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Effects of Colour and Light on Customer Experience and Time Perception at a virtual Railway Station

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ABSTRACT
Various studies have shown that colour and light influence our emotions and behaviour. In this paper the results will be presented of research into the combined effects of 5 different colours and 2 different intensities of light for Leiden station.

Two experiments in a virtual Leiden station show that although colour and light are perceived subconsciously, the combination of the two does in fact have significant effects.

Most of the passengers appeared to overestimate waiting time on the platform, which concurs with results from earlier fieldwork. Moreover, time would appear to pass more quickly with low intensity lighting as opposed to high intensity lighting.

The second experiment showed that passengers prefer warm colours in combination with dimmed lighting and estimate the waiting time as being shorter than when cooler colours and a more intense lighting are used. Practical implications will be discussed.

Keywords
Colours and lighting, railway station, virtual simulation, customers' evaluation

INTRODUCTION

In many public spaces, such as railway stations, shopping malls and healthcare institutions, colours strongly determine how we feel and act as service customers. As is also the case with temperature, smell, sound and décor, changing these environmental factors can influence both perceptual and emotional reactions as well as the actual behaviour [28].

For the Dutch Railways Corporation colour and lighting are important instruments to manage the overall impression of the service environment. They are expected to affect customer experiences (via perceived pleasantness, feelings of safety and even (waiting) time perception) and thus customer satisfaction. The key question in this paper is:

How can Dutch Railways specifically deploy colour and light on platforms in stations so as to positively influence emotions? The objective is to win more happy customers by improving the 'servicecape' [13] and its potential to 'signal' service quality. and customer care. Of course, in considering the environmental design of public services such as railway stations, many factors may play an important role, and a variety of quality dimensions may be affected by clever design. In this study we specifically focused on the intangible factor 'time', because the train's departure is scheduled and passengers have to get on the train in time. So time is one of the predominant processes that passengers are dealing with during their stay at the platform. Time also has a crucial impact in quality surveys in public transport.

This paper presents the results of 2 studies into the combined effects of colours and intensities of light on emotions and time perception in a virtual simulation of Leiden station.

SERVICE ENVIRONMENT

According to Parasuraman, Zeithaml and Berry [37], three aspects play a role in the service environment: intangibility, the simultaneous course of the production and consumption, and the heterogeneity of the service. Through the intangibility of the service, people cannot feel, taste, see or smell it. They can only experience the service. Owing to a lack of tangible proof, customers perceive other aspects of the environment to evaluate the service and determine its quality [2], [13], [14]. A service environment comprises all the objective factors that can be controlled for by the organization with the aim of prompting employees and consumers to a specific behaviour. Baker [5] divides the physical environment into three components: design elements that are visually and tangibly present, ambient elements that are intangible and often processed subconsciously, and social elements, other people present in the service environment, such as customers and personnel. Colour and lighting belong to the category of ambient and intangible elements of the environment.

STIMULUS, ORGANISM, RESPONSE

This research employs the model of Mehrabian and Russell [32] to investigate whether colour and light influence the degree of pleasure, arousal and dominance that determine behaviour. The relationship between environmental variables and approach or avoidance behaviour in a service setting can be modeled (after Mehrabian and Russell, [32]) as a stimulus-organism-response (SOR) chain:

- *Stimulus (environment)*: all ambient aspects such as colour, light, smell, sound etc.
- *Organism (emotions)*: emotional reactions on the basis of pleasure, arousal and dominance (PAD model).
- *Response (behaviour)*: the degree to which consumers show approach or avoidance behaviour.

Many studies have focussed on the influence of pleasure on behaviour (e.g. [9]). Also the relationship between arousal and behaviour has been empirically demonstrated. However, little attention has been paid in literature to the degree of dominance [9]. Imperative for a station environment is a sense of control, and thus dominance; likewise for emotional aspects such as feelings of uncertainty and pressure, how easy it is to orient oneself and how one experiences the wait. These aspects will thus be included in this research.

LITERATURE OVERVIEW OF COLOUR AND LIGHT

Colours with a short wavelength are specified as cool colours (blue and green), whereas those with a long wavelength are warm (red and yellow). Light comprises the light intensity and the spreading of the colour tone. Bright or dimmed light is determined by the light intensity. Little research has been conducted on the combination of colour and light ([16]; [43]). The majority of (published) studies of the effects of colour in retail environments was conducted in laboratory settings. To our knowledge, no research has yet been published on the usage of light and colour in a railway station.

Colour

In public environments there is often a need for the right colour that incorporates the element of 'pleasantness'. Although the optimal design may strongly differ across service contexts and situations (and even across individual customers), it appears that specific colours, generally perceived as pleasant, may result in very specific emotions.

Cool colours, such as blue and green, have a relaxing effect, whereas colours with a long wavelength, such as orange and red, are stimulating [1], [26], [43], [47]. Warm colours are perceived as being protective [46]. Clear and saturated colours are generally experienced as more pleasant [24], but are also more strongly associated with fear than cool colours [26]. Dark colours are perceived to be more dominant and more strongly provoke hostility and aggression. So, with the environment and state of mind determining the effects of colour, red in the cinema foyer will exude a warm, festive aura whereas the same colour in a hospital can have a negative influence on the state of mind of the already anxious visitor.

Research on the use of colour in retail environments has shown that it influences buying behaviour [9], purchasing speed [9], time spent in the shop [9], pleasure [9], [18], arousal ([18], image of shop and merchandise [8] [18] and the potential to draw customers into the shop [8]. Blue and green are perceived to be the most pleasant in a retail environment [20], [26] and are also evaluated higher than shops with a warm (orange) interior [8], [18]. The results for pleasure strongly resemble the scores for arousal. From research by Kwallek et al. (1988; in [42]), it appeared that people who performed a business task in red surroundings later scored higher for stress and anxiety. Colours with a short wavelength cause a person to be more externally oriented and to show forceful and extrovert behaviour.

From the study by Belizzi et al. [8], it appeared that respondents, irrespective of their colour preference, felt more drawn physically to warm colours yet perceived surroundings in warm colours as less pleasant [8]. Warm colours are apparently successful when it comes to drawing people in (entrances, shop windows), but less so when it comes to making them feel at ease. In situations where people experience mental pressure, it is better to keep the colours cool; with their calming effect people are prepared to remain longer in such surroundings. Brengman [15; 16] showed respondents photos of a shop in which the colours were manipulated. She concludes that people will spend more time and money in a shop if they find the colours agreeable [15]. Blue and yellowish red are perceived as pleasant, as are light colours. Such atmospheres invoke approach behaviour and the desire to explore. According to Brengman [15], red and yellowish green, just like bright and dark colours are perceived as less pleasant; these colours lead to tension and stress and cause a distasteful feeling. Such negative stress leads to avoidance behaviour [15].

Light

Psychologists state that light has a tremendous influence on human behaviour. Baker and Cameron [5] and Küller et al. [29] indicate that there is a basic level of how people experience light as the most pleasant. A preference for light intensity depends on the situation, the task and one's surroundings [7], [10], [43].

Light has a strong effect on the degree of arousal [7], [19], [22], [27], [34]. Light also influences a shop's image and the stimulus to look at and scrutinize the merchandise [6], [16].

Colour *and* light

Valdez and Mehrabian [43] have shown that it is not only colour hue that determines the evoked emotions but also the saturation and brightness (i.e. intensity) thereof. It appears, for example, that although there is hardly any difference in the way men and women react to colour, women are more sensitive to the colours' brightness. In a study of non-chromatic colours (black-white-grey), it appeared that the brightness strongly determines their degree of stimulation and dominance [43]. Mehrabian suggests that "brightly lit rooms are more arousing than dimly lit ones" and that light, besides colour, has a strong influence on arousal [32]. From a scenario study [4], in which a blue and an orange shop were compared, it appeared that the blue shop was preferred the most and that it generated a greater willingness to shop or buy there. A brightly-lit orange shop was perceived as having the greatest adverse effect. However, when soft lighting was introduced to this orange shop, it became almost as positively rated as the blue one. With a blue shop the effects are even more positive in a brightly-lit variation. The combination of light and colour seem to qualify the perceived effects quite convincingly. A restriction, however, is that this was a scenario study and its results should preferably also be tested in a realistic setting [4]. Generally speaking, the studies of the effects of colour have predominantly focussed on the wavelength of the colour and hardly at all on the brightness and the saturation of the colour ([15], [43]). Light and colour combined were seldomly investigated.

COLOUR BRIGHTNESS, LIGHT AND TIME PERCEPTION

Smets [41] demonstrated how people estimate the length of an interval as being shorter after having seen a red as opposed to a blue colour. Under red light, time would appear to pass more slowly and objects seem bigger and heavier, whereas under blue light time seems to pass more quickly and objects look smaller and lighter. Casinos use this information and opt for red as a basic colour which excites the customers without their realizing that they are spending a lot of time there [40]. Research into the waiting time of downloading internet pages in various colours, with different levels of saturation and brightness, revealed that respondents felt more relaxed by particularly the bright colours and that time seemed to pass more quickly. Conversely, tension and stress when downloading seems to slow down the subjective experience of time. Analogous to other studies of the usage of colour, it would appear that blue screens have a more calming effect than red or yellow ones [23].

In the context of traditional –off-line- shopping, Markin et al. [31] suggest that dimmed light calms customers, causing them to move more slowly through the shop, which means that they then take their time to pay attention to and scrutinize the merchandise. This suggests that the shopkeeper can use the intensity of light to keep customers in the shop for a longer or shorter period of time. As pleasant and stimulating colours combined with bright lighting appears to lengthen the perceived waiting time [5], it would be better to opt for softer lighting to prevent overestimation of the actual wait.

STUDY 1: VIRTUAL LABORATORY

Method

A 2 (colour hue: red vs. blue) x 2 (light: high vs. low intensity) between-subjects design was used. At the VR Laboratory at the University of Twente, 130 participants were asked to navigate through a virtual simulation of Leiden station.

Procedure

The experiment ran for four executive days, during which the different conditions were arbitrarily distributed among the respondents. Participants who indicated they wished to take part in the experiment were first subjected to a test for colour blindness, after which they were invited -in a separate room- to practise with the navigation system that was used in the experiment. Subsequently the respondents entered the VR lab where the final instructions were given. After the simulation the respondent was requested to fill out a questionnaire. Following completion, (s)he was thanked for his/her time.

Participants

In total, 142 respondents, all Master/PhD students at the University of Twente, took part in the experiment. Of these, 130 (65 men and 65 women; average age 22; range 18-29 years) questionnaires were included in the final analyses. Twelve respondents dropped out because of colour blindness, or because they experienced a mild nausea in the virtual environment.

Stimulus material

The virtual simulation was projected on a 10 meter screen. Figure 1 depicts one of the participants at the Virtual Reality Laboratory at the University of Twente and Figure 2 depicts two stills of the simulation. After reading an instruction on the start page, participants could navigate through an animation of Leiden station with a mouse and scroll arrows on a keyboard. They were instructed to: "...get the first train to Amsterdam. Find out at which platform and at what time your train leaves. Wait on the platform until your train arrives. You already got your ticket. Please, try to imagine the situation, and try to behave as you would in a real life situation". Then, the 'avatar' could enter the station and freely navigate through the station from a first person perspective. From this perspective they were able to 'walk' through the station, climb the stairs and enter the platform. Real life background noises were played during the session to enhance imaginative power.

Figure 1. One of the participants at the Virtual Reality Laboratory

Figure 2. Two stills of the simulated platform

The colours were manipulated on the platform: blue (colour code 000.128.255) and red (colour code 255.075.075). Level of satuaration was held constant for both conditions. Light was simulated by using a omni 1.0 spot 1.5 for the platform roof and omni 1.0 spot 0.4 for the platform to simulate low intensity of light. A high intensity of light was simulated by using a omni 0.5. spot 1.0 for the roof and omni 0.6 spot 0.2 for the platform.

Measures

A questionnaire was used to measure the overall evaluation of the railway station.

Emotions were measured on the basis of the Pleasure Arousal Dominance (PAD) scale [31] with 19 semantic differential items. Pleasure was measured with 6 items (unhappy-happy, annoyed-pleased, unsatisfied-satisfied, melancholic-contended, despairing-hopeful, unpleasant-pleasant; coefficient alpha = .88). Arousal was measured with 7 items (stimulated-relaxed, exited-calm, frenzied-sluggish, jittery-dull, wide awake-sleepy, aroused-unaroused; fit-tired; coefficient alpha = .71). Dominance was measured with 6 items (controlled-controlling, influenced-influential, cared for-in control, awed-important, submissive-dominant, guided-autonomous; coefficient alpha = .78).

Evaluation of the platform was measured on the basis of a combination of 3 scales [12], [39] which resulted in a 12-item scale. Participants could indicate to what extent they felt the platform was attractive, comfortable or messy (*1 = totally disagree, 7 – totally agree*; coefficient alpha = .86).

Attitude to the waiting time was measured with 4 items based on a study by Pruyn and Smidts [38] on waiting time. Examples of items are ‘I was annoyed because of the time I had to wait’ and ‘I felt bored during the waiting time’ (*1 = totally disagree, 7 – totally agree*; coefficient alpha = .76)

Time perception - Measures included subjective estimations of time spent in the station and on the platform (‘‘How long do you estimate the time (in minutes)” and the experience of time (‘How long did you think this time took’: *1 = very long, 7 = very short*)).

Cognitive preference was measured by asking the participant which colour they thought was best appropriate for a station (grey, green, yellow, red or blue).

Perceived colour was measured by asking participants what the main colour was they saw on the platform. Also included were a number of demographic variables such as age, gender and gaming experience.

RESULTS

On the basis of a multivariate analysis of variance, we then inspected the main and interaction effects of colour and type of light on the different dimensions of the overall evaluation of the station.

Table 1 shows the results per colour and type of light for all aspects of the judgement.

Table 1

Analysis of variance (interaction) effects colour and light[1]

	Main effect Colour		Main effect Light		Interaction effect Colour x Light	
	F	*P*	*F*	*P*	*F*	*P*
Pleasure	<1		<1		3.55	.06
Arousal	<1		1.08	ns	<1	
Dominance	1.96	ns	<1		<1	
Attitude to the platform	<1		<1		2.72	.10
Attitude to the waiting time	<1		<1		4.95	.03

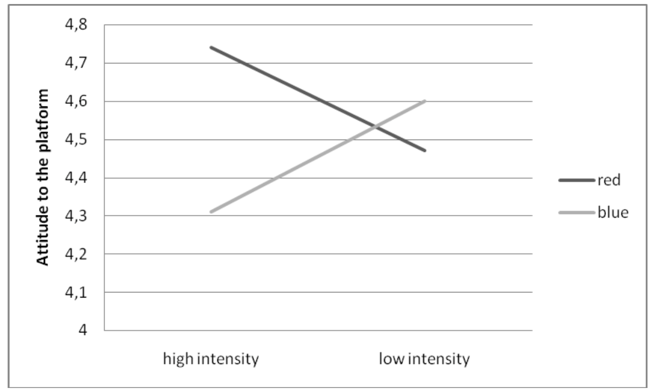
Note: ns = not significant

Although no main effects came to the fore with regard to either colour ($F < 1$) or light ($F < 1$), the analysis does show a marginally significant interaction effect ($F(5,99)=1,93$, p=.09) for colour x light. Because this interaction effect is leaning toward significance, we decided to conduct univariate analyses to further explore a possible tendency.

3A.

[1] Because it is possible that game experience influenced participants' responses, we conducted ANCOVA's with game experience as covariate. The reported results remained (marginally) significant when controlled for game experience.

3B.



3C.

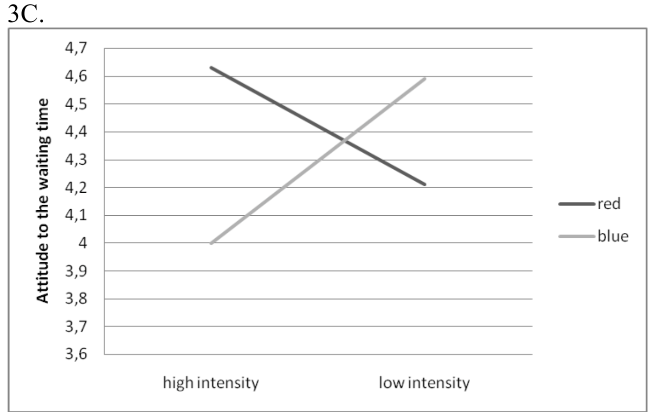


Figure 3. Interaction effects between colour and light for pleasure (A), attitude to the platform (B), attitude to the waiting time (C)

The presence of the two aspects together appear to determine the scores for pleasure, the attitude with regard to the appearance of the platform and attitude to the waiting time. Figure 3 shows the interaction effects that were found. The results reveal a tendency. Figure 3 (panels a, b and c) shows similar patterns of results for pleasure and the two attitude measurements. With pleasure, the attitude to the environment and the attitude to the time spent on the platform, the blue platform tends to score highest with the dimmed lighting whereas the opposite effect is the case for the red platform. In other words, with a low intensity of light one prefers blue as opposed to red surroundings. As the intensity of light increases, a shift occurs and the red environment is found to be more pleasant. The score for the three aspects of station perception is highest with the red platform with the high intensity of light; even higher than the blue platform with the lower intensity.

Additional analyses were performed to gain insight into participants' preference. When asked which colour they thought was best appropriate for a station (grey, green, yellow, red or blue), participants indicated a cognitive preference for the colour blue (36.2%) followed by a the colour grey (21.5%). Various one-way ANOVA tests show that this preference has no influence on the overall evaluation of the station. That is to say that when one prefers (e.g.) blue on a platform, one does not necessarily appear to appreciate that platform better than someone who has a preference for another colour. It also appeared that only one third of the participants could actually indicate which colour was dominant on the platform, suggesting that the effects of colour occur subconsciously. This result is in line with studies on automatic consumer behaviour which suggests that consumers are often unaware of environmental factors influencing their behaviour (e.g., [21]).

Time perception

Time perception was included as a specific focus of interest in this study. Generally speaking, respondents estimate their time spent on the platform as significantly longer (M=4:54, SD=1:57) than the actual time of stay (M=3:18, SD=0:49; t(129)=-11.03, p<.00). Four univariate analyses of variance with the objective and subjective time, the overestimated length of time and how the time was experienced were carried out as dependent variables. No main effect for light comes to the fore from these analyses, nor does an interaction effect occur for colour x light. A main effect for colour did appear, however, for how the time was experienced (F(1,104)=4,63, p=.03). Results show that the time on the blue platform (M=4,66, SD=1.46) was perceived as being significantly longer than the time on the red platform (M=3.98, SD=1.79)). These results show that on a blue platform time is experienced to pass relatively slower than on a red one.

In the study 1 we were able to explore the effects of two colours in combination of intensity of light in a virtual laboratory. To further explore the effects of various colours in combination with intensities of light we need to expand the design of study 1. In a virtual laboratory, the actual performance of a study is time consuming. Therefore the number of participants is limited. Study 2 investigated the interactive effects of 5 different colours and two intensities of light in an online environment which allowed us to include a larger number of participants.

STUDY 2: ONLINE STUDY

Method

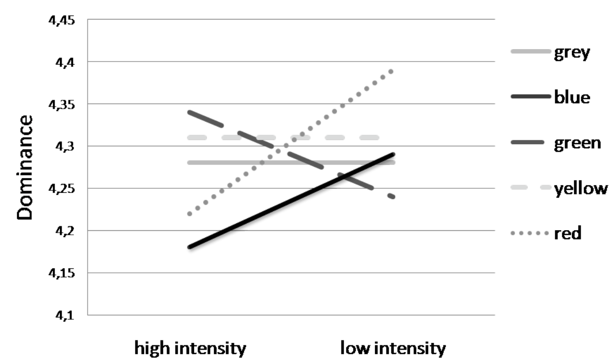
A 5 (colour: grey vs blue vs red vs green vs yellow) x 2 (light: high vs low intensity) between-subjects design was used. The virtual reality environment and the questionnaire from study 1 were converted to an online version. In total 2,360 respondents (56,9% men, 43.1% women) were asked to navigate through the online simulation.

Results

In order to ascertain interaction effects between colour and light, a multivariate analysis was carried out on the various aspects of station perception with colour and intensity of light as independent variables. The analysis yields an interaction effect for colour x light (F(20,9236) = 2.35, p = .001). The interaction effect was found in the degree of dominance (F(4,2310)=2,62, p=.03), and the attitude to the platform (F(4,2310)=2.74, p=.03)[2]. The significant interaction effects 'dominance' and 'attitude to platform' are specified in Figure 4 (panels A and B).

For the degree of 'dominance' the results show that colours with an extreme wavelength (blue and red) achieve the highest score with a lower intensity of light. With a platform with a medium wavelength (green), however, the highest score is reached with a higher intensity of light. With the baseline, or rather the grey platform, the intensity of light makes no difference. The results for the attitude to the platform show that the intensity of light with the blue and green platforms makes little difference. However, the red platform is deemed better with a higher intensity of light. This effect is the opposite of the yellow platform, i.e. on a platform with a yellow colour the platform is appreciated more when the light is less bright. Also noticeable here with the baseline measurement is that the intensity of light has little influence and causes no major differences. The marginal effects for the attitude to the waiting time show another picture: a platform with a short to medium wavelength (blue and green) is valued more positively than a platform with a higher intensity of light. On a platform with colours that have a longer wavelength (yellow and red) the attitude is better with less brightness.

4A.



4B.

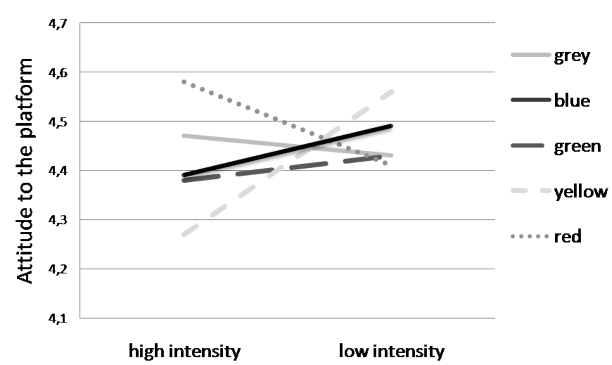


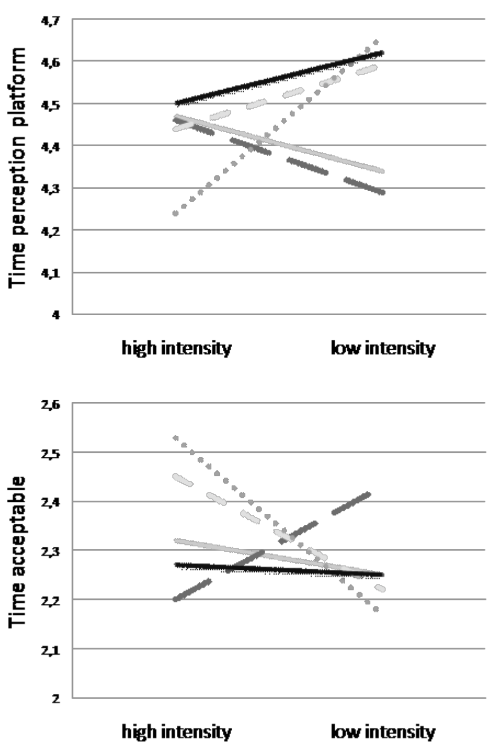
Figure 4 Interaction effects colour and light for dominance (A) and attitude platform (B)

[2] Given the large d.o.f., the statistical significance of these results should be considered with caution.

Aspects of time were also included in study 2. On average respondents spent 7:09 minutes (SD=3:50) at the station, of which an average 3:54 minutes (SD=2:58) were on the platform. A t-test revealed a significant difference between the objective and subjective time on the platform (t(2244)=44,88, p<.001). The perceived time at the station appears to be significantly longer than the actual or objective time.

Again, univariate analyses of variance were conducted with objective and subjective time and time experience as dependent variables. These analyses produce a main effect for the intensity of light and applies to the time perception of the station (F(4,2329)=4,37, p=.04). This main effect demonstrates a difference between the station with the higher intensity of light (M=4,11, SD=1,52) and the station with less light (M=4,26, SD=1,49). The time spent at the station with the lower intensity of light was perceived as being significantly shorter than at the more brightly lit station. The interaction effect shows how time perception (F(4,2329)=2,41, p=.05), as well acceptability of time spent at the platform (F(4,2329)=3,18, p=.01) is influenced by the combined effects of colour x light. Panel A in Figure 5 shows that time was perceived as being shortest on the blue, yellow and red platform when the intensity of light was higher.

5A.



5B.

Figure 5 Interaction effects colour and light for perception platform (A) and time acceptable (B)

DISCUSSION

When we look at the results we can conclude that almost no main effects were found for colour and light. But we did find some interesting interaction effects for light and colour conditions. The results indicate that passenger respond more positively to warm colours in combination with dimmed (low intensity) lighting but at the same time estimate the waiting time as shorter when cooler colours and a more intense lighting are used.

As for time perceptions, most passengers appeared to overestimate the waiting time on the platform, which concurs with results from earlier work [45].

Although passengers have a definite cognitive preference for the colour blue in a well-lit environment, it appeared that only one third of the respondents could indicate which colour was dominant on the platform. In all situations the colour one thought to have seen most often was grey. Despite people indicating they also preferred well-lit surroundings, the results particularly show effects with dimmed situations. Apparently, passengers cling to the image they have of a platform. This confirms that colours and intensity of light are perceived subconsciously. For station evaluation, affective effects are thus more important than cognitive ones.

Both experiments also show the strong influence of waiting time perception in a station environment. Most people tend to overestimate the waiting time on the platform, as was also found in earlier research [25], [30], [35], [45] and can be explained by the attentional model of Zakay [49]. Zakay stated that people divide their attention in a prospective time judgment between the time and other activities. When time gets more attention, time seems to go slower [49], known as “a watched pot never boils” [36]. In a station environment especially daily commuters are focussed on the time. How the wait is evaluated and how useful passengers find it seems to be related to both the attitude to the platform and the impression thereof. In most situations, time in dimly lit surroundings appears to pass more quickly than when the lights are brighter. This confirms the results of Baker and Cameron [5]. In contrast to results found in the literature, time in a blue environment appears to pass more slowly than in a red one. One explanation might be that passengers who feel stressed not only desire cooler colours which are less arousing and distractive, but also pay more attention to the time itself, which makes it seem to pass more slowly [49].

The results show that manipulations in a virtual public environment successfully allow effects with colour, light, crowding and time pressure to be demonstrated. These findings offer an initial insight into the way colour and light work in a station. However, both experiments were conducted in a virtual station which might influence the outcome. Moreover, the significant results obtained in the online study should be considered with caution. Due to the large number of participants any difference in a dependent variable can be considered a statistical artefact evoked by large degrees of freedom. The question arises whether these findings would also be found in a real station. Recent developments in new techniques of lighting (e.g. 'ambilight') make it easier to study these effects of colour and light in real-life public spheres.

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