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Persuasive Ways to Change Entrance Use of Buildings

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ABSTRACT

People tend to use the same door every time they enter and exit a building. When certain entrances are widely preferred over others, congestion can occur. This paper describes two interventions to persuade visitors to use another entrance. The first intervention used sensory deprivation (darkness), and the second used guidance paths. The first intervention on sensory deprivation had the expected outcome. This intervention resulted in an avoidance of the darkened door. The second intervention had a result contrary to the expectations; it resulted in an increased preference for the door without guidance paths.

Keywords : behavioural safety, persuasive safety, safety at work, walking pattern, senses, darkness, guidance paths.

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1. Introduction

There is extensive evidence supporting claims that behavioural interventions are effective in promoting safe working behaviours (Saari, 1994). In this paper we present two studies in which we explored how to support behaviour change by adapting the environment in different ways. Hence, a setting was chosen in which people's normal behaviour could be influenced. Being able to influence the flow of people as they enter or leave a building is important, in particular in emergency cases. Our interventions took place at the university. Dealing with large volumes of students on a daily base, the university is a suited 'living lab' environment for our interventions.

At the main entrance of our university, people have the choice between two identical revolving doors. However, a strong preference exists for one of these doors. That

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preference is so strong, that in case of a queue, people tend to join the queue, instead of using the other door, without a queue. As shown in **Figure 1**, these doors are no more than 10 meters situated from each other.

Congestion in front of these doors is unfavourable; it results in slower evacuation during emergencies. Several studies (de Boer, 2012; Groenewegen-Ter Morsche and Kobes, 2014; Kobes, 2008) show that congestion frequently occurs during evacuation. There are strong indications that people take the same entrance for exiting the building as they take for entering the building (de Boer, 2012; Soomeren, Stienstra, Wever and Klunder, 2007).

The goal of this study is to achieve a more evenly distribution of people over these doors through persuasive interventions. As different people (visitors) use these doors every day, a fixed-moment intervention, or actor-guided intervention is not possible. We chose to make two changes to the environment and see what effect this would produce. Our interventions were aimed at reducing the use of the revolving door that is used by most visitors (i.e., the right door, in this case).

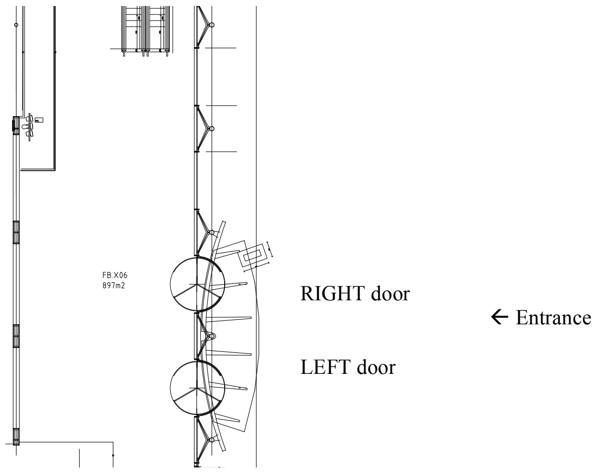

Figure 1. Situation of the interventions.

One way to influence behaviour is by adapting the environment and targeting people's attitudes by changing sensory input. Changing sensory input is accomplished by targeting any of our senses (sight, hearing, taste, smell, touch). A comprehensive description of studies using sensory input are described in one of our previous papers (Teeuw and de Boer, 2011). When looking at our senses, and the supposed environment of the interventions, some senses seem undesirable, inappropriate or impossible to use. In this case sound (hearing) could lead to nuisance. The effects of mild odours (smell) wear off over time, and are unsuitable for outdoors. We therefore chose a visible (sight) adaptation. Visual cues in public spaces can be implemented by influencing light, colours, directions, and the like (Eysink Smeets, Hof, and Hooft, 2011). Sight encompasses the perception of light intensity and colours. During the intervention, we wanted visitors to avoid the door with the highest preference (door RIGHT). We conjectured that one way of making the door less appealing was to darken it. This is what we did in the first intervention.

In the second intervention, we adapted the (design of the) environment and targeted people more consciously. A widely used way in public environments, railway stations, factory halls, and during roadwork to guide people is by the use of guiding paths. Our second intervention used the concept of guiding paths to guide people away from the busiest door.

This paper is organised as follows. First the theoretical framework is explained in Section 2, the literature overview in Section 3, followed by the methods used for the interventions in Section 4. Consecutively in Section 5 we present and analyse the results. Ideas for further research are included in Section 6.

2. Theoretical Framework

The studies described in this paper are embedded within a framework developed in the “Safety at Work” project. The framework aims towards a toolbox for practitioners and researchers. The toolbox is usable for solving behavioural problems in industrial environments (de Boer, Teeuw and Heylen, 2013; Teeuw and de Boer, 2011). The toolbox advises on how to target a behavioural safety problem.

In the framework (**Figure 2**), two axes are distinguished: influencing people versus adapting environments, and influencing directly versus influencing indirectly. On the direct side, the mechanisms are more conscious, and task-oriented. The use of guidance paths in our intervention is an example of this as a conventional method to guide people. And on the indirect side, the mechanisms are more unconscious, and attitude-oriented. The use of sensory adaptation by light in the other intervention leans more to this side of the framework. However, both sides are not necessarily exclusively targeting the conscious or unconscious mind.

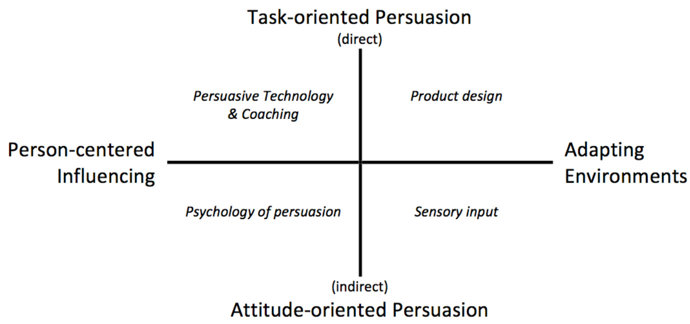

Figure 2. Framework for Industrial Safety.

3. Environmental Queues for Safety

People are sensitive to subtle changes in their environment. By altering environments, people change their behaviour in those environments. Environments can be altered in different ways. In this paper we focus on unobtrusive and non-permanent ways to change environments, i.e. the effects of light intensity, and guiding paths.

In the first intervention we conjectured that making one of the entrances darker would reduce the use of that door. In their book on the psychology of physical environments in offices and factories, Sundstrom and Sundstrom (1986) describe several situations in which people feel uncomfortable, unsafe, or are at unease being in dark environments.

Belluck (2010) and Seitzer (2009) describe the use of carpets in front of hospital-elevators. One does not want people to start a conversation in front of an elevator door, as this will form an obstruction. In the study black carpets were put in front of elevator doors, which had the effect that less people would start a conversation there. People seemed to interpret these black carpets as a black hole or cliff, and no longer lingered around elevator doors. The study shows a strong dislike of dark floors to visitors.

In industrial environments it is common –or even compulsory– to use coloured guidance paths at workplaces. In industrial terms it is called ‘marking of traffic routes’. These paths tell workers where to walk, where to drive with forklifts, and where to stow equipment. The Health and Safety Acts of most countries describe how and where these guidance paths should be implemented (Doornbusch and Homan, 2012; Ministerie van Sociale Zaken en Werkgelegenheid, 2013). A detailed overview of implementations is included in personal protective equipment summaries (Beer, Collee, Putman and Verstraeten, 2012). In the field of road safety we see many examples in

European Standards (EN) (Ministerie van Infrastructuur en Milieu Directoraat-Generaal, 2012) that give guidance to the use of temporary lane marking.

In the field of persuasive technology other ways of changing walking patterns have been studied. A study conducted by Sakai et al. (2011) combined ideas of Cialdini (2008; Goldstein, Martin and Cialdini, 2008) with persuasive technology. The system described in this paper uses a Bluetooth system to send persuasive messages to visitors in a hallway. Goal of the system is to change peoples walking behaviour (use the stairs more often, instead of the elevator). In our setup such is system is not usable to count people, as we do not know in advance who the visitors are.

Based on the literature, we expect an avoidance of dark environments (Belluck, 2010; Seitzer, 2009; Wexner, 1954). In addition we expect a preference for following the guidance paths (Beer et al., 2012; Doornbusch and Homan, 2012; Ministerie van Infrastructuur en Milieu Directoraat-Generaal, 2012). We therefore assumed that there is a relation between environmental conditions in which people use the entrance, and preference for one of the doors.

Studies in the field of CPTED (Crime prevention through environmental design) give evidence for both directions explored in our studies. A widely used definition (Crowe, 2000) of CPTED is “the proper design and effective use of the built environment can lead to a reduction in the fear and incidence of crime, and an improvement in the quality of life”. CPTED is a multi-disciplinary approach to deterring criminal behavior through environmental design. Frequently used CPTED strategies include altering the physical design of residential communities in order to deter criminal activities. It often results in natural access control by selectively placing entrances and exits, fencing, lighting to limit access and control flow. Our interventions can be seen in this light, as they guide people by limiting visibility and using guidance.

For our interventions we thus conjectured that (1) visitors tend to avoid the darkened doors, and (2): visitors have a preference to use of doors with guidance paths.

4. Methods

Two interventions were executed. **Table 1** shows that in both interventions the environment of only one of the entrance doors was changed. The changes were visible both inside and outside of the building. In Figure 3 and **Figure 4** we see both situations. The black foil used to cover door RIGHT in intervention 1 was put on the inside and outside parts of the revolving door. The yellow guidance paths towards door

LEFT in intervention 2 were placed both inside (entrance hall) and on the outside (large square).

	Door RIGHT	Door LEFT
Intervention 1 Sensory deprivation intervention	Black foil covered the door.	Normal
Intervention 2 Guidance paths intervention	Normal	Yellow guidance paths towards the door. Inside and outside of the building

Table 1. Setup.

Figure 3. Intervention 1: Darkened door RIGHT.

Figure 4. Intervention 2: Guidance path to door LEFT.

The first intervention ran from February 11 to April 19 2013, the second intervention from May 24 to July 12 2013. Only data captured during the interventions, and during official opening hours (Monday-Thursday 07:30–22:30, Friday 07:30–17:30h) was used for analysis. We also captured data during long periods before, between and after the interventions.

As there is no collective memory among the participants, the resting periods were used as control conditions. There is a constantly changing course of visitors using the building. Using a different location as control condition would have given comparison problems. For example, there would have been differences in environmental conditions, like more distance between the doors, or a different ratio between the doors. Counterbalancing the interventions across both doors was not executed, as there already was a strong preference for one of the doors. Reinforcing the existing preference for one of the doors was not in the scope of the study.

4.1 Population and Sampling Technique

There was no need to recruit participants, as all visitors of the hallway were automatically participating in the interventions. Before the start of the interventions, a memo was send out via the internal news website of the university, to inform people that a new system for building occupancy was tested. The memo explained that the system did record any video, but only real-time video was used.

4.2 Methods of Data Collection

For each door, an identical computer system counted the visitors. The systems were placed on top of the revolving doors. Both were placed at the same height, position and direction. The system consisted of an Asus EEE Box (Atom N270 processor, 1GB memory, 802.11n wireless connection) running Windows XP SP3, and a Hue HD Webcam. Running on the system was video capturing software and a database, which are discussed in more detail later on.

Both systems captured people walking into, and out of the field of vision. Both systems covered the same surface dimensions, next to the revolving doors. The HUE HD Webcams (**Figure 5**) were connected via an USB 2.0 port to the computers, and were placed on a tripod, in order to cover a larger surface, which resembles the area in which people walk into and out of the building (**Figure 6**).

Figure 5. HUE HD Webcam.

Figure 6. HUE HD Webcam setup.

The system used real-time video to count visitors. The date, time and blob-age (the number of frames a visitors was in range of the camera) of visitors were recorded, and pushed to the database on the system. The camera did not record video; only the life feed was used.

4.3 Instrumentation

Installed on the Asus EEE Box computers were a number of software programs that took care of counting the visitors, and writing the data to a (MySQL) database.

OpenTSPS (Vondle and Walton, 2013), an open-source toolkit for sensing people in spaces, was used to count visitors. OpenTSPS, as shown in **Figure 7** and **Figure 8**, uses blobs to count visitors in range of the camera. It uses a progressive background capture algorithm to compensate for changing lightning conditions in the hallway. Even with the use of the progressive background capture algorithm however, the cameras could not always keep up with the changing light conditions (turning lights on/off) in the hallway, and ghost images (shadows) were recorded. Therefore all recordings larger than a threshold value of 50 frames were excluded from the dataset.

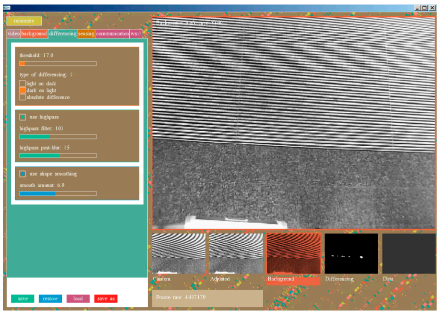

Figure 7. OpenTSPS, camera view.

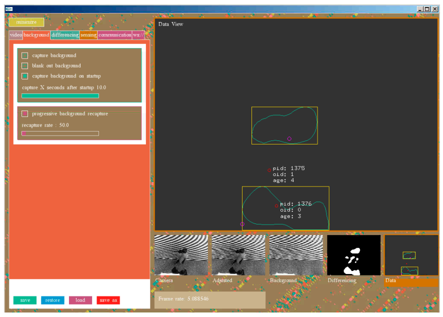

Figure 8. OpenTSPS, blob view.

The data from OpenTSPS was pushed to a Processing JAVA applet that converted the raw data, to a format that is suitable for importing into a MySQL database. The date, time and blob age was converted to a MySQL query.

Data recorded during events in the hallway that obstructed normal use (based on an event-list received from the University's event organization) was excluded from the dataset. In addition, data recorded during maintenance to the system was also excluded from the dataset. Due to the sensitivity of the system, some visitors' arms were recorded separately for some frames. In addition, some ghosts were recorded, before the camera could compensate. Therefore all recordings smaller than the threshold of 2 frames were excluded from the dataset.

5. Results

This chapter describes the results of both interventions. For each intervention, we first describe the raw data: the number of visitors, spread across each period; the ratio of these visitors between the two doors; and the number of visitor on each day during the intervention. Next we analyse the data gathered during the intervention. In the final paragraph a comparison is made between the two interventions.

5.1 Raw Data Sensory Deprivation Intervention

During the period of capturing of the first intervention (including a pre- and post-intervention period), a total of 165624 visitors came in or out of the building. On an average day around 4247 visitors came in or out of the building. The spread of visitors is shown in **Figure 9** and Table 2.

Figure 9 shows an overall preference for the right door. This is true for most days. For the whole period, there are a steady number of visitors coming in and out of the building. On some days there is a drop in the number of visitors.

Period	Session	Door RIGHT		Door LEFT		Total
Feb 11 – Feb 28	S1 Pre-control	34104	62,1%	20834	37,9%	54938
Mar 1 – Mar 19	S2 Intervention	32183	56,9%	24379	43,1%	56562
Mar 20 – Apr 19	S3 Post-control	30091	55,6%	24033	44,4%	54124
Total		96378	58,2%	69246	41,8%	165624

Table 2. Visitors per session, with extended periods and removal of anomalies.

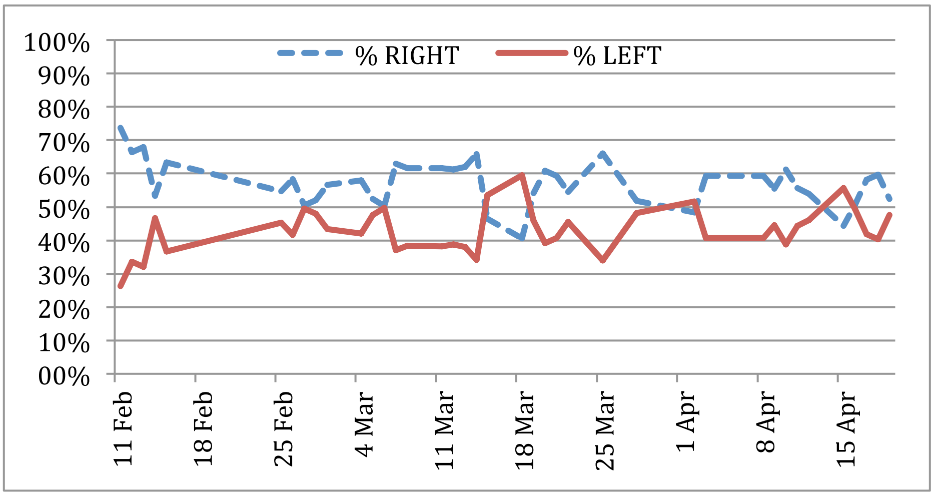

Figure 9. Ratio of visitors per session, with extended periods and removal of anomalies.

Figure 10 shows the number of visitors per day during the intervention including the total number of visitors. During most days there is a preference for the right door. Shortly before the end of the pre-control (February 28th) there is a drop in the number of visitors for the right door. In accordance with the data from Table 2, there is a clear raise in visitors for the left door during the intervention. The overall number of visitors slowly drops during the whole period.

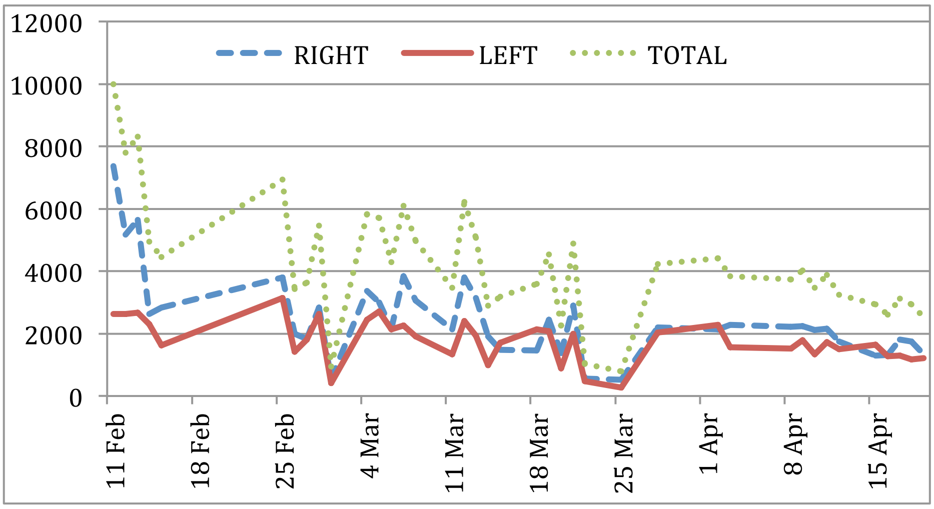

Figure 10. Number of visitors per day.

The variations in number of visitors are easily explainable by the rhythm of a university year: during examination weeks and holidays the buildings are use less crowded with students and university employees.

5.2 Analysis Sensory Deprivation Intervention

The study focused on the differences between a normal condition and darkened condition. We expected that there would be a reduced preference for the darkened (RIGHT) door during the intervention. During the intervention (S2) there are 32183 (56.9%) visitors using the right door, and 24379 (43.1%) visitors using the left door. Compared to the pre-control (S1), where 34104 (62.1%) visitors use the right door, and 20834 (37.9%) visitors use the left door. The independent samples t-test shows a significant difference in the number of visitors for the pre-control ($M=1.38$, $SD=0.485$) and the intervention conditions ($M=1.43$, $SD=0.495$), $t(111489)=-17.637$, $p<0.001$. Supporting our hypothesis, we can state that there is an increased preference for the left door, and so an avoidance (by 5.2%) for the right door during the intervention.

Based on these findings we can conclude that there is an effect for sensory deprivation. During the intervention people tend to avoid the darkened revolving door more, compared to the control situations. Even after the intervention, the effect remains present for some time. This after-effect was not expected, but it is clearly visible in the results. Even without a collective memory of all visitors, it seems that some memory is retained. The results show that our intervention did have an effect on the behaviour of visitors.

5.3 Raw Data Guidance Paths Intervention

During the period of capturing of the second intervention (including a pre- and post-intervention period) a total of 88648 visitors came in or out of the building. On an average day around 3057 visitors came in or out of the building. The spread of visitors is shown in **Table 3** and **Figure 11**. During the intervention a similar problem to the one during intervention 1 occurred. Due to one of the camera's being turned off, a total of 11 days were removed from the dataset. This results in a lower number of overall visitors during the intervention. The data in both **Figure 11** and **Table 3** represents the dataset after removal of the faulty data.

Period	Session	Door RIGHT		Door LEFT		Total
May 24 –Jun 10	S4 Pre-control	19120	58,95%	13315	41,05%	32435
Jun 11 –Jun 27	S5 Intervention	21949	63,96%	12366	36,04%	34315
Jun 28 –Jul 12	S6 Post-control	14362	65,59%	7536	34,41%	21898
Total		55431	62,53%	33217	37,47%	88648

Table 3. Visitors per session, with extended periods and removal of anomalies.

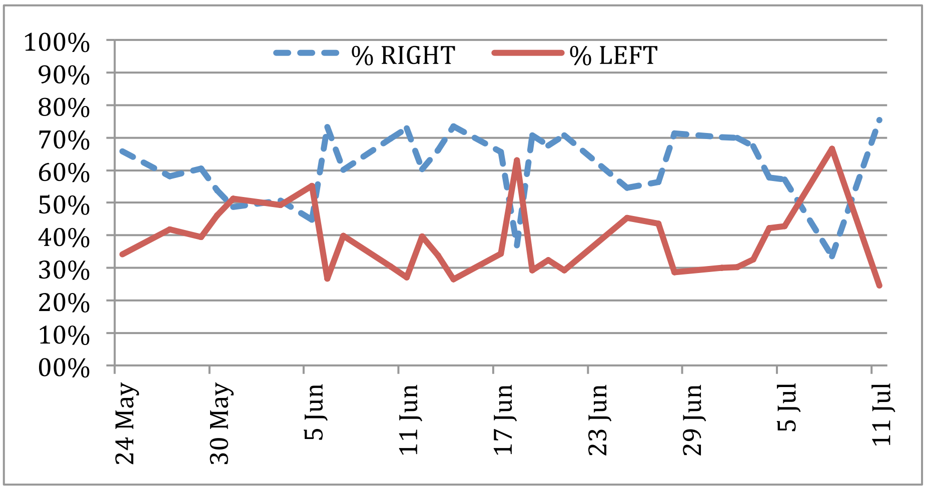

Figure 11. Ratio of visitors per session, with extended periods and removal of anomalies.

Figure 11 and **Figure 12** show an overall preference for the right door. This is true for most days during the intervention. For the whole period, there are a steady number of visitors coming in and out of the building. At the end of this intervention (session S6) it was not possible to extend the period for a longer period of time. This was due to the mandatory removal of the system at the start of the summer holidays.

Figure 12 shows an interesting pattern during the intervention of the intervention (June 11-Jun 27). We see no increase in visitors for the left door during the intervention.

There is even a smaller preference for the right door during the pre-control as during intervention.

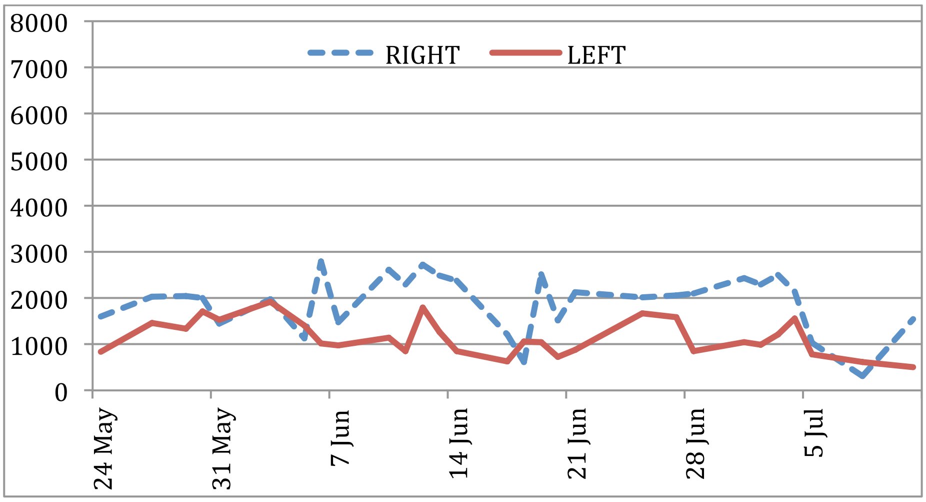

Figure 12. Number of visitors per day.

5.4 Analysis Guidance Paths Intervention

The second study focused on the differences between a normal condition and a condition with guidance paths. The guidance paths were installed nearby the left door. We expected a reduced preference for use of the door without guidance paths (the right door) during the intervention.

During the intervention (S5) there are 21949 (64.0%) visitors using the right door, and 12366 (36.0%) visitors using the left door. Compared to the pre-control (S4), where 19120 (58.9%) visitors use the right door, and 13315 (41.1%) visitors use the left door. According to an independent samples t-test there was also a significant difference in the number of visitors for the pre-control ($M=1.41$, $SD=0.492$), the intervention ($M=1.33$, $SD=0.469$), and post-control ($M=1.39$, $SD=0.487$) conditions, $t(29560)=17.832$, $p<0.001$. Our hypothesis is not supported. On the contrary: during the intervention far more visitors use the right door instead of the left door. During the intervention (S5) there is an increase in visitors of 5.1% for the right door compared to the pre-control condition (S4).

Based on these findings we can conclude that the expected effect for the guidance paths intervention does not exist. During the intervention people tend to use the door without guidance paths more than the door with guidance paths. However, after the intervention the use ratio between the doors went back to normal. Visitors tend to ignore or even avoid the guidance paths, and the preference for the right door remains intact.

5.5 Comparison between the Interventions

The previous section shows a diverse set of results. So as an extra control, we generated an overview of all data, visualized over time. During both interventions, there is a clear pattern in door use. As shown in **Figure 13** the highest volume of visitors are in the morning between 8:00 AM and 8:30 AM, around 10:15 AM, and between 11:45 AM and 12:30 PM. These periods correspond to the start of the first lectures, the morning-coffee break, and lunch. The figure shows a reliable distribution over the day, as can be expected from a university building. The peak in use of the left door around 8:30 AM can be explained by the fact that a lot of visitors arrive by car around that time. The most logical (and shortest) walking path from the main car park into the building is through the main door.

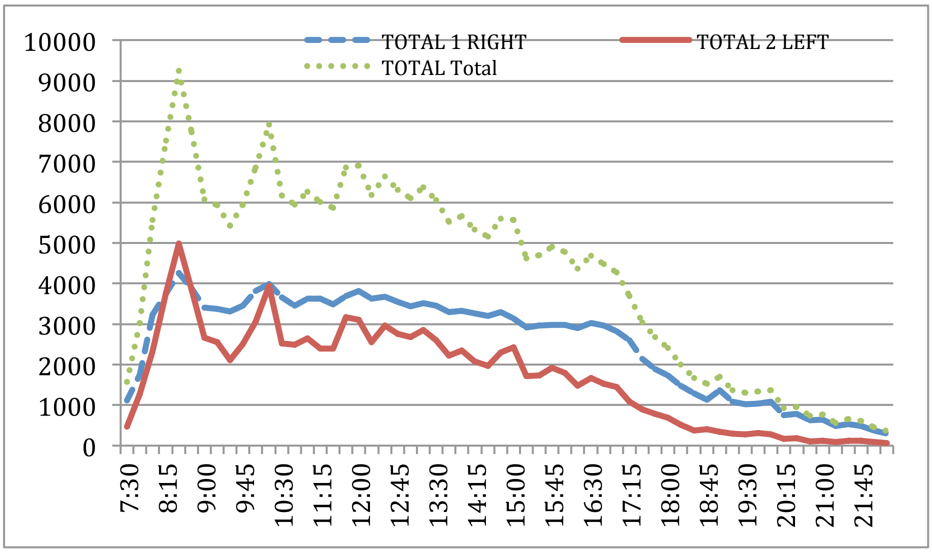

Figure 13. Number of visitors per hour during day during both interventions.

When setting up our interventions, we expected that the results in the guidance paths intervention would be stronger than in the darkened door intervention. The preference for the right door during the guidance paths intervention (S5) is 64.0%. This is much larger than the preference during the darkened door intervention (S2), where it is only 56.9%. The independent samples t-test shows a significant difference in the number of visitors for intervention 2 ($M=1.43$, $SD=0.495$) and intervention 2 ($M=1.33$, $SD=0.469$), $t(23838)=23.992$, $p<0.001$. Therefore our hypothesis is not supported. On the contrary, the effect seems to be totally the opposite of what we expected. It almost looks like visitors deliberately avoid the guidance paths. During the guidance paths intervention less visitors used the left door then during both darkened door intervention and the pre-control situation.

6. Discussion

The results show a strong effect for the sensory deprivation intervention. During this intervention there was a strong decrease in use of the darkened door. Which reflects peoples dislike for dark environments, when given the choice out of two similar situations. Basic statistical analyses show that the evidence for the effect stays strong, especially with the number of visitors that used the doors.

The opposite effect is present in the guidance paths intervention. There are several reasons why this could be the case. For example that people ignored or even avoided the guidance paths that had been placed in the hallway and the outside square.

These findings contribute positively to the framework described by de Boer et al., (2013). In this particular situation, the use of sensory deprivation (darkness) has a stronger effect than the use of environmental cues. Regarding to our framework (**Figure 2**), there are strong indications that changing sensory input contributes to safety (by adapting the environment and targeting people's attitudes).

Further work in this field should be done, as it can contribute to the knowledge in how to change people's habits during their everyday lives. In addition, it is interesting to see how their behaviour can be influenced in emergency situations. Also, more work should be done on triggering other senses. For example by providing auditory cues, fragrances, or communicative messages using social proof, authority, and commitment.

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