The actual question is if cleanliness is perceived in a different way when travellers are exposed to different density levels? There were no direct relations found for the relation between cleanliness and density. In the following sub paragraph, the relation between the perception of ambience and density will be discussed.

5.4.3 Perception of ambience

The following research question was answered in this sub paragraph: *''what is the relation between density and perceived ambience by travellers at train stations?''*. The actual question is if ambience is perceived in a different way when travellers are exposed to different density levels? There were no direct relations found for the relation between the perception of ambience and density. There is however, as mentioned in sub paragraph 5.3.3 a more complex relation between goal- orientedness and density on ambience. It turned out that ambience was perceived differently by must and lust travellers influenced by density. In the quiet moments lust travellers perceived the train station as more ambient, whereas the station was experienced as more ambient in the busy moments by must travellers. The general conclusion of this study was drawn in the following paragraph.

5.5 General conclusion

The purpose of this paragraph is to answer the general research question and provide the reader with a quick overview of the main conclusions of this study. The research question which was addressed in this paragraph is: '*What is the relation between illuminance and light colour temperature on the one hand and perceived safety, cleanliness and ambience by travellers on train stations on the other*?'. The main conclusion is that there is not a single setting for illuminance and light colour temperature in order to improve the perception of safety, cleanliness and ambience as a whole. It turned out that the perception of safety and cleanliness was influenced by the illuminance level employed at the train station. Whereas the perception of ambience was mainly influenced by the light colour temperature. This conclusions will be summed up in the following sub paragraphs.

5.5.1 Perception of safety

1. The perception of safety was mainly influenced by illuminance and partly by light colour temperature.
2. Lust travellers feel most safe when exposed to a low or medium illuminance level, and must travellers feel safer exposed to a high illuminance level.
3. Density is mediating the relation between light and the perception of safety.

5.5.2 Perception of cleanliness

1. In line with literature it turned out that the train station was perceived as more clean when a high illuminance level was employed.

2. Merely illuminance was influencing the perception of cleanliness. Light colour temperature, goal- orientedness and density turned out to have no effect on the perception of cleanliness.

5.5.3 Perception of ambience

1. Light is having a major effect on the way in which the ambience of the train station was perceived. Especially a warm light colour temperature was leading to a more positive perception of ambience.
2. A low or medium illuminance level is enhancing the positive effect of a warm light colour temperature.

The general conclusion of this study is that there is not a unique lighting setting (e.g. warm light colour temperature, combined with a high illuminance level) which is able to positively influence the perception of safety, cleanliness and ambience as a whole. It is however possible to make a distinction between the variables safety and cleanliness on the one hand and ambience on the other. Safety and cleanliness were particularly influenced by illuminance and ambience by light colour temperature (paragraph 4.2.5, 4.2.6 and 4.2.7). This was in line with the findings of Van Hagen (2011), who found that the perception of safety and cleanliness at the train station are highly correlating. Which is the case in this study as well ($r = .377$, $p = .000$). As mentioned in sub paragraph 2.1.2 is the perception of cleanliness not only determined by the actual cleanliness of a place. Other factors, such as the perception of safety was also contributing to the perception of cleanliness. It works also the other way around, the perception of safety is not only caused by actual safety. And the degree of actual cleanliness is also contributing to the perception of safety. Therefore, the conclusion this study is twofold. The perception of safety and cleanliness can be influenced by changing the illuminance level, whereas the perception of ambience can be affected by changing the light colour temperature. This conclusion will be translated to recommendations and managerial implications in the following paragraph.

5.6 Recommendations and managerial implications

This paragraph is consisting of two sub paragraphs. The first one is focussing on the recommendations and managerial implications for Netherlands Railways and the second one on the field of facility management (FM). To improve the ease of reading, recommendations are marked in the text with a number, e.g.: (1).

5.6.1 Recommendations and managerial implications for Netherlands Railways

This study was commissioned by the Dutch railway operator Netherlands Railways (NS). Based on the conclusions, this sub paragraph contains a set of recommendations and managerial implications for NS. First of all it is important to mention that there is not a single lighting configuration which is able to positively influence the perception of safety, cleanliness and ambience as a whole. It is however possible to simultaneously influence the perception of safety and cleanliness, since those two concepts are closely related (as found by Van Hagen, 2011). The following paragraphs describe practical light measures which will improve the perception of safety, cleanliness and ambience.

Improve the perception of safety

For NS safety is one of the most important topics when it comes to the physical environment of the train station. The importance of safety was mentioned in the first paragraph (1.1.1, traveller experience) of this report. Safety and more specific the perception of safety was found to an important prerequisite for the functioning of the train station as a public space (Van Hagen, Peek and Kieft, 2000). People will probably avoid (consciously or unconsciously) the train station when it is not perceived as safe. The perception as well as actual safety can be influenced by physical measures, such as cameras, presence of rail staff, the presence of police and the introduction of access gates. In addition to these rather expensive measures, it turned out that light is a useful component of the physical environment which is able to positively influence the perception of safety and indirectly actual safety. It turned out that the perception of safety is mainly influenced by the illuminance level of light. Lust travellers prefer a low or medium illuminance level, whereas must travellers feel safer when exposed to a high illuminance level. This is in line with the characteristics of both types of travellers. As described in sub paragraph 5.2.1 do lust travellers attach most value to a warm atmosphere, where must travellers find fast passenger flows more important. *(1)* If NS wants to improve the perception of safety by using light, NS needs to adapt the illuminance level to the moment of the day. Lust travellers make up the majority during off- peak hours and must travellers during peak hours. Therefore a low illuminance level needs to be applied during off- peak hours and a high illuminance level during peak hours. *(2)* The positive effect can be enhanced by applying warm light colours and a low illuminance level (figure 8) during the off- peak hours and cold light colours in combination with a high illuminance level (figure 9) during the peak hours. The recommendations for cleanliness will be discussed in the following paragraph.

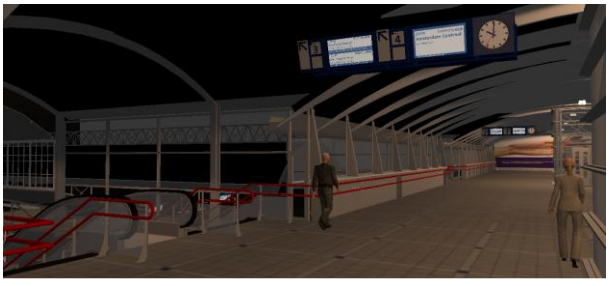

Figure 8: low illuminance level, warm light colour temperature

Figure 9: high illuminance level, cold light colour temperature

Improve the perception of cleanliness

During the cleaning strike in 2014 it became clear how important a clean train station is. Travellers complained about the waste piles and the corresponding effects. Cleaning is a labour- intensive service which makes up a large part of the financial budgets of NS. Despite the scientific evidence is scarce, there are some indications that the perception of cleanliness can be influenced by using light. When this topic is explored more extensively, it might lead to a future decrease of the cleaning costs for NS. This study indicated that a higher illuminance level is positively influencing the perception of cleanliness. *(3)* If NS would like to increase the perception of cleanliness by using light, a high illuminance level is recommended. Although this finding is in line with earlier findings (Molenaar and Hu, 2013) it is recommended to perform more (scientific) research on the perception of cleanliness at train stations as well as in trains due to the scarcity of the current evidence. Improving the perception of cleanliness by using light might have social consequences, which will be discussed in paragraph 5.8.

Improve the perception of ambience

In contrast to the concepts of perceived safety and perceived cleanliness, ambience is a rather vague concept. There is no such thing as actual ambience which can be measured, in contrast to actual safety (e.g. number of crimes) and actual safety (e.g. dirt per square meter). Although ambience is a very relevant to NS, ambience is about offering a place to travellers which is pleasant to stay. This study indicated that a warmer light colour temperature is leading to a more positive perception of ambience, which might sound pretty straightforward. *(4)* Since travellers are more receptive for stimuli (and therefore ambience) while waiting at the train station (Van Hagen, 2011), the recommendations associated with this finding is to apply a warm light colour temperature to areas where travellers wait for the train. *(5)* This positive effect can be enhanced by applying a low or medium illuminance level to the train station. Another interesting finding, which is especially relevant for NS is that the perception of ambience (and pleasure) is very closely related ($r = .538$, $p = .000$) to the general score of the train station. The general score of the train station turned out to be also significantly related to the light colour temperature employed. In other words, is a warm light colour temperature not only positively influencing the perception of ambience, the general score of the train station is positively influenced as well. The general score of the train station is relevant for NS, since this is one of the factors on which NS is monitored by its shareholders. *(6)* In addition to the perception of ambience, NS is also able to influence the general score of its train stations by employing a warm light colour temperature. Based on the results of this study, this can be achieved by applying light with a warm light colour temperature to the train station. As probably noticed are the recommendations for the different environmental variables contradicting. Which means, as mentioned in the introduction of this chapter, that it is not possible to influence the perception of safety, cleanliness and ambience by one single setting. Therefore different light plans were discussed in the final paragraph.

Final recommendations and managerial implications NS

It is, as mentioned before, not possible to influence the perception of safety, cleanliness and ambience as a whole by using a single light setting. A train station with ambient lighting is not a train station which is positively influencing the perception of safety (and vice versa). Therefore a light plan is discussed which can be considered to be applied in practice by NS. The very essence of these recommendation is to make a distinction between functional and ambient lighting in different areas of the train station. Functional lighting is used to positively

influence the perception of safety and cleanliness, whereas ambient lighting is used to enhance the perception of ambience. It is therefore important to make a distinction between different areas of the train station. The most obvious one is the distinction between areas in which people move (functional) and areas in which people stay (ambient). Van Hagen (2011) found that people are more receptive for stimuli while waiting at the train station than when they are moving. When people are moving they want to feel at ease while moving quickly from A to B, experience and comfort are becoming more important when people are waiting for their train. In line with this findings, a high illuminance level (225 lux) was proposed for the functional areas, such as the station hall and the (area near) escalators and/or stairs. NS could consider to switch between low (75 lux) and high (225 lux) illuminance levels during off peak and peak hours. By applying these light settings to the functional areas, the perception of safety and cleanliness will be positively influenced and thereby contribute to the perception of a pleasant and fast moving process. When people arrived at the train station they are more receptive for environmental stimuli and more specific ambience. A train station will be perceived as more ambient when light with a warm light colour temperature is applied to the areas in which people wait (platform) for their train. In addition, this effect can be enhanced by combining the warm light colour temperature with a low illuminance level. The recommendations and conclusions drawn in the previous paragraph will be translated to some general recommendations for the field of facility management in the following sub paragraph.

5.6.2 Recommendations and managerial implications for field of FM

Since this study is performed as a final piece of an MSc program in facility management (FM), some final thoughts and recommendations for the field of FM were described in this sub paragraph. The conclusions of this study are applicable to places with similar characteristics as train stations. The characteristics of a train station can be generalized as a place in which a (relative) large number of people gather for a short amount of time while consuming a service. Spaces, other than a train station which meet this characteristics are for example, airports, retail, theatres and restaurants. Hotels, offices and educational buildings are in addition to that partly meeting this description. One could argue that traffic areas, such as hallways, elevators, stairways and lobbies are spaces in which a relative large amount of people gather for a short amount of time while consuming a service. It might also be possible to make a distinction between regular users of the space (office workers and teachers e.g.) and occasional users of the depending space (clients and suppliers and students e.g.). Regular users will experience and perceive space in a different way than occasional users do. The most important recommendation for the field of FM is that light is able to influence the perception of safety, cleanliness and ambience. In addition to that it is possible to make a distinction between functional and ambient lighting by adjusting the illuminance and light colour temperature level of light. The following paragraph is dedicated to future research, the second sub paragraph focusses on future research specifically for FM.

5.7 Future research

This paragraph is focussing on future research which can be performed based on findings in this study. The paragraph is divided into two sub paragraphs, the first one focusses on future research on lighting and the second one on the use of virtual reality as a research tool for future research.

5.7.1 Future lighting research

Many studies performed the effect of light on behaviour of human beings. There is however a lot of future research possible in this field, especially in the area of trains and train stations. A first suggestion *(1)* is to replicate this study on a train station instead of a virtual train station. The reason to perform this experiments in a virtual environment instead of on a 'real' train station is because of time and financial reasons. The preparation and coordination of such experiment costs a lot of time and financial resources. This study indicated however that there are plenty of clues which indicate that experiments in a real- life situation would be useful. (2) In line with this, the finding could be tested that illuminance could be used to facilitate lighting in the functional areas and light colour temperature to enhance the ambient aspect of space. *(3)* Another possibility is to take a closer look at the relation between light and actual behaviour instead of the perception of the environment. Light could for example be used to support the smoking policy on the train station or invigorate the characteristics of the silence coupe in the train. *(4)* Another concept which is often associated with light, is the circadian rhythm (biological cycle) of human beings. A study could be performed on the relation between light (and daylight) and the biological cycle of people who travel by train or are waiting on the train station. *(5)* Finally, interesting insights were gained about the perception of cleanliness in relation to light. It became evident in the different phases of this study that there is a lack of (empirical) knowledge on the way in which the perception of cleanliness can be influenced by using light. The same applies to the relation between the perception and cleanliness and other environmental factors, such as, odour, colour, the presence of other travellers, the presence of employees e.g. The mentioned possibilities for future research are useful for railway operators, such as NS, also for other FM related companies (offices, universities, hotels, retail e.g.). The following sub paragraph will focus on the use of virtual reality in future research.

5.7.2 Virtual reality in future research

The research method which was employed, a virtual train station, turned out to be a really valuable and useable for future studies. There are however some attention points for future research, the graphics of the virtual train station were relative high. This made it hard for some participants to open the experiment, due to the low specifications of their personal computer (PC). This point can be solved in future research by only inviting people who have a PC which meets the graphical specifications of the virtual train station. A drawback of this solution is that the group of people who own such a PC might have specific characteristics (age, income, profession e.g.). Another option is to lower the graphics of the virtual station which makes it possible for more participants to open the experiment. The downside of this solution is, that the virtual train station is less realistic, results might therefore be less reliable. Virtual reality is a decent research tool for research on space in relation to behaviour of

people. The following paragraph contains different views on the outcomes of this study seen from a social perspective.

5.8 Social implications

One of the main findings of this study is that the perception of cleanliness can be positively influenced by using light (sub paragraph 5.5.2 and 5.6.1). Although this finding needs to be tested more thorough, it can have impact on the way in which cleaning is currently organised at train stations. What are the possible consequences if the cleaning budgets of railway operators such as NS can be cut by 5%, by employing different lighting settings? Besides the financial benefits for NS, there are social implications which needs to be addressed. Lowering the cleaning budgets will probably lead to lower cleaning frequencies, which means that fewer employees are needed in the process of cleaning train stations. NS and organisations related to NS, such as NedTrain and ProRail are together probably one of the major employers (or purchaser) in the area of cleaning by annually spending millions on this service. With this leading position comes a social responsibility for a large group of employees who often have a vulnerable position in society. Although the exact numbers are not available one can imagine that a cut of 5% has enormous consequences for the employment of cleaning staff. This can therefore be seen as an ethical issue, which cannot be solved with one single answer, therefore different options were formulated which can be adopted by NS:

1. Reducing the number of employees (social impact) and use cost savings for further development of lighting innovations on the train station.
2. Using the cost savings to employ the redundant cleaning employees elsewhere by investing in training and coaching. This scenario will lead to cost savings in the longer run.
3. Invest the cost savings on additional cleaning services in order to increase the cleanliness level on train stations.

Most lighting researchers/designers would go for the first option, whereas a facility management professional probably would go for cost efficiency or corporate social responsible and feel most comfortable with the second or third option. Although it is not usual to provide an opinion on such ethical issues in science, I really would like to state my opinion on this topic. Personally I prefer the second option to employ the cleaning staff elsewhere and invest in training and coaching in order to help them find an alternative suitable job. In my opinion (based on what I heard and read in the previous months) there is a certain level of cleanliness which can be reached by actual cleaning. One can imagine that it is much cheaper to get from a 3 to a 5 (on a scale from 0 to 10) by actual cleaning. This can be done by cleaning of large stains and the removal of bulky waste on the train station. When NS wants to raise the overall assessment mark of cleaning from for example a 7.5 to an 8, it will cost a lot more. This is probably due to the fact that cleanliness is a dissatisfier, travellers expect the train station to be clean, when this is not the case it affects their perception of cleanliness. When the cleanliness is at an acceptable level (let us say a 7.5), travellers will probably not observe the level of cleanliness. The level of cleanliness will only be observed when it is not sufficient. It is therefore a bad idea to spend budget on additional cleaning services. It would be more efficient to invest in research and development of lighting concepts, but other concepts such as odour, colour and sound are probably also highly relevant for a positive perception of cleanliness. The limitations of this study will be discussed in the following chapter which contains the discussion.

6. Discussion

The limitations of this study will be discussed in this paragraph. This paragraph is divided into two paragraphs which treat the two main subjects, namely, the virtual train station and composition of the sample.

6.1 Virtual train station

As mentioned many times before a virtual train station was used to study the effect of light. To get a better impression of the virtual train station and the different conditions it might be useful to take a look at the screenshots in appendix B. However the virtual station offers a pretty good replication of reality, there are some limitations attached to the use of this research method. The first one is about the environment in which the questionnaires were filled out. Disruptive factors, such as daylight and the behaviour of other people, can be controlled in the virtual train station, but cannot be controlled in the environment in which the questionnaire is filled out. In the case of this study most participants were students who filled out the questionnaires in a classroom of their university. Possible factors which could have disrupted the experience of the train station could be for example the lighting in the class room, the behaviour of other students and noises (figure 10). This issue can be solved in future research by using a virtual reality head-mounted display, such as the Ocolus Rift (Wikipedia, 2014). A possible drawback of the use of the Oculus Rift could be the time needed to gather a sufficient amount of participants. Another alternative option is to perform the experiments on an actual train station, the drawback of this option are the high costs and time consumption. Another possible limitation which should be taken into account is the fact that the participants needed to recall a memory when filling out the questionnaire. After going through the virtual train station the participants were asked to fill out a questionnaire, the train station was not visible to the participants while filling out the questionnaire. When the experiment was performed at a real train station, the participants would have been able to look around, in the case of this study, the participants needed to recall a memory. There might be a difference between recalling a memory and an actual perception. This difference can be tested by performing exactly the same experiment at a real train station.

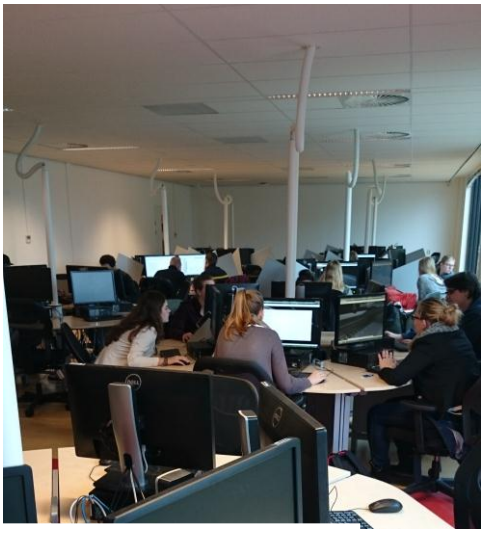

Figure 10: Execution of experiment

6.1.2 Composition of sample

Another limitation of the study, which should be mentioned, is about the composition of the sample. The sample was only consisting of Dutch students with a background in facility management or hotel management. This limitation was identified in an early phase of this study and the main conclusion was, that the composition of the sample is less relevant for a study which is focussing on the perception of an environment. This in contrast to studies who are for example assessing the attitude of travellers towards (new) services of NS. The environmental perception is a more generic topic which is not significantly influenced by the background (age, education level or nationality) of the participants. Although, the

composition of the sample is probably a weakness of this study. Future research on the effects of light on the perception of the environment need to make clear if the composition of the sample influenced the results of this study.

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Apendix A: Description of Used Constructs

It is important to mention that the different are translated from Dutch, therefore, there could be some small differences between the Dutch and English constructs. There is for example some discrepancy between the Dutch and English PAD scales. The actual questionnaires are adopted to the depending part of the train station, the questionnaire of for example the tunnel is dedicated to the tunnel.

All constructs are scored on a seven -point Likert scale	
Socio- demographic information (*basic information, available in NSpanel therefore not included in questionnaire*)	What is your gender? • Male • Female What is your age? (OPEN) • _____ years
Perceived goal- orientedness (partly adopted from Sauren, 2010) *Totally disagree – totally agree*	Indicate to what extent you agree with the following statements: • At the station I wanted to reach my goals; • At the station I wanted to get the train as quick as possible; • At the station I wanted to focus on my task; • On the station I have experienced stress.
Perceived density (Sauren, 2010) *Totally disagree – totally agree*	Indicate to what extent you agree with the following statements: • There are a lot of travellers present on the train station. • At the station I am limited in my freedom of movement; • At the station, I had to adapt to the pace of other travellers; • The station is quiet; • It is very crowded at the station.
Approach & avoidance behaviours (Mehrabian et al., 1974) *Totally disagree – totally agree*	Indicate to what extent you agree with the following statements: • I would like to avoid this station; • I would easily appeal to a stranger at the station; • I would avoid other travelers at the

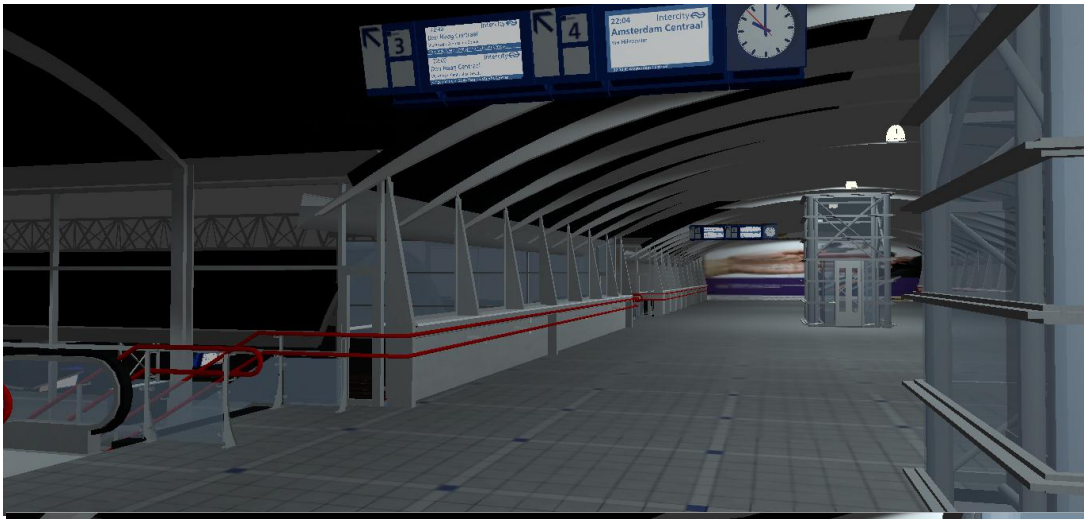
	station; • I would like to explore the station; • I think that the station is attractive.
Pleasure (Russell & Mehrabian, 1974)	Indicate how you felt at the station: • Unhappy – happy (gelukkig); • Irritated – happy (blij); • Unsatisfied – satisfied; • Unpleasant – pleasant.
Arousal (Russell & Mehrabian, 1974)	Indicate how you felt at the station: • Relaxed – stressed; • Calm – excited; • Listless – reared; • Quiet – excited.
Dominance (Russell & Mehrabian, 1974)	Indicate how you felt at the station: • Impressionable – influential; • Docile – leading; • Insecure – in control; • Submissive – Dominant.
Perceived social safety (Taylor, 1994 and Vos, 2014) *Totally disagree – totally agree*	Indicate to what extent you agree with the following statements: • At the station I felt calm; • At the station I felt at ease; • At the station I felt anxious; • At the station I felt uncertain; • At the station I felt safe.
Perceived cleanliness (developed for this study) *Totally disagree – totally agree*	Indicate to what extent you agree with the following statements: • The station looks messy; • The station looks neat; • The station is well maintained; • The station looks clean.
Perceived illuminance (developed for this study)	Indicate to what extent you agree with the following statements: • The lighting at the station was: very weak - very bright;

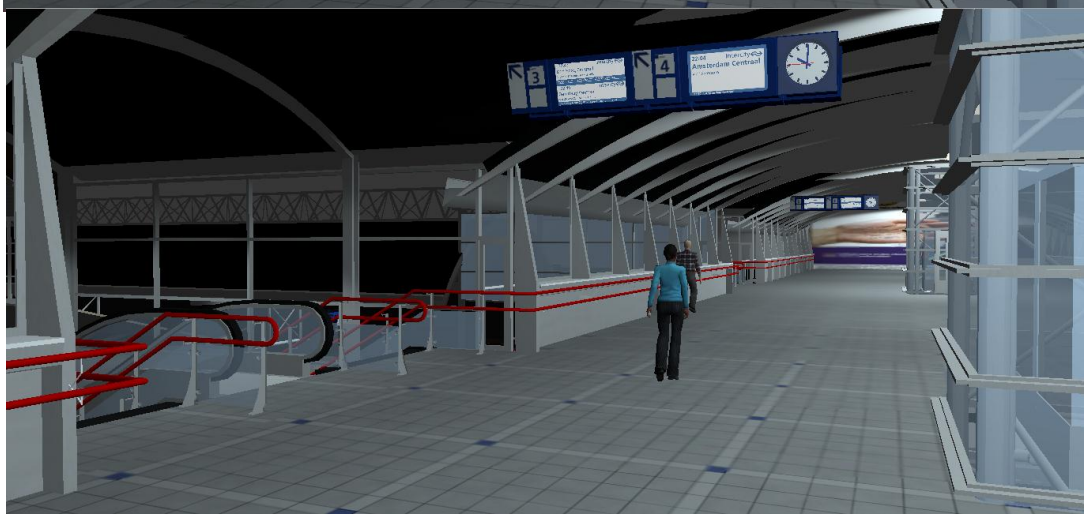
	• The lighting at the station was: very unpleasant - very pleasant; • The lighting at the station was: very dark - very light; • The lighting at the station was: very uncomfortable - very comfortable.
Perceived light colour temperature (Peters, 2008)	Indicate to what extent you agree with the following statements: • The lighting at the train station was: very dark - very light; • The lighting in the station was: very cool - very warm; • The colours on the train station were: very drab - very colourful.
Perceived ambience (SBM, 2013) *Totally disagree – totally agree*	Indicate to what extent you agree with the following statements: • I think this station has a warm atmosphere; • I think the station looks professional; • I think the station is colourful; • I think that the station is atmospheric.
General questions (general attitude, departure station, recognition of station and final comments).	• What is your overall assessment of the train station? (0-10); • Which station is usually your departure station? *(LIJST MET ALLE NEDERLANDSE STATIONS);* • Which station do you think this is? *(LIJST MET ALLE NEDERLANDSE STATIONS);* • Do you have any comments about this research? No - Yes, namely.

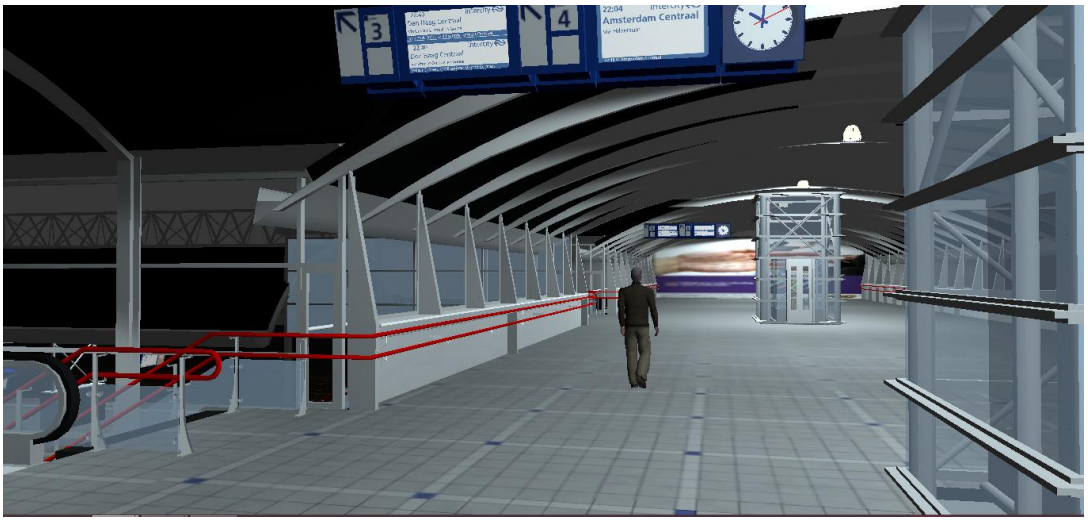
Appendix B: Screenshots conditions virtual station

This appendix is divided into four different sections. The first two contain the cold light colour temperature, the first one with a low density and the second one a high density level. The final two sections contain screenshots of the warm light colour temperature, the first one with a low density level and the second one a high density levels. Each section contains three screenshots, the first one represents the low illuminance level, the second one the medium illuminance level and the third one the high illuminance level.

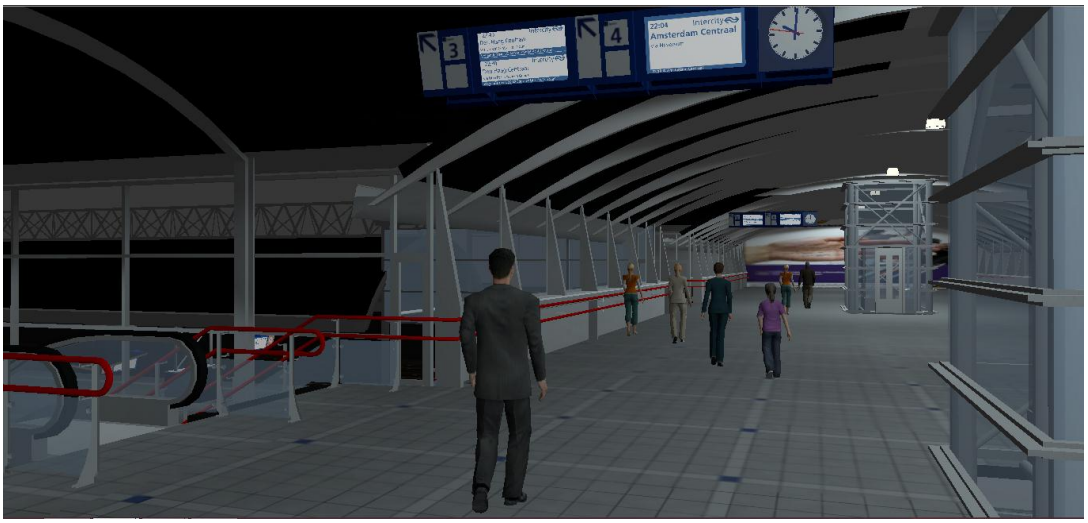
Cold light colour temperature and a low density level



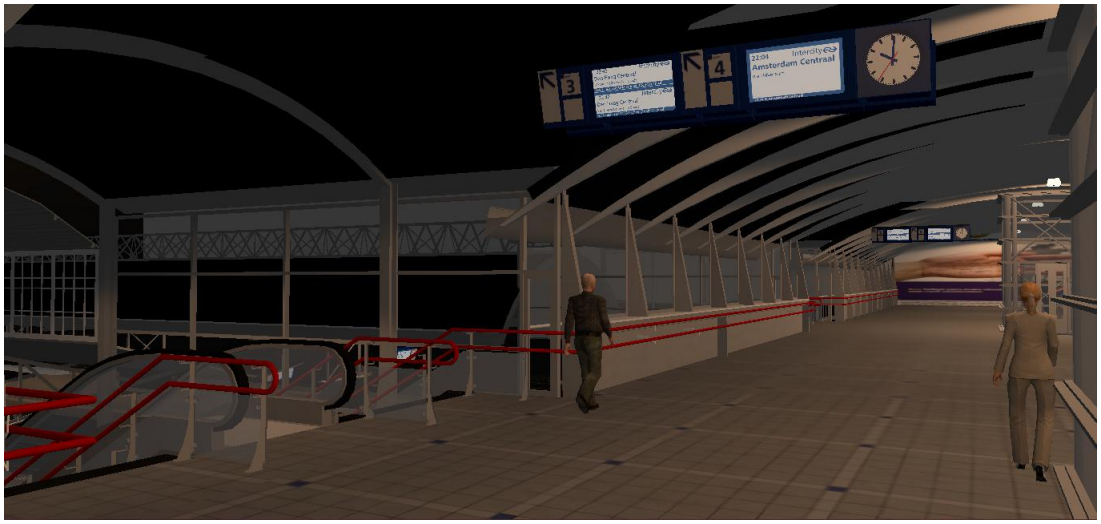


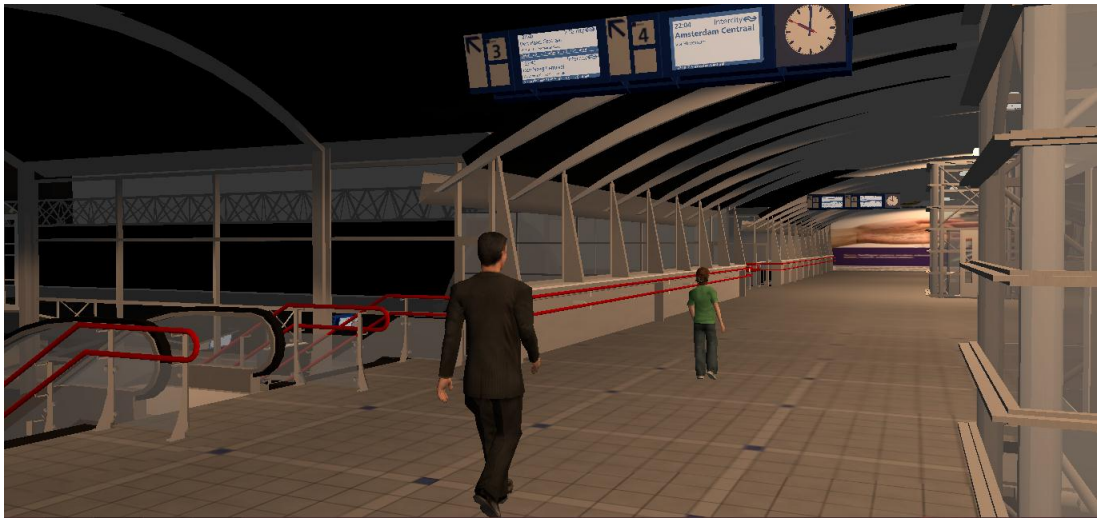


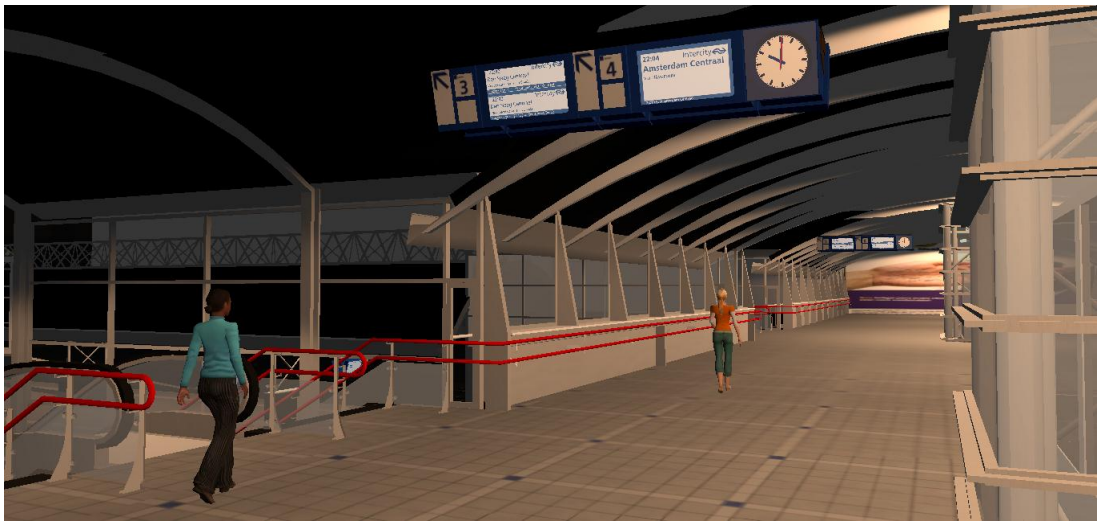
Cold light colour temperature and a high density level



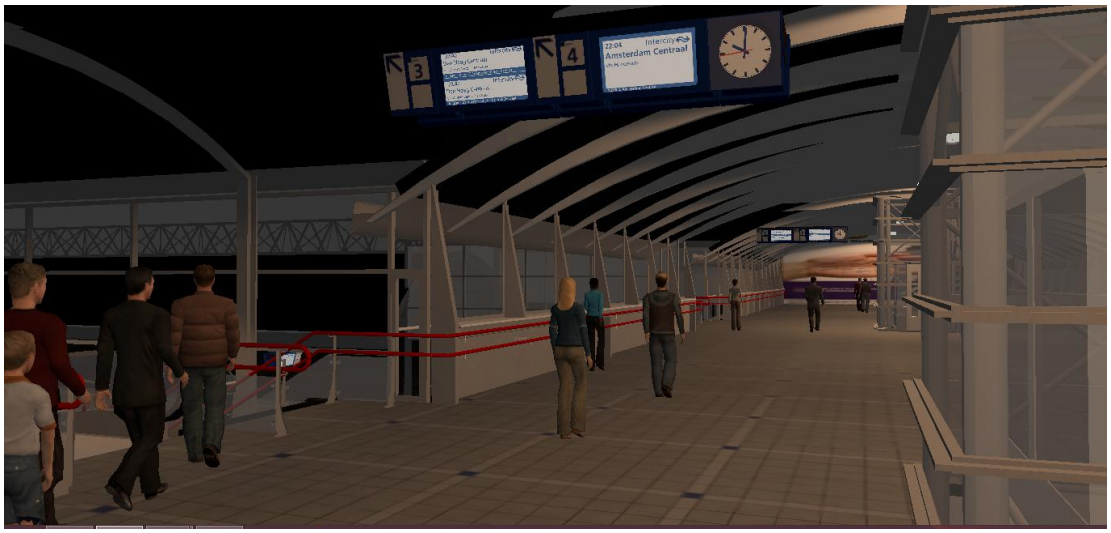
Warm light colour temperature and a low density level

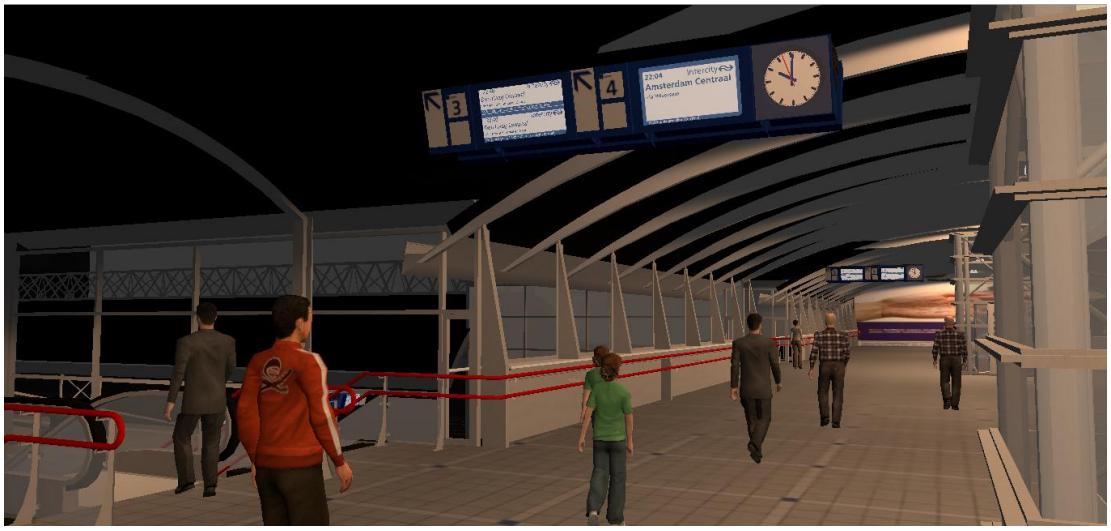


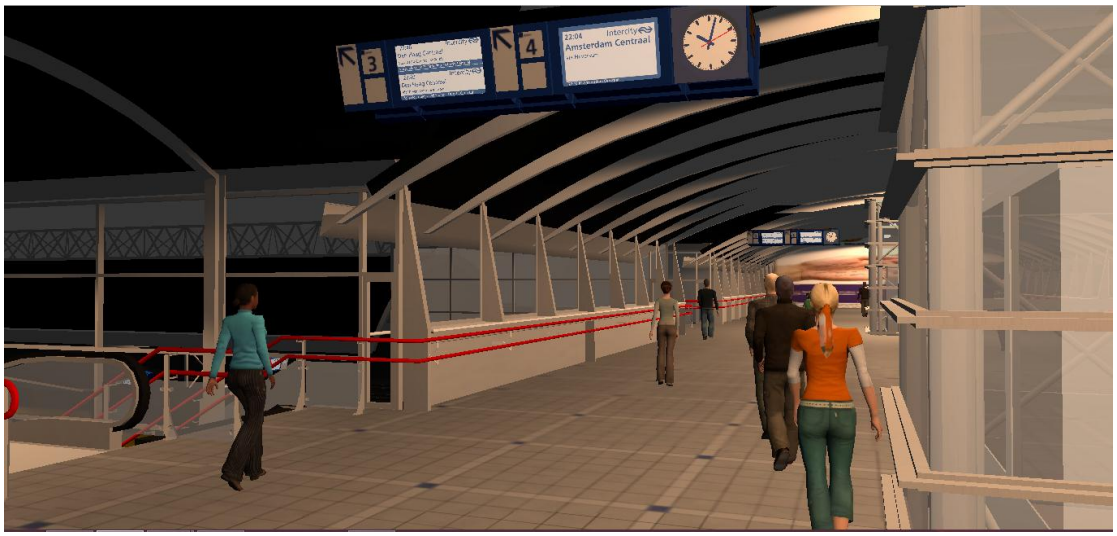




Warm light colour temperature and a high density level







Appendix C: Scenarios goal- orientedness

The scenarios which were presented to the participants are described below.

Lust traveller

It is Friday night, you have just arrived on the station square. You are planning to visit the 'Rijksmuseum' in Amsterdam tomorrow, in order to use Saturday as efficient as possible you are staying in a hotel from Friday till Saturday morning. Since you can check in at the hotel the whole night, it does not matter what time you arrive there.

Assignment: Take the next train in the direction of Amsterdam. Find out where and what time your train leaves and wait until your train arrives. You do not need to buy a ticket or to check in with your chip card. Move about the station as you normally would do in such a situation.

Must traveller

It is Friday night, you have just arrived on the station square. You have a really important meeting in Amsterdam, therefore is really important for you to arrive in time. In order to arrive in time in Amsterdam you need to catch the first train to Amsterdam. You are in a rush, delay would be really annoying.

Assignment: Take the next train in the direction of Amsterdam. Find out where and what time your train leaves and wait until your train arrives. You do not need to buy a ticket or to check in with your chip card. Move about the station as you normally would do in such a situation.