Wayfinding and signage for mobility hubs:

a case study at Utrecht Central Station

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Abstract

Mobility hubs are places where multiple transportation modes are available and where these different kinds of transportation can be shared. These kinds of commercial, public areas need good wayfinding strategies to make every traveler's journey as successful and safe as possible. The goal of this thesis is to identify what the information wants and needs are for different travelers. In the first study, 92 travelers were interviewed at Utrecht Central Station to find out what kind of traveler wants what kind of information, what they think of the current signage at the station, and how they would improve this. Results indicated that most travelers had trouble locating themselves, thought signage was not well placed, and had trouble finding different modes of transport, especially bus stations. In a second study, I looked at the questions that were asked at the information booths at the station. The questions correlated with the problems found in the interviews and gave some additional insights. Taken together, this research recommends taking the more vulnerable target groups into consideration, like older adults and people who rarely visit the hub, when designing a future mobility hub.

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1. Introduction

Urban areas are becoming more and more popular to live in (United Nations, 2018). Walkable urban design is defined by higher densities of residential, retail and public transport facilities, greater street-level connectivity and proximity to attractive destinations. It has been known to stimulate physical activity through walking (Saelens and Handy, 2008). This is positive for physical health, leading to improvements such as reduced risks of obesity, type 2 diabetes, and cardiometabolic disease (Sarkar, Webster, & Gallacher, 2018). However, urban areas have a negative impact on the environment, because of increased air pollution due to high industrial production and road transportation (Rodríguez, Dupont-Courtade, & Oueslati, 2016). In addition, because more people live in big cities, more housing must be built, which takes up a lot of space and creates high-density living situations.

So-called 'mobility hubs' could provide a way to reduce the negative impact on the environment and traffic flow, while also allowing for high-density living. Mobility hubs are places of connectivity where different modes of travel – walking, biking, transit, and shared mobility – converge and where employment, housing, shopping, and/or recreation are concentrated. They provide an integrated suite of mobility services, amenities, and technologies to bridge the distance between high-frequency transit and an individual's origin or destination. They are part of a network and facilitate transfers between different kinds of transportation (Villarreal, 2018). Because of the large availability of other kinds of transportation there is less need for cars and therefore less need for parking spaces. The reduced need for parking spaces creates room to build houses and accommodate more people. Sample mobility hub services, amenities, and technologies include: bikeshare, carshare, neighborhood electric vehicles, bike parking, dynamic parking management strategies, real-time traveler information, real-time ridesharing, micro transit services, bike and pedestrian

improvements, wayfinding, and urban design enhancements. These features help travelers connect to regional transit services and make short trips within the neighborhood and beyond. Figure 1 presents an example of a mobility hub to illustrate what a mobility hub would look like and what kind of services and stores it would consist of. In the next section, where the location of the study will be explained, more details about the Merwedekanaalzone will be described.

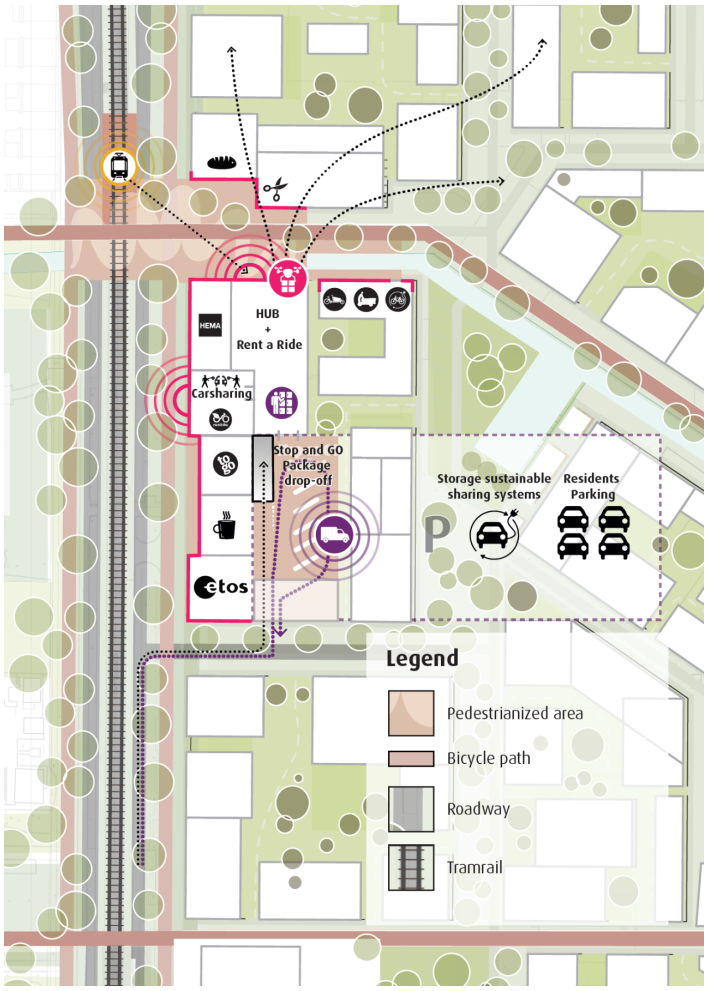

Figure 1. Mobility hub example, mobility plan for Merwedekanaalzone, Utrecht (Goudappel Coffeng, 2018)

Integration of information technology helps travelers find, access, and pay for transit and on-demand shared mobility services. This is called mobility as a service (or: 'MaaS'). MaaS is a mobility intermediary and provides the best service for every trip, whether that is (rental) cars, public transport, taxi, bicycle or other forms of transport. It brings all forms of transport together in one mobile service; The convenience of quick and easy access to all mobility options, with less hassle of planning and without separate payments. It is a carefree and sustainable alternative to owning a car. MaaS provides smart transport for both daily commuting and occasional leisure trips (e.g., a weekend away). For the user it provides a system that reduces cognitive effort. People can have a subscription to a MaaS provider and use any transportation they want. They do not need to think about booking, payment, and ticketing, because the MaaS service provider arranges everything. A MaaS user no longer pays for mobility itself (e.g., owning a car or bike), but for use (e.g., car or bike sharing; Lyons, Hammond, & Mackay, 2019).

1.1 Location of study: Utrecht, The Netherlands

This study will focus on wayfinding in the city of Utrecht. Utrecht is an interesting city for this study because the population of Utrecht grew by 5.000 citizens in 2018 (CBS, 2019) to 352.795 citizens and is expected to continue to grow to more than 400.000 citizens before 2024 (Gemeente Utrecht, 2018). To accommodate all these new inhabitants, the municipality of Utrecht proposes the Merwedekanaalzone as an inner-city development site for 6,000 to 10,000 new homes. To make the Merwedekanaalzone successful, an innovative mobility strategy is required where walking, cycling, public transport, and shared mobility are the main modes of transport. Creating this new building with 10.000 homes is possible only if the parking norm is reduced from 0.7 to 0.3 parking spaces for each household (Gemeente Utrecht, 2013). To accomplish the reduction in parking spaces, car ownership could be

replaced by other means of transport. This could be facilitated by mobility hubs as they promote shared mobility.

For instance, a study about Greenwheels (Goudappel Coffeng, 2018) showed that the shift from car owning to car sharing is possible. Greenwheels is a company that rents cars to people who want to share a car with other people. Because many drivers share the same car, many drivers sold their own car or opted not to purchase the car they intended to buy. This resulted in 18.700 fewer privately owned cars for all 1.700 current Greenwheels cars available. The use of car sharing also results in a reduction of CO_2 pollution. In total, users drive 81 million kilometers per year less, which represents a CO_2 saving of 14,500 tons. Reduced traffic, in general, will reduce air pollution and will thus be better for the environment (Rodríguez, Dupont-Courtade, & Oueslati, 2016). Car sharing is also beneficial for the traffic flow in the city and accessibility around the district.

Analysis of the current policy (Goudappel Coffeng, 2018) shows that if the Merwedekanaalzone was build according to current standards it would cause so much car traffic, that the accessibility of the surrounding area would be severely compromised, furthermore cyclists and pedestrians would not be able to cross the street safely. Calculations (Goudappel Coffeng, 2018) show that the problem with accessibility would be solved by halving the car traffic from the Merwedekanaalzone and the number of passing cars through the district. To achieve this, transportation needs to be shifted from going by car to walking, cycling or using public transport. Mobility hubs facilitate multi- and intermodal transport and would perfectly fit the needs of the Merwedekanaalzone.

Building of the Merwedekanaalzone mobility hubs raises new questions for the city of Utrecht, as mobility hubs are a new concept. Questions such as how the Merwedekanaalzone should be set up, and how will people find their way. This last question is what this study will

focus on. The next section will discuss what is already known about wayfinding and signage before explaining more about the conducted study.

1.2 Wayfinding

At mobility hubs there are various forms of transportation available, and the aim is for people to use different forms of transportation for different needs (e.g., daily commute versus leisure trip). Given the variety of options, people might need to occasionally search for the location of their (less frequently used) mobility options. Good wayfinding and navigation, and thus, good signage, is needed to successfully move through a mobility hub and find the chosen mobility option.

Wayfinding is defined as a complex cognitive function involving different types of information, such as knowledge about landmarks and direction information (Darken, & Peterson, 2014; van Asselen, et al., 2006). It involves tactical and strategic cognitive processes that guide movement but does not involve actual movement. An essential part of wayfinding is the development and use of a cognitive map, this is a mental representation of an environment. Motion is the motoric element of navigation, and navigation is the aggregate task of wayfinding and motion.

Successful wayfinding means remembering the spatial layout of an environment and using that information to find one's way (van Asselen, et al., 2006). To be able to reach one's goal, information about what and where things are in the environment is needed. This information may be stored internally in cognitive maps, externally in information displays, or in a combination of the two. Effective wayfinding requires information about the environment to be sufficiently accurate, precise, complete, and up to date. Once knowledge about the environment is acquired, it must be organized in such a way that it can be used during navigation. Furthermore, this information must be accessible and has to be used

properly according to the situation someone is in. Information must be sufficient, but not excessive. For instance, information that is overabundant can prevent us from focusing on relevant information by distracting us with irrelevant information (Montello, & Sas, 2006). However, navigation rarely is the main focus. It only tends to get in the way of what someone actually wants to do, which is getting to the desired destination. The objective is to make navigation and wayfinding as transparent and trivial as possible, to avoid anxious, uncomfortable and disoriented people.

Wayfinding in public places, like train stations or mobility hubs, is a complex problem. Travelers are likely to experience occasional stress because they have to navigate their way to multiple locations in the course of a single visit and might have to do this in an unfamiliar location. While good wayfinding can reduce stress, poor wayfinding can not only increase individuals' anxiety but also generate additional costs: staff members need to direct or help travelers instead of concentrating on their designated tasks, and additional security staff is needed to ensure that people do not enter restricted areas (Morag, Heylighen, & Pantheon, 2016).

As new buildings or expansions are being added to already large and complicated buildings, and routes constantly need to be adapted, demand for good wayfinding systems becomes more acute. These characteristics are also applicable to mobility hubs. Plans for mobility hubs are emerging fast, and as hubs are the expansion to an already large and possibly complicated network, they also need good wayfinding systems. People will need to adapt their habits and routines to new structures and that requires good information systems for these people to find their goal destination. Successful wayfinding systems should provide people with multiple types of information: identifying their location, orienting themselves within a building or external space, reinforcing that they are traveling in the correct direction, understanding hazards and how to escape safely in the case of an emergency (Baskaya,

Wilson, & Özcan, 2004; Gibson, 2009). People need to be provided with a consistent set of indicators that help them efficiently use their capabilities of language, perception, knowledge, memory, and problem-solving.

Wayfinding systems should be accessible to, and usable by, the broadest user group possible. People with the widest range of abilities within the widest range of situations need to use the systems without the need for special adaptation or design. As the range of sensory, physical, language, intellectual, and social and cultural backgrounds is quite diverse, it is important to use an inclusive design for the wayfinding systems (Clarkson, Coleman, Keates, & Lebbon, 2013).

When passengers are on a journey, they need to take multiple steps to reach their destination. At a minimum, barriers may affect user-friendliness for the average passenger. However, mobility hubs are intended to be used by a wide set of users which also need to be accommodated. Small barriers may prevent those with any of a variety of impairments from simply getting from A to B.

An example of this are older passengers, who might be at higher risk of physical (Lee, Agarwal, & Kim, 2012) and/or cognitive impairments (Klencklen, Després, & Dufour, 2012), while at the same time depending more on public transportation. Older passengers have more trouble walking, biking or driving in cars. They also have more trouble with wayfinding than younger adults. Older adults tend to learn new routes more slowly, have a lower accuracy of spatial navigation, make more wayfinding errors and tend to adopt different navigation strategies than younger adults (Newman and Kaszniak, 2000; Bates and Wolbers, 2014; Wiener, de Condappa, Harris, & Wolbers, 2013). With age-induced spatial navigation decline, heightened by visual and/or cognitive decrements, it is important for airports and train stations to develop comprehensive and supportive wayfinding programs to promote travel independence. Planning and design of these transportation hubs and use of specific

technologies can have positive impacts on the ability of older adults to find their way around. These should therefore be considered when developing future mobility hubs (Bosch, & Gharaveis, 2017).

Getting lost is an indication of a poor wayfinding system rather than inadequacy on the part of the wayfinder. Even though the signs can be well-designed, they may not provide good enough cues (Morag, Heylighen, & Pantheon, 2016). The degree of familiarity someone has in a given environment has a powerful influence on their wayfinding behavior. Complexity in an unfamiliar environment can be a serious problem, although initial difficulties in orientation can be overcome. Performance in wayfinding and spatial orientation tasks improves in both accuracy and latency as familiarity with an environment increases (Baskaya, Wilson, & Özcan, 2004).

Even without comprehensive knowledge of an environment, it is possible for people to reach their destination, this is done with the use of a cognitive map or by using schemas of typical building layouts (Passini, 1984; Tolman, 1948). This general knowledge of buildings enables people to orient themselves in unfamiliar settings. However, if the physical surroundings make the prediction of the schema difficult, this can result in stress (Gross, & Zimring, 1992; Evans, 1998). Weisman (1981) studied factors that influence wayfinding in buildings and found that plan configuration was the most influential, followed by spatial landmarks, spatial differentiation, and finally signage. People rely on plan configuration and the scenes that might contain spatial landmarks and spatial properties of the setting when they have incomplete cognitive maps in an unfamiliar environment (Baskaya, Wilson, & Özcan, 2004).

People tend to rely heavily on signage when navigating a large commercial complex (Lam, Tam, Wong, & Wirasinghe, 2003; Peponis, Zimring, & Choi, 1990). Wayfinding, when assisted by proper signage, will seem natural rather than forced when important

facilities and key points such as the entrance are carefully positioned. There is a positive relationship between the number of decision points (such as the intersection of two corridors) and wayfinding difficulty. If signage is placed at decision points of complex buildings, it improves wayfinding performance (Tzeng, & Huang, 2009). The presence of signs also significantly reduces perceived crowding, discomfort, anger, and confusion as well as the amount of time spent to complete the process (Wener, & Kaminoff, 1983). This study will look into the use of landmarks, how older adults experience wayfinding, and how complete and easy to use wayfinding systems are.

1.3 This thesis

This study investigates what different kinds of pedestrians that pass through a mobility hub and the signage they require to complete their journey. As there is no mobility hub to study in The Netherlands, this will be done by studying travelers at Utrecht Central Station. This station is very similar to future mobility hubs: both have multiple ways of transportation (i.e., train, bus, tram, bike, walking, car sharing, parking, taxi), shops, are near residential areas, are used for both commuting and incidental traveling, and are crowded areas with a lot of people.

The key difference between the mobility hub that is planned for the Merwedekanaalzone and the Utrecht Central Station is the availability of MaaS. This is going to be incorporated into the design and implementation of the Merwedekanaalzone but is not a part of Utrecht Central Station. Other differences are the purpose of visits, location, and size: the mobility hubs at the Merwedekanaalzone will be placed in the district for the people that live there and will be focused on the shift from owning cars to sharing cars and other transport options, the station is a train station with a lot of extra’s and with a main goal of

moving people from A to B. Also, the Merwedekanaalzone hub will be at multiple smaller locations on the edge of the district, whereas the train station is one big hub in the city center. The smaller hubs at the Merwedekanaalzone will all have the same mobility options as the ones that are available at the Utrecht Central Station.

The question that this thesis answers is: What kind of information do different kinds of travelers require at mobility hubs to reach their desired destination, with a case study at Utrecht Central Station. This question was answered using two studies. In the first study, interviews were conducted to see what kind of problems different kinds of travelers have with the current signage. The method of interviews was chosen to be able to assess the users view. For example, what kind of concerns, problems and opinions they have. A broad group of different travelers was interviewed at different times during the day, to be able to identify any problems with the current signage experienced by specific groups or at specific times as there was no hypothesis or expectation of where the problems could lie. Questions about what kind of signage they would prefer instead of the current signage were also asked.

The second study investigates what types of questions are asked at information booths at the station to see if the questions correlated with themes I found in the interviews. This was done using naturalistic observation (McLeod, 2015). This method involves observing spontaneous behavior of participants in their natural surroundings. The researcher records what they see and hear. By being able to observe behavior in a natural setting, this method offers greater ecological validity. Like the interviews, this method was chosen because it can be used to generate new ideas on how signage can be used.

The importance of this thesis lies within the need for customer satisfaction and safety. When people come into a new environment and have to find their way, they should be guided and helped in an efficient way though a good wayfinding system. Mobility hubs are a new concept where a lot of mobility options are available in a small area, a good wayfinding

system is needed to help guide people in a fast and safe way to throughout their journey. Large public spaces are usually easy enough to navigate, but people are never fully satisfied. I will look at Utrecht CS and study what problems emerge with wayfinding and signage so these problems can be reduced or avoided during the design of future mobility hubs.

2. Methods study 1

2.1 Participants

92 Dutch-speaking individuals volunteered in the first part of this study. All were travelers at Utrecht Central Station and approached using opportunity sampling. Of the 92 participants (M = 40.25 years of age, SD = 17.32 years of age, range 14-72), 45 were male (M = 45.16, SD = 16.43) and 47 were female (M = 35.55, SD = 17.00). The number of participants in each category is shown in table 1. I attempted to acquire a balanced sample of different ages and genders, and to this end reviewed the amount of people interviewed in each category after each day. If any of the samples were skewed, this was adjusted the next day. All participants gave verbal informed consent prior to the start of the interview. The researcher explained what was asked of them during the interview and indicated that the participants could stop at all times, that participation was voluntary, that no personal data would be asked, and that the acquired data would be saved anonymously.

Table 1

Number of participants per category

Category	Group	Men	Women	Total
Gender		45	47	92
Age	30-	12	23	35
	31-59	21	16	37
	60+	12	8	20
Location	Center side exit	12	18	30
	Jaarbeurs side exit	15	17	32
	Middle exit	18	12	30
Frequency of visits	Daily	20	21	41
	Weekly	9	16	25
	Monthly	11	8	19
	Yearly	5	2	7
Time	Rush hour	20	20	40
	Off-peak	25	27	52
Travel motive	Personal use	21	14	35
	Work	6	17	23
	School/study	18	16	34

2.2 Apparatus

As a starting point, a set of 16 questions was asked by the interviewer. Some questions were added, and some were removed based on given responses in the interviews. The first five questions were about traveler demographics, how often and why they visited the train station, how they arrived (which travel mode), and how they would continue their journey. The next four questions were about their opinion on the current signage, whether they had problems differentiating between the different sides of the station (Jaarbeurs and city center side), what they thought about placement of the signs, and whether they missed certain information on the signs. Followed by these questions three questions about possible future additions, like stripes on the ground or interactive displays. If the participant still had time, four questions were asked about different kinds of transportation. For example, if they knew where they could find rental cars and where they could or would find information about these. Questions about mobility hubs were not included, because people have difficulty correctly imagining future concepts. The questions of the semi-structured interview can be found in Appendix 1.

2.3 Procedure

People that were standing still and/or waiting at the station were approached for the interview, as they were the most likely to have 4 minutes to spare. They were told the research was about the signage at the station and that the interview would take about 4 minutes. If they wanted to participate, the recording was started, and verbal informed consent was explained. The first set of questions was asked, and if the participant still had time, the last set of questions about specific types of transportation and where they could be found was also asked. As it was a semi-structured interview there was room to ask further questions if needed. After the interview, I thanked the participants and saved the data with participant number, gender, time of the day and place where the interview was held.

As I only had a brief time to interview each participant, and some questions lead to more insight than others, I reviewed all questions after each interview session. Each session consisted of approximately 20 participants and took about 2 to 2.5 hours. There were five sessions in five days that took place between 7.00 in the morning and 18.00 in the evening. Both rush hours (7.30 - 9.30 and 16.00 - 18.00) and non-rush hours, multiple locations (Jaarbeurs side, city center side, and middle of the station), and all ages were covered to ensure diversity.

2.4 Data analysis

The interviews were recorded on a mobile phone and transcribed into Microsoft Excel 365 ProPlus for further analysis. This was followed by a thematic analysis of the data. For this analysis, all interview transcripts were printed out and, using colored markers, put into different categories. The different categories that were found were then put into Microsoft Word 365 ProPlus.

The interviews were first analyzed with a thematic analysis (Braun, & Clarke, 2006). This was done to identify patterns and themes in the interview data. The interviews were transcribed using edited transcripts, this meant that I omitted sentences while transcribing without changing the sense of the recording. The following preliminary codes were assigned to the data to describe the content: rental car, buses, differentiating exits, what aspects are positive about the train station, what can be improved at the station, stripes, and interactive displays. I searched for patterns and themes within the codes across the different interviews and computed more specific codes: location of buses is unclear, placement of signage is bad, central display with train information needs to come back, pros and cons of stripes and interactive displays. The themes were then reviewed, defined and named.

The interviews were also analyzed to find possible patterns between gender, age group, rush hour and non-rush hour travelers, method of transportation, and the different kinds of opinions of the signage at the station. Age groups were divided into people under 30, people between 30 and 60, and people of 60 and over. Modes of transportation were bus, train, walking, bike, tram, and car. The codes from the thematic analysis were used for the pattern analysis. If a pattern emerged the participant number was looked up to analyze corresponding quotes.

3. Results study 1

3.1 Thematic analysis

The thematic analysis revealed six themes: differentiating exits, problems with finding bus stations, placement of signage, finding different kinds of transportation, international signage, and future additions to the signage. These are the themes that will be discussed next, each supported by quotes from specific participants. After each theme some recommendations will be given.

Theme 1: Differentiating exits

The first theme was about keeping both sides of the central station (Jaarbeurs and city center) apart. People might have had trouble doing this because both sides are very similar in their appearance and the exact location cannot be easily identified by looking outside, as high buildings largely obstruct the view. For example, participant 80 said, “De eerste keer hier na de verbouwing, moest ik zoeken naar de goede uitgang. Ik heb vooral gekeken naar het uitzicht op de gebouwen, maar niet naar de borden” [“The first time I came here after the rebuilding, I had to search for the right exit. I mostly looked at the view of the buildings outside, but not at the signs”].

The information about where which side of the station is located can be found on the big blue information signs throughout the station, however, the results suggest they are not seen by travelers. Perhaps because these signs are all the same font and color, as seen in figure 2, and might be discarded easily as they do not attract enough attention.

At the city center side there is also a ‘meeting point’ indicated by a large hanging sculpture with lights, which is shown in figure 3. Given that the only meeting point is only at

the city center side, this landmark could help with locating oneself at the station, and thus, reducing the difficulty with differentiating between the different sides. Participant 71 said: “Het enige wat ik nu mis is, ik moest bij het meeting punt zijn, maar ik kan dat hier niet vinden. Dus ik sta hier maar middenin. Hij had het over een geel iets, ik vrees dat dat er niet is” [“The only thing I’m missing is, I had to go to the meeting point, only I can’t find it here. So, I’ll just stand in the middle of the station. They said it was something yellow, but I’m afraid that that does not exist”]. In other words, passengers do not know that the sculpture was a meeting point, or do not recognize it.

Figure 2. Photo of blue information signs that are placed throughout the station, with information about where to find train platforms, bus stations, toilets, taxi’s, lockers, rental bikes, trams, and exits.

Figure 3. Meeting point cloud at Utrecht Central Station (DUIC, 2016).

Recommendations following from theme:

The general recommendations that follow for the design of mobility hubs is making sure that both natural and artificial landmarks are visible and recognizable. People use landmarks to locate where they are and where they have to go. In the case of Utrecht Central Station, and possibly also at future mobility hubs, natural landmarks are not always visible, while other (artificial) landmarks that are currently at the station are not recognized as a landmark. Two solutions to this problem can be to make the natural landmarks more visible, to minimize covering them up with other structures, and make the artificial landmarks inside the station stand out and recognizable. In effect, people can use the landmarks to locate themselves. Another possible solution to tell the sides apart is suggested by participant 22, “Een leuk patroontje op de grond die naar een busstation of uitgang wijst, leuk en decoratief” [“A fun pattern on the floor to indicate bus stations or exits, fun and decorative”].

Theme 2: Problems with finding bus stations

The second theme was that people had trouble finding the bus signage. The station was recently renovated, and the location of the bus stations changed frequently from being at the city center side to being at the Jaarbeurs side and back. In the current state of the station, there is one bus station at the city center side, which is rather new, and one at the Jaarbeurs side.

Participants indicated having a lot of trouble finding the different bus stations and thought that the letters on the signage indicating the different stops (A on city center side, C and D on Jaarbeurs side, and H are trams) were confusing. Take for example participant 6, who said: "De bewegwijzering voor bussen kan beter, de letters van de vertrekhaltes zijn verwarrend. Ik heb een app nodig om te weten welke nodig is, anders is de bus al weg" ["The signage for the buses could be improved, the letters of the stops are confusing. I need an app to know which one I need, otherwise, the bus is already gone"]. They did not know which bus stopped at which stop, and then, how to get to that specific stop. It could have also been a problem that the information about busses was on the same blue information sign as the trains. People might not have thought to look on this sign as they thought there was only information about trains on the blue signs.

The information about which bus stopped at which stop was placed at three different points at the station (city center side, middle, and Jaarbeurs side), but the one in the middle of the station was not noticed by any of the participants, even by people who arrived by train from the middle of the station or entered the middle of the station from outside. About 17 people had the same problem as participant 48, "De businformatie staat pas helemaal aan het einde, dan moet je mogelijk weer het hele station over naar het andere busperron" ["The bus information is only at the end of the station, it is possible that you would have to go the whole way back"]. They would go to one of the ends of the station to see which stop they needed,

and if they were unlucky, they had to walk all the way back to the other bus stations at the other end of the station. The problem they would then face was finding the stop, as participant 8 indicated, “De laatste busperrons zijn niet herkenbaar, ze verschillen niet van treinperrons” [The last bus stations are not recognizable, they do not differ from train stops”], and thus the bus stations get easily overlooked.

Another problem was that people thought the bus stations at the Jaarbeurs side were outside, as the Jaarbeurs itself (an exhibit hall complex), is also outside just past the station. In the map that is displayed in figure 4, I have illustrated how people usually walk, and why they might easily walk past the bus stations and go the wrong way. Participant 62 also encountered this problem, “Als je hier voor het eerst komt en je moet naar de Jaarbeurszijde voor de bussen, dan kun je dat niet direct vinden, want dan loop je te snel naar buiten en dan mis je een bord dat je eerst al naar beneden moet” [“When you come here for the first time and you have to go to the buses at the Jaarbeurs side, you can not find them directly. You walk outside too quickly and miss the sign which says you need to go downstairs before walking outside”].

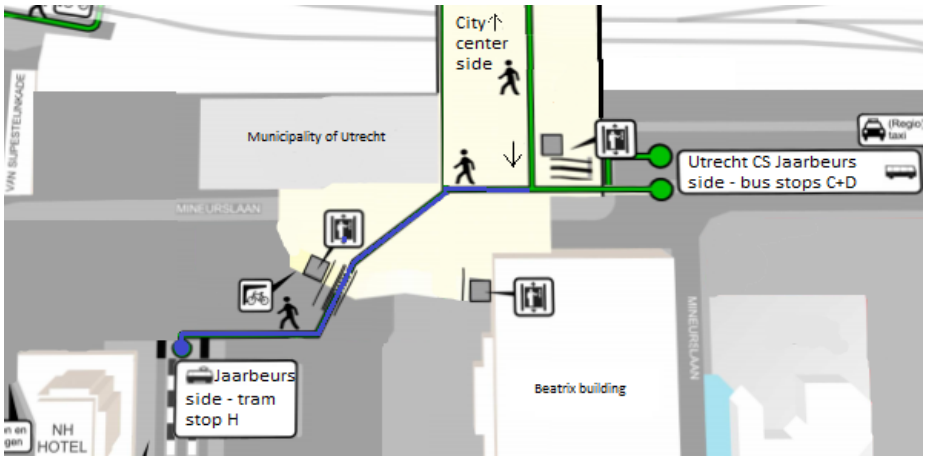

Figure 4. Map of the Jaarbeurs side of Utrecht Central Station. The walking route to bus station C+D is depicted by the green line. The walking route to tram stop H is depicted by the blue line. People often accidentally walk the blue route, when they actually wanted to go to bus station C+D.

Recommendations following from theme:

The general recommendation that follows for the design of mobility hubs is that it is important to make the signage for different travel modes distinct enough from the other signage, so it is more easily noticeable and can be traced to reach the final destination. This does not necessarily mean putting more signs up, but for instance, giving different modes of transport, which are already indicated on the same sign different colors. When you do not see the specific color or pictogram of the signage you were following anymore, it is a clear indication that you are going the wrong way and that you need to go back.

It is also important to put enough information throughout the hub, and not just at the places where the buses actually stop. One solution is to concentrate the buses in one location and not have four different stops at two different locations, as is the cast at the Utrecht Central Station.

Another solution is to make sure that the places where information about different travel modes (bus information in the case of Utrecht Central Station) is available, are visible and recognizable enough by putting a landmark there. For example, a post with a pictogram of a bus and an 'i' for information. That way people can recognize this as an information post and know that they can go there for information about busses.

Theme 3: Placement of signage

The third theme was that the placement of the signage was not optimal. The first problem here was that about 13 participants complained that signage was superimposed, like participant 51, "De bewegwijzering is redelijk goed. Het is een beetje rommelig, borden zitten vaak op elkaar" ["The signage is pretty okay. It is a bit messy, signs are often on top of each other"]. An example of this is seen in figure 5. The sign with information about buses was placed recently, and this sign is now concealed by the blue information sign. Because of

this concealment of the bus sign a lot of people did not see the bus sign and did not know there was a bus station there.

Figure 5. Photo of two overlapping signs at the city center side of the station. In the front is a blue information sign, in the back is a sign with information about the departure times from buses leaving from bus station A.

A second problem is that the signage is not on the walking routes and is limited to the inside of the main hall, as seen with the problem of finding the Jaarbeurs side bus stations when arriving from the city center side. Participant 50 said, “Als ik beneden kom op het perron met de trap wil ik gelijk als reiziger een informatiebord zien, maar die moet ik zoeken want ze liggen om de hoek. Het is allemaal schots en scheef, ik ben er niet tevreden over” [“When I come downstairs to the train platform, I want to immediately see information on signs, only I have to actively search for them as they are around the corner”]. Participant 90, who always uses the bike to get to the station says, “De borden met vertrektijden staan pas bij de poortjes, het zou handig zijn als dit al in de fietsenstalling of het plein tussen het station en Hoog Catharijne wordt weergegeven” [“The signs with departure information are first

displayed at the gates inside the station, it would be useful if they were already displayed in the bicycle parking or the square between the station and the Hoog Catharijne shopping mall"].

The third problem was that some signs were back to back, and people had to walk under them and turn around to be able to see them. As did participant 8, "De borden bij de ingang van de centrumzijde hangen verkeerd om. Vanaf buiten hangt de bus informatie, vanaf binnen de trein" ["The signs at the entrance of the City center side are hanging the wrong way. Looking from the outside there are signs with bus information, and from the inside with train information"]. This should be avoided, as people will not notice the sign was even there, and if they do it is inconvenient for them and the people around them to have to turn around.

Recommendations following from theme:

The general recommendation that follow for the design of mobility hubs is to make the most important signs the most visible. A possible way of identifying the problems with the placement of the signage is to have someone who is unfamiliar with the environment walk different routes to see if there are mistakes like the superimposed signs, or the back-to-back signs. Signs with information about transfers should be placed at different modalities, so people can adjust their journey accordingly and rush or take it easy. An example of this is when people arrive on their bikes and their transfer on train or bus does not arrive soon or has a changed schedule.

It is possible that not all the signs can be equally visible because of the large areas where they have to indicate many different things, but the most important signs should be the most visible, like the big central display with information about train departures that many people want for the main hall at the station. This sign is shown in figure 6. The solution of

having one big central sign is in alignment with the solution for theme 1, both indicate that important signs should be most visible. In the case of theme 1 this is made possible by landmarks, in this theme, the big central display can be seen as a landmark of its own.

Figure 6. Big central sign that was located at the city center side of the Utrecht Central Station from 1989 until 2011 ("Geschiedenis van station Utrecht Centraal", n.d.).

Theme 4: Finding different kinds of transportation

The fourth theme was about locating different kinds of transportation. All people who came or left the station by tram, said that they had no problems with finding the tram station. This was probably as they were only located in one place where they have been for years. Rental bikes were easily found for people who use them, but their location is unclear for people who do not use them.

Rental cars (like Greenwheels) were not easily found, but people also did not need or want them. Participant 25 said, "Geen idee waar ze staan, ze staan niet op de borden" ["I have no idea where they are, they are not indicated on the signs"]. Participant 15 said, "Ik weet niet waar ze staan, ik zou het vragen en online opzoeken" ["I do not know where they are, but I

would ask around and look it up online"]. Most people indicated that they would ask the information booth or search on Google or the NS app if they wanted more information.

Information about trains is abundant and people had almost no problems with this. The only thing people indicated was that information about departure times should be displayed on a big central display, instead of smaller ones like the one in figure 7. People said these signs were too small to read and there was too much information cramped in such a small space. As participant 76 said, "Dit is een heel groot en druk station met veel perrons, juist een groot scherm is erg fijn, daar kan je alles op zien. De huidige digitale borden zijn erg klein, je kan niet in een oogopslag zien wat je nodig hebt" ["This is a very large and busy station with a lot of platforms, a very large screen would be very nice, that way you could see everything on it. The current digital signs are very small, you cannot see what you need at a glance"].

Figure 7. Photo of digital sign with train departure times.

Recommendations following from theme:

The general recommendation that follows for the design of mobility hubs is to make sure every traveler can find their chosen form of transportation, even if that is something they had not used before. It can be useful to indicate all kinds of transportation on signs.

When designing a hub with environmentally friendly solutions to a car, the directions to shared cars could be left out of the signage to steer people to use other kinds of transportation that are more environmentally friendly, like a bike or public transportation. If people really want the shared cars, they can always look it up themselves. On the other hand, sharing a car is already better for the environment than owning a private car.

In the case of Utrecht Central Station, rental cars should be included on the blue information signs. The digital signs with information about departure times of trains or buses should be big and clear enough for everyone to read, even if they have poorer eyesight. A possible solution is a big central screen on a few different locations at the station, instead of multiple smaller displays.

Theme 5: International signage

The fifth theme was about signage being only in Dutch. Three people expressed their concern about the signage not being in English, or they had trouble themselves as they did not understand the language completely. So did participant 53, who said, “Informatie staat op de borden alleen in het Nederlands, dit is onmogelijk voor meeste buitenlanders. Alleen met pictogrammen is ook lastig, vooral voor mensen uit andere cultuur. Ik gebruik wel 9292, helaas is dit ook alleen in het Nederlands” [“Information on the signs is only in Dutch, this is impossible for most foreigners. Only with pictograms it is also difficult, especially for people from other cultures. I do use 9292, unfortunately this is also only in Dutch.”]. 9292 is a Dutch travel planner app for trains, buses, and trams. All the signage at the station is in Dutch.

Standardized and internationally applied ISO (Internation Organisation for Standardisation; ISO, 2013) pictograms are used for the reference and identification signs. The main problem is probably with the Dutch text on the signs.

Recommendations following from theme:

The general recommendation that follow for the design of mobility hubs is that every traveler should be able to find their way inside and outside of the hub. It is possible that for example the Merwedekanaalzone mobility hub does not need pictograms or text in English as it is located in a district and primarily made for the citizens of that district, who probably all speak Dutch. A possible solution for the hubs at places where international people come more regularly, and the Utrecht Central Station, could be that important signage has pictograms or icons to help with understanding what is said on the sign but putting informative text in both the native language and in English.

Theme 6: Future additions to the signage

The sixth theme was about possible future additions to the information facilities. In the first few interviews I asked a general question about what kind of signage people would like to see in the future. After the first session, when I reviewed the questions, I changed the question to specifically asking about the addition of stripes on the floor or the application of an interactive display. This was done because people had a lot of trouble coming up with answers on the spot. These two possible future additions were chosen because they already exist in big public spaces where good wayfinding is necessary, like airports, shopping malls, and hospitals.

Participants' opinions were split for each option. I will first discuss their opinions about the stripes on the floor. Participants who were in favor of the stripes said that stripes are

good to indicate walking routes, and for people who cannot read. They said that the stripes would work especially well for people who are not familiar at the station, but that the number of stripes should be minimal to avoid chaos and confusion. For example, as participant 53 said, “Strepen moeten wel rustig zijn, niet te veel kleuren of lijnen. Misschien alleen bovenaan de trap om de centrumzijde en tram aan te geven” [“Stripes must be quiet, not too many colors and lines. Maybe only at the top of the stairs to indicate the city center side and the tram”].

In contrast, participants who were against the stripes on the floor mainly said this because stripes would cause confusion and would be unclear. Participant 48 also said “Strepen zouden misschien goed werken, maar tijden de spits is het te druk om dit goed te kunnen zien” [“Stripes would maybe work, but during rush hour it would be too busy to be able to see the stripes clearly”]. People indicated they would first look up at signs before looking down at stripes, and that they knew the way and thus did not need the stripes. Stripes could help with wayfinding in an unfamiliar place, but only when it is clearly indicated what stripes go where and the number of stripes is limited.

The second possible addition people were asked about were the interactive displays. These displays would be big touch screens where people could see a detailed map of the station and its surroundings, information about the area, and a travel planner. As with the stripes, roughly half of the participants were in favor, and half were against.

The participants who were in favor of the display said they did not have a smartphone or internet and would use this display as a travel planner. Like participant 90, “Schermen zou ik handig vinden, want ik heb geen smartphone. Ik zou mijn hele reis willen plannen met verschillende diensten en verschillende opties zoals wat is het snelste, goedkoopste of meest comfortabele” [“I would find screens useful, because I do not have a smartphone. I would want to plan my entire trip with different transport services and different options, like what is

the fastest, cheapest or most comfortable"]. Some people said they would like to use it for the information about the area, a floor plan, or for more detailed information about buses.

The people who said they would not use the display said this was because they would prefer to use their own mobile phone to check all these things, or they planned their journey at home. Like participant 93, "Ik heb geen internet op mijn telefoon, maar ik plan mijn reis liever thuis. Als er iets veranderd aan mijn reis, dan vraag ik het gewoon. Een scherm is voor mij niet nodig" ["I do not have internet on my phone, I prefer to plan my trip at home. If anything changes to my journey, I would just ask that. No screen needed for me"].

Recommendations following from theme:

The general recommendation that follows for the design of mobility hubs is that people can locate all the different mobility options in an easy way. Something that can help with this are stripes on the ground that indicate different places. The people who were against it in the interviews mostly said that they would not mind if they were there if it helped other people, they would just not use them themselves. Interactive displays are another possible addition for people to help them navigate. These displays are multifunctional, they can also have a travel planner, floorplan, or platform to buy tickets or possible future MaaS subscriptions.

Table 2

Themes and corresponding problems

Theme	Problem
Differentiating exits	Keeping apart different exits/sides
Problems with finding bus stations	Location of the bus stations is unclear
	Letters of the bus stations are confusing
	Insufficient information about departure times/locations of the buses
Placement of signage	Superimposed signs
	Signs were not in the walking routes
	Back-to-back signs
Finding different kinds of transportation	Location of rental cars is not displayed
	Digital signs with departure times of trains are too small with too much information
International signage	International travelers have trouble with signs that are only in Dutch

3.2 Pattern analysis

In the following section I will discuss patterns between categories and the opinion about the signage at the station. The different categories are age group, gender, rush hour and non-rush hour travelers, location of interview, method of transportation, frequency and purpose of visits at the station. These categories will be discussed separately below. I looked at all the issues in table 2, but I only mention the relevant results. Graphs of the results of all categories are shown in Appendix 2.

Age groups

The youngest group, people who are under 30 years of age (N=35), have the most problems with buses, has the least problems with the current digital signs, and with keeping the different sides of the station apart, as seen in figure 9 in Appendix 2. For example, participant 13 said, “Strepen zouden gaaf zijn. Het station is nu al erg modern, maar ik sta open voor nieuwe dingen” [“Stripes would be cool. The station is already pretty modern, but I’m open to new things”].

The middle group of people between 30 and 60 years old (N=37), has the most problems with differentiating the different sides of the station and have the most other improvements for the main hall of the station. They also have the most positive things to say about the station. For example, participants 24 said, “Het station is helemaal goed, netjes en logistiek fantastisch georganiseerd” [“The station is very good, clean, and the logistics are organised fantastically”].

The oldest group, of people over 60 (N=20), had the most trouble with the digital signs and the overall placement of signs. As did participant 75, “Ik mis nog steeds het grote centrale bord, dat was fantastisch. Dit is een heel groot en druk station met veel perrons, juist dat grote scherm was erg fijn, daar kon je alles op zien. De huidige digitale borden zijn erg klein, je kan niet in een oogopslag zien wat je nodig hebt” [“I still miss the big central sign, that was fantastic. This is a very big and busy station with lots of platforms, that big screen was really nice, you could see everything on it. The current digital boards are very small, you can't see at a glance what you need”]. The central sign that is mentioned here is a big blue analog sign with train departure times (see figure 6), until it got replaced by the digital signs in 2011.

Gender

There are some differences between men and women, as seen in figure 10 in Appendix 2. Women (N=47) have the most problems with the difference between the Jaarbeurs and the city center side, but they also have the most good things to say about the main hall. Men (N=45) think the placement of the signs is bad and the location of the bus stations is unclear. For example, participant 82, “De borden aan de Jaarbeurszijde werken vaak niet of staan uit en ze staan niet in de looproute als je gelijk doorloopt naar de perrons, ze staan er eigenlijk voor niets” [“The signs on the Jaarbeurs side often do not work or are switched off, and they are not in the walking route if you walk straight to the platforms, they are actually there for nothing”].

Women have less problems with the placement of the signs but think there is insufficient information available about the buses. As did participant 47, “De bushaltes waren onduidelijk tijdens de verbouwing, mijn vrienden vinden het nu nog steeds erg onduidelijk, ik niet meer. Informatie over de bussen staat pas helemaal aan het einde, dan moet je mogelijk weer het hele station over naar het andere busperron” [“The bus stations were unclear during the renovation, my friends still find it very unclear, I don't anymore. Information about the buses is only at the very end, then you may have to cross the entire station to the other bus platform”].

Rush hour

People who are at the station during rush hour (N=40), and who possibly have less time and are more hurried, have more problems with finding the location of the bus stations and think that there is insufficient information about the buses. Results are shown in figure 11 in Appendix 2. They also think the letters of the bus stations are confusing and that the main hall at the station needs a lot of improvement. For example, participant 5 said, “De

bewegwijzering voor bussen kan beter, de letters van vertrekhaltes zijn verwarrend. Ik heb een app nodig om te weten welke nodig is, anders is bus al weg" ["The signage for buses could be better, the letters of the departure points are confusing. I need an app to know which one is needed, otherwise the bus is already gone"].

People who visit the station outside of rush hours (N=52), and who maybe have more time to look, want the central sign back and have more trouble with differentiating the Jaarbeurs and city center side. As did participant 88, he said, "Ik weet niet goed waar ik er hier uit moet, ik kan door Hoog Catharijne en dan het centrum in? De bewegwijzering van Hoog Catharijne en het centrum is niet goed" ["I'm not sure where to get out of here, I can go through Hoog Catharijne and then into the center? The signage at Hoog Catharijne and the city center is not good "].

Location

People that were interviewed at the Jaarbeurs side (N=32) and middle of the station (N=30) had the most problems with finding the location of the bus stations and the information about busses, this is shown in figure 12 in Appendix 2. Most bus stations are located at the Jaarbeurs side, and as shown in figure 4, it is easy to walk in the wrong direction. Participant 61 also had trouble with the bus locations at the Jaarbeurs side, "Als je hier voor het eerst komt en je moet naar Jaarbeurszijde voor de bussen, dan kun je dat niet direct vinden want dan loop je te snel naar buiten en dan mis je een bord dat je eerst al naar beneden moet" ["When you come here for the first time and you have to go to Jaarbeurs side for the buses, you can't find it right away because then you walk out too fast and you miss a sign that you have to go down first"].

The result about the bus locations being unclear is consistent with the results from the thematic analysis, which revealed that people want more information throughout the station

about buses, instead of only at the ends of the station. For example, participant 20 said, “Er moet meer info over komen, er is veel veranderd na de verbouwing. Ik ben verkeerd gelopen de eerste keer, er moet informatie op midden van station komen” [“There must be more information about it, a lot has changed after the renovation. I went wrong the first time, there must be more information in the middle of the station”].

People at the city center side (N=30) were most unhappy about the signage. They had a lot of problems with the placement of the signs and with keeping the city center side and the Jaarbeurs side apart. This is also consistent with the thematic analysis, which showed that some signs were not placed well at the city center side. An example of this is also seen in figure 8, where the sign with bus information and train information are back-to-back. Participant 7 also addressed this, “De bustijden op de busborden van de OV-service kloppen niet, maar bij haltes kloppen ze wel. De borden bij de ingang van de centrumzijde hangen verkeerd om. Vanaf buiten hangt de bus, vanaf binnen de trein” [“The bus timetables of the public transport service of the OV service shop are not correct, but at the actual bus stops they are correct. The signs at the entrance of the city center side are hanging on the wrong side. From outside you see the bus, from the inside the train”].

Figure 8. Photo of back-to-back signs. The entrance from the city center side is seen in the background. When entering the station, the sign with bus information is seen, but only when walking past these signs and turning around, the sign with train information can be seen.

Method of transportation

People who come or leave by train (N=75) have the most problems with insufficient information about buses and are the most unhappy with the main hall. These results are shown in figure 13 in Appendix 2. They also have trouble with finding the location of bus stations and with keeping the different sides of the station apart. For example, participant 47 said, “Voor mij is het verschil tussen de centrum en Jaarbeurszijde duidelijk. Het kan nog groter en duidelijker aangegeven worden, aangezien ze een eind uit elkaar liggen en op elkaar lijken” [“For me the difference between the city center and the Jaarbeurs side is clear. It can be indicated even bigger and more clearly, since they are a long way apart and resemble each other”].

Travelers who come or leave by bus (N=34) have a lot of trouble with the location of the bus stations and that there is insufficient information about the buses, as shown in figure 14 in Appendix 2. Like participant 36 for example, he said, “Perron A was lastig te vinden en lastig aangegeven. Het was niet duidelijk waar ik heen moest” [“Platform A was difficult to find and badly indicated. It was not clear where I had to go”].

People who walk either to or from the station (N=20) think there is insufficient information about the buses but have almost no issues with the signage. For example, participant 55 said, “De bewegwijzering is goed genoeg om voor mij de weg te vinden voor dat het voor mij een routine werd” [“The signage is good enough to find my way around before it became a routine for me.”]. Results are shown in figure 15 in Appendix 2.

People who use the tram at the station (N=5) think the letters of the bus stations are confusing, as shown in figure 16 in Appendix 2. As said earlier, bus stations are indicated on the same sign with the letters A, C, and D, and tram stops are indicated with an H. Like participant 1, who said, “Bij de tram is het niet duidelijk dat dit halte H is, dit lijkt op de borden op een bushalte” [“It is not clear that platform H is a tram platform, on the signs it

looks like a bus station"]. It is interesting that people who go by bus do not have a problem with the letters, but people who use the trams do.

People who travel by car (N=2) or bike (N=10) have trouble differentiating both sides of the station, think the placement of the current signs is bad, and want the central sign to come back. For example, participant 89, she said, "Ik had de eerste keer problemen met het uit elkaar houden van de centrum en Jaarbeurszijde, maar nu niet meer. Ik krijg wel vaak de vraag van toeristen hier, ik merk dat centrum makkelijker te herkennen is dan Jaarbeurs. Niet iedereen weet wat de Jaarbeurs is, dus ik vraag mij af of dit wel de handigste manier is om dit aan te duiden" ["The first time I had problems separating the city center side from the Jaarbeurs side, but not anymore. I often get the questions from tourists here, I notice that the center is easier to recognize than Jaarbeurs. Not everyone knows what the Jaarbeurs is, so I wonder if that is the best way to indicate this."]. Results are shown in figure 17 and 18 in Appendix 2.

Frequency of visit

People who visit the station only a few times a year (N=7) have trouble differentiating the different sides and finding the bus stations, as shown in figure 19 in Appendix 2. For instance, participant 81 also had this problem, he said, "Ik ben een keer met de bus geweest, toen had ik problemen met bushalte Jaarbeurszijde vinden, ik moest ineens naar beneden" ["I went by bus once, then I had problems with finding the bus station at Jaarbeursside, I suddenly had to go downstairs"].

People who come a bit more often (monthly; N=19) have the least trouble with anything at the station, they only have some trouble with the placement of the signs. Participant 18 said, "Ik heb weinig te zeggen over de bewegwijzering. Alles is op zich wel duidelijk" ["I don't have much to say about the signage. Everything is clear"].

People who come here weekly (N=25) think that there is insufficient information available about the buses and that the letters indicating the buses are confusing. Like participant 69 said, “Er stonden wel borden waar de haltes waren, maar niet bij welke halte de bussen stoppen” [“There were signs where the stops were, but not at which stop the buses stop”].

Daily commuters (N=41) have the most problems with locating the bus stations and with the placement of the signs. For example, participant 31 said, “Soms gebruik ik de bussen, maar het is wel ingewikkeld waar ik moet zijn. Er zijn veel verschillende haltes en ik moet goed zoeken en kijken op 9292” [“Sometimes I use the buses, but it's complicated where I have to be. There are many different stops and I have to search and look carefully at 9292”].

Goal of visit

People who come to the station on their way to work (N=23) think the placement of the signs is bad and have the most complaints about the main hall. An example of these complaints is participant 49, who said, “Het is rommelig, veel borden hangen in een dusdanige positie dat je niet alles kunt zien. Als ik beneden kom op het perron met de trap wil ik gelijk als reiziger een informatiebord zien, maar die moet ik zoeken want ze liggen om de hoek. Het is allemaal schots en scheef, ik ben er niet tevreden over” [“It's messy, a lot of signs hang in such a position that you can't see everything. When I come down on the platform with the stairs, I immediately want to see an information sign, but I have to look for it because they are around the corner. It's all crooked and skewed, I'm not satisfied with it.”].

People who visit the station for personal reasons (N=35) want the central sign to come back and have the most problems differentiating the different sides of the station. For example, participant 68 said, “Als ik binnenkom dan weet ik niet waar ik moet zijn, ik mis

het grote centrale bord. Ik moet actief gaan zoeken waar ik heen moet" ["When I come in, I don't know where to go, I miss the big central sign. I have to actively look where I have to go"].

Students (N=35) have the most trouble with the location of bus stations and think that there is insufficient information about buses. Like participant 54, he said "De borden met vertrektijden van de bussen zijn onoverzichtelijk, van treinen zijn ze wel goed" ["The signs with departure times of the buses are confusing, but the ones for trains are good"]. Results are shown in figure 20 in Appendix 2.

Conclusion

People who overall have the most trouble with the signage at the station are: people who walk or take the car, visit the station yearly, are at the city center side, are students, or are people who are above 60 years old. They all have different kinds of problems, some with the signage for buses, some with the placement of the signs, but overall these groups have the most problems with the current signage.

People who transfer from different transportation modes should be able to complete this transfer in easily and conveniently. Signage should be placed throughout the hub, so every possible transfer happens without too much difficulty or inconvenience. Students take the bus more often than other groups, so the information about busses should be clearly indicated in multiple locations. Older adults have more trouble with the digital signs. When designing a mobility hub, the digital signs should be understandable, not to crowded, and big enough so that older adults can also benefit from those signs. These groups and their capabilities should be taken into consideration when designing signage for a mobility hub.

4. Methods study 2

4.1 Participants

A non-participant observation design was used to assess the problems within the signage. Participants were travelers at Utrecht Central Station and asked a question at the information booth. Multiple languages were spoken, such as Dutch, English, and German. Informed consent could not be given because there was no interaction between participant and observer, it was a naturalistic non-participant observation. No personal data was asked or written down. A total of 215 questions was tallied across multiple people and subsequently analyzed, some people asked multiple questions.

4.2 Procedure

I stood outside the information booth, next to the booth window. This way I could talk with the employee inside the booth, and hear the travelers ask questions, but not stand in the way. I composed topics beforehand to be able to focus on the questions asked. If someone asked a question which did not fall into the existing topics, I added a topic to the list. Sometimes a question fitted in multiple topics, for example when a foreign traveler asked about which bus they needed to their destination, and where the bus station was located. This question would be tallied with the following three topics: foreign language, travel information about buses, and ‘Where is the bus?’.

The tally was made in a notebook that contained all topics I composed beforehand. It also minimized reactivity from participants. The times, days, and locations of observation are displayed in table 3. The observational periods were designed to be long enough and at similar times to allow establishments to be compared. Locations included all three

information booths available at the station, two outside of the gates (City center side and Jaarbeurs side), and one inside of the gates (by the middle exit). This way observations within contrasting settings could be compared.

Table 3

Locations and times of the second study

Location	Time
City center side, outside of the gates	Morning rush hour from 8:20 to 9:30
	Outside of rush hours from 14:00 to 14:30
Middle of the station by the middle exit, inside the gates	Evening rush hour from 16:30 to 17:40
	Outside of rush hours from 14:30 to 15:00
Jaarbeurs side, outside of the gates	Outside of rush hours from 12:00 to 13:10
	Outside of rush hours from 15:00 to 15:30

Instantaneous, or target time, sampling was used. The pre-selected moments when observation would take place were decided in advance. Observations made before or after the selected period were ignored. This method was chosen to prevent selection bias on certain types of behaviors, or an overrepresentation of behaviors in a certain time period. Two sessions took place during rush hours (from 8:00 - 9:30, and 16:30 - 18:00), and two outside of rush hours (from 12:00 - 13:30, and 14:00 - 15:30).

4.3 Data analysis

The list of topics and frequency of those topics was put into a Microsoft Excel file after each session. The list of all topics and the frequency of questions asked is shown in Appendix 2. There were 30 topics in total.

5. Results study 2

As shown in table 4, the topic with the most asked questions was ‘Train information’. This topic consisted of questions about which train departed from which platform and at what time. These questions were asked most frequently at the information booth in the middle of the station, inside the gates. This was an interesting result, as the information booth was situated next to the digital sign with departure information about trains, but people would still rather ask a question at the booth than look for the answer themselves. It could be possible that they did not notice the sign, or that the sign was unclear. The placement and clarity of the signs was also an issue that was found in the first study, but it was not specifically a problem in the middle part of the station.

Information about buses and their location was asked most frequently at both ends of the station, outside of the gates. This is also where the bus stations are located. Results are shown in table 4. These results confirm the results from the interviews in the first study. The location of bus stations is unclear, and there is insufficient information about the buses.

The information booths are operated by the railway company NS, but the buses belong to QBuzz, which is a different Dutch transportation company. At the information booths there was mainly information about trains and almost no information about buses, this information could be found at the OV service shop at both ends of the station. Most travelers who had questions about buses were referred to the service shop. A possible cause to the confusion of the travelers could be the names of the information booth and the service shop. The information booth had a sign which said “OV informatie” [“Public transport information”], but had mainly information about trains, and the service shop was named “OV Service & Tickets” [“Public transport service and tickets”] and had information about buses, but also information and tickets for international trains. Travelers were often confused about

where to get what kind of information. Clearer, more logical signs are needed to direct travelers where they need to go, especially when they have questions about specific transportation modes or facilities. A single booth for all information might only be beneficial if the hub does not have as many different transport companies or options as Utrecht Central Station for example, who has NS, QBuzz, and the international trains.

Table 4.

List of question topics and how many times they were asked, in the three locations of the information booths, and with a minimum frequency of 3 questions.

Topic	City Center	Middle	Jaarbeurs
Travel information about trains	11	58	15
Where are the bus stations?	10	7	9
Travel information about buses	3	2	5
Where are (rental) bikes?	3	0	0

45 foreign travelers who did not speak Dutch asked questions at the information booths, especially in the middle and Jaarbeurs part of the station, as seen in table 5. An office with information about international trains was situated at the city center side of the station. It is possible that people at the city center side were more likely to go there directly than to go to the general information booth, whereas at the other sides the people who spoke a foreign language needed to be guided to this office. These results are consistent with the results found in the first study, where a few people said that the signage is only in Dutch and that they can be difficult to understand for someone who does not speak Dutch.

Some people had questions about NS products, like different subscriptions, their OV Chipkaart (The OV-chipkaart is the payment method for public transport in the Netherlands),

or to check their balance. These results are shown in table 5. Most of these answers could be found at the service machines, which are located throughout the station. The people who asked these questions could have missed these machines, or just wanted a quick answer. The questions about NS products were most asked at the middle of the station, and less at both ends. This could be because at both end of the station there was also a ticket and service store, which was not available in the middle. It is possible that people were more inclined to go there, instead of going to the information booth.

There were also a lot of questions at both ends of the station about the surrounding area, as seen in table 5. Most asked questions about the location of certain buildings and how people could get there fastest. People also asked for maps of Utrecht, but after receiving the map they frequently had trouble locating themselves on that map and needed help from the employee inside the information booth. A possible explanation why these questions were asked less at the middle of the station is because the information booth at the middle of the station was inside of the gates and people needed an OV Chipkaart to get there. These findings are consistent with the first study, which revealed that people had trouble with differentiating the Jaarbeurs and the city center side.

The last topic was about the different facilities at the station, such as lockers, toilets and ATM's. These questions were asked most at the Jaarbeurs side and the middle of the station, as seen in table 5. This is probably because most of the facilities are at those two locations. The toilets are almost directly behind the information booth in the middle of the station, even though people still needed to ask where it is. The lockers are located at the upper level of the station. These findings are an addition to the first study, as the interviews did not contain questions about the different facilities at the station.

Table 5.

List of question topics and how many times they were asked, in the three locations of the information booths, and with a minimum frequency of 3 questions.

Topic	City Center	Middle	Jaarbeurs
Question asked in a foreign language	8	21	16
Information about NS products	7	13	9
Check-in/check-out problems	8	9	11
Surroundings question: City Center	7	2	5
Other: Found or stolen items	1	4	3
Costumer asks question about travel planner on own phone	2	2	1
Station facilities: Lockers	1	1	2
Station facilities: Toilet	0	0	3
Station facilities: Shops	0	1	2
Station facilities: Photo booth	1	1	1
Station facilities: ATM	1	1	1

Conclusion

The results from the second study are consistent with the results from the first study. The specific questions that the travelers had is indicative of a probable larger issue. Because there were several people who had questions about a subject, there is probably something unclear about this subject in general. The reason why it was unclear may be due to the layout of the station. The questions travelers asked were about the following aspects: keeping apart the different sides of the station, finding busses and information about them, understanding signs if someone does not speak the native language, and the placement of the signs. The second study also revealed new insights, for example, that the different facilities at the station are also hard to locate.

6. Discussion

Designing a good and functional wayfinding system for a busy and big area is a difficult but important task. There are many different kinds of people to consider, who all have different wants and needs. In this study the signage at Utrecht Central Station was studied in two different ways, by interview and observation. Five themes were identified, namely locating and orienting oneself inside the station, locating the correct bus stations, the placement of the signs, trouble with Dutch signs, and locating different modes of transport.

People use landmarks to navigate, some were not visible from inside the station, which is probably why people had such trouble finding certain places. There should be enough natural and artificial landmarks for people to locate themselves, and certain destinations.

It is also important to make the signage for different kinds of transportation distinctive and recognizable. In this study it was found that the signage for the bus was confusing and not informative enough, if the design was different from the general signs it might have been recognized more easily.

Information about departure times should be displayed on a clear and big enough sign. This also means that there should not be too much information, because then it can become confusing. Signs should also be placed on common walking routes at the station, so people do not walk past them or have to actively look for them while navigating the station. Wayfinding should feel natural and easy.

Information booths should be placed at multiple, practical locations. They should also have clear, and informative signs on what kind of information can be provided there.

6.1 Implications

The results from this study are consistent with findings found in previous research. The first result that was consistent with theory is that people rely on plan configuration and scenes that might contain spatial landmarks and properties (Baskaya, Wilson, & Özcan, 2004). In this study, where there were no recognizable or visible landmarks, the interviews revealed that people had difficulty finding certain locations or trouble locating themselves.

A second result that was consistent with the theory, was that older adults may have more trouble with wayfinding than younger adults (Bosch, & Gharaveis, 2017). In the interviews, a distinction was made between young adults, adults, and older adults. The older adults had the most trouble with the digital signs, and the placement of the signs. For this group it is very important that they can see and understand the signage, as they depend a lot on public transport and tend to make more wayfinding errors (Newman and Kaszniak, 2000).

There is a lot of focus on studies at hospitals and airports because these are big and busy areas (Morag, Heylighen, & Pantheon, 2016), but not a lot being done at train stations. The big interesting difference between hospitals, airports, and trains stations is that train stations are places with multiple forms of transportation, many different kinds of people, and people with different goals, destinations, and knowledge about the area. That is why this study can contribute new ideas to the field of wayfinding, as it looks at a different kind of area than other studies.

Recommendations and advices are given in this study to avoid certain pitfalls. For example, how different of travelers should be taken into account, such as international people who do not speak the native language. This might be a problem for immigrants who do not speak the language yet, international students or professors who study and teach at the Utrecht University. Only having Dutch signage might not be that big a problem for other mobility hubs in other cities, where only Dutch people live. Nonetheless, international

travelers should be able to correctly interpret the signage and understand how to get to their destination.

Another example are students, who have other needs than people who travel for work. They possibly use different vehicles, such as a bus instead of a car, and also need good signage and information to get to that vehicle. Signage at places with a lot of transportation options should be clear and easy to follow, so, for example bus routes to the bus stops should be distinguishable from routes to different transportation modes.

6.2 Limitations

The results of this study could contain reliability errors. There could be a sampling bias as the interviews were only done on people that were standing still and therefore had time to participate. These people might not have been representative for people who visit mobility hubs, because they mostly transferred from train to train, and not to other modes of transport. A sampling bias might have also occurred because the interviews and observations were only done Monday through Friday, but not on the weekends. It could be that there are other kinds of travelers on the weekend than during the week, people that usually do not come to Utrecht but visit the city only occasionally. The people who visit the station less often are also the ones with more trouble with the signage, so it might be interesting to study wayfinding in the weekends.

Another possible problem is that people's opinions are subjective and changeable. The experience that people have is a complex phenomenon, the image that people have of a place is the result of a continuous interaction of all the ideas, opinions and experiences that one has or gets from others.

A second problem with the first study might be that the interview questions did not measure the construct of wayfinding and navigation correctly or fully. If there was more time

to conduct the interview, it might have given more insights as more questions could have been asked.

A problem with the second study is that not all questions could be understood correctly because of the distance that had to be taken from some of the employees who did not want the observer too close. Another problem was that not all locations were observed at all times during the day. There might be some information missing from the Jaarbeurs side, because no observations were done during rush hour. The observations were conducted on a small scale and may lack a representative sample (biased in relation to age, gender, social class or ethnicity). This might have resulted in the findings not being generalizable to wider society. Natural observations are also less reliable than other more controlled observations as other variables cannot be controlled (McLeod, 2015). This makes it difficult to replicate the results.

6.3 Recommendations

Based on this study, a few recommendations were made that could benefit Goudappel Coffeng and the municipality of Utrecht in improving the designs for future mobility hubs and help NS with improving their stations. The first is making good use of natural landmarks because people use them to locate themselves. Therefore, make sure that natural landmarks are visible from within the building or area. The second recommendation is to ensure that artificial landmarks are visible and recognizable, so people are able to use them and not accidentally overlook them. A third recommendation is to make signs that are not too small, and that there is not too much information on them. People have to be able to read and understand them quickly as they walk by.

The signs also need to be understandable by everyone, that includes travelers who do not speak the native language. A possible solution to only having signs in Dutch is putting

color coded stripes on the ground, paired with icons to give context to the stripes, that lead to different locations or directions. This way the foreign travelers do not need the signs to orient themselves.

Another recommendation is having the signs for different modes of transport in different colors, so they are easily distinguishable. That way you can also color code the signs and follow them to your desired method of transport. If you accidentally make a wrong turn, you will not see the colors of the signs that you were following before and you will know that you are going the wrong way and retrace your steps until you see the right color signs again. A second addition to signage might be interactive displays with a floor plan, travel planner, and possible MaaS (e.g. Mobility as a Service) services. This display is a possible solution for people who do not have a smartphone or internet or prefer to use a big screen to navigate.

Future research might look at other stations in The Netherlands to see if the results found in this study can be generalized to stations across the country, or if the identified problems are only relevant at the station in Utrecht. It might also be interesting to compare the results this study at Utrecht Central station to a smaller station that still has multiple mobility options to see if the same problems still occur, or if a smaller station/hub has other problems.

In conclusion, all travelers should be able to make use of the signage and reach their desired destination. Especially vulnerable groups like older adults and people who rarely visit the station should be taken into account when designing a mobility hub. In the future, especially with automated and connected transportation services, it is vital to ensure a good wayfinding system to provide a safer environment for all mobility hub users.

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Appendix 1

List of interview questions in English:

- What is your age?
- How often do you visit Utrecht Central Station?
- With what purpose do you visit the station today?
- With what kind of transportation did you come here today?
- How will you continue your journey?
- What do you think of the current signage for the different kind of transportation and services at the station?
- What do you like about the current signage?
    - This question was removed after day 2 because of the lack of different answers.
- Do you miss certain information on the current signage?
- Do you have trouble keeping apart the different sides of the station, the Jaarbeurs and city center side?
    - This question was added after day 2 because of the recurrence of the problem in previous interviews.
- If you could come up with completely new signage system, what kind of system would that be?
    - This question was removed after day 3 because people had trouble coming up with new systems in the limited time for the interview.
- What would you think of stripes on the floor indicating different services or sides of the station?
- If there would be an interactive display with floor plan, information about the area, and a travel planner, would you use it?
- Did you have trouble finding the newly relocated bus station?
    - This question was added after day 2 because a lot of people indicated that they had trouble with this, I wanted to get a more in-depth view of this problem.

If participants still had time, extra questions were asked:

- Do you know where you could rent a rental car in the station area?
- If yes: Where can you find this information? If no: Where would you look for this information?
- Do you know where you can find rental bikes and bicycle parking in the station area?
- If yes: Where can you find this information? If no: Where would you look for this information?
- Do you know where you can find trams in the station area? Where can you find this information?
    - This question was removed after day 2 because no one had trouble finding the tram, as there is only one location where it is. As opposed to buses and bike parking, that are available in multiple locations.
- Do you know where you can find buses in the station area?
- If yes: Where can you find this information? If no: Where would you look for this information?

List of interview questions in Dutch:

- Wat is uw leeftijd?
- Hoe vaak per week of per maand komt u op Utrecht Centraal?
- Met welk doel komt u vandaag op Utrecht Centraal?
- Met wat voor vervoersmiddel bent u hier vandaag gekomen?
- Hoe gaat u nu uw reis verder vervolgen?
- Wat vind u van de huidige informatievoorziening voor de verschillende vervoersmogelijkheden en voorzieningen op het station?
- Wat vind u goed aan de huidige informatievoorziening?
- Mist u nog bepaalde informatie binnen de huidige informatievoorzieningen?
- Heeft u problemen met het uit elkaar houden van de Jaarbeurs en de centrumzijde?
- Als u zelf volledig nieuwe informatievoorziening mocht bedenken, wat voor soort informatievoorziening zou dat dan zijn?
- Wat zou u vinden van strepen op de grond die bijvoorbeeld verschillende vervoersmiddelen of de zijdes van het station aangeven?

- Denkt u dat als het op het station een interactieve scherm met bijvoorbeeld een plattegrond, reisplanner en wat informatie over de omgeving zou staan, dat u die dan zou gaan gebruiken?
- Heeft uw problemen gehad met het vinden van de recent verhuisde bushaltes aan de centrumzijde?

- Extra vragen als er tijd is:
- Weet u waar u in het stationsgebied een huurauto zou kunnen huren?
- Zo ja: Waar kunt u deze informatie vinden? Zo nee: Waar zou u deze informatie gaan zoeken?
- Weet u waar u in het stationsgebied OV huurfietsen en fietsenstallingen kunt vinden?
- Zo ja: Waar kunt u deze informatie vinden? Zo nee: Waar zou u deze informatie gaan zoeken?
- Weet u waar u in het stationsgebied trams kunt vinden?
- Zo ja: Waar kunt u deze informatie vinden? Zo nee: Waar zou u deze informatie gaan zoeken?
- Weet u waar u in het stationsgebied bussen kunt vinden?
- Zo ja: Waar kunt u deze informatie vinden? Zo nee: Waar zou u deze informatie gaan zoeken?

Appendix 2

Graphs of pattern analysis, percentage of people per category who said something about a certain issue.

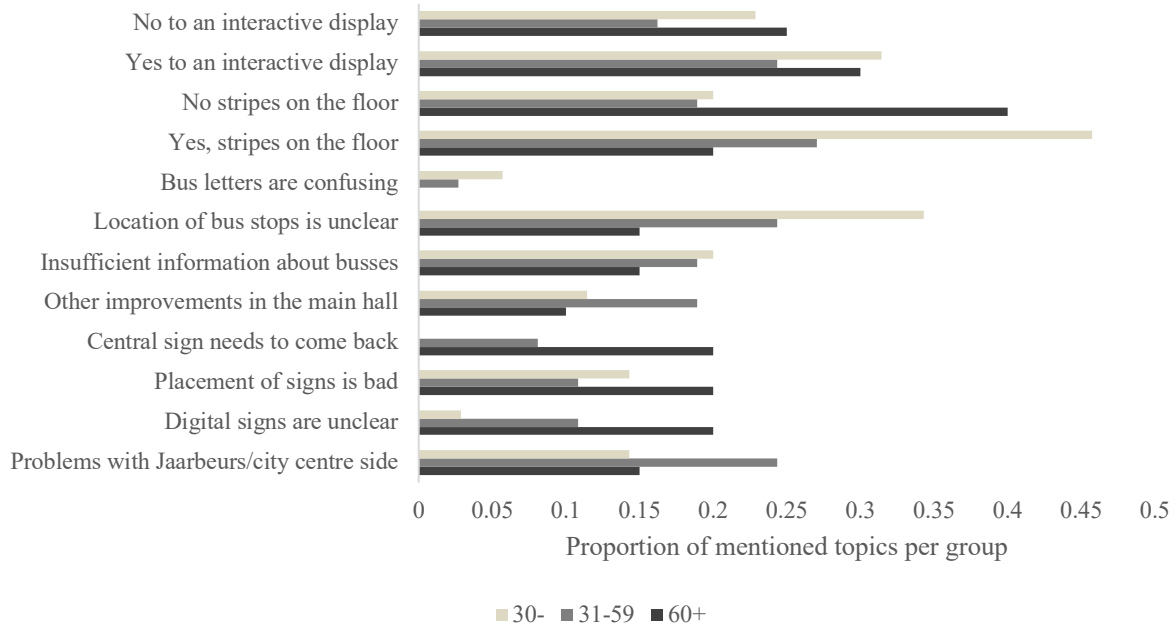

Figure 9. Percentage of people of different age categories who said something about the issues from the thematic analysis.

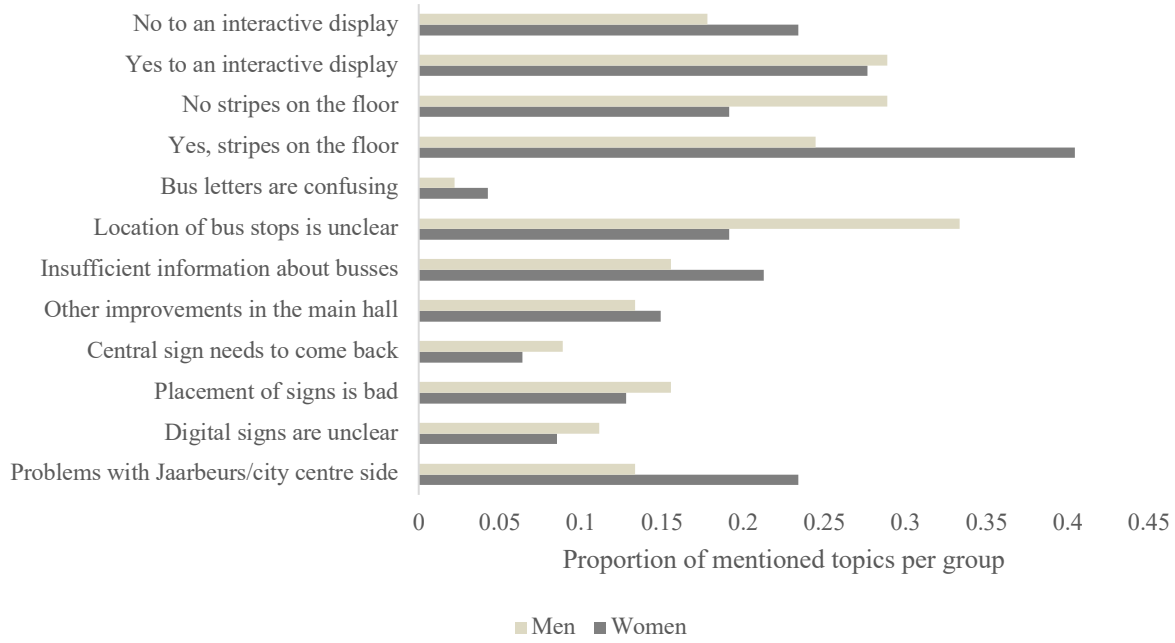

Figure 10. Percentage of men and women who said something about the issues from the thematic analysis.

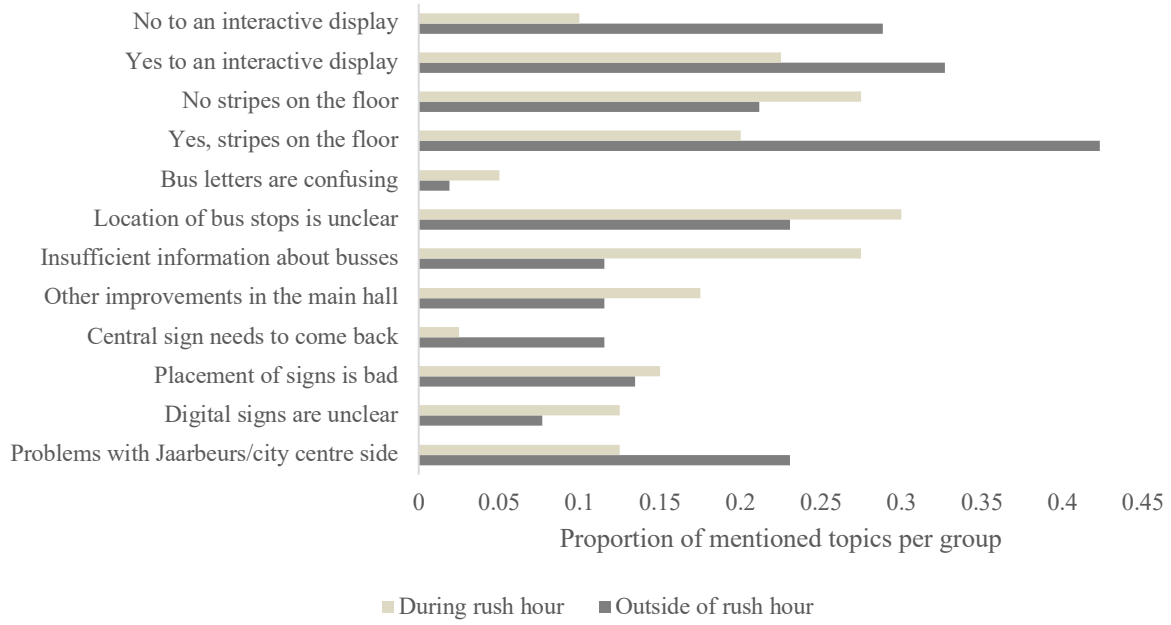

Figure 11. Percentage of people who were at the station during or outside of rush hours, and who said something about the issues from the thematic analysis.

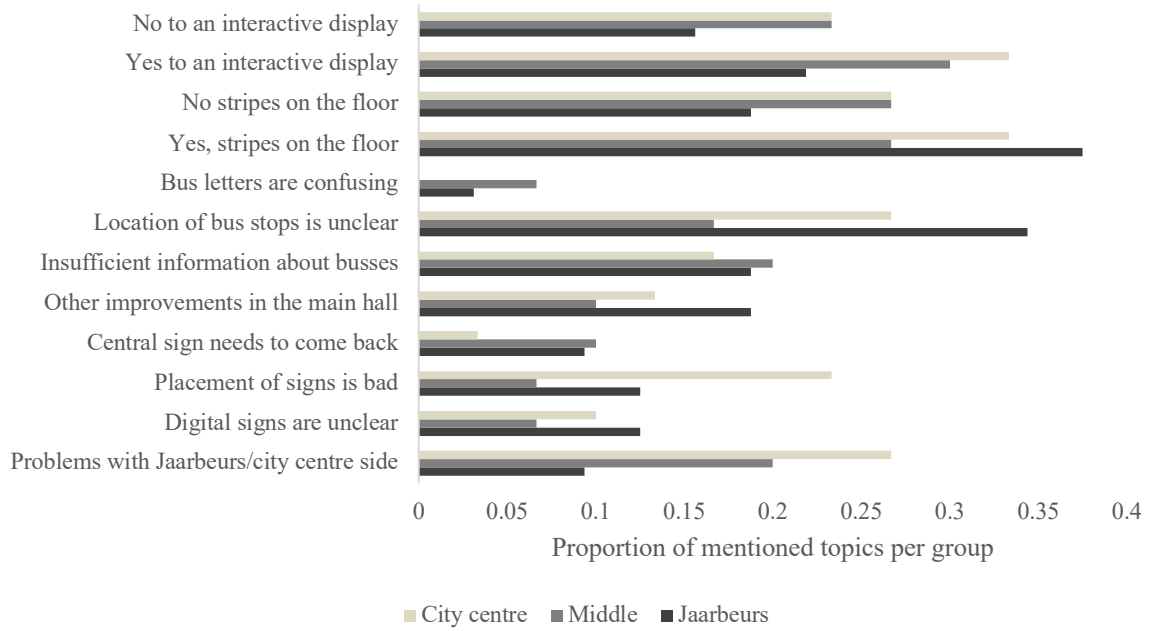

Figure 12. Percentage of people at the different locations of the station, who said something about the issues from the thematic analysis

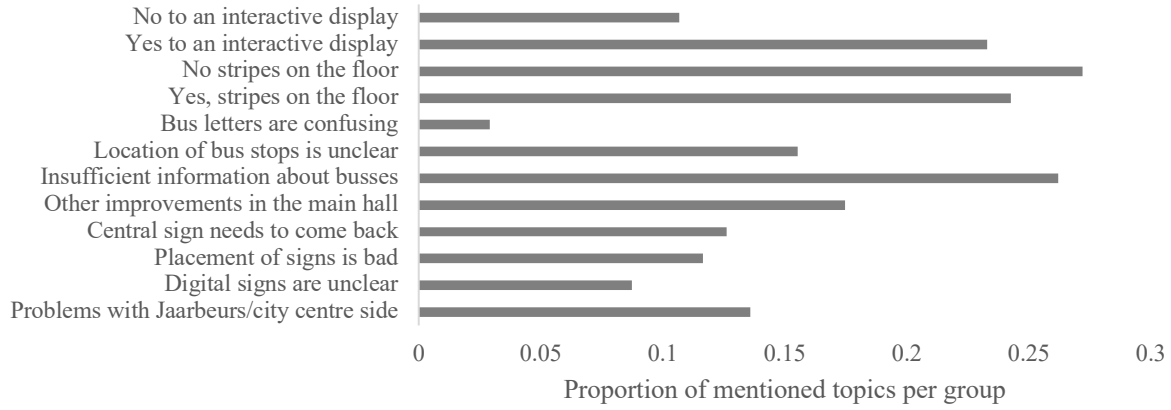

Figure 13. Percentage of people that travel by train, who said something about the issues from the thematic analysis.

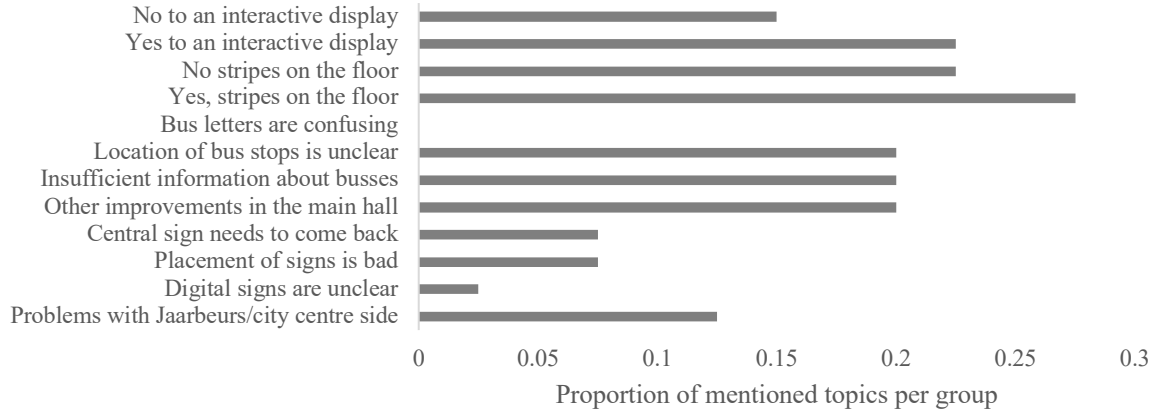

Figure 14. Percentage of people that travel by bus, who said something about the issues from the thematic analysis.

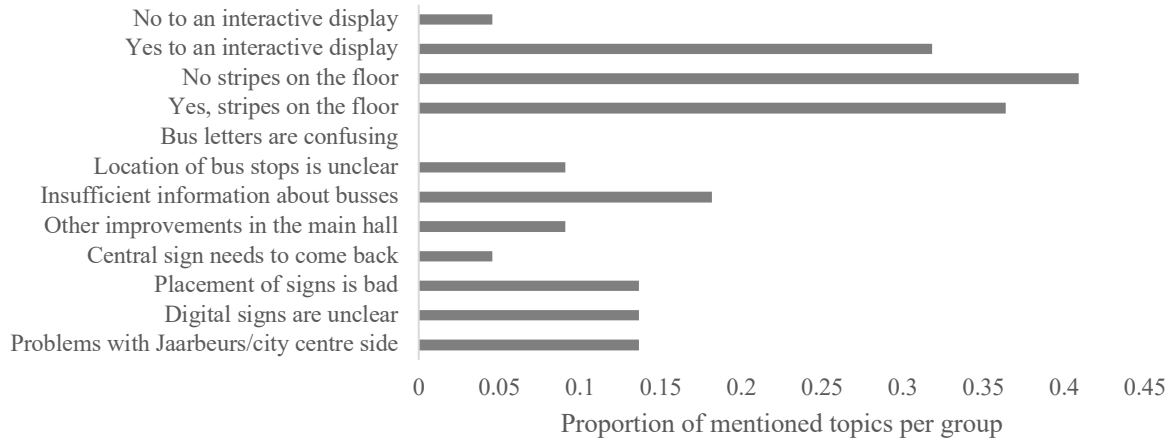

Figure 15. Percentage of people that walk to or from the station, who said something about the issues from the thematic analysis.

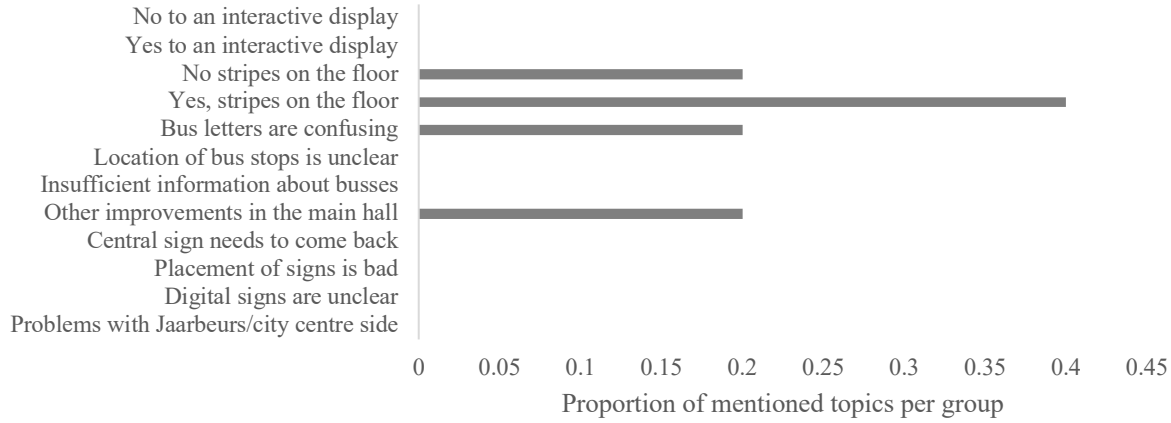

Figure 16. Percentage of people that travel by tram, who said something about the issues from the thematic analysis.

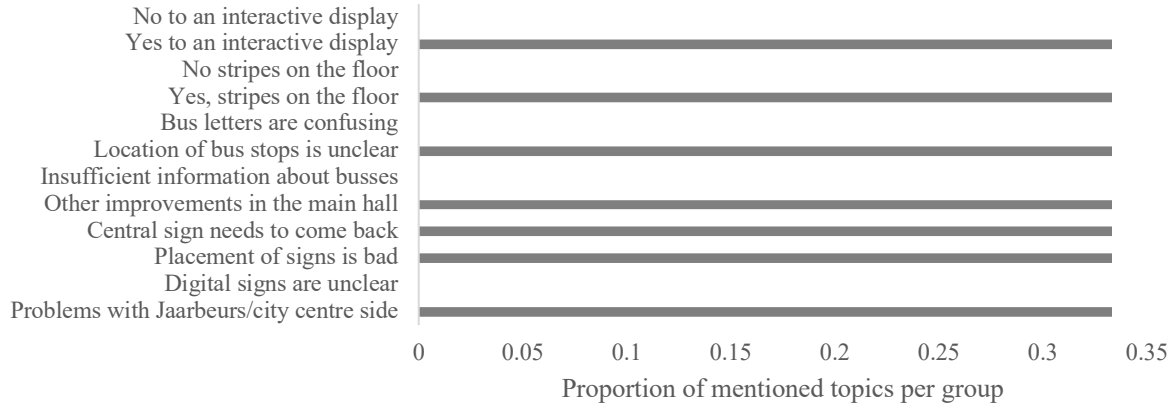

Figure 17. Percentage of people that travel by car, who said something about the issues from the thematic analysis.

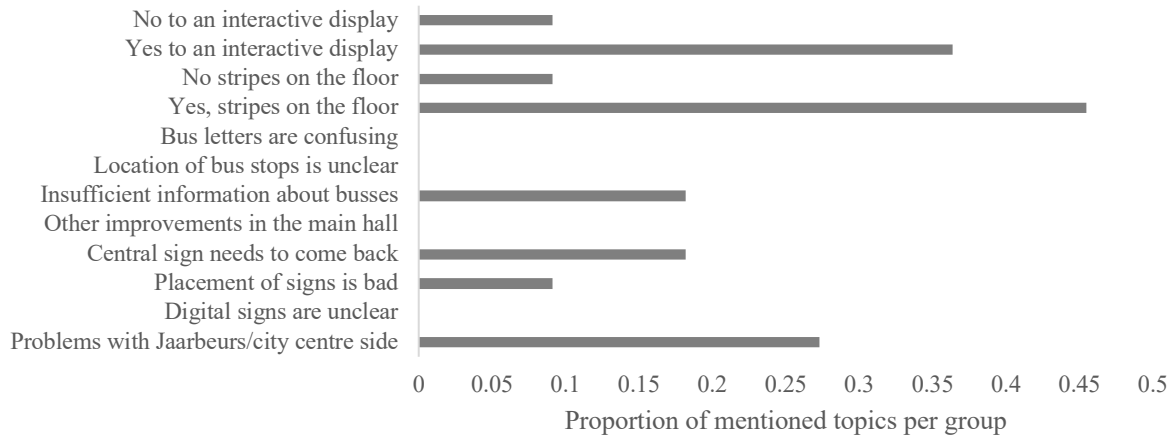

Figure 18. Percentage of people that travel by bike, who said something about the issues from the thematic analysis.

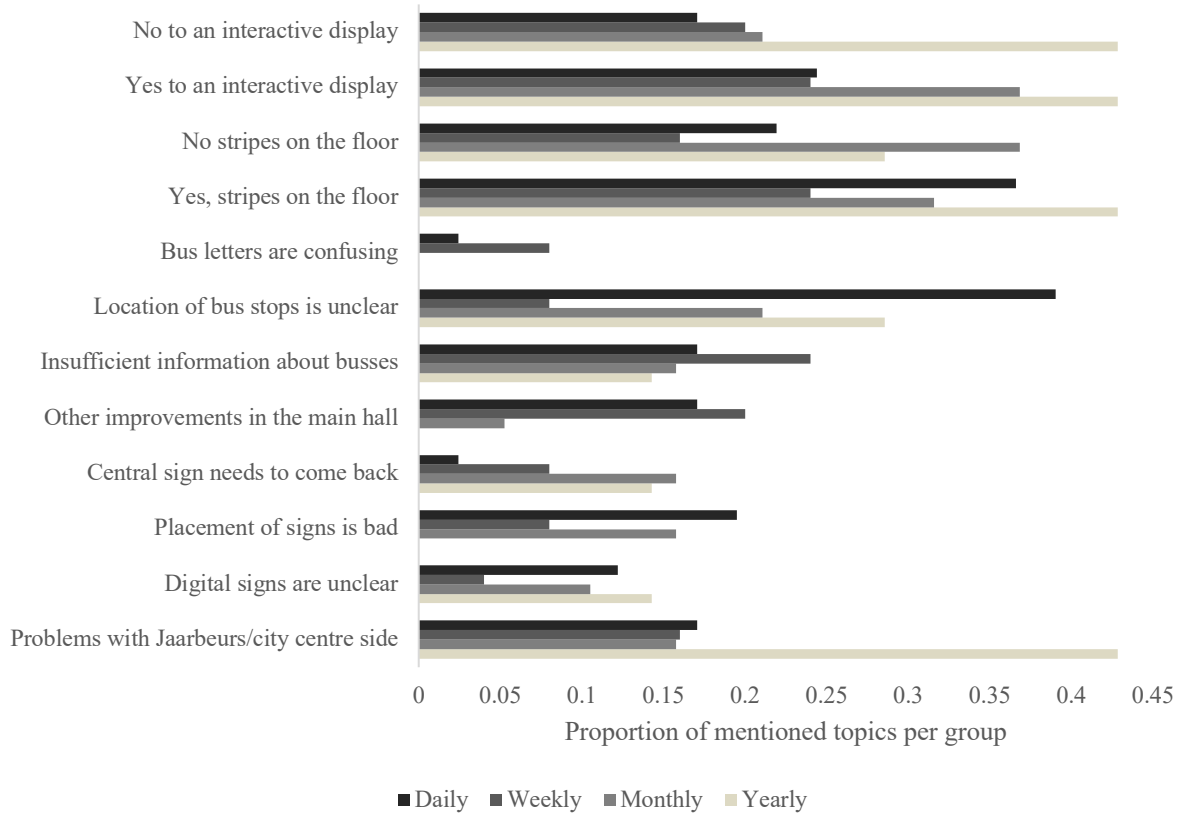

Figure 19. Percentage of people that visit the station at different frequencies, who said something about the issues from the thematic analysis.

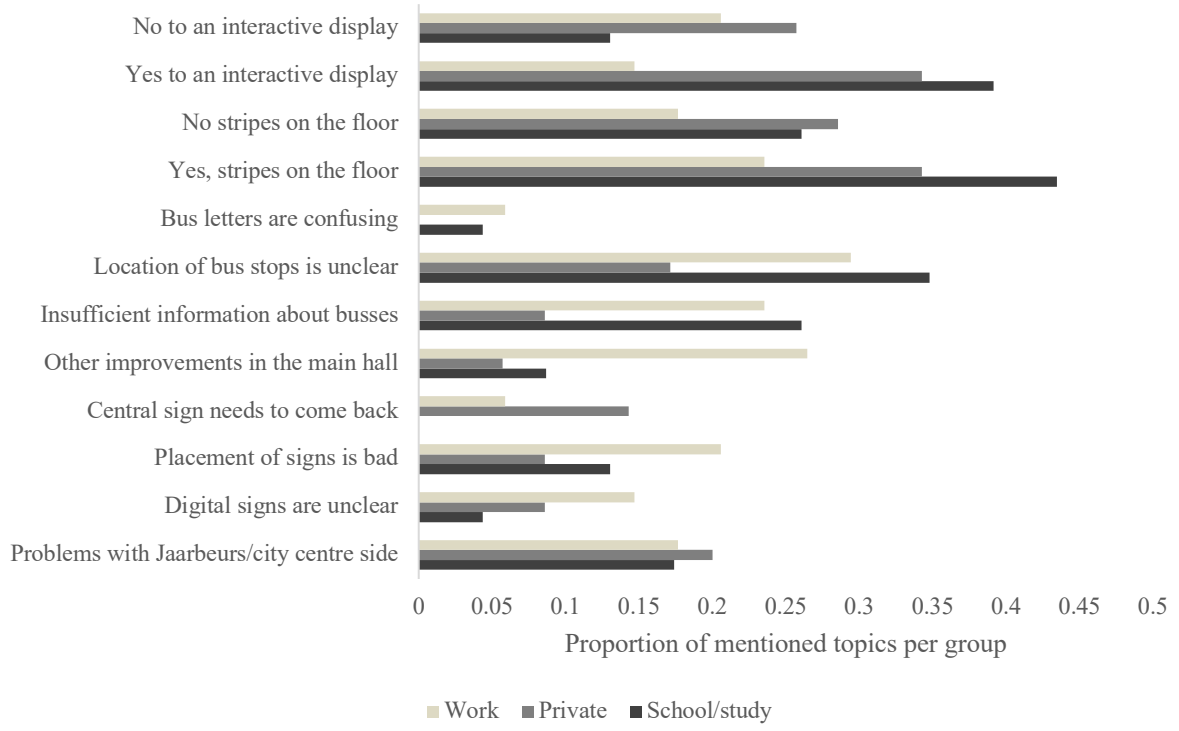

Figure 20. Percentage of people that visit the station for different reasons, who said something about the issues from the thematic analysis.

Appendix 3

List of topics used in study 2 and how many people asked a question that fell into that topic, and what location of the information booth this was at.

Topic	City Center	Middle	Jaarbeurs
Travel information about trains (platform/departure time)	11	58	15
Foreign language	8	21	16
Information about NS products (subscription, balance, etc)	7	13	9
Check-in/check-out problems	8	9	11
Where are buses?	10	7	9
Surroundings question: City Center side	7	2	5
Travel information about buses	3	2	5
Other: Found or stolen items	1	4	3
Costumer asks question about travel planner on own phone	2	2	1
Station facilities: Lockers	1	1	2
Station facilities: Toilet	0	0	3
Station facilities: Shops	0	1	2
Station facilities: Photo booth	1	1	1
Station facilities: ATM	1	1	1
Where are (rental) bikes?	3	0	0
Surroundings question: Jaarbeurs side	1	0	0
Surroundings question: Map of Utrecht	0	0	1
Surroundings question: Travel Office	0	1	0
Other: Help handicapped people	0	1	0
Other: Police questions	1	0	0
Travel inforamtion about (rental) bikes	1	0	0
Station facilities: Money exchange	0	1	0

Station facilities: Charging station	0	1	0
Other: Mechanic	0	0	0
Travel information about (rental) cars	0	0	0
Travel information about trams	0	0	0
Where are (rental) cars?	0	0	0
Where are trams?	0	0	0