Light and the perception of cleanliness in the metro environment

Niels Molenaar

Technische Universiteit
Eindhoven
University of Technology

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Niels Molenaar

Coach: J. Hu

Faculty of Industrial Design

University of Technology, Eindhoven

n.molenaar@student.tue.nl

Table of Contents

Abstract

The point of this project is to find a relation between litter, light and perception of cleanliness. By using the Cobes metro environment platform a test is set up to observe how people react to darkened and lightened litter. This report will show why people perceive an environment as cleaner when attention is drawn to litter by focusing light on it.

Introduction

Platform

This project tries to answer the questions that arose during the Design Class, which focussed on the perception of cleanliness in a metro environment. My team (T. v. Bergen, M. Brugmans, B. Dohmen and N. Molenaar)created Cobes, a concept that tries to hide litter by dynamic lighting in the metro environment.

Cobes analyzes the physical presence of passengers in the metro over time with a neural network, this network will be able to identify and locate possible irregularities in the metro (Figure 1). Using this information Cobes adjusts the lighting in the metro cart accordingly.

Identifying dirty or broken chairs is not just a matter of looking at which chairs are being used and which chairs are not. For example, outside rush hour, the window seats facing towards the rear of the metro are hardly used. However, if the chairs around them are often in use, this probably means that there is nothing wrong with these chairs. Therefore, the full pattern of an entire metro carriage needs to be taken into account in order to draw a proper conclusion.

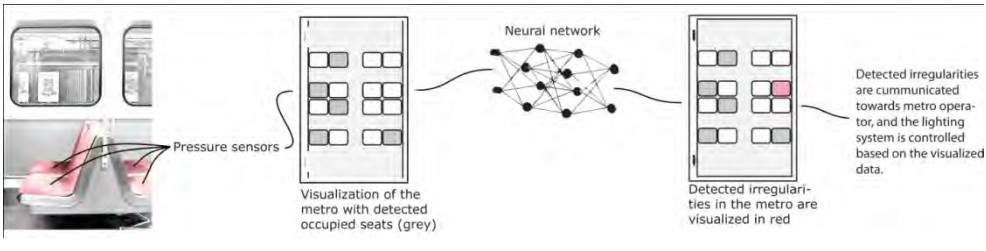


Figure 1; visualization of data processing

When the metro is riding, all light intensities are equal (Figure 2, left image). When the metro stops, littered places are darkened, and empty seats are illuminated slightly more (Figure 2, middle image). When a seat is in use, the light also is also slightly dimmed, but only during stops (Figure 2, right image).

Figure 2; from left to right, even lighting, dirty chair, dirty chair and passenger

Research boundaries

During the Design Class the designed system appeared promising. The different lighting patterns appeared to influence the people inside. There was no evidence on how light changes the perception of the space. Also no literature was available on this topic. Therefore this project was initiated.

As was questioned during the Design Class; by hiding garbage with light, it seems like you are hiding the problem, which might make the space even more uncomfortable.

Today's metro cart seats are evenly lit. For the experiment this is control situation. Two variances on this are studied: Darkening the litter (lightening the clean spots), and lightening the Litter (darkening the clean spots.

For this experiment the Neural Network intelligence is left out. Instead three static light scenarios, are compared. Side effects like whether people keep the space cleaner are also very interesting. These effects are not yet included in this study, due to the time consuming nature of these investigations.

Personal motivation

This period I focussed on research and statistics, which fitted well in this project. There is already an existing platform to use, and design on. This allowed me to have enough time to fine-tune the soft- and hardware to end up with a reliable and repeatable test platform on which I could execute a thorough user test.

I am personally interested in light, and how people react to that. It was a challenge to try to break the subject of light down into small pieces, and see if certain lighting can make a space seem cleaner. Figuring out light scenarios and executing such an experiment was not only a useful experience for future projects, but the result also gives me an insight in how light affects the human psyche.

This project is initiated by myself. I felt I had to do this as a continuation of the Design Class platform. Luckily Jun Hu was interested as well, and willing to coach me.

Background

Metro's today

The metro is an environment where commuters and tourists pass each other each day. Moving people from one side to another side of town numerous times a week.

One of the previous observations in the metro in Amsterdam was that people tend to distribute themselves (physically) in the metro carriages according to fixed patterns (T v Bergen, 2009). In general, one could say that people tend to sit as far as possible from other people. This only applies to individual carriages, since the middle part of a metro train is always more crowded than the front and rear end.

Unfortunately this is accompanied by filthy interiors from litter and vandalism. Amsterdam for example has big problems with litter. A metro that has been used through rush hour needs to be taken out of service and be cleaned. This is a good environment where something can be done by design to make the environment friendlier. This is shown by studies done by the GVB(GVB, 2008). Even though the metro in Amsterdam is the most punctual and the most reliable source of public transport. Commuters vote for it as the lowest quality. This is mainly due to the perception of an unsafe and unclean environment.

Perception of cleanliness

In sociology it is since long accepted that there is low empirical correlation between perceived cleanliness, and actual cleanliness(M Robin, 2007). In New York an experiment has been done to use a quality index based on parts of litter per meter, and how clean people perceive the street to be (G Ryzin, 2008).

The perceived cleanliness is agreed on by people, but not based on the actual amount of litter. Instead secondary factors come into play. The overall feel of the rest of the neighbourhood, the weather and such environmental factors are more important then the actual amount of litter. These factors are called place attachment (M Bonaiuto, 2003).

When people perceive an environment as cleaner or safer, they start to behave appropriately(D P Farrington, 2004). In a dirty environment, people litter more and more is stolen. This shows that by changing the perceived cleanliness, one can slow down the littering of the streets. This not only makes the environment feel cleaner and maybe safer, but on the long run it keeps this effect of enhanced cleanliness and safety for a longer period of time. When it is possible to keep up the perceived cleanliness through lighting, people in that environment will also act more appropriate.

When applying this on a metro environment, it would mean that by using a design solution to enhance the perceived cleanliness, littering is postponed, and the metro cart stays cleaner for a longer time.

Effects of light

Light is a subconscious guide when moving through spaces. While we will not necessarily go towards the lightest or darkest place, but by changing these factors and applying colours, different moods can be applied to the same environment (P R Boyce, 1990). Light enables designers to make people feel different about a space, perceive it differently. Warm colours can make people feel warmer, quick moving light can make people feel more active. With all these aspects designers can play in an environment.

Light is also very flexible. The direction, intensity and colour are easily manipulated. Thereby a small change can have a great effect efficienctly. This flexibility enables an environment to inhibit different qualities at different moments. As to say, an environment can tailor towards a certain moment.

Experiment

Goals

The goal of this experiment is to find out how the different lighting scenarios (even, darkened and lightened litter) influence the subject's perception of cleanliness differently. Does hiding garbage by darkness result in a higher perceived cleanliness of the environment? And, the other way around does lighting the garbage mean that people perceive the environment less clean?

The research question thus is: Is it possible to use a balance between ambient light and focussed light on litter, to enhance the perception of cleanliness?

The two sub questions focus on two situations: First, does darkening the litter makes people perceive the environment cleaner? Second, does lighting up the litter make people perceive the environment as dirtier?

A verified scale is used on which people can rate their perceived cleanliness. For all three situations the results from those scales are compared.

Design decisions

The Cobes platform is quite elaborate in a sense that it includes neural network intelligence and has 16 chairs each with one sensor. For this test however the quality of neither the neural network, nor the chair sensors are not relevant.

The goal is to investigate how people react on this environment. Therefore three lighting scenarios were created. These lighting scenarios where not based on the location of people, but by the location of the litter. The only thing the scenario did was change the relation between the ambient lighting and the focussed light on the litter. A 'wizard of ozz' set-up was to accomplish this. This ensured the greatest stability and repeatability for the test. This was chosen to minimise noise created by an awkwardly trained neural net, or a sensor in the chair performing poorly.

Light scenarios

The three scenarios are based on three theories. One is the control situation where the relation between the ambient and focussed light is even (Figure 3), and all lights are on normal intensity. This is most comparable to a normal metro lighting situation. Assuming no lights are broken.

Figure 3; even lighting

The second scenario darkens the litter (Figure 4), as to hide it. This means the ambient light, or clean chairs are much brighter then the garbage. The hypothesis is that this is considered cleaner, as the litter doesn't draw your attention.

Figure 4; litter is darkened

The third scenario puts focus on the garbage (Figure 5). This as to see how people react when you turn down the ambient light, and let the litter stand out. The hypothesis her is that this is considered dirty.

Figure 5; litter is lightened

By comparing these three static light scenarios without play for changes due to occupied chairs, trained neural networks or noise. The experiment is executed to find out how the second and third scenario relates to an evenly lit room.

Set-up

To use the static situation, an environment with 16 chairs positioned in a way used in metro carts. One chair is littered with bread, cheese and old newspapers (Figure 6). This is the situation that stayed the same throughout the test. When taking this environment, and taking the three lighting situations the actual cleanliness will stay the same, searching for differences to be found in the perceived cleanliness.

18 subjects where involved in the experiment. The average age is 26 years old. Seven females are included and eleven males. By showing the subjects the scenarios in random order the noise is eliminated that comes in when showing one scenario after another. This removes a bias from the results that might influence that data. The second and third time the subjects enter the environment, they have more knowledge about the questions. Also the subjects might compare the scenario with a previous scenario set as a benchmark.

The within-subjects study is used to compare three scenarios. The rating for scenario 1 might be totally different for three people, yet the difference with scenario 3 might be the same for all. And these differences in scenarios within people are useful to answer the research question. The sample size of 18 subjects is sufficient since a within-subjects study is used. This eliminates the noise for different people.

Previously a study on perceived cleanliness is done to compare different neighbourhoods(M Bonaiuto, 2003). To do this properly the researchers used a Principal Component Analysis. This resulted in over 60 verified questions. Since these questions are often related to certain situations (parks, trees etc.) I picked 11 questions that made sense in this environment (appendix 1).

Before the test the subject were told that they were entering a metro environment with three different lighting scenarios. They were asked to go in, look and walk around, come outside, and fill out a form (Table 1). After doing this two more times they had seen all lighting scenarios. In the end 11 questions were filled out three times, one for each scenario. Afterwards subjects were given the chance to elucidate their experiences.

Analysis

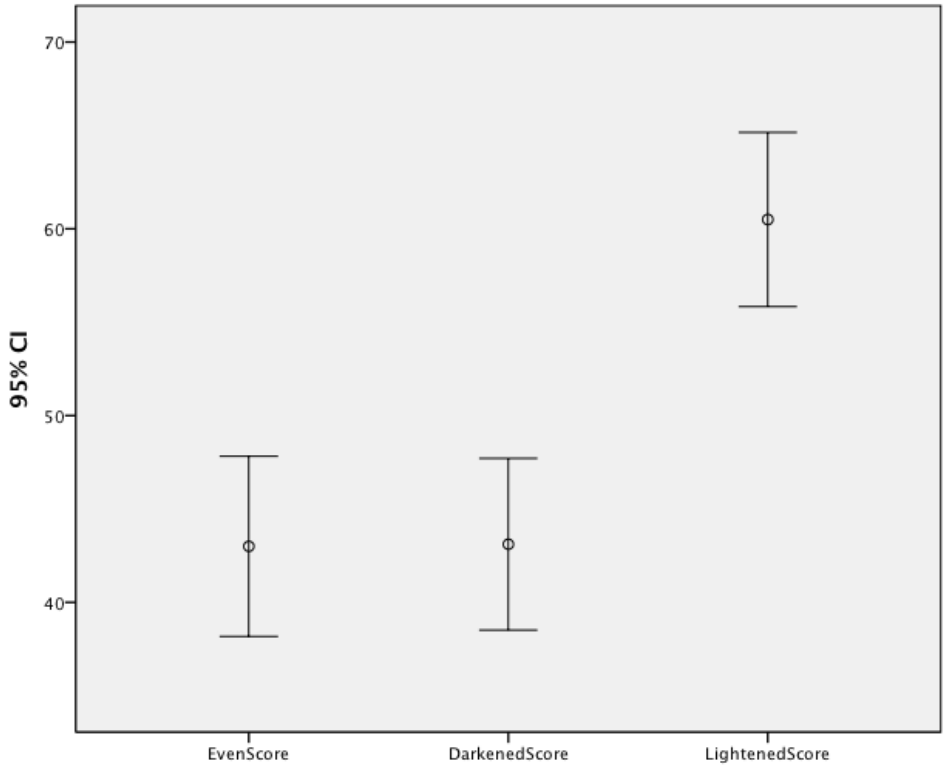
To look at the within-subjects test a Wilcoxon test is used. This compares two scores and doesn't look at the mean, but looks at the differences between the control and one situation (either darkened or lightened litter) for each person. Then by looking at these differences (Table 2) for all 18 subjects, it gives the differences between two groups based on their perception.

Table 1; subject scores

Total score even lighting	Total score darkened litter	Total score lightened litter
35	55	66
31	40	68
37	32	51
40	42	70
62	39	62
61	31	46
45	56	67
36	49	38
49	29	60
32	39	64
47	53	46
40	40	69
50	58	60

27	48	72
37	31	59
49	37	62
48	49	66
48	48	63

Table 2; subjects scores error graph



Wilcoxon Signed Ranks Test

Table 3; wilcoxon results

Ranks

		N	Mean Rank	Sum of Ranks
DarkenedScore - EvenScore	Negative Ranks	6[a]	10.17	61.00
	Positive Ranks	10[b]	7.50	75.00
	Ties	2[c]		
	Total	18		
LightenedScore - EvenScore	Negative Ranks	2[d]	4.25	8.50
	Positive Ranks	15[e]	9.63	144.50
	Ties	1[f]		
	Total	18		

a. DarkenedScore < EvenScore

b. DarkenedScore > EvenScore

c. DarkenedScore = EvenScore

d. LightenedScore < EvenScore

e. LightenedScore > EvenScore

f. LightenedScore = EvenScore

Test Statistics[b]

	DarkenedScore - EvenScore	LightenedScore - EvenScore
Z	-.362[a]	-3.220[a]
Asymp. Sig. (2-tailed)	.717	.001

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

There is no significant (0.717) difference between the darkening of the litter and the even situation (Table 3). This means that the control situation has the same influence on the perception of cleanliness. These situations are essentially the same; for this test the darkening of the garbage made no significant difference. Subjects stated darkening the garbage made them feel like somebody tried to hide it. It had a negative feel to it.

Lightening the garbage had a fascinating influence on the subjects. That situation was rated significantly higher (0.001) in perceived cleanliness (Table 3).

This suggests that lightening the garbage does help to improve the perceived cleanliness in this environment. Subjects said afterwards that by lighting the garbage they are convinced something is going to be done soon about it. They feel like it takes guts to focus on garbage like this. It makes them feel like litter on the already dirty chair is ok, but it enhances the clean feel of the rest of the train.

Even so, by putting such focus on garbage, subjects feel confronted with their behaviour. This might make them think twice about littering.

Discussion

Feel of Safety

Most subjects were familiar with the space in which the experiment was conducted. This might have influenced their feel of safety in the environment. The feel of safety is often based on three aspects: quality of overview, easy escape possibilities and freedom of location and route. Since they are all known, there is no reason for a threat. The situation is relatively safe, and there is no need for an overview. This makes this test different from a real situation where there is more need for overview. This feeling of safety might make the influence of the darkened ambient light less invasive in the aspect of safety. Usually when a space is darkened to such an extent people tend to feel unsafe very quickly. This means that it might only work on situations where people feel safe. On the other hand one could continue this project and apply this notion of putting focus on litter, by applying it in a way less intrusive for the ambient lighting.

The challenge is to apply focus on the litter, still allowing people to grasp the overview. They might feel safe and still perceive the environment as clean.

Another aspect of safety and perceived cleanliness is that they are related according to the broken window theory (Gladwell, 2000). So it might also be that people feel safe in a darkened ambient light, as the environment is perceived as clean. These are aspects open for research in the future.

Noise

By using a within-subjects test the subjects are used in all situations. This to level out the noise.

Since the results are ordinal and based on perception, the score itself doesn't mean a lot in small sample sizes. This is why looking at differences between the control and another scenario is preferred. Even though this takes out a lot of personal noise, still subjects are expected to fill out the scale different next time. Perceived cleanliness might be, for a part, based on how subjects feel and enter the room at that moment. So even though the test is spread over 5 days and 18 people. By enhancing the sample size, and spreading over more time, results will become more accurate.

Applications

Designers might help people feel more comfortable in work environments, or at home. In ambient intelligence for example, the environment may

notice something is not working properly. By focussing on this it keeps the user satisfied and creates a feeling of empathy. This is an example of a situation of possible interest for these research finding.

Let's assume that it can be taken in a broader sense, even though this is tested in this very specific situation. Maybe one could clean their house less often, or the front desk of your company might change their cleaning habit.

When people feel the focus on litter, this is not only a reminder, but also a virtual trash point. Litter is thus concentrated on certain areas; making it easier to clean it in the first place.

This can and should have a number of effects on how people design such environments right now. Even though I am not saying we must throw out all trashcans, and make piles of litter in our home with a beam of light on top of it. It does make one think. When an environment isn't kept clean without effort. This might be an interesting direction to explore.

Future research recommendations

It would be interesting to see how lighting litter applies in situations that are potentially less safe to people. By testing this one could get a feel for how darkening the ambient light works in these situations. Safety changes the design brief when working with light and litter.

Another aspect is how the improved perceived cleanliness works in the long run. People stated they would throw their litter on the littered enlightened pile, instead of the ground. Is this actually true? Does the litter stay concentrated longer, and for how long?

Also an important question in the end is how does it tie to the broken windows theory (Gladwell, 2000). Does it actually make people litter less? Does the environment stay clean for an extended period of time?

Relevance

Instead of trying to hide failures and uncomfortable space, we can use sensors and dynamic lighting systems to enhance the feeling of perceived cleanliness in the metro.

This enables designers to create scenario's that can deal with people littering in an environment.

Conclusion

Darkening littered places has no significantly different impact on how people perceive the cleanliness of that environment compared to an evenly lit situation.

Putting light on littered places significantly increases the perceived cleanliness of people compared to an evenly lit situation.

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Appendix

1: Research questions

Person __

Scenario __

Age __

Gender male/female

	Agree						Disagree
Space is unpleasant	1	2	3	4	5	6	7
This is a roomy space	1	2	3	4	5	6	7
It is dangerous to be in this space	1	2	3	4	5	6	7
There is a risk of dangerous encounters	1	2	3	4	5	6	7
It is not risky to go around in this space	1	2	3	4	5	6	7
The space has good lighting facilities	1	2	3	4	5	6	7
The quality of this space is poor	1	2	3	4	5	6	7
Space is to uncomfortable	1	2	3	4	5	6	7
The space is clean	1	2	3	4	5	6	7
I would avoid dirtying this space	1	2	3	4	5	6	7
I would not respect this environment	1	2	3	4	5	6	7
This is an ideal space for me	1	2	3	4	5	6	7


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