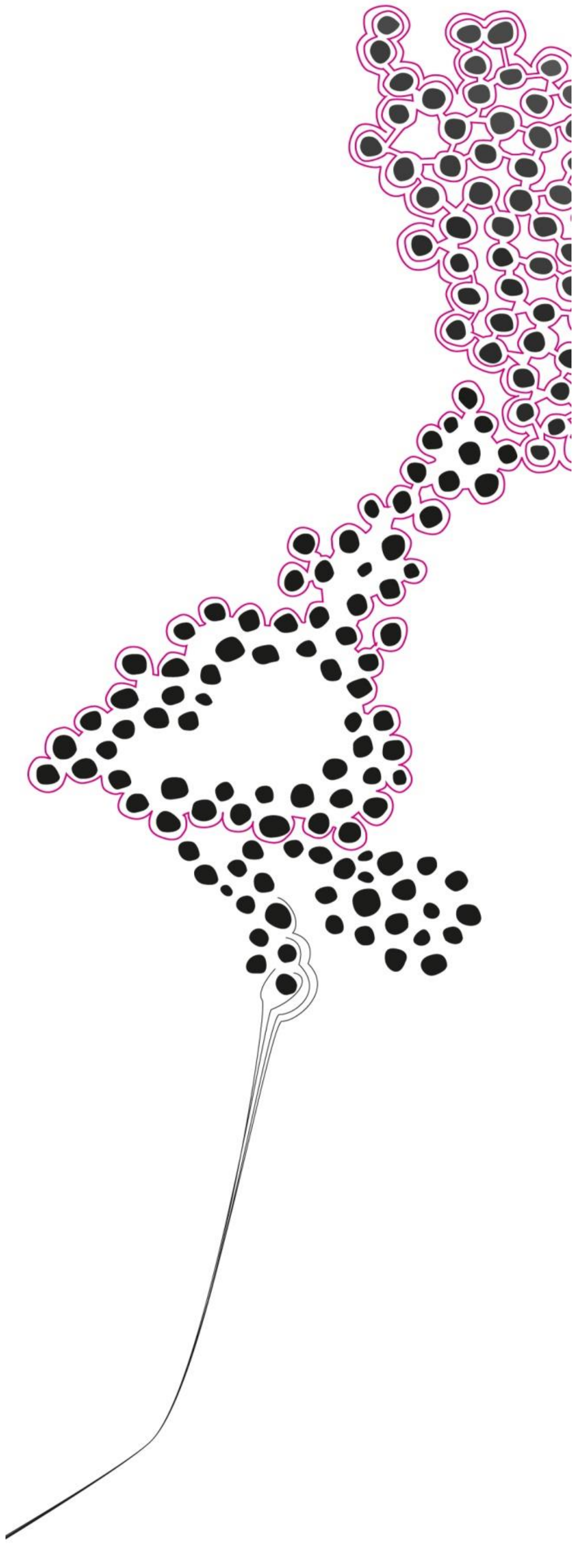
Master thesis



COMMUTER STRESS AT A DYNAMIC BUS STATION

Martijn Broeks (s0175315)

FACULTY OF BEHAVIORAL SCIENCES

DEPARTMENT COGNITIVE PSYCHOLOGY AND ERGONOMICS

EXAMINATION COMMITTEE

First supervisor: Willy Siegel, MSc.

Second supervisor: Prof. Dr. Ing. Willem Verwey

First external supervisor: Gertjan Stoel

Second external supervisor: Cees Bakker

Abstract

Dynamic bus stations have been around for some time, but thus far no research has been done on how commuters experience a dynamic bus station. The uncertainty aspect of a dynamic bus station was expected to be the biggest downside for commuters (Turksma, 2000). Commuting stress is affected, among other factors, by predictability (Evans, Wener, & Phillips, 2002). The present study investigated whether dynamic vehicle allocation system of a dynamic bus station is experienced as more stressful by altering preferred platform allocation. This was tested by exposing 18 commuters to a change of the dynamic vehicle allocation system. Questionnaires were used to determine whether they experience stress and if the situation was experienced as less predictable. A control group of 17 people was used to reduce noise in the data. The results did not show an increase in stress or predictability between groups. This implies that a change in preferred platform is not experienced as less predictable or stressful. This might be explained by the fact that variance is already present in public transport (Bonsall, 2004), the uncertainty of a dynamic bus station can be experienced as yet another variation of public transport. Commuters develop routines, based on experience, to cope with these uncertainties. The effects of a change in preferred platform on commuter stress was not supported by strong evidence due to the low power of the experiment. Suggestions are made for follow-up research, as this subject requires more research to enhance user comfort at a dynamic bus station.

Samenvatting

Dynamische busstations bestaan al een tijdje, echter is er nog geen onderzoek gedaan naar hoe forenzen een dynamisch bus station ervaren. Er werd verwacht dat het onzekerheidsaspect van een dynamisch busstation het grootste nadeel is voor forenzen (Turksma, 2000). Stress onder forenzen wordt beïnvloed door, naast andere factoren, door voorspelbaarheid (Evans, Wener, & Phillips, 2002). Er was verwacht dat dynamische perron toewijzing leidt tot een minder voorspelbare situatie. In het huidige onderzoek werd gekeken of dynamische perron toewijzing zorgt voor meer stress zorgde bij de forens. Dit is onderzocht door 18 forenzen een verandering in dynamische perron toewijzing te laten ervaren. De ervaren stress en voorspelbaarheid is gemeten door middel van vragenlijsten. Bevindingen werden versterkt door een controle groep van 17 mensen om ruis in de data te beperken. De bevindingen laten geen toename in stress of een afname in voorspelbaarheid zien tussen de twee groepen. Een mogelijke verklaring is dat de variatie van het dynamische busstation wordt ervaren als een zoveelste variatie van het openbaar vervoer (Bonsall, 2004). Echter omdat de statistische power van beide studies laag is kunnen de resultaten niet als sluitend beschouwd worden. Er zijn suggesties gedaan voor vervolg onderzoek omdat er meer onderzoek nodig is om de gebruikers ervaring op een dynamisch busstation te verbeteren.

Table of content

1. Introduction

The dynamic bus station is a type of bus station that has been around for two decades (de Boer & Krul, 2005). There are few technical limitations to the use of a dynamic bus station (van Vlijmen, Klusener, & Schrijver, 1999; Wieringa, 2006). However, the user is expected to experience more difficulties when using a dynamic bus station (Boersema, 2010). Keypoint consultancy, who is involved in multiple projects on dynamic bus stations, wanted to look at dynamic bus stations from a user's point of view. This led to the following question: "What is the ideal dynamic bus station from a user's point of view?" This is still a broad question and will be narrowed down to a more specific question, starting by looking at the user's point of view.

Bus users come in all shapes and sizes, some are fully aware of the way a bus station system works, whereas others actively need to search for information regarding their trip (Sloot & Keesteren, 2002). Regular users are familiar with the dynamic bus station and experience the uncertainty associated with the dynamic bus station on a regular basis. This makes them an interesting group to study as they experience a certain level of uncertainty and are less able to create a routine. For the present study a group of regular users was chosen, the commuter. A common effect of uncertainty is increased levels of stress (Gottholmseder & Nowotny, 2009). So it is expected that if commuters experience uncertainty caused by the dynamic bus station, it should lead to more stress. Therefore the present study focuses on commuter stress at a dynamic bus station.

1.1 Commuters

Prior to addressing commuter stress the concept of commuter needs to be clarified. The term commuter might seem straightforward, however, this is not the case. A clear definition is needed and will be largely based on other studies. Costal, Pickup and Martino (1988) used travel time to define commuters. Their definition of the commuter was: "workers whose journey from home to work usually does not take less than 45 minutes in each direction". They defined non-commuters as those whose journey does not take more than 20 min, oddly people that traveled between 20 and 45 minutes were not categorized. Sposato, Röderer and Cervinka (2012) defined the commuter as someone who leaves his home to go to work, including students and trainees. His definition clarifies two locations between which commuters travel. But Sposato et. al. (2012) and Costal, et. al. (1988) do not take into account the number of trips one makes during a specific period. No literature was found on the frequency at which a user has to use public transport in order to become a commuter. But for commuters to be familiar with a dynamic bus station they need some experience with a dynamic bus station. According to Sloot and Keesteren (2002) there are two types of public transport users who are aware of the way the public transport system works. These users travel either every day of a working week or on a regular basis. Looking at the different definitions of a commuter there are three aspects which appear to define the commuter: The commuter travels between two different places, the trip has to be a noticeable distance and it has to be on a regular basis. Demanding a noticeable distance for commuters to travel will not be a part of the definition of commuting, because there is no need for a minimal travel distance. As for the frequency, a regular basis is still a vague description, so for the purpose of this research the frequency at which a commuter has to travel using public transport would be three or more times a week. There will be no requirements for the two places commuters travel between. This leads to the definition of the commuter that will be used in the present study as “A person who travels over three times a week between two places.”

1.2 The dynamic bus station

With the concept commuters defined, we will focus in this section on the aspects of a dynamic bus station. Up until the early nineties all bus stations operated as a static bus station. This means that a bus is running a certain line stops at a fixed platform, which it may share with busses of a number of other lines. The static bus station has certain advantages for its users. Due to the fixed platforms it is certain where a bus will depart, this enables passengers to wait on the platform instead of a central waiting area. This disperses passengers over the different stops and reduces the amount of people in one spot. However, when a bus station serves as a node multiple busses will arrive at the same time, which requires quite a lot of space when all busses are limited to using only their designated platform. This also causes another downside, due to the larger size of a bus station it is harder to find individual busses (Boer, 2007).

In the early nineties another type of the bus station was introduced, called dynamic bus station. It differs from a static bus station as it dynamically assigns busses to a platform (also known as dynamic vehicle allocation) based on arrival time, available platforms, preferred platform and departure time. Dynamic bus stations solve the problems of space and visibility of the static bus station by compressing the station and making the presence of the bus visual (Boer & Krul, 2005). Other advantages are that a more compact bus station increases comfort and social safety of the passenger and the usage of a single platform increases as it will accommodate more bus routes (Turksma, 2000).

So the dynamic bus station provides advantages for passengers, however, there are also downsides to the use of a dynamic bus station. One of the main points of criticism is the uncertainty prior to departure in which passengers find themselves (Boersema, 2010). This uncertainty can be attributed to the way dynamic vehicle allocation works. The system of dynamic vehicle allocation distributes arriving busses among the available platforms while taking into account the arrival and departure time and available platforms of those busses. However, the time of arrival of busses varies in practice (Yu, Wu, Yao, Yang, & Sun, 2011) and can differ from two minutes prior to planned arrival to 30 minutes past the planned arrival (Rietveld, Bruinsma, & van Vuuren, 2001). A bus reports to the bus station three minutes before his expected arrival, from that moment on it is possible to assign the bus to one of the available platforms. Bus stations are often the final stop on a bus route and busses therefore do not always immediately continue their route. Thus the time between the departure of the bus and the moment passengers are informed of its departure platform varies, with a minimum of three minutes prior to departure.

In a fully dynamic bus station the arrival platform of busses can differ at each arrival. The arbitrary distribution of busses on the available platform creates a bus station at which the arrival platform is highly unpredictable. Bus stations that are fully dynamic do not exist in the Netherlands. Dynamic bus stations in the Netherlands use a system that assigns busses based on a predetermined preferred platform. Each bus route has a preferred platform and when a bus on that route is about to arrive at the bus station it is assigned to the preferred platform. However, when this platform is unavailable the system assigns the bus to an available platform near the preferred platform. The arrival platform of busses becomes more predictable when bus routes have a preferred platform. (Turksma, 2000). In summary, it can be said that a dynamic bus station is more compact than a static bus station, which makes busses more visible to its users and increases comfortable and socially safer environment. A downside for the commuter is the uncertainty caused by the dynamic vehicle allocation, which could lead to a less predictable situation (compared to for example a static bus station) for commuters. How this affects commuter stress will be discussed in the upcoming sections.

1.3 Model of commuter stress

In the present study the model of commuter stress is used to explain stress among commuters. This requires a clear definition of stress, even though stress is commonly used in commuting literature, the concept of stress is not always clearly defined (Sposato et al., 2012; Wener, Evans, Phillips, & Nadler, 2003). Koolhaas and colleagues (2011) provided a clear definition of stress: “a situation where an environmental demand exceeds the natural regulatory capacity of an organism.” Which is simply put, not being able to cope with external demands. This definition is found suitable for the present study.

The upcoming section will give a brief history of the research done on commuting and at the same time clarify the various concepts of the model which were not defined yet. In the late seventies Stokols and Novaco (1978) first proposed a model, suggesting commuting creates stress for commuters, which is caused by the distance a commuter has to travel combined with the time it takes to make that trip (Also know as impedance). In this early model of commuter stress control was found to be a moderator of stress. Later research proved a more direct effect of control on commuting. Control is the level of influence a commuter experiences to have on the commuting trip. Kluger (1998) found that control strongly correlates with stress. Wagner and Evans (2011) confirmed these findings and found their measure of control is most highly correlated with commuting stress. The model of commuter stress by Stokols and Novaco (1978) is therefore considered insufficient in explaining commuter stress. This was clarified even more by Evans, Wener and Phillips (2002), who found that commuters who perceived their journey as less predictable had increased physiological stress levels. These findings were confirmed by Wener, Evans, Phillips and Nadler (2003) who reported a correlation between unpredictability and stress. Thus, aside from control and impedance, commuter stress is also affected by predictability, which is the ability to predict certain aspects of the trip.

Other studies also found how the duration of the commute also affects the stress experienced by the commuter (Evans & Wener, 2006; Wener et al., 2003). At first glance the duration of the commute might seem just a part of impedance, however, these concepts are not the same. The duration of the commute is a variable that changes with each trip, due to delays or traffic congestion the duration of a trip can change and thus effect commuting stress. Impendence does not depend on duration of a single trip, but is the overall time and distance of a trip.

Sposato et al. (2012) found two other factors, years of commuting and commuting cost, related to commuter stress, which were not seen as such until then. The years one has spent commuting seemed to reduce commuter stress, which is reasoned to be due to the adaptation of commuters to their situation. The other factor was rather unexpected, Sposato et al. (2012) found an increase of commuting stress with the rising cost of the commute. Cost, which was initially thought of as a control variable, was not mediated by any related variable such as the duration of the commute or the length of the commute and was therefore considered another variable affecting commuter stress.

In 2012 Sposato et al. proposed a new model of commuting stress. This model is based on results found in their own study and builds on the results of previous studies (e.g. Evans et al., 2002; Kluger, 1998; Koslowsky & Kluger, 1995; Wener & Evans, 2011; Wener et al., 2003). Prior research largely focused on a single commute characteristic (e.g. impedance, control or stress), Sposato et al. (2012) combined multiple factors into a single model (Fig 1.). Their model of commuter stress describes an interaction between two categories, which are commute characteristics and stressors. The commute characteristics: impedance, predictability and cost, interact with the stressors: control and environmental stressors, and directly affect commuting stress. The effect which the stressors have on commuting stress is moderated by the duration of the commute and the years of commuting, the effect of commute characteristics on commuting stress is moderated by the years of commuting. The present study is focused on how commuters experience a dynamic bus station. Up until now this model is the most complete model describing commuter stress. Therefore the model of commuter stress is used, as it describes multiple aspects that affect a commuter. Eventhough not all the aspects of commuter stress will be adressed in the present study, it was deemed usefull to create a complete picture of variables affecting commuter stress.

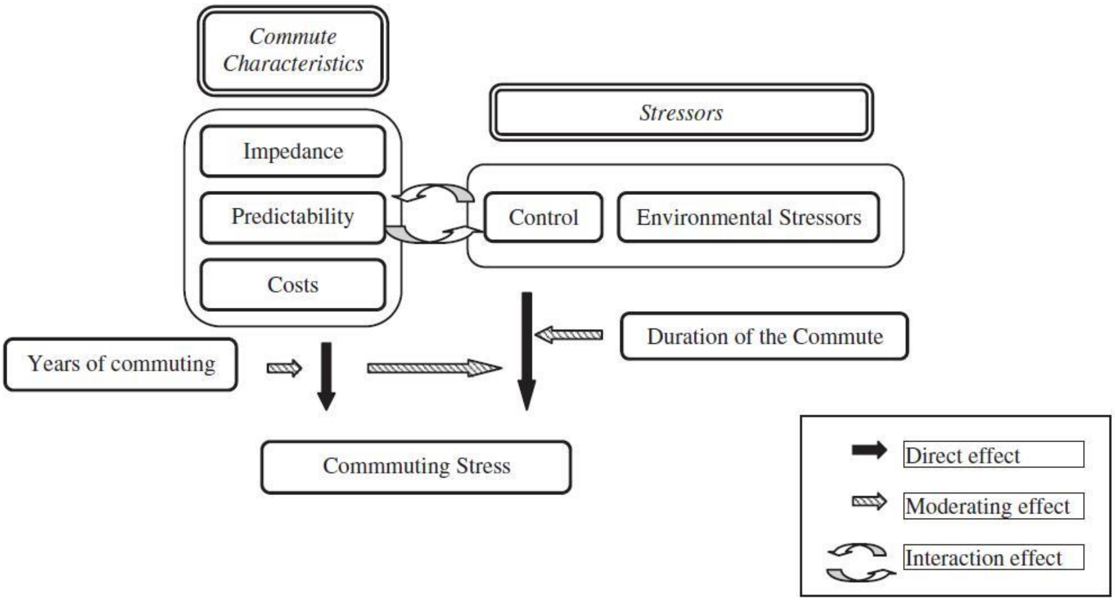


Figure 1. Sposato et al. (2012) model of commuter stress

1.4 Apply commuting stress on dynamic bus station

As stated prior, a dynamic bus station has a downside, which is that it is less predictable. Going back to the model of commuter stress, one of the factors affecting commuter stress is predictability. Commuters who perceived their journey as less predictable had increased physiological stress levels (Evans, Wener, & Phillips 2002). Based on this we could assume that a dynamic bus station is inconvenient for commuters and would lead to stress among commuters. Even though this might seem a straightforward conclusion, this doesn't necessarily have to be the case. The upcoming section will illustrate the ambiguity of the effects of dynamic vehicle allocation on commuters.

First, why do people like situations to be predictable? Wener and Evans (2011) described how control and predictability are linked, low levels of predictability also induce low levels of control and vice versa. This could be explained as follows: predictability serves as a form of cognitive control, when behavioral control cannot be exercised. This provides people with a coping strategy for situations which they cannot control (Evans, Shapiro & Lewis, 1993). So in a low control environment like public transportation, it is important to be able to predict events in order to maintain the feeling of control (Averill, 1973; Evans et al., 1993). This was found in several studies, showing the importance of predictability during a trip, for example: Making a trip more predictable improves user satisfaction and increases the use of public transport (Mishalani, McCord, & Wirtz, 2006) and with increased predictability the feelings of control increased and stress could reduce (Dziekan & Kottenhoff, 2007). Thus, predictability is to be desired in a public transport to increase people's feeling of control.

So why should people be able to cope with the a dynamic bus station? Two concepts in public transport which are closely related, but not quite the same are variance and predictability. Public transport varies in practice (Yu et al., 2011). Some of the variability in public transport is due to more or less predictable events such as public transport service schedules, planned road maintenance, the daily tide of commuter traffic, or the traffic associated with sporting fixtures or public holidays. But much of it results from seemingly random events such as road accidents, severe weather, technical failure/malfunctioning of equipment, or, most particularly, the behavior of other people – being fellow travelers, service operators or traffic wardens (Bonsall, 2004). The variance of public transport is well known and the term variance is often used interchangeably with predictability in public transport. However, variance and predictability are not the same. Variance is a statistical term, if something is not constant then it is variable and the extent of its variability can be measured. For example, the departure time of a bus can vary and this can also be measured. Unpredictability is a not simply a statistical concept and does not depend on any environmental aspect. Instead it is the ability of a traveler to predict aspects (e.g. travel time, or depature platform) of the trip. Making predictability harder to measure as it is a personal experience (Bonsall, 2004).

Predictability thus, like stress, is a personal experience. Commuters using public transport experience the variation of public transport over a period of time. However, a commuters knowledge or experience of the distribution of possible outcomes of any given course of action is typically very sparse and unlikely to be representative of the full distribution (Bonsall, 2004). It is thus very unlikely that commuters have an accurate perception of the relative frequencies with which certain events might arise. Not knowing the exact distribution of the departure platform of the bus, commuters do not experience the change in platform as less predictable. The change in variance in the arrival platform could just merely another varying factor in public transport and does not necessarily have to be experienced as unpredictable by commuters. Whether or not a dynamic bus station could lead to more stress depends on how commuters experience the variance created by the dynamic vehicle allocation.

1.5 Research

There is no scientific literature describing the effects of dynamic vehicle allocation on the commuter. The present study addresses a part of the gap in the literature by researching the effect of dynamic vehicle allocation on commuter stress. The model of commuter stress describes how multiple aspects of the commuting trip affect commuter stress (Sposato et al., 2012). Commuters are expected to experience a certain level of stress based on various aspects of their trip. As described in the previous section, the dynamic vehicle allocation system of a bus station could be experienced as less predictable for commuters. According to the model of commuter stress this will lead to more stress among commuters. Therefore the focus of the present study is on the effects of dynamic vehicle allocation on commuter stress. This leads to the following research question: "How does dynamic vehicle allocation at a bus station affect commuter stress?"

As argued before a change in dynamic vehicle allocation is expected to affect predictability and predictability in turn affects commuter stress. Therefore the main research question is divided into two hypotheses aimed at answering the effect of a change in dynamic vehicle allocation on predictability and in turn if a lack of predictability leads to more stress.

A variance in public transport is well known. However, whether this variance is experienced as unpredictable is still unknown. The experience of unpredictability is personal it is unsure whether commuters experience the dynamic vehicle allocation as unpredictable Therefore the first hypotheses is focused on the effects of dynamic vehicle allocation on predictability. This leads to the following hypothesis: "Changing the preferred platform is experienced as less predictable

The second hypothesis is focused on the effects of a dynamic bus station on commuter stress. As argued before dynamic vehicle allocation could lead to a less predictable situation. This in turn should lead to higher levels of stress according to the model of commuter stress. This leads to the second hypothesis: "A less predictable situation at a dynamic bus station leads to more stress."

2. Method

2.1 Location

Keypoint manages the technical system of the bus station in Nijmegen. This created the opportunity to apply changes in the preferred platforms of busses. Therefore the bus station of Nijmegen was the most suitable for this research. The city of Nijmegen has a dynamic bus station in the center of the city, next to the train station.

2.2 Participants

Commuterss were asked to participate at the bus station of Nijmegen and with the use of social media. At the bus station participants were approached randomly with the question if they were willing to participate in a week long experiment. To ensure each participant fitted the definition of commuter participants were asked if they travelled more than two times a week. After a while participants were selected based on their bus route to ensure two equal group sizes. A poster on the twitter- and Facebook page of the local bus operator in Nijmegen was used to recruit additional participants. Participants applying through social media were required to fill in information on their bus route usage to assign them in a condition. Initially approaching people led to 68 participants and 7 participants applied through social media requitement, which resulted in 75 participants. However, some participants eventually did not participate. Also 7 participants had to be excluded from the experiment as they did not meet the requirements to be a classified as a commuter for this experiment. A total of 35 people (18 female) aged between 17 and 62 (*M*: 23.77; *Sd* 9.33) participated in the experiment. This population was to small to make significant conclusions. However, due to the timeschedule the decision was made to proceed with the experiment anyway.

2.2 Materials

Commuters participating in the experiment filled out the same questionnaire for five days and the questionaires were administered online. The questionnaires consisted of questions on their experienced predictability and stress during their commute that day.

Thequestionaires were based on Evans et. al. (2002) questions on stress, predictability and control, using a back-translating technique the questions were translated into Dutch. Then the questions were rewritten to only apply for stress experienced during one day, a small sample test was carried out to validate these questions. The factors stress and predictability in this questionnaire served to answer the hypotheses. Other factors were not included in the questionnaire as they were not expected to be influenced by a change in preferred platform and to reduce the size of the questionnaire. This questionnaire can be found in Appendix 1.

All questionnaires were administered using an online survey application. The University of Twente offers the online open source survey tool Limesurvey to its students. With Limesurvey it is possible to give each participant a unique token which was linked to the participant throughout the experiment. This made it possible to look at individual participants and their results during the experiment. Another advantage was the possibility to send an online survey. This enabled participants to fill out the questionnaire when it was convenient for them.

The bus station in Nijmegen uses dynamic vehicle allocation to assign a bus to a platform. The system which dynamically assigns busses to the different platforms using preferred platforms for the different bus routes. Under normal circumstances, each bus is assigned to the preferred platform and when this platform is not available the system will assign the bus to the nearest platform. The bus station has eleven platforms which are indicated with letters ranging from A to L with the exception of I. Platforms A and B are used as exit platforms which results in nine platforms that are currently in use for departure. Each platform can accommodate two busses, with one bus behind the other. A bus gets assigned to a platform prior to arriving at the bus station, this assignment is passed on to the bus driver and displayed on the information displays at the bus station. When a bus approaches the bus station it gets assigned to a platform, however, due to circumstances the bus might not be able to stop at the assigned platform. The system is not always able to detect a bus, especially when the bus stops at a platform where it is not assigned to. Therefore a camera system was used to determine at what platform the busses stop during the experiment. Knowing where all the busses stop during the experiment is useful for determining how much the arrival platform varies during normal conditions and whether bus drivers were able to follow instructions during the experimental condition.

2.3 Design

The experiment design involved manipulating the dynamic platform allocation system and comparing the stress experienced in the experimental condition with a control condition. To create an experimental condition and a control condition the preferred platform of three bus routes were changed while the preferred platform of the rest of the bus routes remained unchanged. The selecting of bus routes was based the check-in data of passengers on all the bus routes going through the bus station of Nijmegen. Routes 5, 33 and 85 proved to have the highest number of passengers during rush hours and were therefore chosen as experimental condition in this study. This led to two groups, one group that experienced a significant change in preferred platform and a group that experienced no significant change in preferred platform.

Stressful situation are experienced differently by people and people respond differently to stressful situations (Folkman, Lazarus, Pimley, & Novacek, 1987; Matud, 2004). This was taken into account with another control group. Participants who participated during the experimental phase of the experiment also participated the two days before the experimental phase and the day after the experimental phase. Creating a baseline for each participant on the various variables.

This resulted in a 2 × 2 repeated measures design with condition (change in preferred platform and no change in preferred platform) as between subjects factor and day (experimental and non-experimental) as within subjects factor. This is portrayed in Table 1.

Table 1.

Experiment design

	Non-experimental		Experimental		Non-experimental
	Monday	Tuesday	Wednesday	Thursday	Friday
Change in preferred platform			Bus routes: 5, 33, 85		
No change in preferred platform			Other bus routes		

2.4 Procedure

The dynamic vehicle allocation system is not always able to detect a bus, therefore the day prior to the experiment two cameras were placed at the waiting area of the bus station overlooking the bus station. The camera's recorded the text displayed on the displays at platfrom C to platform L with exception of I and the text displayed on the front of the bus. The recordings were used to determine the variation of the bus departure platform. The camera's recordings started at 7:00 am and ended at 8:00 pm, prior to 7:00 am and after 8:00 pm the camera was unable to record the text on the displays due to the contrast difference between the text and the surrounding environment.

The experiment lasted from the 7th of April 2014 to the 12th of April 2014 and on the 10th and 11th of April 2014 route 5, 33 and 85 used different preferred platforms. It was unknown prior to the experiment how often a bus deviates from the preferred platform. It was possible to determine the deviation of busses prior to the experiment using cameras. This is, however, time consuming and would not fit in the timeframe available for this master thesis. The choice was made to change the preferred platform with at least three platforms and was based on the assumption that a bus would not deviate more than two platforms under normal circumstances. The changes to the preferred platforms are displayed in table 2.

Table 2.

Changes to the preferred platforms

Route	Direction	Preferred platform	Experimental platform
5	1	E	J
5	2	C	G
33	1	H	C
85	1	E	H

Note. Route 5 has two directions as Nijmegen is an intermediate stop on this route, for route 33 and 85 Nijmegen is the end stop and these routes therefore have only one direction.

Participants received the questionnaires using the mail system integrated in Limesurvey. From Monday till Friday participants received the questionnaire in the afternoon around four o'clock. After the experiment several gifts were raffled among the participants as a reward for participating.

2.5 Data analyses

To test whether the manipulation had worked and to determine the variation of the departure platform, data from the camera was analyzed. Due to the large amount of data and the labor intensive data analysis only the busses used by the participants were included in the analysis, provided that they used a bus between 7 am and 8 pm. The indicated departure platform and the actual departure platform were noted. The deviation between the indicated departure platform and the actual departure platform was noted and how often they differed. This information was used to determine the success of the manipulation and the accuracy of information prior to arrival of a bus to the commuter.

The data obtained from the questionnaires was analyzed using IBM SPSS 20. The individual questions were converted into subjective values of stress and predictability, which resulted in a value ranging from 1 to 5 for both stress and predictability. Then stress and predictability data were tested for normality, after that the data from the questionnaires was analyzed.

The effects of a change in preferred platform on experienced predictability and stress were analyzed by looking at the differences between results in the exposure and no exposure condition during both the experimental and non-experimental condition. Stress was analyzed as the dependent variable with predictability as covariate and both conditions as factors. With the analysis of predictability there were no further covariates, but both conditions served as factors in this analysis. In this analysis the possibility of an interaction effect between the two conditions was also taken into account. This analysis was done using a GEE analysis, which was chosen over a repeated measures ANOVA due to the small sample size. The results from the GEE analyses include the effect of a change in preferred platform on commuters and also how these effects relate to commuters whose preferred platform did not change. All tests were undertaken with a maximum α of 0.05.

3. Results

Analysis of the camera recordings revealed the difference between the indicated platform and the depature platform for the non-experimental phase (*M*: .51; *Sd* .83) and the experimental phase (*M*: .42; *Sd* .66). Also the difference between the depature platform compaired to the preferred platform for the non-experimental phase (*M*: 1.18; *Sd* 1.19) and the experimental phase (*M*: 1.54; *Sd* 1.03). There was no significant difference between the non-experimental and the experimental group. It was therefore concluded that the manipulation was a success. Stress and predictability were analyzed and found to be normally distributed. The null hypothesis assuming normality was accepted for variable stress $p = .213$ (df= 1.058) and also for the variable predictability with $p = .164$ (df= 1.118).

3.1 The effects of a change in platform on experienced predictability

In the analysis we focused on the effect of a change in preferred platform on predictability and stress. A power analysis on both stress and predictability show a power of .24 for stress and a power of .13 for predictability. As a power of atleast .8 is recommended to draw significant conclusions, any result found in the following analysis cannot be seen as strong evidence. The first analysis is used to answer the first hypothesis: “Changing the preferred platform is experienced as less predictable.” There was no significant difference between the experimental and non-experimental condition with $\chi 2$ (df = 1, N=125) = .017, $p < .897$, the same could be said for the exposure condition, which showed no significant effect between the two groups with $\chi 2$ (df = 1, N=125) = .594, $p < .441$. There was also no interaction effect between the experimental and exposure condition was found with $\chi 2$ (df = 1, N=125) = .028, $p < .867$. Therefore, no further analyses were carried out on the experienced predictability.

3.2 The effects of a change in platform on experienced stress

The following analysis is focused on answering the hypothesis: “A less predictable situation at a dynamic bus station leads to more stress.” For this hypothesis the assumption was made that a change in preferred platform at the dynamic bus station is experienced as less predictable. The results found in the present study do not support this and further analysis could therefore be deemed useless. However, as a change in preferred platform might still be experienced as more stressful it was still analyzed. With stress as dependent variable predictability showed a significant effect on stress with $\chi 2$ (df = 1, N=125) = 68,817 $p < .001$. There was no significant difference between the experimental and non-experimental condition ($\chi 2$ (df = 1, N=125) = .032, $p < .441$) or the exposure and non-exposure condition ($\chi 2$ (df = 1, N=125) = 1.037, $p < .308$). No interaction effect was found either ($\chi 2$ (df = 1, N=125) = 2.185, $p < .139$).

4. Discussion

A power analysis on both stress and predictability show a power of .24 for stress and a power of .13 for predictability. Therefore, any result found in the following analysis cannot be seen as strong evidence. However, for the purpose of this master thesis the data will be analyzed with the assumption that the power is high enough.

The effect of a change in the preferred platform of a dynamic bus station was tested using questionnaires testing for subjective stress and predictability. There were no significant differences between the conditions for the experienced stress. Therefore, one could conclude that a change in preferred platform does not lead to a less predictable situation. So looking at the first hypothesis: “Changing the preferred platform is experienced as less predictable.” The data does not support the idea that a change in preferred platform leads to a less predictable situation. This supports the idea that a dynamic vehicle allocation does not have to be experienced as less predictable, but instead is yet another variance in the public transport system (Bonsall, 2004).

Moving on to the second hypothesis: “A less predictable situation at a dynamic bus station leads to more stress.” For this hypothesis the assumption was made that predictability is affected by a change in preferred platform and would in turn affect commuter stress. Predictability showed a significant influence on commuter stress, this is in line with Evans, Shapiro and Lewis (1993) as well as Evens, Wener and Phillips (2002) and Wener, Evans, Phillips and Nadler (2003), who found that commuters who perceived their journey as less predictable had increased physiological stress levels. There were, however, no significant differences between the experimental and non-experimental condition of the exposure and non-exposure condition. A change in preferred platform does not lead to more stress, which once again supports the idea that a dynamic vehicle allocation is experienced as another variance in the public transport system (Bonsall, 2004).

Going to the main research question: “Does dynamic vehicle allocation at a bus station affect commuter stress?” the present study has found no evidence suggesting that a change in the dynamic vehicle allocation system at a bus station affects commuter stress. The following section will illustrate how these results can be explained. Starting with the way the dynamic bus station works. Prior to the arrival of a bus it remains uncertain where the bus will depart. Even though the departure platform is announced prior to the arrival of the bus, the actual departure platform can still change. But once the bus has arrived at the departure platform there is no uncertainty any more on whether it will arrive and where. So why should a change in the dynamic vehicle allocation system have no effect on commuter stress? Earlier research has shown that removing uncertainty, increases feelings of in control and reduces stress (Schweiger, 2003; Smith, Atkins, & Sheldon, 1994). Eventhough it is not possible to inform passengers decisively well in advance of their bus departure platform they are informed of the departure platform of their bus prior to its departure. Thus the uncertainty on where a bus will depart is removed ahead of departure, so this would explain why a dynamic bus station does not have to lead to stress.

Another aspect, which was already addressed in the introduction, is the variance present in public transport (Bonsall, 2004). It is thus very unlikely that commuters have an accurate perception of the relative frequencies with which certain events might arise. A change in preferred platform can therefore be seen as another variation in public transport and does not lead to a less predictable situation. But how do we cope with the variance in public transport? Jungerman, pfister and fischer (1998) state that most daily decisions can be classified as "routinized" decisions, which the individual makes by relying on behavioral standard responses without much reflection. These routines may even contain higher order subroutines, tied to certain conditions. Klein (1999) emphasizes that efficient routines are at the heart of what is called expertise, which allows for good decisions in dynamic real-world environments without explicitly maximizing expected utility. For instance, in Klein's (1999) recognition-primed decision model, experts are represented as having a rich database, known from past situations that match the current situation from which to choose the appropriate action. Which could explain why a change in preferred platform did not lead to a less predictable situation or more stress among commuters. Commuters can use their rich database which allows them to handle the various situations presented in public transport, which also includes the coping with a change in preferred platform.

Summarizing the findings, there is no evidence in the present study that would indicate more stress among commuters when using dynamic vehicle allocation. It is argued that dynamic vehicle allocation is experienced as another variance in public transport and not necessarily a source of uncertainty among commuters.

4.1 General limitations

Only 18 participants participated in the experimental group, which results in a very low power. Therefore the results of the present study are weak in supporting conclusions. More participants are required to make conclusive statements on the commuter experience of dynamic vehicle allocation.

The bus driver is instructed to follow instructions given on the display in the bus and use the assigned platform. However, as the bus approaches the bus station the bus driver might decide to choose a different platform. The bus station is designed to cope with these changes and in most cases the displays above the platform will change in accordance with the change made by the bus driver. However, because the bus driver is able to choose a different platform, despite what the system instructs him to do, the manipulation in this type of field study depends on the obedience of the bus driver. In most cases bus drivers followed the instructions, during the manipulation. However, the influence of the bus driver has to be taken into account, in further studies.

The system which detects busses at the dynamic bus station was not working properly at the time of the experiment. This meant that not all busses were detected at the departure platform. This affected the way information was communicated to the commuters. When a bus arrived at the departure platform and the system was unable to detect the bus, the display above the departure platform would show: ”look at bus”. When a bus is parked at the front of the departure platform, it is still possible for commuters to read the route information on the bus, however, when a bus is parked behind another bus it becomes difficult to read the route information on the bus. The system being unable to detect a bus at the departure platform can also cause false information to the user. When a bus arrives at the departure platform bus is not detected the system sometimes assumes that the bus is not arrived yet and will display the route information of the bus that has already arrived on the display of a different platform. This can result in a confusing situation. These technical problems might affect commuter stress and affect the way commuter experience their trip.

The experiment was a field study and even though any effect of environmental influence on the results were reduced by using a control group it is still possible for an unknown factor to affect the commuters. It is possible for a third variable to predominate the effects of a change in preferred platform and therefore no differences were found between the experimental group and the control group. This does not seem a very likely assumption as no prior references were found in the literature, however, it is also not possible to exclude an external factor.

4.2 Conclusions

The goal of this study was to look at the effect of dynamic vehicle allocation on commuter stress. This was tested with a manipulation in a field study with subjective measures. A change in preferred platform was not experienced as less predictable and there was also no difference in stress among commuters with a change in preferred platform. It was argued that dynamic vehicle allocation is just another variation in public transport, like for example arrival time, and therefore does not have to be experienced as less predictable and lead to more stress. However, due to the low power of the present study current findings cannot be seen as conclusive. Since the present study is the first to focus on dynamic bus stations there is still a need for further research to test the results found in the present study.

4.3 Recommendations for follow-on research

The present study is a first to focus on a dynamic bus station, current findings create possibilities for new follow-up studies. The results that were found gave an insight into how commuters response to a change in dynamic vehicle allocation when it comes to experienced stress and predictability. However, a major setback of the present study was the low number of participants. This resulted in a low power and made results inconclusive. The same study with more participants would result in a better representation of the commuter experience of a dynamic bus station.

There are two types of bus station in the Netherlands, the present study has only focused on the effects of dynamic bus station on commuters. Interesting would be to compare commuter experiences between a dynamic and a static bus station of comparable size. When doing so by using two bus stations in two different cities, one must take into account the greater effect of environmental differences on the results. Looking at when and if the advantages of a dynamic bus station out weight the advantages of a static bus station could help designers help determining which one they should use. For example: When is a static bus station to cluttered that a dynamic bus station is better suited.

In the present study commuters were chosen because of their familiarity with a dynamic bus station. However, the response of other groups of users to a dynamic bus station is also relevant. Users who are less familiair with the dynamic bus station or users who are limited by disabilities (e.g. blind people). A lot of research is already done on helping out users less familiair with public transport navigating in public transport (Ding, Yuan, Zang, & Jiang, 2007). A dynamic bus station might pose an even greater challenge for these users, because decisive information becomes available shortly before departure. Studying users less familiair with a dynamic bus station might lead to changes to improve a dynamic bus station.

References

Angermeyer, M. C., Kilian, R., & Matschinger, H. (2000). *WHOQOL-100 und WHOQOL-BREF. Handbuch für die deutschsprachige Version der WHO-Instrumente zur Erfassung von Lebensqualität. - Zeitschrift für Klinische Psychologie und Psychotherapie*. Göttingen: Hogrefe.

Averill, J. (1973). Personal control over aversive stimuli and its relationship to stress. *Psychological Bulletin*, *80*(4), 286 – 303.

Boersema, G. (2010). Gebruik reisinfo om busstation aan te sturen. *OV-Magazine, 5*, 28 – 29.

Bonsall, P. (2004). Traveller Behavior: Decision-Making in an Unpredictable World. *Journal of Intelligent Transportation Systems*, *8*(1), 45–60. doi:10.1080/15472450490437744

Bröder, A., & Schiffer, S. (2006). Adaptive flexibility and maladaptive routines in selecting fast and frugal decision strategies. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *32*(4), 904–18. doi:10.1037/0278-7393.32.4.904

Costal, G., Pickup, L., & Martino, V. (1988). Commuting - a further stress factor for working people: evidence from the European Community. *International Archives of Occupational and Environmental Health*, *60*(5), 377–385. doi:10.1007/BF00405674

De Boer, E., & Krul, R. (2005). The dynamic bus station, a user friendly facility? Principles and practices at railway stations in the Netherlands. *Proceedings of ETC 2005, Strasburg, France 18-20 September 2005 - Transportation Policy and Operations - Local Public Transport - Bus and Rapid Transit*, 0–15.

De Boer, S. (2007). *Busstations, meer dan traditionele halte: Integrale oplossing voor inrichting en gebruik (Master thesis)*. TU Delft. Retrieved from http://repository.tudelft.nl/view/ir/uuid:9e7c4d76-46fb-40d3-9bae-f702a919b1a4/

Ding, B., Yuan, H., Zang, X., & Jiang, L. (2007). The Research on Blind Navigation System Based on RFID. *Wireless Communications, Networking and Mobile Computing, 2007. WiCom 2007. International Conference on* (pp. 2058–2061). doi: 10.1109/wicom.2007.514

Dziekan, K., & Kottenhoff, K. (2007). Dynamic at-stop real-time information displays for public transport: effects on customers. *Transportation Research Part A: Policy and Practice*, *41*(6), 489–501. doi:10.1016/j.tra.2006.11.006

Evans, G. W., Shapiro, D. H., & Lewis, M. A. (1993). Specifying dysfunctional mismatches between different control dimensions. *British Journal of Psychology*, *84*(2), 255–273. doi:10.1111/j.2044-8295.1993.tb02478.x

Evans, G. W., & Wener, R. E. (2006). Rail commuting duration and passenger stress. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association*, *25*(3), 408–12. doi:10.1037/0278-6133.25.3.408

Evans, G. W., Wener, R. E., & Phillips, D. (2002). The Morning Rush Hour: Predictability and Commuter Stress. *Environment and Behavior*, *34*(4), 521–530. doi:10.1177/00116502034004007

Folkman, S., Lazarus, R. S., Pimley, S., & Novacek, J. (1987). Age differences in stress and coping processes. *Psychology and Aging*, *2*(2), 171–184. doi:10.1037//0882-7974.2.2.171

Gottholmseder, G., & Nowotny, K. (2009). Stress perception and commuting. *Health Economics*, *18*(5), 559–576. doi:10.1002/hec

Jungermann, H., Pfister, H.-R., & Fischer, K. (1998). *Die Psychologie der Entscheidung*. Heidelberg: Spektrum.

Klein, G. A. (1999). *Sources of Power: How People Make Decisions*. MIT press. Retrieved from http://books.google.com/books?hl=nl&lr=&id=nn1kGwL4hRgC&pgis=1

Kluger, A. (1998). Commute variability and strain. *Journal of Organizational Behavior*, *19*(May 1996), 147–165.

Koolhaas, J. M., Bartolomucci, A., Buwalda, B., de Boer, S. F., Flügge, G., Korte, S. M., … Fuchs, E. (2011). Stress revisited: a critical evaluation of the stress concept. *Neuroscience and Biobehavioral Reviews*, *35*(5), 1291–301. doi:10.1016/j.neubiorev.2011.02.003

Koslowsky, M., & Kluger, A. N. (1995). Commuting stress: causes, effects and methods of coping. Springer.

Matud, M. P. (2004). Gender differences in stress and coping styles. *Personality and Individual Differences*, *37*(7), 1401–1415. doi:10.1016/j.paid.2004.01.010

Mishalani, R., McCord, M., & Wirtz, J. (2006). Passenger wait time perceptions at bus stops: empirical results and impact on evaluating Real-Time Bus Arrival Information. *Journal of Public Transportation*. Retrieved from http://www.nctr.usf.edu/jpt/pdf/JPT 9-2.pdf#page=94

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin*, *124*(1), 54 – 74. doi:10.1037/0033-2909.124.1.54

Rietveld, P., Bruinsma, F. ., & van Vuuren, D. . (2001). Coping with unreliability in public transport chains: A case study for Netherlands. *Transportation Research Part A: Policy and Practice*, *35*(6), 539–559. doi:10.1016/S0965-8564(00)00006-9

Robin, M., Matheau-Police, A., & Couty, C. (2007). Development of a scale of perceived environmental annoyances in urban settings. *Journal of Environmental Psychology*, *27*(1), 55–68. Retrieved from http://www.sciencedirect.com/science/article/pii/S0272494406000624

Schaeffer, M. H., Street, S. W., Singer, J. E., & Baum, A. (1988). Effects of Control on the Stress Reactions of Commuters. *Journal of Applied Social Psychology*, *18*(11), 944–957. doi:10.1111/j.1559-1816.1988.tb01185.x

Schweiger, C. L. (2003). *Real-Time Bus Arrival Information Systems*. *TCRP Synthesis of Transit Practice*. Washington: Transportation Research Board. Retrieved from http://trid.trb.org/view.aspx?id=661923

Seligman, M., & Miller, S. (1979). *The psychology of power: Concluding comments*. (L. Perlmuter & R. Monty, Eds.)*Choice and Perceived Control, Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Sloot, M., & Keesteren, G. (2002, July). De ene reiziger is de andere niet. *Centrum Vernieuwing Openbaar Vervoer*, 1 – 4. Retrieved from http://www.kpvv.nl/KpVV/KpVV-Overige-Content/KpVV-Overige-Content-Media/Bijlagen-publicaties/CVOV-bericht72pdf.pdf

Smith, R., Atkins, S., & Sheldon, R. (1994). London Transport Busses: ATT in Action and the London Countdown Route 18 Project. *First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems* (3048 – 3055)

Sposato, R. G. (2010, June 7). *Stress und Lebensqualität bei PendlerInnen*. University of Vienna. Retrieved from http://othes.univie.ac.at/9989/1/2010-05-26_0302460.pdf

Sposato, R. G., Röderer, K., & Cervinka, R. (2012). The influence of control and related variables on commuting stress. *Transportation Research Part F: Traffic Psychology and Behaviour*, *15*(5), 581–587. doi:10.1016/j.trf.2012.05.003

Stokols, D., & Novaco, R. (1978). Traffic congestion, Type A behavior, and stress. *Journal of Applied Psychology*. Retrieved from http://psycnet.apa.org/journals/apl/63/4/467/

Turksma, S. (2000). Compact dynamic bus terminal technology in the Netherlands. In *Proceedings of the 7th world congres on intelligent systems* (p. 8). Retrieved from http://trid.trb.org/view.aspx?id=727758

Van Vlijmen, S. F. M., Klusener, A. S., & Schrijver, A. (1999). The Compact Dynamic Bus Station. *Electronic Notes in Theoretical Computer Science, 21*, 1–20. Retrieved from http://www.sciencedirect.com/science/article/pii/S1571066105011904

Wener, R. E., & Evans, G. W. (2011). Comparing stress of car and train commuters. *Transportation Research Part F: Traffic Psychology and Behaviour*, *14*(2), 111–116. doi:10.1016/j.trf.2010.11.008

Wener, R. E., Evans, G. W., Phillips, D., & Nadler, N. (2003). Running for the 7: 45: The effects of public transit improvements on commuter stress. *Transportation*, 203–220. Retrieved from http://link.springer.com/article/10.1023/A:1022516221808

Wieringa, R. J. (2006). Using the tools in TRADE III : a controller for a compact dynamic bus station. University of Twente, Centre for Telematics and Information Technology (CTIT). Retrieved from http://www.narcis.nl/publication/RecordID/oai:doc.utwente.nl:63139

Yu, B., Wu, S., Yao, B., Yang, Z., & Sun, J. (2011). Dynamic Vehicle Dispatching at a Transfer Station in Public Transportation System. *Journal of Transportation Engineering*, *138*(2), 191–201.

Appendix 1 - Questionnaire

Welkom,
Dit is de eerste korte vragenlijst van het onderzoek.
Het is bij de bedoeling dat u de vragenlijst invult op basis van uw ervaringen vandaag tijdens het reizen. Lees alstublieft de vragen precies en beantwoordt deze zorgvuldig. Beantwoordt de vragen alleen en zo spontaan mogelijk. Er zijn geen "goede" of "foute" antwoorden. Het gaat puur om uw eigen mening.

Van welke buslijn(en) maakte u vandaag gebruik?

Buslijn:

Buslijn:

Buslijn:

Buslijn:

? Het lijnnummer is voldoende

Hoelaat ging u vandaag met de bus?

'S Ochtends

'S Middags/'S avonds

*

	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
Vandaag was reizen lastig.	○	○	○	○	○
Het reizen vandaag was erg vermoeiend.	○	○	○	○	○
Mijn reistijd was vandaag niet anders dan normaal.	○	○	○	○	○
Het reizen beïnvloede mijn productiviteit op mijn werkplek/onderwijsinstelling.	○	○	○	○	○
Ik raakte vandaag niet vermoeid door het reizen.	○	○	○	○	○
Ik heb mij vandaag geërgerd aan moeilijkheden die voor mij door het reizen ontstonden.	○	○	○	○	○
Vandaag duurde mijn reis zo lang als ik verwacht had.	○	○	○	○	○
Mijn reis vandaag ging gemakkelijk.	○	○	○	○	○
Ik kon er niks aan doen om mijn reiservaring te beïnvloeden.	○	○	○	○	○
Ik kon vandaag voorspellen hoelaat ik op mijn werkplek/onderwijsinstelling zou zijn.	○	○	○	○	○
Ik had geen keuze in hoe ik naar mijn werkplek/onderwijsinstelling reis.	○	○	○	○	○
Mijn reis was erg onvoorspelbaar.	○	○	○	○	○

* **De volgende stellingen gaan over uw ervaring op busstation Nijmegen vandaag.**

	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
Mijn bus kwam vandaag waar ik hem verwacht had.	○	○	○	○	○
Ik had geen moeite met het vinden van mijn bus.	○	○	○	○	○
Het was te druk op het busstation.	○	○	○	○	○
Het was onduidelijk hoelaat mijn bus er zou zijn.	○	○	○	○	○

Hier is ruimte voor verdere opmerkingen over uw ervaringen vandaag.
Daarnaast is het ook mogelijk algemene opmerkingen te maken over busstation Nijmegen.

Versturen