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Identifying Attributes relevant for Route Choice in Public Transport

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Markus Sommer
Matrikelnummer 0525129

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Betreuung
Betreuer: *Univ.-Prof. Mag.rer.nat. Dr.rer.nat.* Georg Gartner
Mitwirkung: *Dr. Haosheng* Huang

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Markus Sommer
Feuerwehrgasse 1/3/7, 7083 Purbach

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Kurzfassung

Routenplaner sind heutzutage in vielen verschiedenen Geräten verfügbar. Es gibt eine Menge von Online-Tools, viele neue Autos haben ein Navigationssystem eingebaut und beinahe jedes Smartphone hat eine Navigationssoftware installiert. Im Gegensatz zur Personalisierung in anderen Bereichen des Internets liefern Routenplaner größtenteils noch immer jedem Benutzer die gleiche Route. Während diese Routen zwar technisch korrekt sind, berücksichtigen sie jedoch keine individuellen Präferenzen.

Diese Diplomarbeit untersucht die Attribute von Stationen im Netz der öffentlichen Verkehrsmittel die für einen Menschen relevant sind bei der Entscheidung für eine Route. Die Attribute werden in einem ersten Schritt mit Hilfe einer Focus Group ermittelt. Danach werden sie als objektiv oder subjektiv kategorisiert. Ein besonderes Augenmerk gilt den subjektiven Attributen, da davon auszugehen ist, dass sie einen erheblichen (unterbewussten) Einfluss auf die Routenplanung haben. Abschließend wird die Bedeutung jedes Attributes durch einen Online-Fragebogen bewertet. In diesem Fragebogen werden die Teilnehmer mit verschiedenen Situationen konfrontiert so dass der Unterschied der Bedeutung der einzelnen Attribute festgestellt werden kann.

Einige wichtige Ergebnisse sind die Bestätigung, dass Routen-Entscheidungen tatsächlich von vielen verschiedenen Faktoren beeinflusst werden. Eine große Anzahl an Attributen wurde festgestellt und von den Teilnehmern bewertet. Zwölf dieser Attribute wurden in mehr als 20% der Fälle als wichtig ausgewählt. Unter den gefundenen Attributen befinden sich einige die als subjektiv bezeichnet werden können und die daher nicht so einfach zu messen sind.

Abstract

Route planners are available in a variety of devices today. There are a lot of online tools, many new cars are equipped with navigation systems and almost every smartphone has some sort of navigation software installed. Contrary to all the personalization elsewhere on the internet route planners still provide, for the most part, the same route to everybody. While those routes are technically correct they don’t take individual preferences into account.

This thesis investigates the attributes of stations in the public transport system that are relevant for a human being when making routing decisions. The attributes are determined in the first step through a focus group. After that they are categorized as objective or subjective. Subjective attributes are of special interest since they are believed to have a substantial (subconscious) influence on route choice. Finally the importance of each attribute is rated by the use of an online questionnaire. In this questionnaire the participants are presented with several trip purposes so that the difference of the importance of certain attributes can be evaluated.

Important findings involve the confirmation that routing decisions are indeed influenced by a lot of different factors. A large number of attributes was discovered and rated by the participants. Twelve of those were selected as important more than 20% of the times in the survey. Among the determined attributes are quite a few that can be seen as subjective and are therefore not that easy to measure.

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1.Introduction

In the 21st century it is no longer a problem to find a way from one location to another. With the help of GPS satellites it is possible to detect the exact location of a ship or a vehicle. With additional information about the road or railway network we have all the information necessary to determine the fastest route from A to B. In essence the calculation of the best route comes down to a mathematical problem: Finding the shortest path in a graph.
The problem with this approach is that it assumes that every person has the same needs. Whether you are a business person or a tourist, you would always get the same route. In a time where everything can be customized to personal preferences it seems odd that we would all be presented with the same route.
Many websites use information about the user to customize the information they present to him/her. The start page of Amazon.com will look different for every user depending on what he/she was searching for or what he/she bought. Also the results returned by Google will be different depending on what is known about the user.

The science of navigation focuses heavily on different techniques to present a route. Many improvements of car navigation systems were simply better ways to present a route to the driver. As for the route itself it is often assumed that everybody wants the shortest/fastest path. As stated by Golledge (1995) “Traditionally, the path selection problem has been ignored or assumed to be the result of minimizing procedures such as selecting the shortest path, the quickest path or the least costly path” [16, p. 1]. While this is a valid approach to get a technically correct result, it may not be what every user expects. In a certain context we may not want the fastest route but something else that fits our current situation better.

1.1. Goal

The goal of this thesis is to determine the factors that are relevant when making route choices. In current route planning systems only time and distance are used to calculate routes. Research suggests though that humans take several other factors into account when choosing a route [16] [15] [2] [5]. To identify these factors a

combination of qualitative research methods (focus group) and quantitative research methods (survey) are used to get an understanding of what is important to a person when he/she makes routing decisions. Specifically the attributes of stations of the public transport system are investigated. Of particular interest are comparisons of paths that are almost equal in distance. Here it will be possible to determine what makes the difference between two seemingly identical routes in terms of distance.
Furthermore the determined factors will be categorized as objective or subjective. The question here is whether subjective factors are relevant for making route choices when compared with the objective factors.

1.2. Methodology

A focus group is used to determine the factors, or more precisely the attributes of stations, that influence routing decisions. It is a proper choice especially when little is known about the research area. After the attributes are clear the next task is to rate them according to their importance. For this an online survey is used as it represents an easy way to reach a lot of people. Based on the results of the survey a weight can be established for each attribute of a station. It is also possible to eliminate certain attributes that were found in the focus group but don't seem to be relevant to a greater number of people. Similarly it offers another chance to determine more attributes that were missed in the focus group.

1.3. Structure

Chapter 2 gives an insight into the research field of navigation. Chapter 3 deals with route choice, how humans make routing decisions and what role subjective information plays. Chapter 4 explains the setup of the empirical test. What is the network for the route calculations? Who are the participants? In chapter 5 the results of the empirical test and conclusions based on them are presented. Finally chapter 6 provides a summary and an outlook.

2. Navigation

The term “navigation” developed in the 16th century [52]. It is derived from the Latin word navigare (“to sail”). This already hints that navigation was the art of maneuvering a ship over the ocean. As the word “art” implies, it was no easy task. In order to be able to navigate accurately one has to know two things: The current location and how to get from the current location to the destination. The first problem was solved by using objects in the sky. Celestial navigation uses certain stars or planets to determine an accurate position on an ocean that provided little other points of reference [22].

Today of course the term navigation is not limited to the naval sector anymore. Whereas in former times it was a matter of reaching faraway places, we are now dealing with the same problems also for much shorter distances. With an increasingly complex network of streets and railways it is hard to navigate even within a city. Because of this it was necessary to develop systems that would help with the navigation.

Modern navigation systems consist of three components: positioning, route planning and route communication [25]. The first navigation systems only considered the first part [21]. The goal was simply to get an accurate position. In order to do this they used radio signals of several sender stations. Because of the time differential when the signals reach the receiver, the position can be calculated. The first two meaningful systems of this kind were LORAN-C and DECCA. Both of which were developed during the Second World War. Later on they were mostly used for maritime navigation.
The first GPS enabled car navigation systems were developed in the early 1990s. But it wasn’t until the year 2000 that these systems were affordable for a larger part of society. Their popularity increased also because of the decision by the US military to enable high precision positioning for civilian purposes.

Today’s navigation systems rely almost exclusively on GPS satellites [21]. In addition to determining the current location, they can also calculate a route to the destination.

This way it is possible to find places even in an environment that is totally unknown to the traveler.

2.1. Positioning

The first task when trying to navigate is to determine the current position. Without it we cannot relate where we are at the moment to the destination. In ancient times people were looking for markers like trees or wall paintings to tell them where they are and where they have to go next. The problem of determining one's current position became especially important once people started to travel the oceans.

One option would have been to only sail along the shorelines so that land is always in sight. But this has two major downsides. First it takes a lot longer than just taking the direct route. And second it is not always possible because of dangerous coastlines and the risk of running aground. So the only alternative was a technique that would let the sailors determine their position anywhere on the ocean without any land in sight. The only things that are visible everywhere on earth are stars and planets. This type of navigation, which relies on any kind of objects in the sky, is called celestial navigation.

2.1.1. Celestial Navigation

This type of navigation uses angular measurements between celestial objects and the visible horizon to determine the current position [22]. Such objects are planets, the sun or other stars. Usually a sextant is used to calculate the angle. With this technique it was possible to determine the local apparent noon and then compare the local time to a reference time, which is usually the Greenwich Mean Time GMT. (Or Coordinated Universal Time UTC as it is called today) Obviously, one needs a very accurate clock that doesn't deviate much from the actual time of the reference point. Today of course this is not a problem but in the 18th century it was a big hurdle which was ultimately overcome by the invention of high precision clocks called chronometers.
Before these high precision clocks were available another method called "Altitude-intercept method" was used. Here the angle between the horizon and a celestial object is taken. After some calculations a line of position can be drawn on a map. This is actually a circle where the observer is located at some point on that circle. By measuring another object from the same position one could draw a second line. The position of the observer is at one of the two intersections of the circles. Which one is the correct position is usually obvious since they are far apart.

2.1.2. GPS

The most important technique today to determine one's current position is the Global Positioning System or GPS. It was originally developed by the US military for the accurate calculation of the position of vehicles, battle ships or planes [20]. In 1995 it went fully operational. In the first years civilian users could only receive an artificially degraded signal that was only accurate to about 100 meters. It was only after this "Selective Availability" was turned off that GPS could be used for accurate civilian navigation.

The basic idea of GPS positioning is based on the triangulation of at least three satellite signals [24]. The satellites send coded information to the receiver. With this information the receiver can calculate the distance to each satellite. Basically GPS is a timing system, in that it calculates the time it takes for a signal to reach the receiver. It can then create imaginary spheres around each satellite. The point where all those spheres intersect is the location of the receiver. If at least four satellite signals are received it is possible to calculate 3D coordinates. With only three signals only 2D positioning is possible. The accuracy of GPS today is around 3 meters [36].

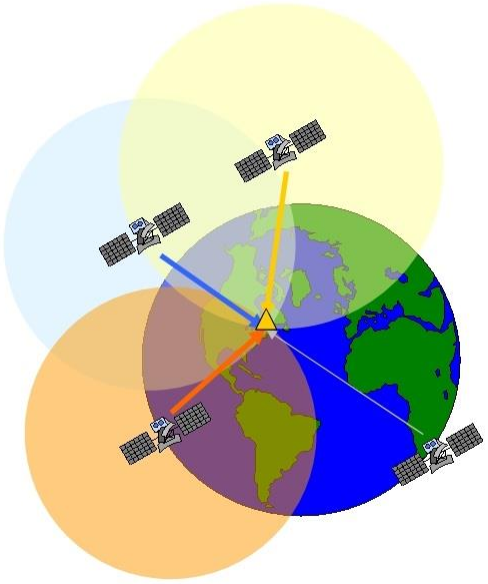

Figure 1 – GPS Triangulation (www.sxbluegps.com)

GPS positioning is used in all kinds of devices today, most notably in car navigation systems. In recent years it has also found its way into smartphones and thereby enables users to navigate also when walking. GPS receivers can also be found in the latest generation of digital cameras. Here it is used to determine exactly where the picture was taken. For obvious reasons it cannot be used to determine a position within a building. For indoor navigation technologies such as WiFi networks or RFID are used.

2.2. Route Planning

Route planning is the process of calculating a route from one position to another. On the ocean or in the sky this is fairly straight forward. One only has to draw a line from the start to the destination. It gets more complicated when a network of roads or railways is involved. Such a network can be modeled as a graph. Every intersection

or stop is represented by a node and every street or connection between two stops is represented by an edge. The shortest path from one point to another is then a minimization problem. Route planning software has been used by booking agents in the travel industry since the 1970s [23]. With such a software tool it was a lot faster and easier to calculate the shortest route between two places. Most route planning software is based on Dijkstra's shortest path algorithm [13].

2.2.1. How does a computer make routing decisions?

Shortest path queries are among the most frequently used queries in geographical information systems [7]. As stated above most route planning software uses Dijkstra's algorithm at least as a basis for the calculation of a route.

Every node has three attributes [10]:

- Distance – the current shortest distance from the source to this node
- Visited – boolean which is true if the node has been visited already
- Predecessor – The predecessor of the node in the shortest path

The initial distance of all nodes except the source node is infinity (∞). The source node, of course, has a distance value of 0. Now the distance values for all neighbors of the source are calculated. If this value is smaller than the current value of the node then it is overwritten with this new value. Once all neighbors have been evaluated, the source node is marked as visited. A visited node will not be evaluated again; its distance value is minimal. Now the unvisited node with the smallest distance is selected as the new "current" node and the process is repeated. The algorithm stops once the destination node has been marked as visited. Because of the predecessor attribute the shortest path from source to destination can be constructed once the algorithm has finished.

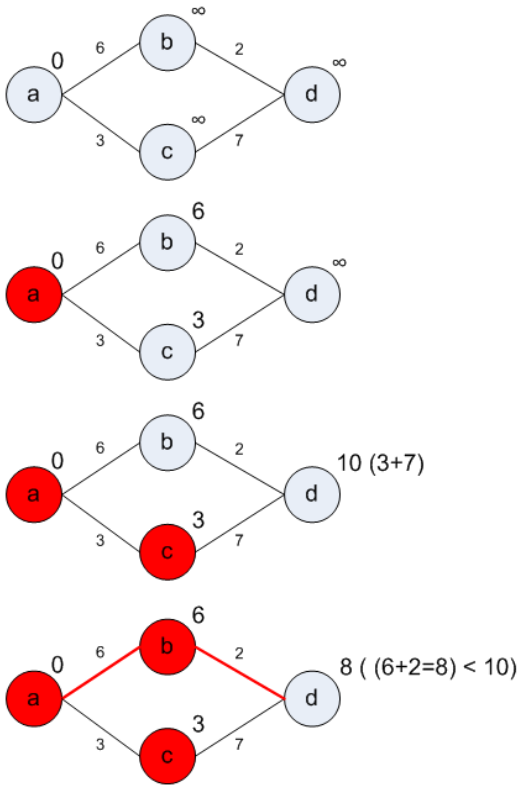

Figure 2 - Dijkstra Algorithm Example

The biggest downside of Dijkstra's algorithm is that it assumes that the entire graph can be stored in the main memory [7]. So if the graph is too large it cannot be

handled by Dijkstra. To address this problem, other algorithms have been devised which can handle very large graphs. They do this by partitioning the graph into smaller graphs and processing the entire network incrementally. While these algorithms deal with the problem of very large graphs or even improve the runtime they all essentially work very similar to Dijkstra's algorithm.

Looking at the most popular online services for route planning it becomes clear that they mostly rely on finding the fastest route which is calculated with the help of Dijkstra's or a similar algorithm. Some planners like ViaMichelin [53] are strongly focused on car trips. Therefore a lot of additional options are provided that let the user choose to avoid tolls or favour highways. On ViaMichelin there is also an option for the "Discovery" or "Sightseeing" route which will take certain points of interest into account. Other planners offer similar additional options.

2.2.2. How does a human being make routing decisions?

As we have seen in the previous section, the route planning used in navigation systems (e.g. car navigation systems) is basically a solution to the question: What is the shortest path between two nodes in a graph? However, a human being would consider other criteria than shortness as well [16] [5]. A person may choose another route than the fastest one, because it is perceived as "safer", "easier" or "nicer". Especially when there is no time constraint. As stated by Bederson et al. (2008): *"People have different criteria for the 'best' route: fastest, most scenic, lowest fuel consumption, or even perceived safety – so combining objective and subjective measures may enhance the route selection process"* [1, p. 2]. It is quite obvious that an algorithm like in the previous section will produce a technically correct route. But it fails to take into account a lot of other criteria that are important to a human being. The tricky part is to first of all identify these criteria and then in a second step to integrate them into a route planner.

One interesting project that is trying to enhance the route planning process is called "MyITS – Der intelligente Routenplaner" [11]. ("MyITS – The intelligent route planner") Two kinds of routing are provided: "Neighborhood Routing" and "Via Routing". The first option lets the user enter his intention rather than a specific destination. For example if he/she enters 'restaurant' the planner will return routes to several restaurants in the neighborhood. The second option lets the user enter a destination but he can also add an intermediate activity like a pharmacy. Again the planner will search for places near the main route without asking the user to enter a specific address. In addition to these two options MyITS also offers a lot of options to personalize the resulting routes. Unfortunately those options are rather basic and can

be found in other planners as well. Still MyITS is one of very few examples that try to take the human route planning into account in that it doesn't require the user to enter an address but simply the kind of destination he wants to go to.

Human route choice will be discussed in more detail in chapter 3.

2.3. Route Communication

After a route from A to B has been found, the person has to be guided along the way. This is called route communication. Since the first problem of navigation, positioning, is basically solved by GPS and route planning is seen as the result of a Dijkstra-like algorithm, research turned to the presentation of the route. It seems to be the best way how manufacturers of navigation systems can differentiate their product from those of competitors.
One of the most prominent features of today's navigation systems is speech output. Whenever the driver's attention is required he/she will be alerted by a synthetic voice that tells him/her what to do. This way the driver doesn't always have to look at the screen but can concentrate on the road. The newer systems will also show more detailed visualizations of important decision points. This way the driver will see which lane he/she has to be on before taking an exit or it might help on very complex junctions.

Figure 3 - TomTom Lane Guidance

Navigation systems often provide metric information to the user. For example "turn left in 200 meters". However, the most natural way of navigating for human beings is by the use of landmarks [15][6]. If an instruction would be "turn left after the museum" instead of the example above, this would be much easier for a person because it reflects how we would find our way without an electronic helper. Landmarks could be integrated quite easily in today's navigation systems. What's missing is the databases that contain this kind of information.


Figure 4 - BMW Head-Up Display (Augmented Reality)

Route communication is dealing with a problem regarding the cognitive load of the driver. While the aim is to help the driver reach his/her destination in the least

intrusive way, the driver still has to look at a small screen to get the information. Because of this he/she has to look away from the street. Once he/she has processed the information he/she has to map the things he/she sees on the screen to the real world, thereby increasing the cognitive load [51]. A more natural way would be to include routing information in the windshield (“augmented reality”). Thereby the driver never has to turn his/her attention away from the street and routing instructions are seamlessly integrated into the driver’s field of vision. Several car manufacturers are working on these technologies and have already included these head-up displays in their higher class cars.

All points above relate to car navigation, but in recent years also pedestrian navigation was put into focus. Here the use of landmarks is even more important since a pedestrian has a much more open environment [15]. He/she is not constrained by roads and therefore it may not be clear what “turn left in 200 meters” means. Instead semantic-based instructions like “walk straight ahead and turn left after the library” should be provided.

3. Route Choice

Navigation software presents us with a route from our current position to our destination. It does so by looking at all the available objective information. It chooses one route over another because it is shorter or it takes the least amount of time. But there is another important aspect of human behavior that is not considered in this approach. We all use subjective information to make decisions every day. The way we perceive our environment is different for each individual. Two different persons may not see the same thing when looking at the same object [46]. Additionally we perceive many things subconsciously [9]. So we don't even know that they influence our decisions and judgments. A route through a park may be perceived as a very scenic route by some, but it could seem scary to others. Only when these things are taken into account a route that fits a specific person can be generated.

3.1. Human Route Choice

In [16] an experiment was conducted where participants had to choose between different routes, once on a map and once in a real environment. The experiment showed that shortest distance was the dominating criterion. And rightfully so, because we generally do not want to travel any longer than we have to. But the research also showed that other criteria, like "least turns", "preference for curves/diagonals" or "most aesthetic route" was very important to the participants too. This is especially true if the alternatives are not very different in length.
For many people though, this seems to be a subconscious process. So if they're asked whether they would choose for example a more scenic route over the fastest, they would most likely decide on the fastest route. If you present the same people with some real routing choices, often the result will be that they use other criteria as well. (as shown by the truck drivers in [29] that subconsciously combine a lot of factors to determine the perceived speed of a route)

In [29] an experiment was conducted where the focus was on the route choice of truck drivers. Specifically, when the drivers arrived at a city they faced a decision between the downtown route through the city center or a bypass route.

Understandably truck drivers are mainly time minimizers. Their goal is to get their goods to their destination as fast as possible. They are not interested in a very scenic route or any sights along the way. But how do they determine the fastest route? They cannot simply take the shortest route because there might be congestion or maybe an accident. The authors of this thesis propose that the drivers don't just pick a route randomly. Instead they use criteria like time of the day, current traffic conditions, knowledge of the route and past experience to determine the fastest path. This decision process is further elaborated in chapter 3.2 but it already shows that the decision about which route to take is not based on objective criteria alone. A lot of subjective information is taken into account as well.

In contrast to the truck driver experiment above, congestion is usually not a factor for pedestrians. That's why they normally tend to take the shortest route. But in [2] it is suggested that other factors like the presence of shops, traffic noise or air pollution (to name a few) may also influence the route choice. A study was conducted with 364 people between the ages of 55 and 80. The participants were asked to draw paths on maps for three different tasks: going shopping, going to a health care facility and visiting a relative or friend. All these paths were then entered into a GIS database. In an earlier study [3] the researchers had already determined the street characteristics of the observed environment. The goal of this study was to be able to evaluate existing urban environments based on the found characteristics and thereby improve the attractiveness of these spaces. Elderly people were chosen because of the need to animate these citizens to walk more and thereby improve their health. The participants were asked to rate the attractiveness of certain paths. By comparing these ratings with the determined street characteristics the researchers were able to determine the factors that make a route attractive. Among others they identified zebra crossings, trees along the route, shops, passing through parks or front gardens as positively related to the attractiveness.
The results of the study in [2] showed that only 20% of the reported trips were made on the shortest possible route. Another 28% were equal to or less than 1% longer than the shortest route. The remaining trips were more than 1% longer than the shortest route. Based on the gathered data the researchers developed a route choice model that takes into account all these factors that influence the path we choose. *Figure 5* shows an example of three of those routes. Here we can see that the participants did not take the shortest route but rather the route that was predicted by the route choice model. Another strong indicator that the routes calculated by navigation systems are not the routes a human being would choose.

Figure 5 - Route Choice Model. (Borst et al. *Influence of environmental street characteristics on walking route choice of elderly people*, Journal of Environmental Psychology 29, p. 482) The first column (a) represents the reported walking route. The middle column (b) displays the shortest route and the column to the right (c) shows the route calculated by the route choice model.

In general it is accepted, that people use other criteria than just the fastest or shortest distance for routing decisions. The question is how to implement this in navigation systems. Of course a major problem for using subjective criteria is the lack of required data. There simply are no datasets that specify how “safe” or “beautiful” a place or a road is.

Bederson et al. [1] proposed a framework for incorporating subjective human experience into in-car navigation systems. Their assessment of the current situation is that navigation solutions rely on automatically collected objective data and at the same time ignore human subjectivity. They also state that personal experience is very important for making a route choice and that people often use their own knowledge or impressions to do so. They asked people to rate the importance of

route criteria. The outcome showed that measurable attributes are very important but people also care about more subjective attributes. One conclusion drawn from the survey conducted for this paper therefore was *"However, there will always be subjective attributes that cannot be measured – like beauty or feelings of safety – which our survey indicates are very important"* [1, p. 5]. In this paper's survey most respondents said that they consider all alternatives and choose the one that seems best judging by all their available information. Some of that information is based on very personal impressions.

3.2. Decision making with subjective information

We all have many decisions to make every day. To come to a rational decision we should process all available objective information and find the best choice. But our decisions aren't always totally rational. A wide array of factors influence the way we make decisions.

There is, for example, the number of choices we have. As suggested by Payne et al. [38] the strategies we use for making a decision are different whether we are dealing with a small (2-3) or a large (>10) number of choices. In the first case people often look at all available information and decide how much they are willing to trade off less of one attribute for more of another attribute. This process is often called preferential choice.

When dealing with many alternatives the above mentioned process is too complex and people often use simplifying (heuristic) strategies. This often means that alternatives are eliminated because of poor values in a certain attribute. So instead of comparing all attributes of all alternatives people tend to eliminate some choices early on so they can focus on the remaining. When navigating it may make a difference if we are dealing with just two or many alternatives.

An experiment by Kelley and Jacoby [26] shows that people tend to base their judgments on earlier subjective experiences. They asked people to judge the difficulty of anagrams. To do this the participants had to find some kind of measure as to how difficult it would be for somebody else to solve this anagram. The author's assumption was that the participants either use their own subjective experience or a theory as a base for their judgments. Whereas the first relies a lot on a person's own experiences while solving a particular problem, the second should enable the participants to ignore those things and base their judgments on other factors. To test this assumption the participants were asked to rate the difficulty for others to solve an anagram. One group was presented with the anagram alone. This way the person could solve the anagram and use this experience for the judgment of difficulty. The other group was presented with the anagram and its solution. By doing this the

subjective experience of solving the anagram was taken away from the person and he/she had to switch to another kind of measure to rate the difficulty. The authors of the paper concluded *"Participants given the opportunity to solve an anagram before rating its difficulty for others appeared to use their own subjective experience of item difficulty as a basis for judgment"* [26, p. 162].
So when subjective experiences about the solving of an anagram existed, people used them instead of a more generally applicable theory to judge the difficulty of that anagram for others to solve. They predict the difficulty for others based on the difficulty they experienced themselves. This also shows that human decision making is very much based on subjective criteria and personal experiences and not only on objective factors.

Research by Nussinson et al. [35] suggests that people tend to see objects as more similar when they are in an approach orientation than when they are in an avoidance orientation. The basic principle of this theory is that people would minimize the distance between themselves and a positive object like a cake. (approach orientation) In the same way they would maximize the distance between themselves and a negative object like a snake. (avoidance orientation)
These findings show that the decisions/judgments we make depend on the state we are in. The same situation could be judged very differently depending on whether we try to find the similarities in two objects or rather the differences. In a route decision context this could mean that different persons see either the positive attributes of a public transport station or they focus on the negative attributes.

The before mentioned examples can give a general idea about how people make decisions. For this thesis the most interesting question is of course how route choices are made, especially in terms of subjective information. Bovy and Stern [5] consider travel behavior and route choice as the result of the following series: (*figure 6*)

Figure 6 - Series resulting in route choice (Piet H.L. Bovy, Eliahu Stern, *Route choice: Wayfinding in transport networks*, p. 27, Kluwer Academic Publishers, Dordrecht, 1990)

The decision process starts with the objective situation that is then transformed into a subjective situation by personal perception. The personal decision is then made on the subjective situation.
They further described the factors influencing travel behavior with the model in *figure 7*. The three factors on the top together form the objective situation. The ***physical environment*** includes the surroundings like buildings or mountains and also network infrastructure like streets or railroads. The ***socio-demographic environment*** defines for example the age, income or what modes of transportation are available to a person. These things can determine the alternatives a person perceives and may also exclude certain options. Finally the ***normative environment*** contains a set of norms, values and concepts derived from society.

The personal feelings, attitudes and observations form the ***personal environment*** which may cause the objective environment to be perceived subjectively. This again shows that a decision is not made on objective parameters alone.

Bovy and Stern further conclude that the physical environment is predominant for route choice [5]. They see the other three factors as secondary, but still relevant. A person's perception of the alternatives is inaccurate because it is linked to personal experiences and preferences. Also not all parameters are equally important to a person. It is even possible that some attributes can compensate for others in making a decision. Finally the authors state that the decision process is a very personal process and can differ substantially from one person to another.

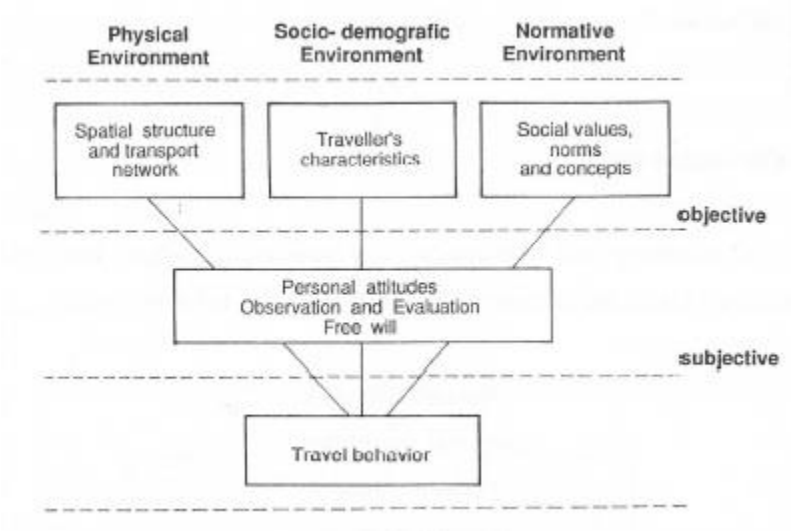

Figure 7 - Influences on travel behavior (Piet H.L. Bovy, Eliahu Stern, Route choice: Wayfinding in transport networks, Kluwer Academic Publishers, p. 28, Dordrecht, 1990)

3.3. Subjective vs. Objective

Defining subjective and objective information is no easy task. On a very basic level and in colloquial language the word ‘objective’ is often seen a something that is a fact. There are no two ways to interpret it. Whereas ‘subjective’ is more about perceptions, feelings or emotions of individuals. The term ‘objective’ is normally seen as something positive while ‘subjective’ carries negative associations [39]. This likely can be traced back to the fact that a certain point of view is only accepted as objective if it has been examined, challenged and criticized by others. Phillips (1990) states: *“A view that is objective is one that has been opened up to scrutiny, to vigorous examination, to challenge. It is a view that has been teased out, analyzed, criticized, debated – in general, it is a view that has been forced to face the demands of reason and of evidence. When this has happened, we have some assurance (though never absolute assurance) that the view does not reflect the whim or bias of some individual or group; it is a view that has respectable warrant”* [39, p. 30]. He therefore sees ‘Objectivity’ as something like a “stamp of approval” for inquiries that have been tested and criticized [39]. For better illustration Phillips gives the following example [39, p. 23]: Two students of a difficult science class claim that their colleagues did not understand the topic. The first student bases this claim only on his personal experience. The second student presents some evidence for his claim in the form of test scores, a videotape showing the puzzled look of the students during class and interview transcripts he conducted with a sample of the class. The first student presents only a personal point of view. So if challenged by others this view will be labeled as subjective. The second student on the other hand has gathered some data that proofs his claims with scientific methods. Because of this these claims will be viewed as more objective.

Objective attributes can usually be measured more easily. Often times a number or characteristic can be assigned to them. Subjective attributes on the other hand often deal with perceptions, feelings or emotions of people. It is not as easy to assign a number to how comfortable you are for example. One way to measure subjective attributes is category scaling or anchored scaling where a person has to choose the word on a scale that fits his personal perception best [8]. In the case of a question like “How stressed do you currently feel?” for example the words on the scale would range from “not stressed” to “very stressed”.
Research suggests that subjective information has an impact on human decision making [16] [5] [1] [30]. In [30] a study was conducted with the goal to design a handheld power tool. In addition to the objective attributes (shape, switch type, weight and price) the researchers also identified two subjective attributes as important factors: perceived power and perceived comfort. The researches see those

subjective attributes mostly as perceptions by individuals. Take the power of the electrical drill for example. One could measure the power in newton meter and use this as an objective factor. But the perceived power as experienced by an individual may be influenced by other things like the sound of the tool or a secure grip. So a drill with 30 Nm of torque may be perceived as more powerful than a drill with 40 Nm of torque. They further stated that the subjective attributes influenced the purchase intention and that these attributes should not be ignored in the design process of any product.

3.4. Selective Perception

Perception is the process of categorizing and interpreting information [44]. Through our eyes we may see an image. By perceiving this image we may come to the conclusion that what we are seeing is a tree.
Selective perception describes how we perceive information in a way that favors one interpretation over another. Often times past experiences influence how we perceive new information. Imagine for example that you hear of a new Chinese restaurant. You have never eaten there before but you know another Chinese restaurant where the food is really bad. In your own perception the food of the new restaurant will not be very good because past experiences were taken into account. Usually we are not aware of this process since it happens subconsciously.
Another example of selective perception is information filtering. If we were to process every kind of information we come across every day we would be overwhelmed by all the stimuli. Instead we filter out all information that feels unnecessary to us. This way we can focus on the most important things that need our attention.

The above mentioned points apply also to decision making when navigating. The same environment will be perceived differently by different persons because they relate it to past experiences or they just don't perceive certain things because they deem it unnecessary. In [29] an empirical evaluation of the route selection of truck drivers was conducted. While, contrary to the hypothesis of this thesis, the truck drivers in the study are primarily time minimizers, the way they choose one route over another is rather interesting. Time is the most important factor for a truck driver. Therefore he/she should know the speed he/she can go on a particular route. Because of possible congestion the real speed of a certain road is unknown. Earlier research suggested that since the drivers do not know the speed of a route in advance, they cannot make rational decisions about which route to choose.
The study in [29] suggests that the individual perception of a driver is an important factor when choosing a route. His/her perception is the product of many factors like past experience, current traffic condition or time of the day. With this information the

driver is able to determine the expected time of the trip, should he/she choose this route. Once this information is calculated the driver will compare his alternatives and choose the route that seems to be the quickest. Especially past experiences play a crucial role here. One driver may have needed just 20 minutes to go through a city on the downtown route. Another driver may have needed two hours because there was an accident. These two drivers will have completely different perceptions of the same route.

The decisions we make are influenced by our subconscious perception. In an experiment by Debner and Jacoby [9] the goal was to find evidence for the existence of subconscious perception. They conducted a test where the first three letters of several five-letter words were shown to the participants. Each of the three letter partial words had several possible solutions. They were asked to complete the words. Before that a solution for the current word was shown to them for a very short amount of time. (sometimes other meaningless random strings were shown to cross check) Too fast for the most part to consciously perceive the word. One group of participants (exclusion group) was asked to not use the flashed word as a solution, whereas the other group (inclusion group) was told to use this word as the solution. In the exclusion group the experiment showed that when the solution word was shown for only 50 ms this word was presented as the solution 50% of the times. Even though the participants were told not to use the solution word they had seen before. The authors concluded that this is evidence for subconscious perception. The persons were not aware of having seen this word before, but they gave that word as their solution.
This is another strong indicator that our decisions don't only rely on objective criteria. Even though we may think that we base our routing decisions on objective criteria, it is very possible that we may be influenced by all kinds of subjective impressions that we aren't even aware of.

3.5. Personalization on the Internet

In its early days the internet was not much more than a repository of articles. One typed an address into a browser and the desired page was shown. The information was provided by whoever ran the website. The user only accessed this information.
In recent years the internet has changed a lot. Faster connections and more powerful browsers allow websites to include much more multimedia content. The biggest difference to the early years though is what is usually called the Web 2.0. The content on websites is no longer supplied by the owner of a website alone. Instead the users themselves create the content on websites like Wikipedia, YouTube or Twitter.

Another aspect of this “new” internet, that is often forgotten, is the personalization of many websites. Without a big public announcement Google has adapted their PageRank algorithm to the specific needs of the user. That means that if two persons are searching for the same word, they may get very different results. A good example for this is given in [37]. The author of the article asked two friends to search for the term ‘BP’. This happened in the spring of 2010, when the Deep Water Horizon oil rig accident was still contaminating the environment in the Gulf of Mexico. Both persons were white females of similar education and political views and they both lived in the Northeast of the USA. Yet the one person saw investment information about BP while the other saw news about the accident. So while one person saw all kinds of information about the oil spill, all the other person saw was some promotional ads from BP. This example shows that even for two rather similar persons the results of a search for the same term can be very different. For two persons on opposite ends of the political scale this might even be worse.

Another example of personalization on the internet is the advertising industry. The goal of any advertising campaign is to present the product to the appropriate target group. On television we can observe that ads for toys will usually be shown around noon, between shows intended for children. Ads for beer or cars will more likely air during a football game in the evening. The internet gives advertisers a much better tool to show the right ads to the right people. Depending on what you search for, you will leave a trail on the internet. With every website you visit your own profile gets clearer. After a while you will only see ads for products you are interested in.
A while back I was looking for new running shoes on a sports website. I didn’t buy them there but I spent a good amount of time on that website. After a while I noticed that I saw ads for running shoes on almost every website I opened. I also got a coupon for free shipment from the sports shop.

The ‘next big thing’ in personalization on the internet may be behavioural pricing [48] [14]. The intention behind it is to adjust the price of any good to the behavior of a person. A lot of data is collected every day about what we do on the internet. With the rise of social networks, the idea of ‘liking’ something has gained importance. If a person for example clicks on the ‘Like’ button on a social network to express that he/she is interested in a certain product, this could influence the price of that product. Because in terms of behavioural pricing this could be interpreted in such a way that if a person likes this product, he/she will be willing to pay more for it than others. While this new pricing model seems like the next logical step, it will be very hard to implement. People compare prices online and if they realize that their personal price is higher than the price others have to pay, it could destroy the seller’s reputation very quickly.

Of course personalization on the internet should be watched with a critical eye. We can no longer be sure that when we search for a certain topic we will get objective results. The search engine may try to find the result that most likely is what we want to see. That of course bears the risk that we will only be presented with our own point of view. We may never see the other side of the medal. The personalization of the internet certainly also raises a lot of privacy issues. The collection of personal data with cookies and other techniques is a very sensitive topic and should be handled with the utmost care.

In terms of navigation though, personalization has a lot of potential for the route calculation process. One of the biggest players in the maps and navigation field, Google, also has big plans with personalization of maps. Daniel Graf, Google's director of Google Maps for mobile put it like this: *"There is a lot more you can do with a map. If you look at a map and if I look at a map, should it always be the same for you and me? I'm not sure about that, because I go to different places than you do"* [18]. At the moment we are all presented with the same route. Route planning is thought of as a very objective task. Individual preferences aren't taken into account at all. But research has shown that people prefer different attributes in a route. If it was possible to create a navigation profile for a user, it might be possible to calculate a route that fits his/her personal preferences better.

3.6. Summary of existing Research

Some of the existing research on route choices and how to improve the routes generated by various tools is summarized below.

Hochmair [19] has used a similar approach to the one in this thesis to determine a list of criteria for a bicycle route planner. He used an online survey to gather criteria that is considered by tourists in an unfamiliar city. He also states that while a large number of attributes is vital to understand what factors are most important, it is necessary to present the user with only a limited set of options. He therefore grouped the criteria into four classes to reduce the cognitive load for the user.

Borst et al. [2] [3] have collected street characteristics and related them to the perceived attractiveness of that street. The data collection was done through elderly people since the goal was to find ways to encourage them to walk more. Finally a route choice model was created that generated a route closer to the one actually chosen by the participants as opposed to the shortest path. More details can be found in chapter 3.1.

In the EmoMap project [28] data about emotions experienced in various places was collected with the help of an app for mobile phones. The aim was to create a layer of emotions on top of a map and make this database about emotions accessible to route planning software. The focus here was on pedestrian navigation.

Su et al. [47] present a web-based cycling route planner that takes factors like safety, elevation gain, air quality or type of environment into account. The planner is based on Google Maps and therefore presents a user interface familiar to many users.

Golledge [17] asked people to rate route criteria from “unimportant” to “extremely important”. Those criteria included “Shortest Path”, “Most Scenic”, “Longest leg first”, “Most turns” etc. He concludes that most computer models do not reflect the decision strategies of people and that more research has to go into what criteria is important for those decisions.

The above mentioned research takes a similar approach to the one of this thesis in that it aims to identify the criteria that are important when humans make route choices. To the knowledge of the author the same has not been done for public transport systems. Especially with a focus on subjective criteria that is usually harder to determine and measure.

4. Empirical Test

As stated before, the main question of this work is whether route choice is affected by other factors than time and distance and what those factors are. Therefore the focus of the empirical test is to provide an answer for this and gather a list of attributes of stations that are relevant. Special attention is on subjective criteria as they are often less obvious and harder to measure. In this section I will specify the test setup. I will define the questions which should be answered. Also I will define the participants and the investigated part of the public transport system.

In order to be able to compare results and derive useful information from it, the focus was put on a navigation problem that many people share. In particular the dormitories 'ÖJAB Haus Burgenland 2' and 'ÖJAB Haus Burgenland 3' and the routes the students choose to get to the university were investigated. All students need to go from the dormitory to the University of Technology. And they can choose between several routes to get there.

Going forward the 'ÖJAB Haus Burgenland 2' and 'ÖJAB Haus Burgenland 3' will be referred to as 'B2' and 'B3' respectively. The University of Technology will be referred to as 'TU'.

4.1. Test Setup

This section describes how the test was prepared, what the boundaries are and how the actual test was conducted.

4.1.1. Goal of the Test

To answer the questions of this thesis it has to be established that people will not always use the shortest route. The shortest route can be calculated by the use of existing websites. In this thesis the information on the website of the Wiener Linien www.wienerlinien.at was used for this purpose.

In the focus group the goal was to determine those routes that are frequently used by students living in the B2 or B3. The interesting question here was whether there would be routes totally different from the fastest routes.
The next important question is why people choose a certain route. Here the goal was to collect all the attributes that are considered when making a choice. Some of those attributes may only be perceived subconsciously, so it was important to get people to think about their route choices.
Finally the attributes found in the focus group have to be rated by a large group of people. Potentially an attribute could only be important to one person but totally irrelevant to others. To get a better idea of the importance of each attribute a survey was created with the findings of the focus group.

4.1.2. Participants

The focus group method was chosen to gather the necessary data. The idea behind it was that this way only a general topic would be established and participants could answer freely. And maybe even more importantly, by having several people in this session the participants would also start discussing with each other. By doing so they can come up with more ideas than they would have in traditional interviews.

For the focus group students who live or have lived in the B2 or B3 for an extended time were asked to participate. Flyers were distributed in the dormitories and some participants were asked personally to join the focus group. Finally a group of seven people who all attend (or attended) the TU was found. Five of them were male and two female. They were all between 21 and 28 years old. Some of them didn't know each other before and others were kind of familiar with each other. All in all, the group was diverse enough to stimulate some animated discussions about several topics.

For the survey no specific requirements towards the participants existed other than at least some knowledge about the Viennese public transport system. Participants for the survey were acquired through social networks, online forums and email.

4.1.3. Study Area

For the focus group the two dormitories, the TU and the connections between them were relevant. Later on for the survey the study area consisted of the entire public transport system of Vienna. The address of the B2 is Mittelgasse 18, 1060 Vienna. The B3 is located just around the corner at Bürgerspitalgasse 19, 1060 Vienna. Both

dormitories together offer accommodation for 461 students. There are several public transport stations nearby. Some of them are marked in orange in the picture below. As one can see in *figure 8* a person has several choices on where to start a route. Of course there could be even more choices later on when two (or more) lines intersect.

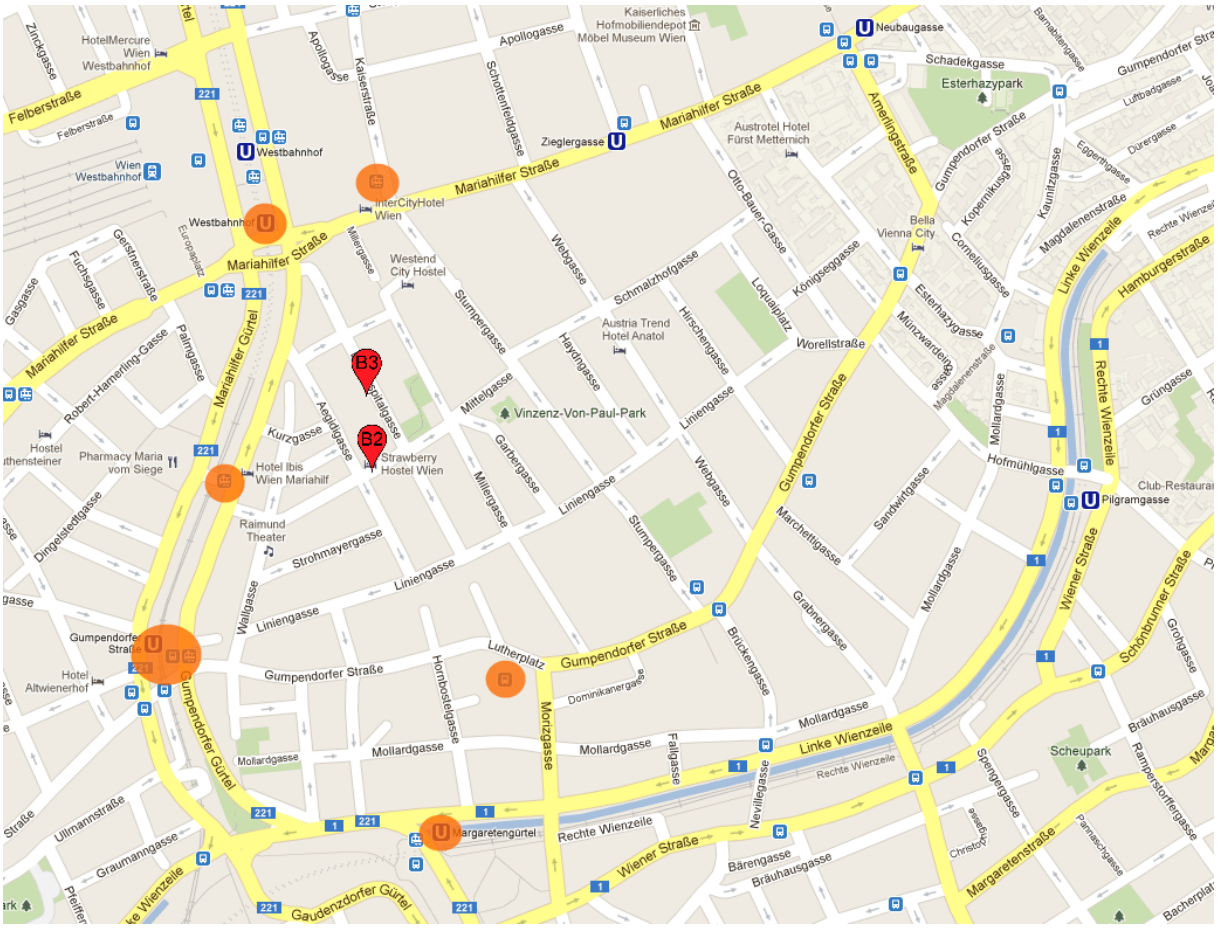

Figure 8 - Location of B2 and B3 and nearby public transport stations (Source: Google Maps)

The Vienna University of Technology is spread over the 4th district and some parts are even in the 6th district. (see *figure 9*) For this experiment the three addresses Karlsplatz 13, 1040 Vienna (Main Entrance) 1, Getreidemarkt 9, 1060 Vienna 2 and Gußhausstraße 30, 1040 Wien 3 are relevant. Most students will have to visit those three destinations on a regular basis as the lectures are distributed over auditoriums in all three locations. In the following section the shortest route to each of those three locations is presented. It should be noted though that all those buildings are quite close to each other. So it is very possible that students use public transport to go to one location and then walk to another destination from there. That means that the shortest route to location 1 can also be an option (not the shortest though) for location 3 etc.

The map in *figure 10* shows all the possible public transport lines that are available between the dormitories and the TU.

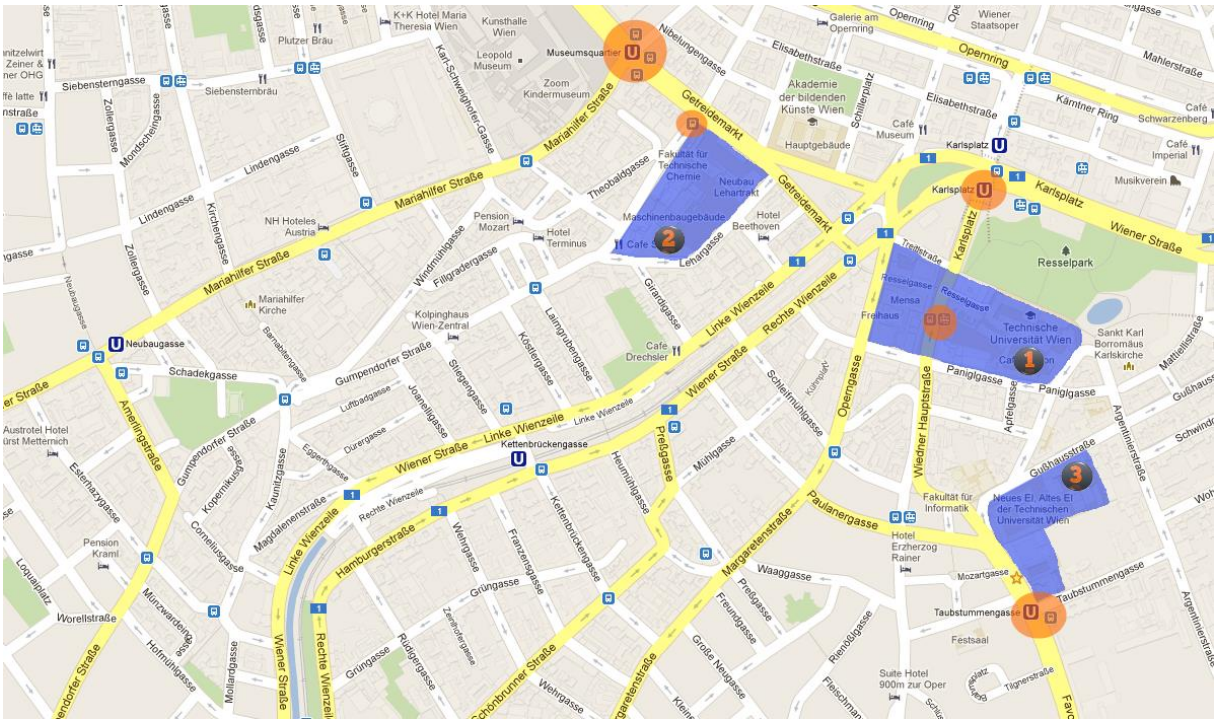

Figure 9 - TU Vienna and nearby public transport stations (Source: Google Maps)

Figure 10 - Map of all public transport options between B2/B3 and the TU (© Ben Lode, Netzplan Wien, http://web.student.tuwien.ac.at/~e1025108/?page_id=13, 2012)

4.1.4. Shortest Route

The shortest routes below are calculated using the route planning tool on the website of the Vienna public transport organization www.wienerlinien.at

<u>TU Main Building / Freihaus</u>

The shortest route takes 23 minutes:

- Walk from B2/B3 to Margarethengürtel
- U4 from Margarethengürtel to Karlsplatz
- Walk from Karlsplatz to Main Entrance/Freihaus

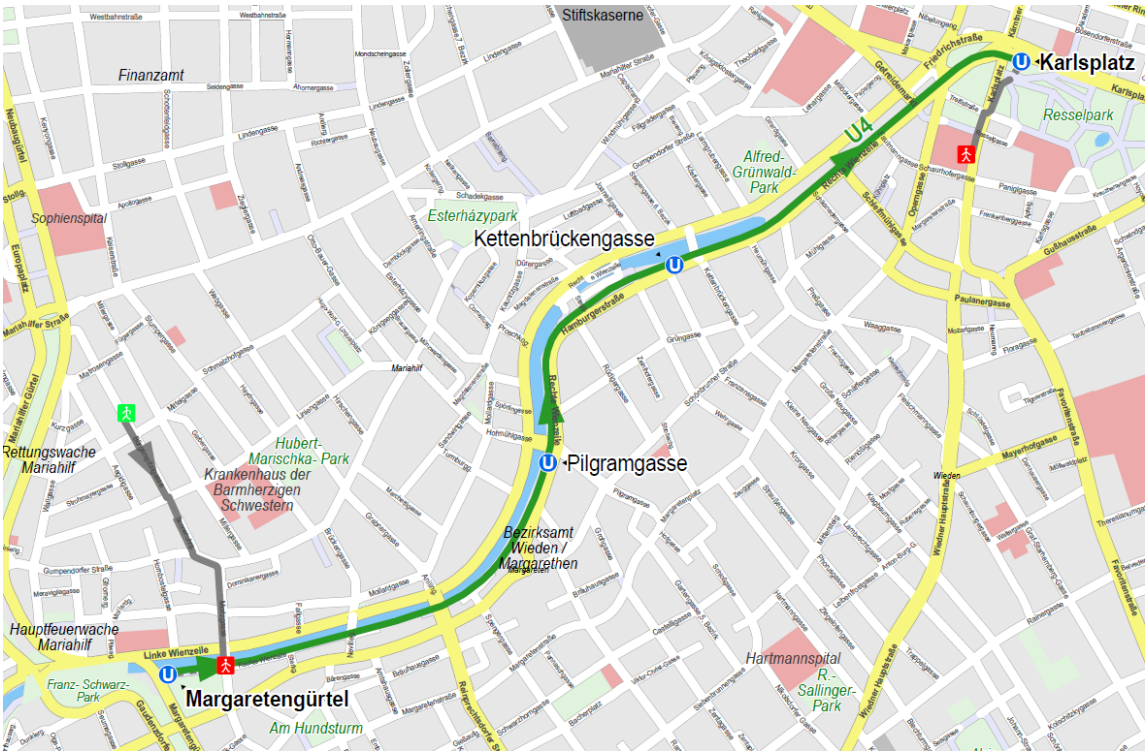

Figure 11 - Shortest route to main building (Source: www.wienerlinien.at)

Another route with less walking distances is the following which takes 27 minutes:

- Walk from B2/B3 to Westbahnhof
- U3 from Westbahnhof to Volkstheater
- U2 from Volkstheater to Karlsplatz
- Walk from Karlsplatz to Main Entrance/Freihaus

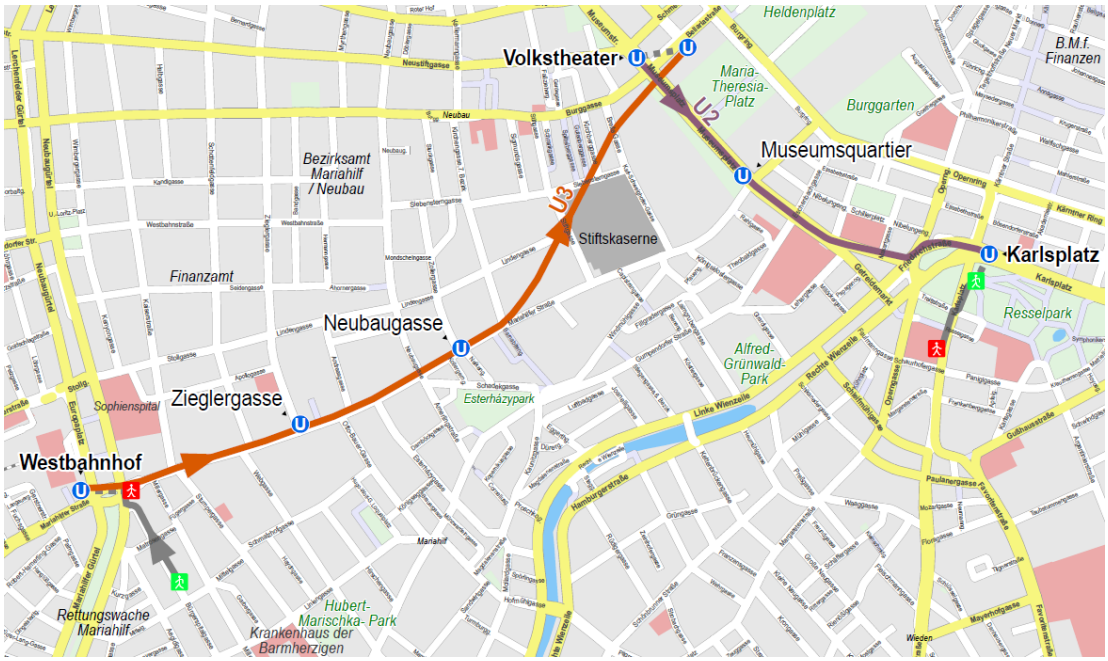

Figure 12 - Shortest route to main building with less walking distance (Source: www.wienerlinien.at)

Getreidemarkt

The shortest route takes 17 minutes:

- Walk from B2/B3 to bus stop Sonnenuhrgasse
- Bus 57A from Sonnenuhrgasse to Getreidemarkt

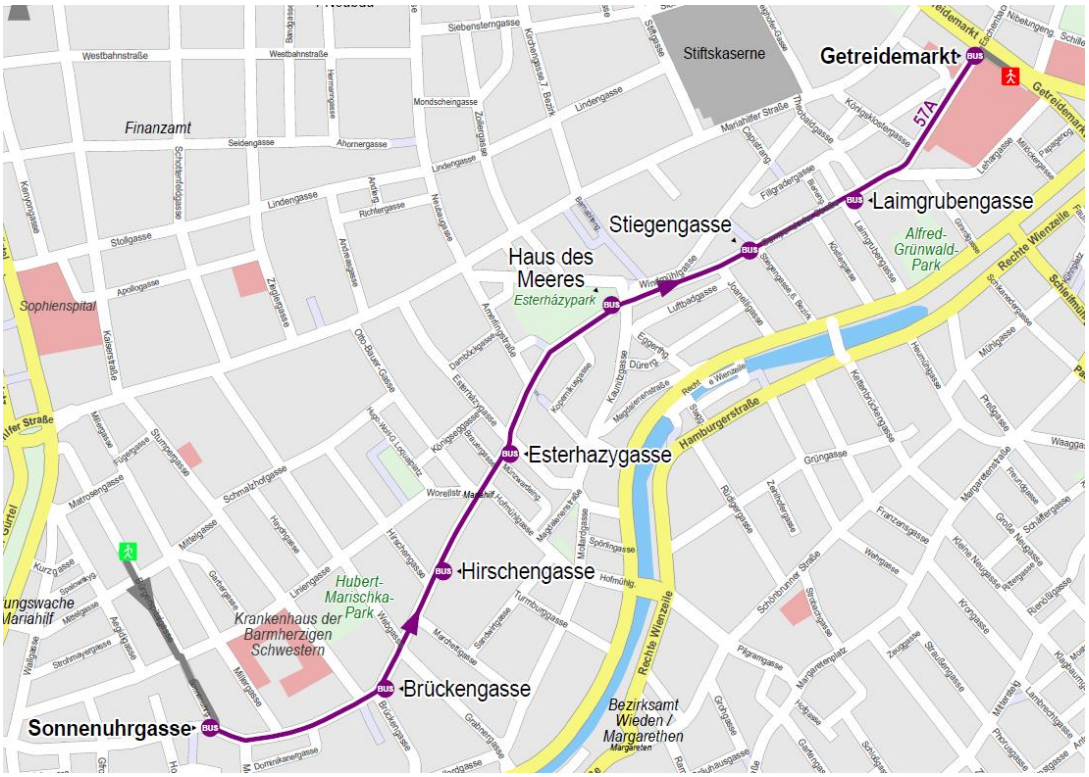

Figure 13 - Shortest route to Getreidemarkt (Source: www.wienerlinien.at)

Gußhausstraße

The shortest route takes 27 minutes:

- Walk from B2/B3 to Margarethengürtel
- U4 from Margarethengürtel to Karlsplatz
- Walk from Karlsplatz to Gußhausstraße

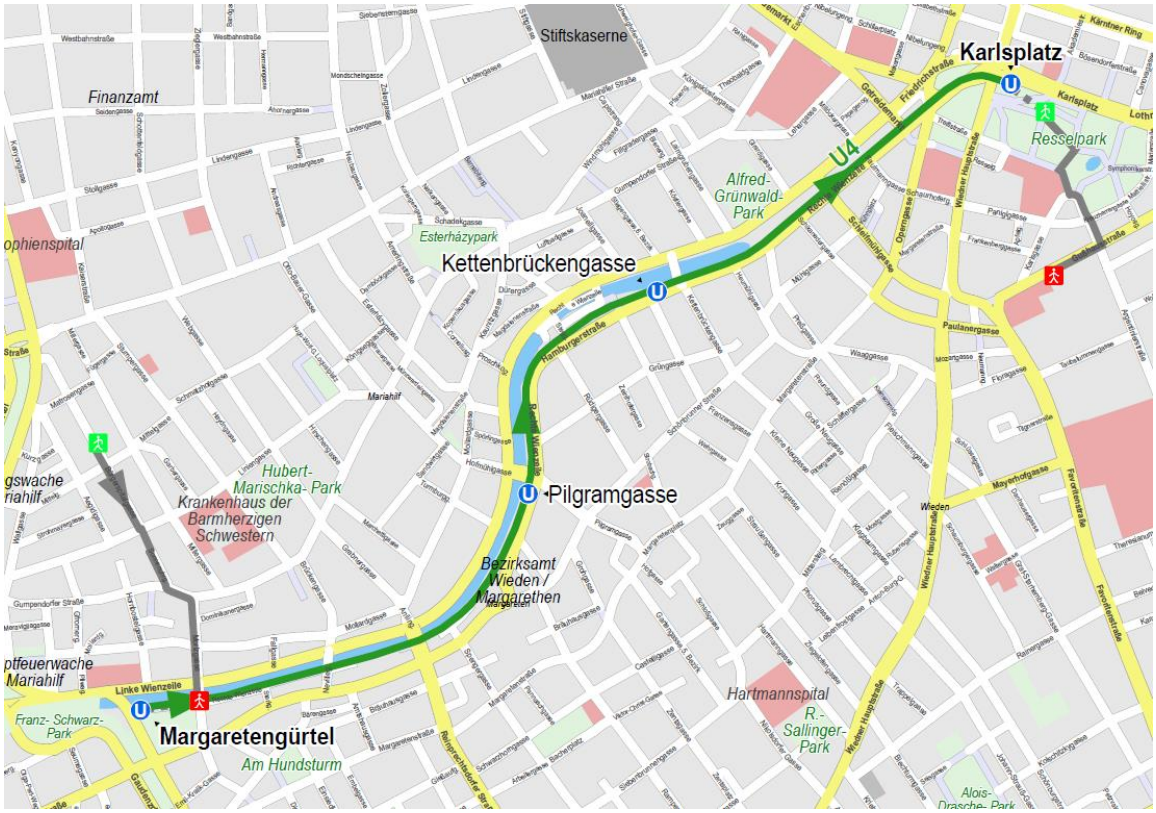

Figure 14 - Shortest route to Gußhausstraße (Source: www.wienerlinien.at)

Another route with less walking distances is the following which takes 28 minutes:

- Walk from B2/B3 to Westbahnhof
- U3 from Westbahnhof to Stephansplatz
- U1 from Stephansplatz to Taubstummengasse
- Walk from Taubstummengasse to Gußhausstraße

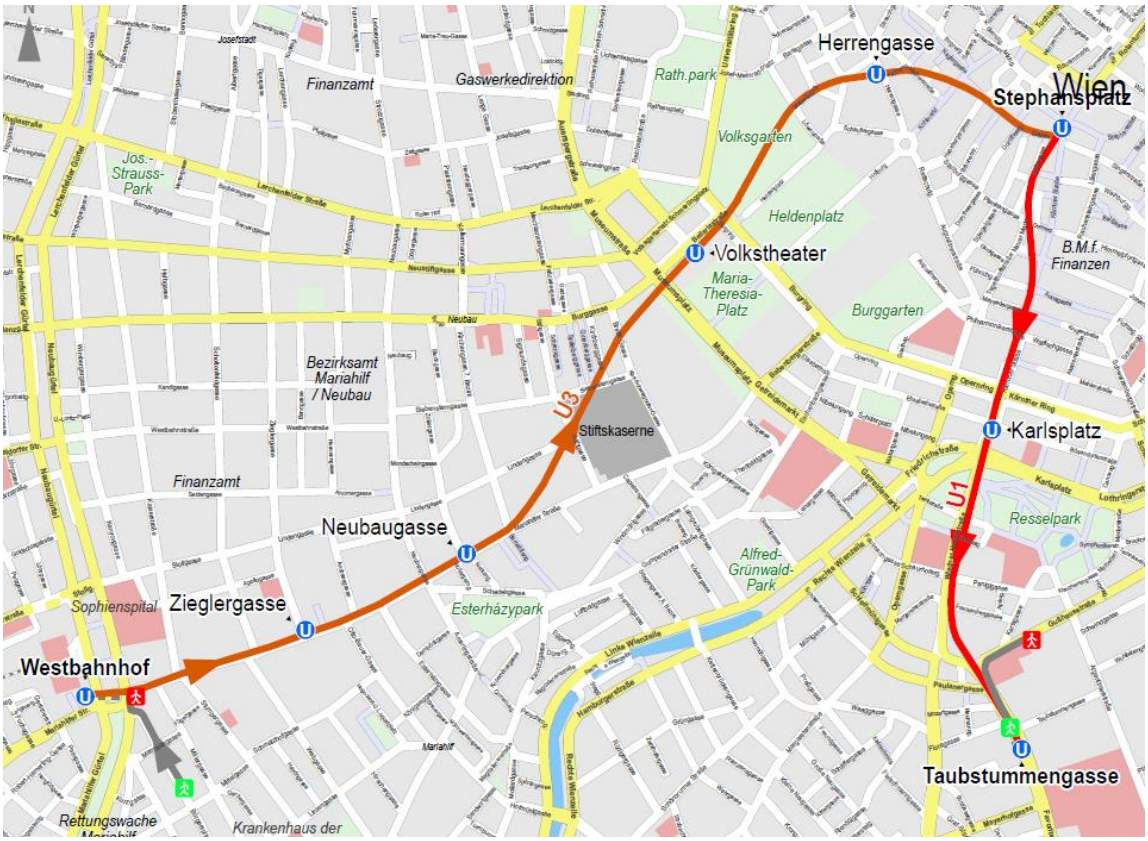

Figure 15 - Shortest route to Gußhausstraße with less walking distance (Source: www.wienerlinien.at)

There are several possible routes for the main building that all take between 23 and 30 minutes. For Gußhausstraße there are at least two options within a few minutes. We can assume that a difference of a few minutes will not have a very big impact on route choice. The actual time needed for one of the routes depends on the schedule of the trains or buses. If you miss one train/bus by a few seconds even the shortest route may take up to 30 minutes. Instead I will view these routes as equal. Because all possible routes are so similar in duration the 'time' attribute of the route is not that important for making a decision. Therefore the decision for a certain route will rely heavily on other factors.

4.1.5. Context

The Context of the travel has to be considered. In the focus group it was important to learn something about the context under which a person takes one route over another. In another context he/she may behave differently. (e.g. early morning → needs breakfast, lots of time, short of time, etc.) The assumption was that most students will use more than one route regularly. Therefore it was crucial to understand what makes them choose a certain alternative at a certain time.

4.2. Focus Group

One of the most important questions with regards to this thesis is what attributes influence a route choice and how important each one of them is. Since these attributes are not known it is almost impossible to conduct any kind of quantitative research. As Kahn et al. [27] suggest a focus group can be used as an idea-generation tool which can help the researchers understand what issues are most important to the participants. Kahn et al. [27] also state that the focus group can function as a preliminary step of a questionnaire where the results of the focus group represent the foundation of the quantitative research.
When a survey is handed out to people, we assume that they will tell us how they feel about or perceive a certain situation [12]. But it's possible they aren't even aware of that. A focus group gives the moderator the chance to see the real meaning of an answer. The participants can hear the opinions of others and that may stimulate them to think about the situation in a different light. The goal is simply to get a deeper understanding about a topic than you could obtain through a survey alone.

4.2.1. Focus Group Theory

As Robinson (1999) put it *"A focus group can be defined as an in-depth, open-ended group discussion of 1-2 hours' duration that explores a specific set of issues on a predefined and limited topic. Such groups consist typically of between five to eight participants and are convened under the guidance of a facilitator"* [41, p. 905].
The traditional way to gather data from several persons is a questionnaire or interviews. A participant would have to answer closed (yes/no, multiple choice) or open questions in the process. In the 1930s and 1940s scientists like Paul Lazersfeld and Robert Merton were looking for a different approach for gathering data from a group of people [32]. They were among the first who used the focus group technique. Later on the focus group gained popularity in market research. It was an ideal instrument to understand the customers' needs and ultimately make the product as attractive as possible.
As already stated before, focus groups are used to gather qualitative data. They should be chosen if why, how or what..if questions need to be answered. The focus group can be the single source of data or it can be combined with other methods like a survey. It may be conducted before the survey to identify issues the survey will focus on or after the survey to get a better understanding of the results. As Morgan [33] states the biggest difference between the two methods is that the focus group provides more in-depth information about the research topic.

There are a few important points to consider when preparing or conducting a focus group [12] [32]:

- ***Participants***
  All participants are comfortable with each other so that they can talk freely in the group. (ideally they don't know each other) Also most of the times the selection of participants will have to be based on some sort of criteria. For example if you want to gather data about a new tool that is supposed to replace an existing tool the participants should have worked with the existing tool for a certain time.
- ***Group Size***
  The group should consist of 4 to 10 people. It should be small enough so everybody can contribute but also big enough so that it generates discussions among the participants.
- ***Qualitative Data***
  The result of a focus group will always be qualitative data. The researcher is able to gather a lot more in-depth information about a topic than what would be possible with quantitative research methods. The interaction between participants can stimulate more detailed answers.
- ***Topic***
  The moderator's job is to steer the discussion in the right direction. He/she has to make sure that all the research questions are discussed without disclosing the questions to the participants.

Criticism

Often the group dynamics are mentioned as a source of criticism [42] [41] [27]. One concern is that a focus group doesn't produce individual data. Even if a statement was made by one person this statement could be influenced by the group. The term "groupthink" is supposed to indicate that all participants in the group tend to come to one very similar conclusion. This is why the role of the moderator is so important. It is his/her job to ensure that on the one hand even introverted persons get a chance to speak and on the other hand that the discussion isn't dominated by one participant. In a similar way the results can be biased by the moderator if he/she steers the discussion in certain direction.

Advantages

The same point that is seen by some as a disadvantage is also the biggest advantage of focus groups. The interaction between participants when they explain themselves to each other and ask each other questions makes the outcome much more than what you would get from individual interviews. As Morgan (1996) writes

"This ability to observe the extent and nature of interviewees' agreement and disagreement is a unique strength of focus groups" [33, p. 139].
It is also a relatively low cost method since there is no questionnaire to prepare or send out. And it has the potential to explore unanticipated issues because of the interaction between the participants.

4.2.2. Focus Group Preparation

The ideal number of participants is 4 – 10. With a larger group it would be hard to let everybody express their thoughts. As stated above the focus group was conducted in the dormitories B2 and B3. A session was arranged in the B3 dormitory to make it as easy as possible for the participants to take part. It proved to be a bit harder than originally anticipated to find people who were willing to participate. Initially some flyers were placed in the entrance area of the dormitories with a quick explanation of what the goal of the session was and the contact information if somebody wanted to participate. After only a few replies it was necessary to go door to door and talk to the students in person. This way enough people could be acquired for the focus group. The group consisted of seven TU students who all live or have lived in the dormitories.

The questions that were prepared for the focus group were integrated into the conversation. It wasn't supposed to feel like an interview with one question after the other. Instead the aim was to have an open discussion in which the questions are introduced by the moderator.

<u>The questions are:</u>

1. How often do you go to the TU using a public transport system?
2. Where do you go exactly? (Main Building, Getreidemarkt, EI, Favoritenstraße)
3. Do you always take the same route?
    a. If not, why not?
4. What routes do you choose?
    a. When do you choose what route?
5. Why not one of the other routes?
6. Describe the stops you use and also the ones you avoid.

These questions were chosen to gather information about the alternative routes that are used to get from the dormitories to the TU. Also the context of those trips was

explored. The ‘Why’ questions were supposed to lead to the attributes that are important for a certain decision.

Additionally maps of the relevant part of the public transport system of Vienna were prepared. This helped to visualize the routes on paper so that everybody in the group understood what route was being discussed.

Another important point was the documentation of the conversations. Since there was only one moderator conducting the focus group it was not possible to take any notes during the session. Therefore the entire conversation was recorded and later transcribed.

4.2.3. Focus Group Execution

One thing to consider in a dormitory is that there will always be people around and it usually isn’t very quiet. So to ensure that we wouldn’t get interrupted all the time a room was organized where the focus group could be conducted uninterrupted. The participants sat on a round table with the voice recorder placed in the middle of the table. Everybody was asked to introduce themselves so that everyone was familiar with each other. It also gave a clearer picture about what each person studies, in what semester they are and how often they have to go to the TU. After that a short introduction about the topic of the research was given to them without revealing too many details. The idea behind this being that the results would be better if the participants didn’t know exactly what the purpose of the questions is.

The session was started off with the most basic questions of ‘how often do you go to the TU?’ and ‘what routes do you use?’. After the first few comments from some of the participants the group started discussing. At times they were ignoring the moderator altogether, which provided the chance to observe and note down some things. At times when the discussion died down the next predefined question was thrown in. After about 45 minutes the session was finished. After a short summary everybody had the chance to add some final comments. The results of this focus group can be seen in chapter 5.

4.3. Online Questionnaire

The focus group provides a set of ideas and opinions that are necessary to understand the problem at hand better. In this specific case the main goal was to

understand the reasons why people choose a route that is not the fastest one. So the main outcome of this first part is a list of attributes that influence the route choice.

But how important is each one of those attributes? From a small sample like the focus group no general conclusions can be drawn. However the results of this first step can be used as the input for a second step. Most of the times a focus group is used in combination with another research method, most commonly with individual interviews or surveys [33]. Since the aim is to get a rating of how important each attribute is and a large number of people have to be contacted for this, a survey is the method of choice. The most common way to combine the two methods is to use the focus group as a preliminary step [33]. This helps researchers to define the content of their questionnaires. Sometimes it is not entirely clear what question should be asked in a survey. The results of the focus group can provide a much clearer picture.

4.3.1. Survey & Questionnaire Theory

If the participants are presented with questions in written form and they are asked to answer them on their own this is called a written survey [4]. The execution of this type of research is rather cheap. No meeting in person is required. The questionnaire is sent to the participants who then answer the questions and return the results.

The evaluation of the results is ideally also not very time consuming, at least if the respondents can only choose from a set of predefined answers. Closed-ended questions are preferred when creating questionnaires because the evaluation is much easier and the results are more objective [4]. Of course open questions and free text responses can be included as well. This way the mostly quantitative data can be expanded by some qualitative data. But as Rattray & Jones (2007) put it *“However, whilst this approach can provide the interviewer with rich data, such material can be difficult to analyse and interpret”* [40, p. 237].

The greatest effort is required to prepare the questionnaire. Generally a questionnaire can only be created if a lot is already known about the research subject. As stated by Rattray & Jones (2007) *“Questionnaire-based methods are, therefore, not the method of choice where little is known about a subject or topic area. In such an instance, qualitative methods may be more appropriate”* [40, p. 235]. As mentioned in the previous section, a focus group can be used to get a better understanding about the subject.
Special care should be taken when selecting the specific questions. The type of the question (e.g. question vs. statement) or the language used can bias the results [40].

Also the order in which the questions are presented may influence the results. Controversial topics for example should not be discussed right at the beginning.

The quality of a questionnaire can be measured by three criteria: objectivity, reliability and validity [4].

Objectivity: The execution of the test and the evaluation of the results is independent of a certain tester. The tester must not interfere during the test and the points assigned to answers must be independent of a certain person.

Reliability: A test is reliable if the same test is conducted with the same participants several times and always produces exactly the same results. In reality this is never the case. The deviation is attributed to a measuring error which should be as small as possible.

Validity: The validity of a test indicates how well the test actually measures what it is intended to measure. A test can be very reliable while it does not produce the results needed to make a decision.

Online Survey

Before the age of the internet a survey was conducted by sending out the printed questionnaires by mail. The participants had to fill in their answers and send the questionnaire back. This process has nowadays mostly been replaced by online surveys where the participants receive an invitation e-mail with a link to the questionnaire which is filled in online. The evaluation of the results is then mostly automated as long as closed ended question are used.
Of course only people who actively use the internet can be reached with this method. In 2012 around 80% of all Austrians have used the internet [45]. The only notable exception is people older than 54 years where internet usage decreases significantly. In the age group of 65 – 74 years only around 38% use the internet. Therefore an online survey is not the best method to reach this group.

Advantages

An online survey offers the opportunity to find people that would otherwise be very hesitant to meet face to face [50]. This may include persons with certain diseases or disorders who would rather stay anonymous. In general one can say that the internet provides access to groups with shared interests. For example it is quite easy to find an online community about almost any topic.

One of the most important advantages is of course the fact that an online survey is a relatively inexpensive method since only a link to the survey is sent out via e-mail. It also requires very little time in the execution step. And the evaluation of the results is almost fully automatic. An online survey also allows multimedia content. It is possible to include videos or links to other websites. In a similar way it is also possible to add a sort of help functionality for the participants.

Disadvantages

One problem of questionnaires in general is that it is impossible to formulate the questions in a totally neutral way [4]. There will always be a certain valuation in some of the questions that bias the results. This can be countered by including several questions on the same topic with different phrasing.

Information about participants of an online survey may not be very reliable [50]. Usually there is not much known about people in online communities. This can be a problem if a very specific group of people is required. Another connected issue is that the same person may fill in the survey several times. Often one person may have several e-mail addresses and can therefore access the survey more than once. This can be countered by using access codes that only work once. Furthermore it cannot be guaranteed that the owner of a certain e-mail address is the one who actually answered the questionnaire.

4.3.2. Questionnaire Preparation

One of the most important issues during the preparation of the questionnaire was what questions should be included. The choice of questions can determine whether the results will be satisfactory or not. The main focus was obviously on the attributes that were discovered during the focus group. The initial idea was to let the participants assign a number to each attribute depending on how important it is for them. But it was soon clear that this would result in a lot of work for the participants and a lot of them would not have finished the questionnaire. Instead the form of the questions was changed to let them pick from a list only those attributes that are important for them. This way they only have to think about a few attributes and they can ignore the rest.

As stated before time is often the most critical factor when choosing a route. When an appointment has to be met all other factors become less important. To understand the importance of certain attributes in different situations it was necessary to define some typical reasons for making a trip with the public transport system. In a study conducted by the U.S. Department of Transportation seven trip purposes were used to categorize the investigated trips: “To/From Work”, “Work Related Business”,

"Shopping", "Other Family/Personal Errands", "School/Church", "Social and Recreational" and "Other" [43]. As seven categories would have been overwhelming for the participants some categories were grouped together in this thesis so that the following three remained: "Work/School/University", "Personal Errands" and "Social and Recreational". An explanation of each category can be found below.

Work/School/University:	e.g. Trips To/From Work, Meeting, School, University, Library, etc. → normally it's important to be on time.
Personal Errands:	e.g. Trips for Shopping, Family Obligations, Doctor's Appointment, Veterinarian, Bank, Administrative Errands, etc. → often it's important to be on time.
Social and Recreational:	e.g. Trips to/from Family/Friends, Cinema, Restaurant, Bar, Sports, etc. → normally it's not that important to be on time.

Unlike in the previous focus group there is no chance to explain a question in more detail to a participant. So they have to understand what is asked of them from the question itself or from the help text. To make sure that the questions are self-explanatory a pre-test was conducted with three participants. The result of this pre-test showed that some questions needed more explanation or a different wording. Overall though, the results were satisfactory.

The main purpose of this questionnaire was to gather some quantitative data to evaluate the findings of the focus group. But it was decided to also add some qualitative questions, similar to the ones from the focus group. Two questions were included asking the participants to name their favorite and least favorite stations and give an explanation for their decision. The number of participants of the questionnaire is much higher than the small sample of the focus group. Therefore some important new insights could come from this larger group.

At the beginning of the questionnaire a few questions were supposed to categorize the participants. How often do they use the public transport system? For what purpose do they use it? How important is it for them to reach their destination as fast as possible? At the very end a few questions were added to determine some demographic information like gender, age and employment status. The full questionnaire is available in Appendix A.

4.3.3. Questionnaire Execution

As mentioned in the previous section, before sending out the invitations a pre-test was conducted with three persons to test whether all questions are comprehensible. The feedback of these participants was overall good. There was one problem in particular where the explanation of the options of one question was not prominent enough. One of the testers had obviously mixed up the options 1 (= not important) and 5 (= very important). Knowing this all the explanations of options were made more prominent and some additional information was added to make each point clearer.

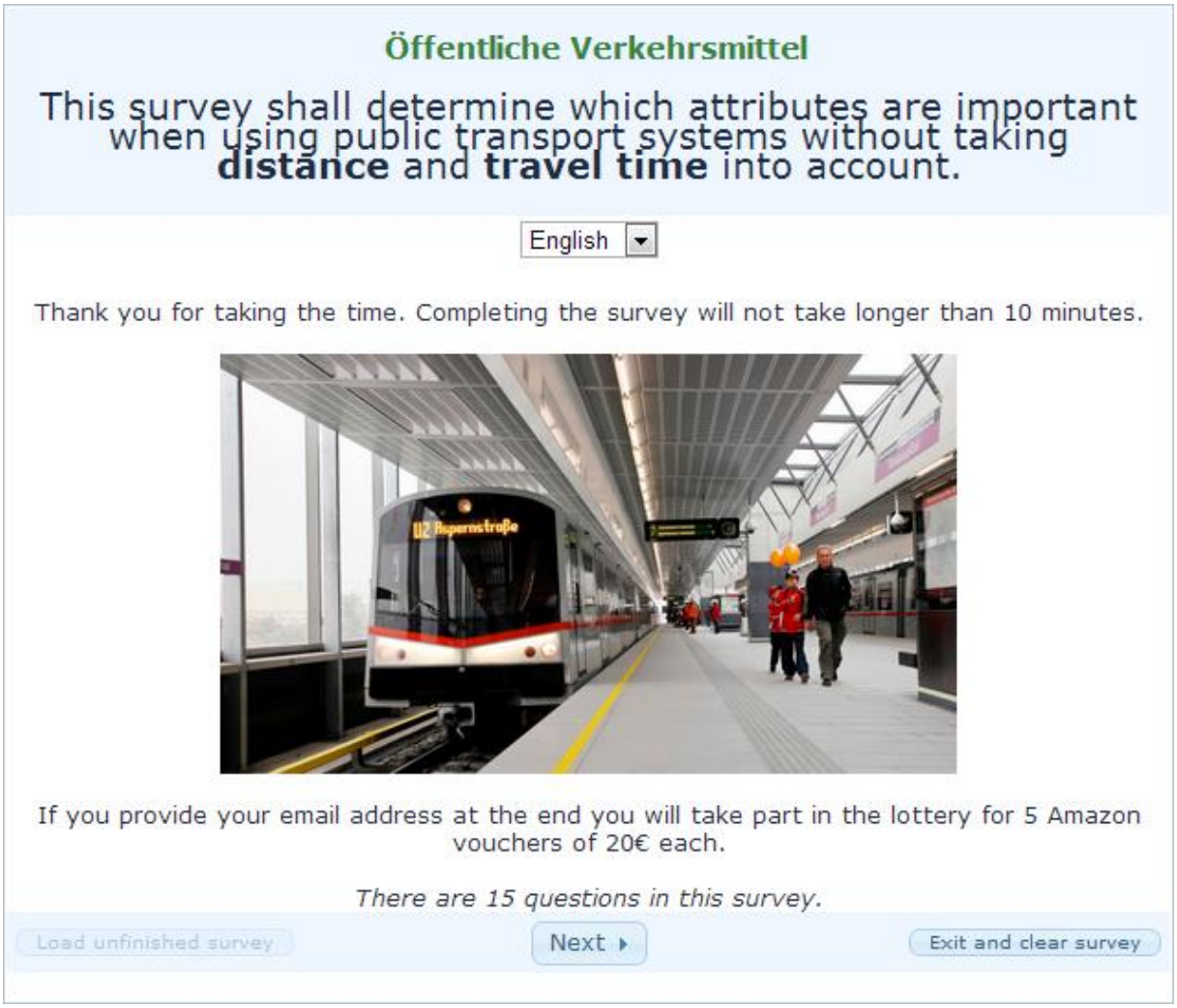

Figure 16 – First screen of the online questionnaire

The questionnaire was started on Friday 2nd August 2013 and ran for around seven weeks until Friday 20th September 2013. The invitations were sent out via email and social network sites. A large part of the responses came in after the invitation was posted on the website of the fanpage of the Wiener Linien (www.fpdwl.at).

The final number of completed questionnaires was 170. The number of incomplete questionnaires was quite high with 76. This shows that even though the intention was to reduce the complexity of the questionnaire as much as possible it was still too high for many participants. Many of which stopped when they reached the screen with the attributes. The full questionnaire can be found in appendix A.

5. Results

The investigation described in chapter four brought some interesting results. This chapter is grouped into five sections. The first one explains the routes that were the outcome out of the focus group session. The second section deals with the attributes identified to influence a routing decision. The third section discusses the findings of the survey. Section four offers an interpretation of those results. And finally the fifth section discusses the implications of the findings for (online) route planners.
Unless stated otherwise the distances and travel times are taken from the website of the Wiener Linien. The distances are measured from one stop to another. The same is true for the travel times. So walking from/to a stop and changing lines is not considered in those numbers.

5.1. Routes

When you search online for a route from the B3 dormitory to the university you will be presented with some of the routes described in section 4.1.4. A student without any prior knowledge will most likely rely on those routes. Therefore the expectation was that most students would choose one of those routes and that there would not be any new routes. Surprisingly though, some participants regularly take other, much longer routes, both in distance and time.

One of the best examples can be seen in *figure 17*. Route number 1 shows one of the two shortest routes to Karlsplatz. It is the route that most participants in the focus group named as their preferred route. One participant though named another route as an alternative he/she regularly uses. This route (number 2) is a lot longer in both distance and time. Route 1 is 2970 m long and it takes 7 minutes whereas route 2 is 5310 m long and takes 20 minutes. As one can clearly see, there is quite a big difference between those routes. This is already evident by looking at the visualization in *figure 17*. At first sight anybody can see that the second option is much longer than the first one. Of course it doesn't feel like that to the participant. In his/her subjective experience it is almost equal to the shortest route. As he/she put it when talking about option 2: "It doesn't take much longer". The specific reasons for this will be elaborated in section 5.4 but it is already clear that this person values the

length and travel time of a route lower than other attributes and therefore chooses a route that is not the shortest.

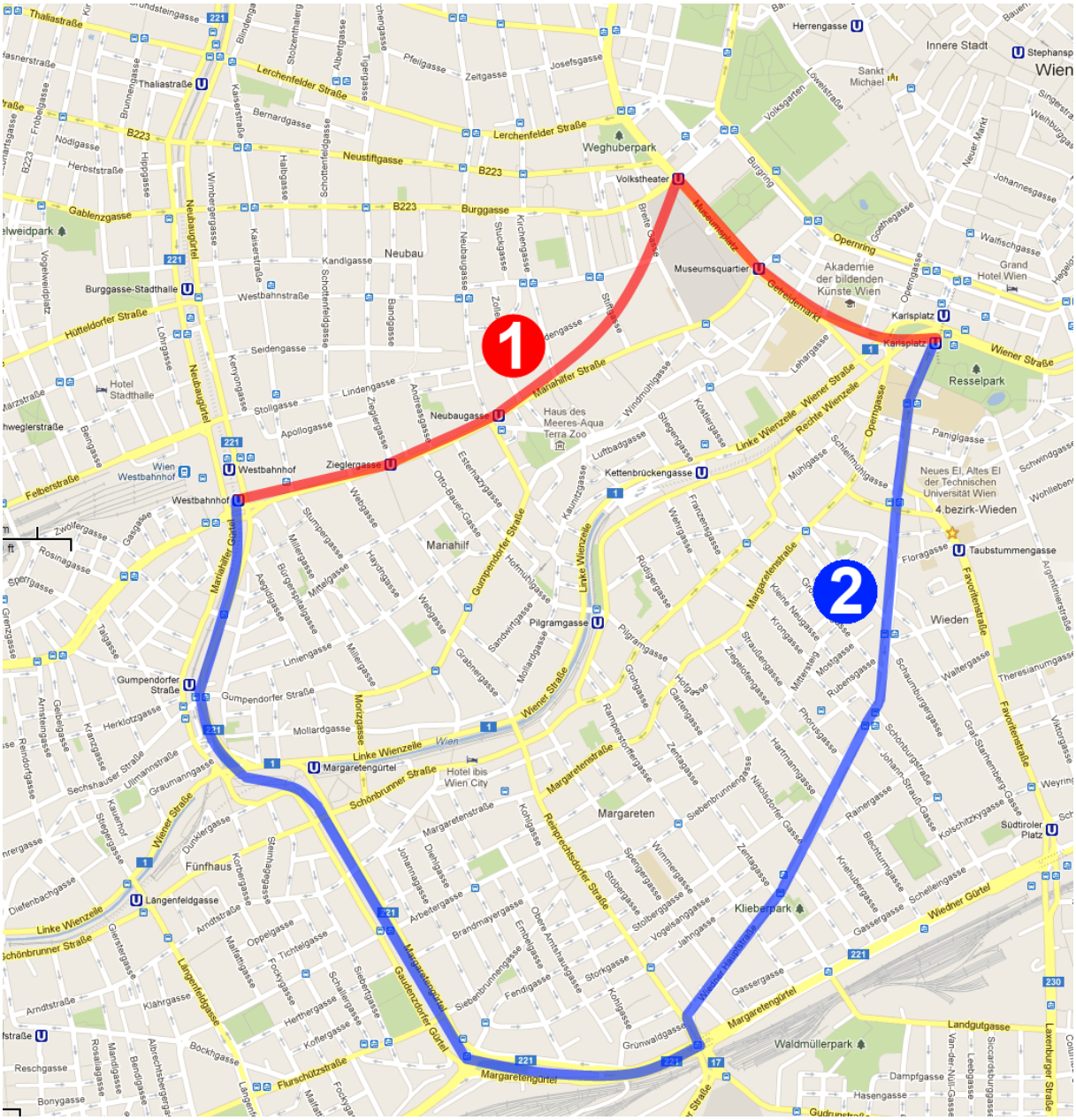

Figure 17 - (1) U3 from Westbahnhof to Volkstheather and U2 from Volkstheather to Karlsplatz (2) U3 from Westbahnhof to Stephansplatz and U1 from Stephansplatz to Karlsplatz

In addition to the route number 1 in *figure 17* described above, most of the participants also named the U4 route as an alternative. (see *figure 11*) Even though the walking distance from the dormitory to the U4 stop Margarethengürtel is quite a bit longer. 5 minutes from the B3 to the U3 stop Westbahnhof versus 10 minutes from the B3 to the U4 stop Margarethengürtel. An interesting point here was the fact that one person stated that he/she sometimes takes the tram from Westbahnhof to get to the U4 stop Margarethengürtel. Thereby eliminating much of the walking distance. It is a curious route though since it replaces one walk of about 10 minutes to the U4

stop Maragrethegürtel with several steps. First one has to walk to the tram station near Westbahnhof, then take a short tram ride of two stops to Margarethengürtel and finally walk from the tram stop to the U4 stop Margarethengürtel. Even though this sounds cumbersome it is perceived as a good option by this participant.

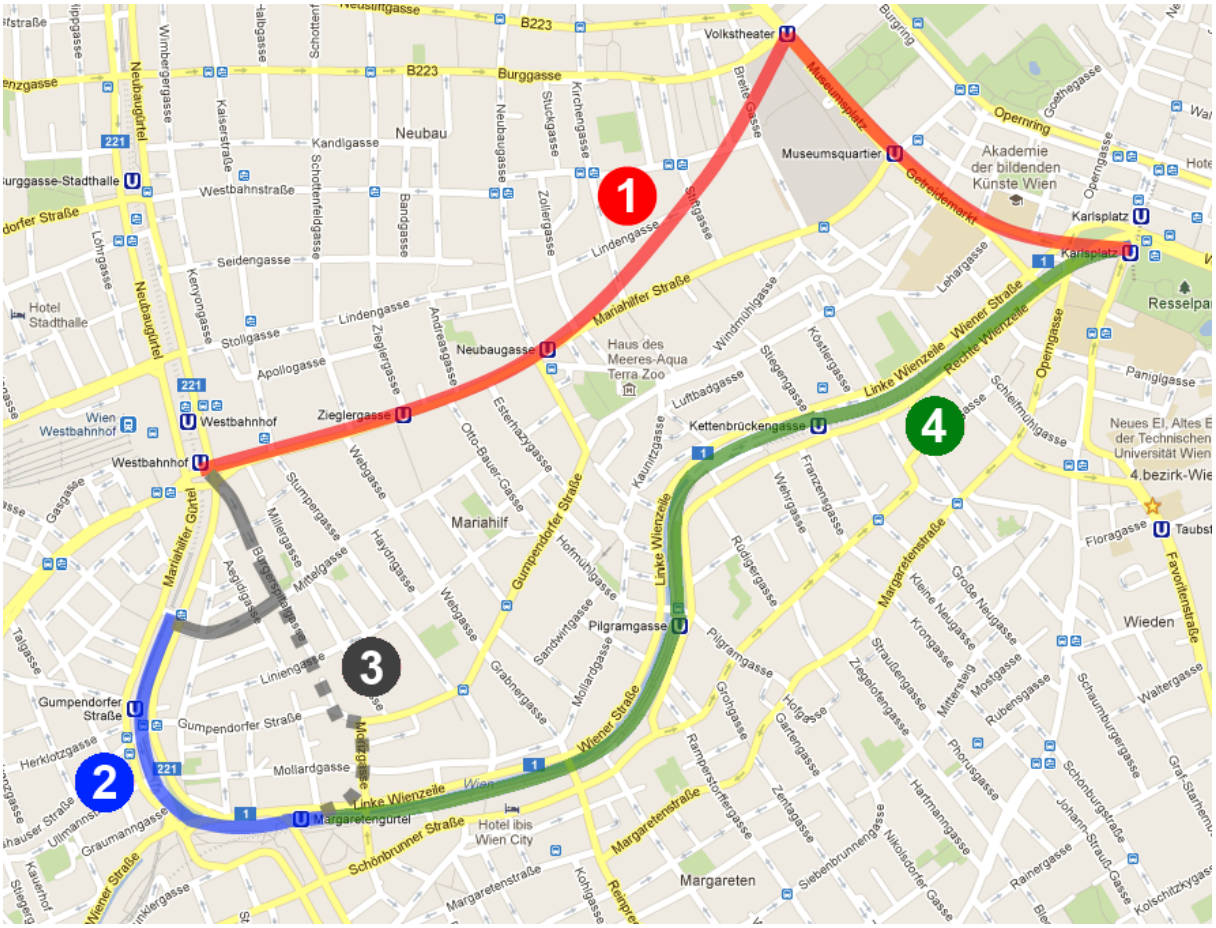

Figure 18 – (1) Shortest Route for reference (2) Tram 6 from Mariahilfer Gürtel to subway Margarethengürtel (3) Walking Path from B3 to Margarethengürtel (4) U4 from Margarethengürtel to Karlsplatz

Another interesting finding was that even though there are two very similar routes to Karlsplatz, one was clearly preferred by the participants. The first alternative is the route U3 from Westbahnhof to Volkstheather and U2 from Volkstheather to Karlsplatz. The second alternative is the route U3 from Westbahnhof to Stephansplatz and U1 from Stephansplatz to Karlsplatz. Both routes have the same stations as starting point and endpoint, so walking distances are equal in both cases. Additionally both routes are rather similar in distance (U3-U2: 2970m; U3-U1: 4007m) and especially time (around 27 minutes). Yet the participants of the focus group clearly preferred the first alternative. The reasons for that are mainly subjective impressions. The second alternative includes the subway line U1. Generally this line is perceived as dirtier than others. Also the second alternative requires a change of lines at the station Stephansplatz. Most participants avoid this station because it is perceived as more crowded and chaotic than others. Also the bad smell seems to

influence this decision. This clear preference for one of two very similar alternatives shows that objective, rational reasons alone are not enough to make a decision.

5.2. Attributes

The decision to choose on station over another in the end comes down to certain attributes that we associate with them. One important goal of the focus group was to gather as many attributes as possible. These attributes would later be the central piece of the online survey where the goal was to assign a weight to each attribute. The first section lists all the factors that were named in the focus group as things that influence the route chosen. The next section then explains which one of those can be seen as subjective. The third section shows all attributes that can be assigned to a station and therefore appeared in the survey.

5.2.1. Determined Factors

Below all the determined factors are listed and a short explanation is given if necessary.

- ***ATM Machine***
  When a person needs money a station with an ATM machine is preferred.
- ***Breakfast***
  In the morning it may be important to be able to get a breakfast on the way
- ***Shops***
  Especially on the way back shops one the way may be important to buy groceries or other things.
- ***Condition of Shops***
  The participants talked not only about the public transport stations but also about the condition of the shops around them. If two stations have a bakery close by the decision for one station also depends on which one has the nicer looking shop. (Or the better bread etc)
- ***Air Quality***
  Quite often I heard statements like “I don’t like the sticky air there” or “I like this station better because there is always fresh air”. The perceived air quality seems to be rather important.
- ***Weather***
  The chosen route also depends on the weather. A favorite route may not be used anymore when it’s raining. Also some people seem to have different routes for summer and winter.

- ***Environment***
  While the subway is often the fastest connection between two places it is also (mostly) below ground. All you see is the tunnel walls. For some participants it is very important to see the environment. Often times they mentioned that they want to see the sky or the sun. Especially on a nice day.
- ***Mood of other People***
  One person felt that people in the subway are in a worse mood than those on the tram. So he/she feels better when travelling with other people he/she perceives as being in a better mood.
- ***Means of Transportation***
  Public transport in Vienna offers several options like subway, tram and bus.
- ***Travel Direction***
  People seem to often take different routes when going from A to B as opposed to going in the other direction from B to A. (see also Golledge (1995) [16]) This is also influenced by potential time constraints explained in the next point.
- ***Time Constraints***
  The routes chosen by the participants are also dependent on how much time they have. For example some of them said that they would rather go to a stop near their final destination when they are in a hurry. But on the way back, when there is no time constraint, they would choose a different route. (Presumably the one they actually prefer)
- ***When do I change Lines?***
  One participant mentioned that he/she would rather choose the route that allows him/her to sit in one line for as long as possible and then change lines only at the very end of the travel. This corresponds with the findings of Wiener at al. (2004) who concluded that people delay a turning decision as long as possible [49].
- ***First Impressions***
  What became clear during the focus group was that most people seem to stick to those routes that they first tried. That was also evident when the participants were talking about their routes. A few times the others said something like “I would have never thought of that route”.
- ***Walking Distance***
  The distance from my starting point to the public transport station.
- ***Walking Distances when changing Lines***
  Length of the walk when I change from one line to another.
- ***Beggars***
  The participants feel that in some stations you see a lot more beggars than in others.
- ***Crowdedness***
  The (perceived) amount of people in a station or in a train/bus.

- ***Condition of Stations***
  Often it was mentioned that some stations look worse than others. In general the stations on the U6 line are perceived as the most unappealing and also the U3 stations were not perceived as much better.
- ***Smell***
  The smell was mostly an issue when talking about the U1 station Stephansplatz. It is avoided by most people also because of the smell.
- ***Layout of Stations***
  It was mentioned that some stations feel very complicated. You have to take several escalators to get where you want to go. Also some participants said that in some stations you have the feeling of always walking in the opposite direction of everybody else.
- ***Temperature***
  Some stations feel not as hot as others in the summer to some people. The U4 stations were named here. Presumably because there are partly above ground.
- ***Probability of Ticket Inspection***
  It should not be a criterion for anybody with a valid ticket, but the probaility of ticket inspections at certain stations was also named as something that is considered sometimes.
- **Cleanness**
  How clean does a station look and feel?
- ***Safety***
  The safety aspect was discussed as well and whether this is important for choosing a route. There was no clear positive answer. It can be assumed that this has got to do with the fact that Vienna is generally a rather safe city. Especially the route from the B2/B3 to the TU is quite safe. Additionally it is travelled mostly during the day. Safety may be more important for other routes and during the nighttime.

5.2.2. Subjective Factors

The term “subjective” usually describes something that cannot be measured that easily. For example, no objective data can be acquired about how nice a certain route is. Each person’s own impressions will influence this judgment. The perception of a route will differ from person to person. There are ways to measure such subjective perceptions. The attractiveness of a route could be gathered by letting people choose from a scale with options ranging from “not attractive” to “very attractive”.

Some of the criteria in the subjective section could be measured in an objective way. Let's take crowdedness for example. Of course it's possible to measure the number of people in a station and compare this to other stations. But in the end every person will have a different view about when a place feels crowded. For some it might be when 300 people are present. For others 50 might be too much already. Another example is the fact that the sun or the sky is visible from certain stations. Of course a chart could be compiled naming those stations that are not totally below ground. But the question here is 'how does the fact that the station is above ground influence my feeling about this station'? Therefore those attributes are marked as subjective.

Out of the first list the below factors can be considered as subjective. The name of the attributes has been adapted slightly in this list to support the subjective character better. The original name of the attribute can be found in brackets. Throughout the rest of this work the original name will used.

- ***Perceived Condition of Shops (Condition of Shops)***
  The number of shops near a station and what they offer is a fact. But it was notable that people also rate those shops in terms of what condition they are in. Is the shop clean? Does it offer a big variety of goods? In a way the attributes of nearby shops are then attached to the public transport station. People consider those attributes when choosing one station over another.
- ***Perceived Air Quality (Air Quality)***
  In this context air quality refers to how sticky or how fresh the air feels. In some stations the participants felt that the air was very stale. In general any stop that is above ground feels better in terms of air quality. (From an objective point of view this may not even be correct since open stations are often close to car traffic and therefore the air could be more polluted than below ground)
- ***Perceived Attractiveness of the Environment (Environment)***
  For some it seems to be important to have a nice view while traveling. They would rather be in a place above ground where they can see their surroundings. Others may be more pragmatic and don't care that all they see is the wall of a tunnel.
- ***Perceived Mood of other People (Mood of other People)***
  One participant even thinks that he/she can see the effect certain characteristics of one station can have on the mood of other people. Because he/she perceives the people in an underground station as in a bad mood he/she prefers any station that is above ground.
- ***Preference for specific Type of Transportation (Means of Transportation)***
  Some people clearly prefer one option over the others . Because of this some stations are rated lower simply because they belong to the wrong type of transportation.

- ***First Impressions***
  The first impressions can increase the rating of one station a lot. So much that other options aren't even considered until somebody else suggests them to you.
- ***Perceived Inconvenience because of Beggars (Beggars)***
  Most participants could name a few stations where they feel that they would see a large number of beggars a lot of times.
- ***Perceived Crowdedness (Crowdedness)***
  The definition of when a station feels crowded to somebody varies. Most people definitely tend to avoid those stations if possible.
- ***Perceived Condition of Stations (Condition of Stations)***
  How a person perceives the condition of a station depends greatly on personal assessments. Some participants named several U3 stations as rather unappealing whereas others feel that they are absolutely fine.
- ***Perceived Smell (Smell)***
  The perception of when something smells bad varies from person to person.
- ***Perceived Complexity of the Station (Layout of Station)***
  Whereas some perceive the layout of a station as complicated others may not view it the same way.
- ***Perceived Temperature (Temperature)***
  The temperature could be measured of course. The limit of when a place feels too hot or too cold is a very personal decision though.
- ***Perceived Cleanness (Cleanness)***
  The definition of when something is clean can vary greatly.
- ***Perceived Safety (Safety)***
  What makes a station more secure than others? Many other people or the existence of a police station nearby may enhance the feeling of safety.

5.2.3. Attributes of a Station

Not all factors found in the focus group can be seen as attributes of a station. The factor 'Time Constraints' for example has got to do with the context of the travel. A person may choose a different route when he/she has more time as opposed to when he/she has less time. While this is a factor to consider it is not an attribute that can be assigned to a station. (The same is true for 'Mood of other People', 'Travel Direction', 'When do I change Lines?' and 'First Impressions') In the survey only attributes of a station can be considered as it would otherwise make the questions too complicated. Therefore the list below is a subset of the list in 5.2.1 of those factors that can be seen as attributes of a station.

- ***Walking time to the station***
- ***Means of transportation***
- ***Walking time in the station when changing lines***
- ***Shops in or around the station***
- ***Safety***
- ***Cleanness***
- ***Food in or around the station***
- ***Smell***
- ***ATM***
- ***Weather***
- ***Beggars***
- ***Environment***
- ***Layout of the station***
- ***Condition of the station***
- ***Number of people in the station***
- ***Air quality in the station***
- ***Temperature***
- ***Condition of shops in or around the station***
- ***Possibility of ticket inspection***

5.3. Survey

The main goal of the survey was to assign a weight to each attribute of section 5.2.3 based on how much it influences the decision for or against using this station. 170 participants completed the survey, 131 men and 39 women. The age of the persons ranges from 13 to 74. The average age was 31,74 years with a standard deviation of 11,37. Around 50% of them are employed full-time with another 30% being full-time students. The rest was either working or studying part-time, retired or unemployed.

5.3.1. General Findings

115 of the 170 participants use the public transport system 4 days per week or more. The remaining 55 are almost equally distributed over the remaining four options as can be seen in *figure 19*. That means that 85% of all participants are using public transport at least once a week. Therefore they should know the stations well and have a good idea about what they like about them and what not.

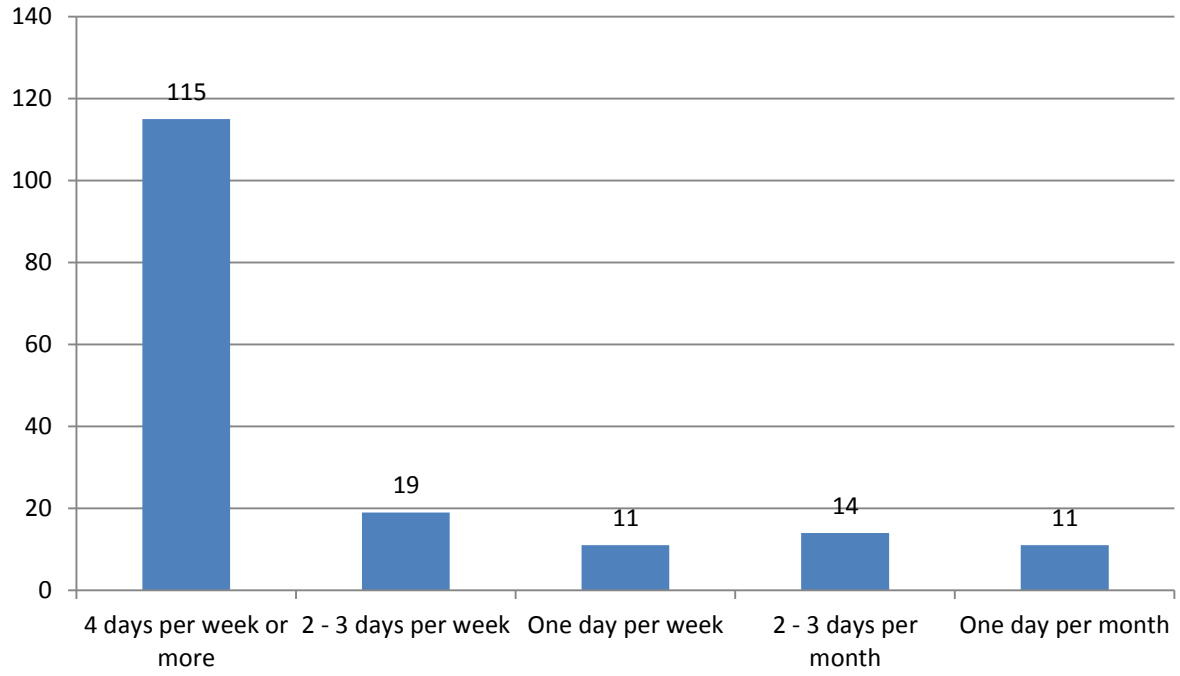

Figure 19 – Usage of the public transport system

78% of the participants stated that they are using online route planning tools for public transport such as the one provided on the website of the Wiener Linien (www.wienerlinien.at). That indicates that there already is a broad acceptance for such tools and people seem to rely on the results provided by them.

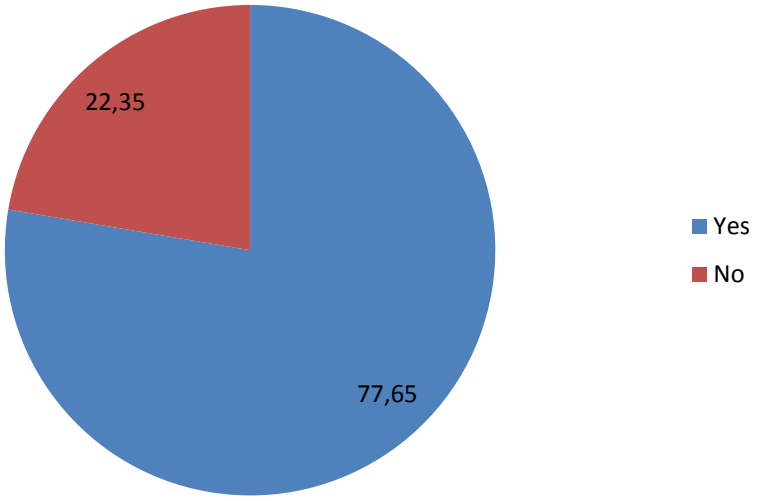

Figure 20 – Usage of online planning tools

For the survey three categories were created to classify the trips: “Work/School/University”, “Personal Errands” and ‘Social and Recreational”. The

participants were asked for which purpose they use the public transport system. On average each person makes 50% of his/her trips for work, school or university related purposes. The remaining trips are on average in 21,5% of the cases for personal errands and in 28,5% of the cases for social and recreational purposes. From this data it is clear that most trips that the participants make have a time constraint. For example when you are going to work or to school you have to be there at a certain time. This is also true for some of the trips of the other category but not to the same extent.

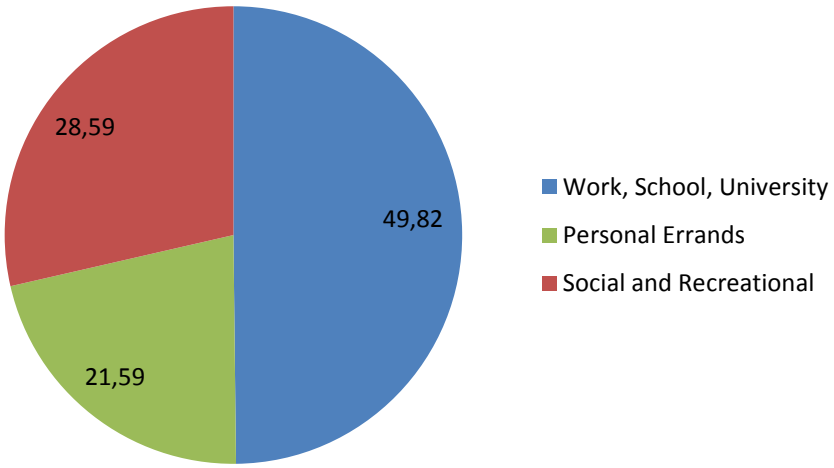

Figure 21 – Average purpose of trip

Another question was how crucial the factor time is in general. How important is it for the participants to reach their destination as fast as possible? The chart in *figure 22* shows that for only less than 20 people in the survey this factor is not important at all. For all the others it is at least a bit important if not very important. One major spike is visible on the category “Work, School, University” where 117 participants (= 69%) stated that reaching the destination as fast as possible is very important. *Figure 23* illustrates that the average importance of the factor time is highest for the category “Work, School, University” with 4,3. It is considerably lower for the other two categories “Personal Errands” with 3,7 and “Social and Recreational” with 3,3. The ANOVA test returns a result of $F(2,507)$, $p<.05 = 27,205$ which is clearly above the critical value of 3,014 and therefore indicates that there is a significant difference between the means in each trip purpose category. As has been stated before the factor time will always be relevant when planning a trip. But the data shows that there are some trips where it may not be the most important factor.

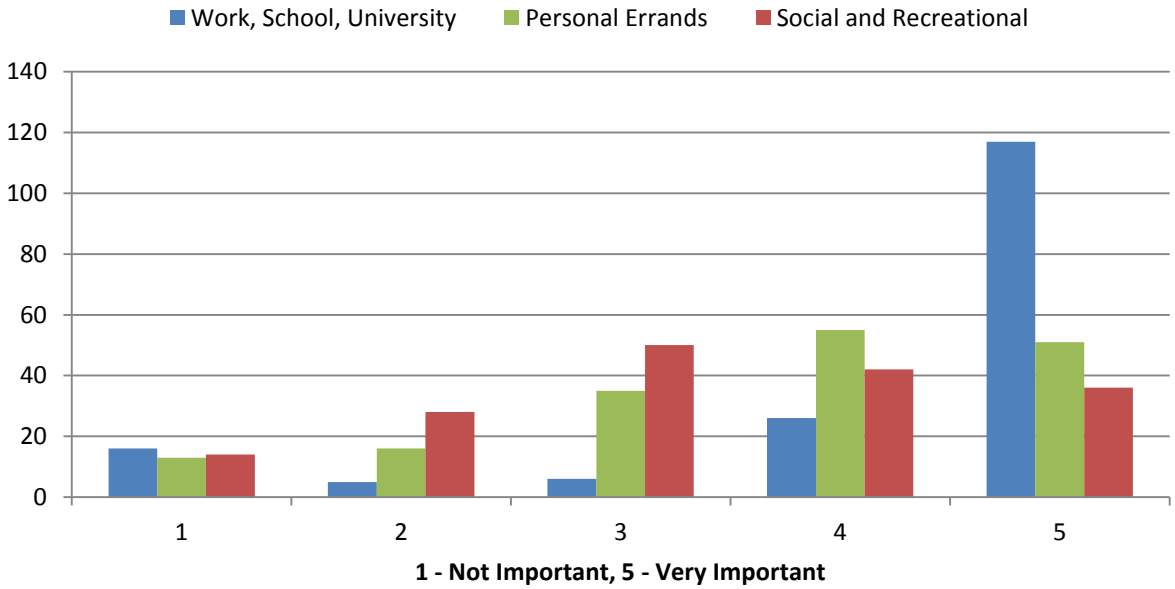

Figure 22 – Importance of reaching the destination as fast as possible

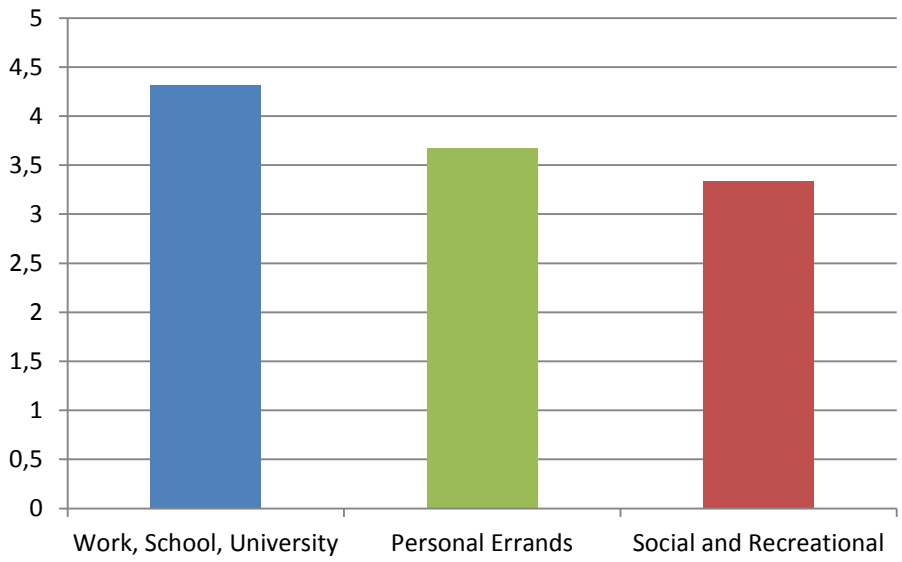

Figure 23 – Average importance in each category

5.3.2. Importance of Attributes

The participants were asked to select from the list of all attributes those that influence their decision for or against using a certain station. That means that if they select an attribute it is important for their decision making process. This procedure was then repeated for all three categories or trip purposes.

Figure 24 represents the number of times (in %) each attribute has been selected by a person in any of the three categories. The results show that the three attributes walking time to the station, means of transportation and walking time in the station

when changing lines are by far the most important ones. The remaining attributes have an importance of between roughly 10% and 30%.The only attribute that can truly be seen as not important is the possibility of ticket inspection. These results show that almost all attributes are somewhat relevant with three of them being clearly more important than the others.

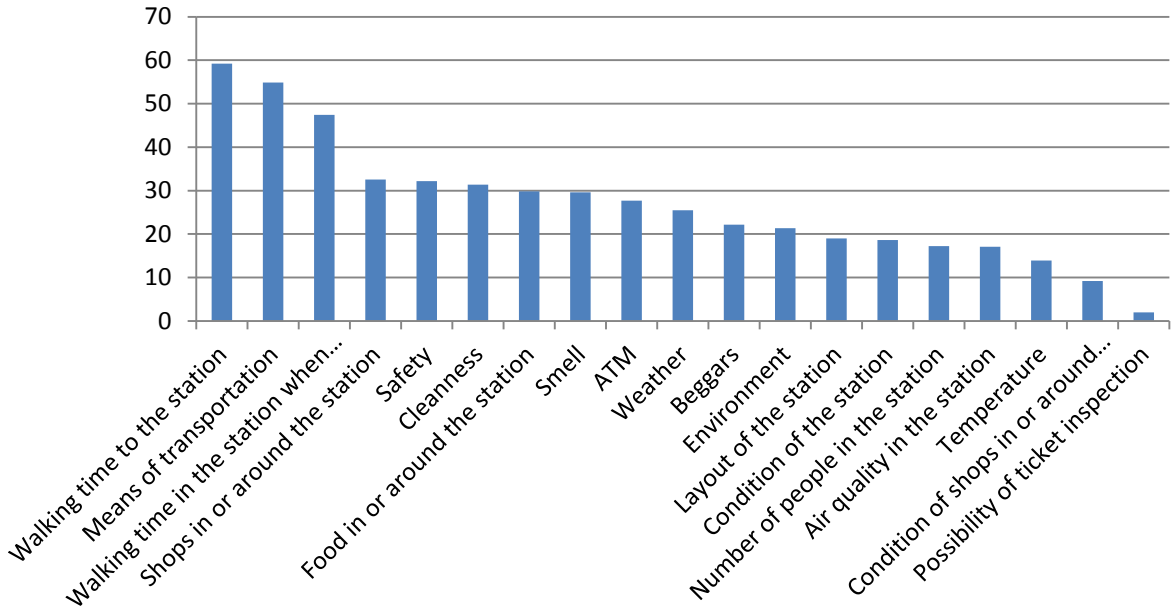

Figure 24 – Importance of each attribute in %

While *figure 24* shows a percentage value of how often each attribute was selected as important irrespective of the category, *figure 25* below illustrates the exact number of times each attribute was chosen in each of the three categories.

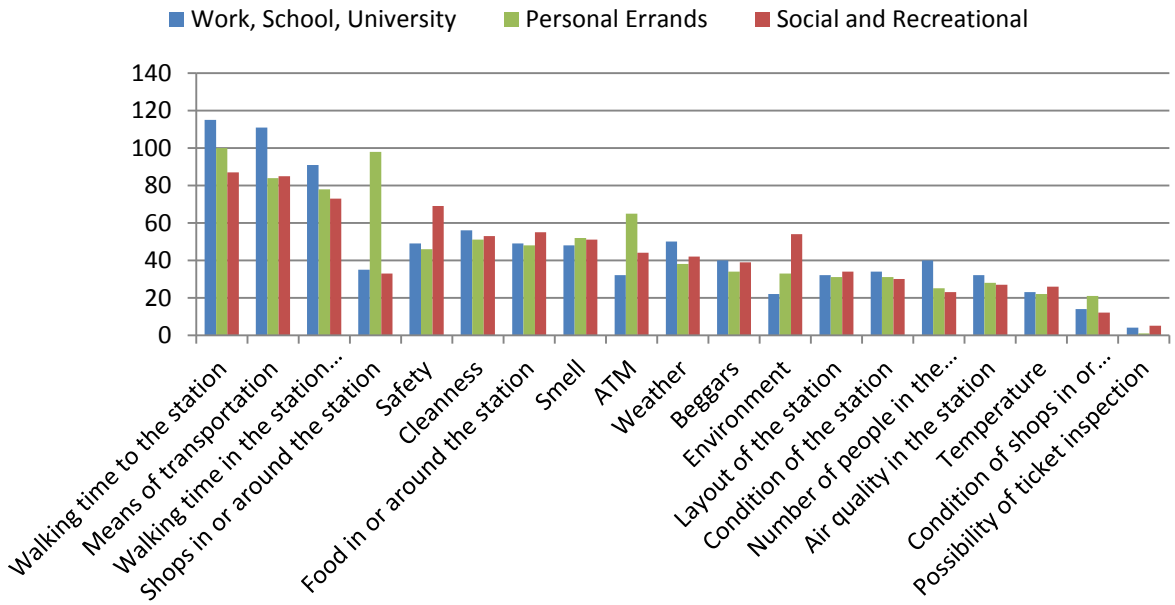

Figure 25 – Importance of each attribute per category/trip purpose

A χ^2 Test was performed for each of the attributes to test whether there is a dependency between the trip purpose and the number of times an attribute was selected as important. The results show that with a significance level of p=0,05 all attributes except “Temperature”, “Condition of shops in or around a station” and “Possibility of Ticket inspection” are dependent on the trip purpose. If we look at a significance level of p=0,001 then there are still six attributes that are dependent on the trip purpose. (see *figure 26* below) The results clearly indicate that the importance of an attribute varies depending on the purpose of the trip.

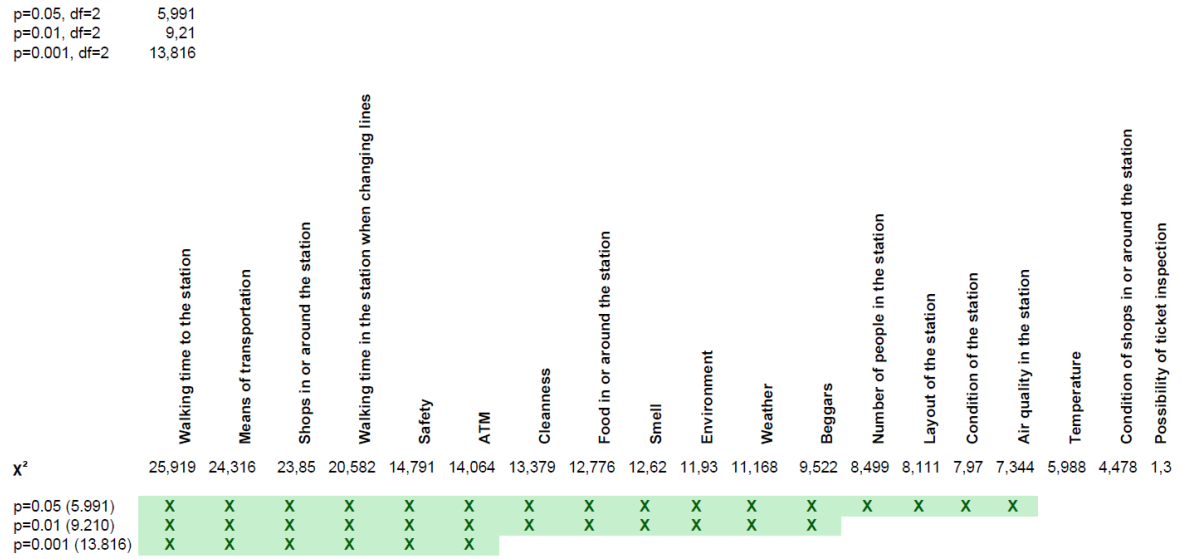

Figure 26 - χ^2 Test indicating whether the number of times an attribute was selected as important is dependent on the trip purpose. An ‘X’ in the cells above means that there is a dependency according to the significance level.

Some notable findings in terms of different importance between categories are:

Work, School, University

The attributes “Walking time to the station”, “Walking time in the station when changing lines”, “Means of transportation”, “Number of people in the station” and also “Weather” are more important than for the other two categories. On the other hand attributes like “Environment”, “ATM” and “Shops in or around the station” are less important.

Personal Errands

The attributes “Shops in or around the station” and “ATM” are more important than in other categories.

Social and Recreational

The attributes “Safety” and “Environment” are more important than in other categories. And, although they are still the top three attributes of this category, the three most important attributes from the “Work, school, university” category are significantly less important here.

It is further interesting to understand whether the importance of an attribute depends on the gender. To answer this question another χ^2 Test was performed. The resulting χ^2 value of 42,709 is larger than the critical value for p=0,05; df=18 (28,869) and the critical value for p=0,001; df=18 (42,312). Therefore it can be stated that the importance of the attributes depends on the gender. It should also be noted that women selected on average 17,69 attributes in all three categories while men only selected 14,62 attributes on average.

One other question that came up during the focus group was regarding the travel direction. While this is not the main focus of this thesis it would be interesting to know whether the direction plays any role in the decision making process. The travel direction was addressed in a separate question. As it turned out the vast majority of the respondents takes the same route traveling to and from their destination. So seemingly the direction does not play a big role. The findings of Golledge (1995) [16] on this topic are a bit ambiguous as well. In two experiments in the same environment the participants were asked to walk from one starting point to an end point and then back in the opposite direction on whichever path they choose. After that they were asked to the same with another starting point and another end point. For the first route 62,9% took the same route in both directions. But for the second route only 15,6% took the same route. Golledge concluded that these differences may be attributed to the layout of the environment around the two routes.
In the case of this survey one has to consider that 50% of the trips the participants are taking are to/from work, school or university. It can be assumed that after a while a certain habit is established where not much thought is spent anymore on the choice of the route. From the findings of the focus group it seems also clear though that if there is not one specific place where you have to be every day at the same time then the route choice can be different depending on the travel direction.

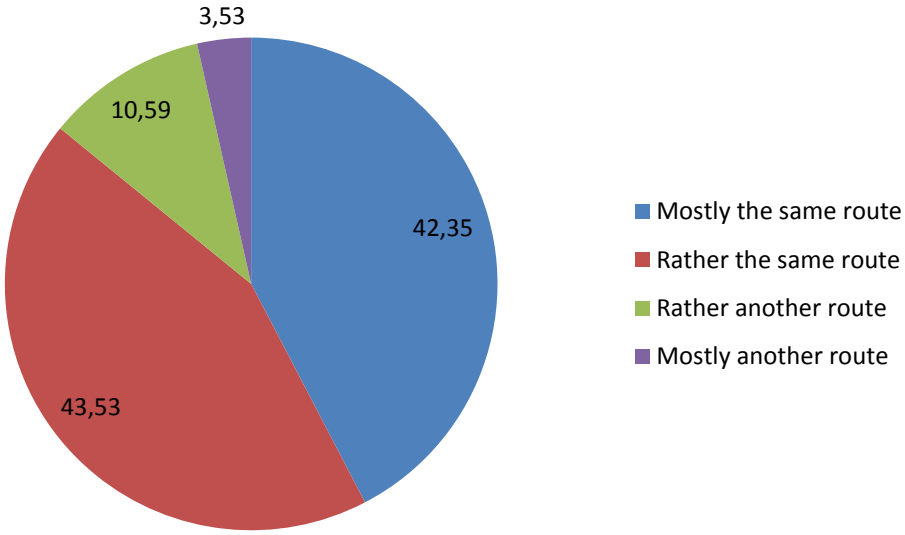

Figure 27 – Is the same route taken on the way back? (in %)

5.3.3. Additional Attributes

All the attributes mentioned in the questionnaire have been determined in the focus group. Since the number of participants was much larger for the survey it was probable that additional attributes would be discovered during this step. For this reason an 'Other' option was added to the questions where the participants were asked to select those attributes that are important for them. Even more importantly, two free-text questions were added before the participants even saw the attributes in the questionnaire. They were asked to name their favorite and least favorite station and explain their decisions. Without being influenced by the predefined attributes of the questionnaire a lot of factors were named that define a good and a not so good station in each person's perception.

Below the additional attributes are listed that were discovered during the survey:

- ***Lighting***
  The lighting was often named as a factor that either makes a station appealing (warm light, no dark spots, natural light from outside) or unappealing (too dark, no natural light)

- ***Architecture or Design***
  The new stations of the lines U2 and U1 were often named as favorites because of their modern architecture or design. Also the historic stations of the U4 were often mentioned because of their architecture. Additionally the art

displays in some stations (e.g. Volkstheater) were mentioned by some as a positive factor.

- ***Information***
  Missing information displays or signs were mentioned a lot. On the other hand some also stated that some stations are preferred because all relevant information is visible at all times.

- ***Intervals***
  Stations with short intervals are generally preferred. This also seems to be one reason why the bus is not very well liked since the intervals there are longer and not as reliable as in the subway.

- ***Barrier-free***
  Accessibility for handicapped people is an important factor. Although this attribute is already available even on the online route planner of the Wiener Linien.

- ***Sanitary Facilities***
  Availability of toilets or the condition of those.

These attributes should be included in further research about this topic. Especially lighting and architecture seem to be rather important to some people.

5.4. Discussion and Interpretation

After living in the B3 dormitory for a few years myself I was rather sure that I would already know all the possible routes from there to the university. My assumption was that in the focus group I would only try to find out why somebody chooses one of those routes over another. As it turned out people use a few more routes I never even thought of. Route number 2 in *figure 17* and route number 2 in *figure 18* are good examples for that. Since those routes are clearly not the fastest options the only conclusion can be that people just like them better. The reason for liking one station better than another one can be broken down to the attributes explained in the previous section. The results of the survey show that most of those attributes were seen as important by a lot of people. So it would make sense for (online) route planners to take them into account.

Some of the attributes are objective. But there are also a lot of subjective attributes that cannot be measured as easily. When talking to the participants it became clear

that those attributes are quite important to most of them, even if sometimes just on a more subconscious level. The findings of the survey reinforce this. Almost all attributes (with the exception of one) were selected as important by at least 9% of the participants. Typical subjective criteria like safety, cleanness, environment or smell have reached an importance of 21-32%. It can therefore be concluded that routing decisions are indeed influenced by subjective criteria.

The participants of the focus group were generally very open to the idea of a different way to calculate a route. They also said that they would not want to enter all kinds of data all the time to be able to calculate a route. So some sort of profile about the user of the route calculation service would have to be created. In connection to that thought they often mentioned a mobile app. The idea was that a mobile device would already know certain things about its user and could therefore calculate a personal route.

It is also quite obvious that somebody who knows an area very well will not calculate a route every time. But for somebody who just moved to a new city or for tourists this could be very helpful. Many in the focus group said that they used the routes they got from a website like www.wienerlinien.at for a very long time before they tried others. That again shows that we depend a lot on information provided by these services. So I believe it would be very helpful if a route calculation tool could also calculate routes that are different from the fastest one.

One thing I want to clearly point out again is that all the factors mentioned in the previous section influence a route choice only to a certain degree. While they all are valid points, the most important one remains time. Only if the factor time can be somewhat eliminated the other factors gain in importance. That could mean that I don't have a fixed time when I have to be somewhere. But it could also mean that I choose to leave home earlier because I am then able to take my favorite route as opposed to the fastest one.

5.5. Implications for (online) Route Planners

The results of the focus group and survey give an insight into which factors are important for people when choosing a route. If these factors are to be applied to (online) route planners there has to be data available on each station as to what attributes are associated with it. It is usually possible to find data about the length of certain road or railway segments in any given network. But there is no data available about most of the attributes discussed in this work. So if a route planner is supposed to use these attributes for calculating a better route then the first question has to be

how to collect data about each station. Essentially a great number of persons has to look at each station in the public transport system and then assign one or several of the attributes to it. A potential solution to this problem can be found in the EmoMap project [28]. There the goal was to collect data about emotions experienced in certain areas. For this purpose an application for mobile phones was developed that allows anybody to share his/her emotions at any time. This data is then recorded in a database and can be used to enhance navigation systems with emotional data. The same principle could be used to collect data about stations in the public transport system.

Another question is how to relate the user's preferences to the route planner? Currently most user interfaces give the user the option to select several checkboxes and thereby express his/her desires. When we talk about a great number of attributes this approach doesn't work anymore. In this thesis more than 20 attributes were determined. Nobody would read through 20 or 30 attributes before every request for a route. A classification of attributes as proposed by Hochmair (2005) [19] would reduce the number of possible options to choose from. Instead of selecting single attributes the user would then select a class like "comfortable". Contained in this class would be several attributes like "clean", "moderate temperature", "natural light" etc.

Related to the previous section about classes is the user profile. It represents another way of minimizing required user input by consolidating all of the user's preferences into one profile. Niaraki et al. (2009) state that *"a user profile is vital for personalization"* [34, p. 2251]. If all the necessary data is contained within the profile then the user never has to enter any data when requesting a route because the system already knows what his/her preferences are.

One particular problem of the determined subjective attributes is that they are often hard to measure. Take the previously mentioned attribute "crowdedness" for example. If a certain station in the public transport network is rated by ten people, five of them may say that it feels crowded while the other five may perceive it as not crowded. So who do you trust? It is not possible for any one person to rate every station in the network for all available attributes. Therefore we have to rely on the experience of others. According to [31] the route planning experience can be shared between similar users. What that means is that data of other users with a similar user profile has to be preferred for generating a route. So in the example above only four of those ten users may have a similar user profile to my own. And let's assume that all four of them stated that the station feels crowded. Then the experience of those four users should be what the route planner relies on for generating my own route.

Coming back to the first point in this section it all starts with the data about stations and what attributes are assigned to them. Only if this data is available in some shape or form a more personalized router planner that takes a great number of different attributes into account can be created.

6. Summary and Outlook

The aim of this work was to determine the attributes of stations that are most important for persons when choosing a route. First the possible attributes were discovered in a focus group. Later on the importance of each attribute was determined with an online survey. The results first of all confirm that people use all kinds of factors to make route choices and they don't always just pick the shortest (in distance or time) option. The most important attributes (importance greater than 20%) were:

1. Walking time to the station
2. Means of transportation
3. Walking time in the station when changing lines
4. Shops in or around the station
5. Safety
6. Cleanness
7. Food in our around the station
8. Smell
9. ATM
10. Weather
11. Beggars
12. Environment

Chapter 5 provides more details on all attributes and on how important they are when making route choices. The results also show that certain attributes become more important when time is not so critical. The three trip purposes, for which the participants had to rate the attributes, show that when you have to be somewhere at a certain point in time the fastest route is preferred and other factors play a small role. When the purpose of your trip is personal errands or social and recreational appointments then other factors become more important. At the same time the assumption is confirmed that for most people time and distance is still very important.

Among the most important attributes above there are quite a few that can be characterized as subjective attributes:

- Preference for specific Type of Transportation (Means of transportation)
- Perceived Safety (Safety)
- Perceived Cleanness (Cleanness)
- Perceived Smell (Smell)
- Perceived Inconvenience because of Beggars (Beggars)
- Perceived Attractiveness of the Environment (Environment)

The question whether subjective factors play a role for making route choices can therefore also be answered with yes.

Future work will have to focus on how to incorporate the determined attributes into route planning tools. As mentioned before one of the key points is to gather the necessary data about the road or railway network. The results have shown that subjective attributes play an important role when making route choices. Collecting data about these attributes is quite hard as it can only come from people directly. Therefore a suitable tool for the collection of the data is the first step to incorporate the attributes into a route planner.

From looking into existing online route planners it seems that most of them still focus on the traditional attributes of distance and time. Some planners try to enhance this with additional options but in the end the routes cannot be called personalized. There is a lot of research being done on the subject of personalized route planning. Google, one of the biggest players in the online maps and route planning business, has also recently stated that personalized maps represent a strong focus for them in the coming years [18]. This could be one push toward a first personalized route planner. In general it can be expected that we will see several of these personalized systems in the not too distant future.

List of Figures

List of References

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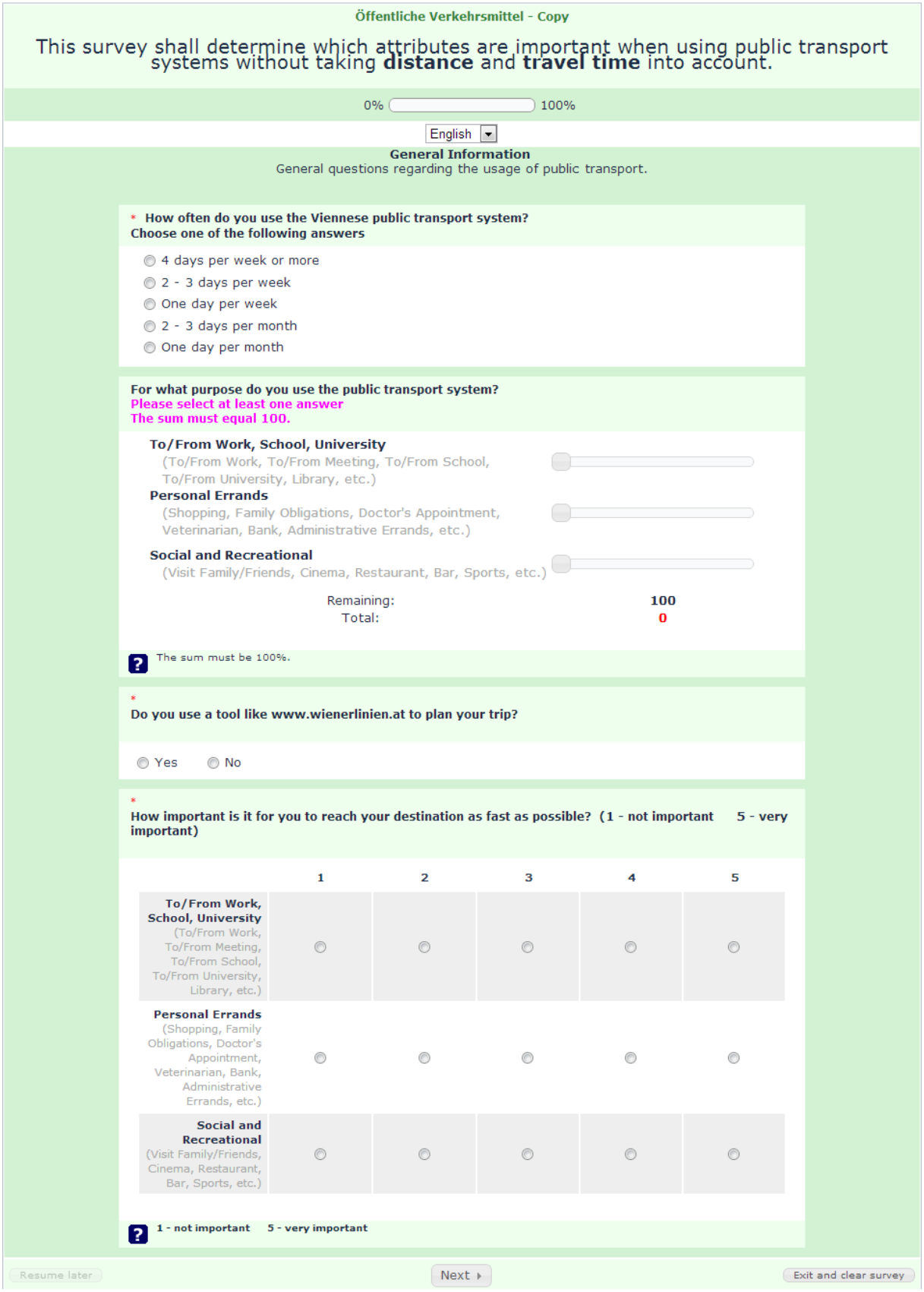
Appendix A

Online Questionnaire



Öffentliche Verkehrsmittel - Copy

This survey shall determine which attributes are important when using public transport systems without taking **distance** and **travel time** into account.

0% 100%

English

General Information
General questions regarding the usage of public transport.

* **How often do you use the Viennese public transport system?**
Choose one of the following answers

- 4 days per week or more
- 2 - 3 days per week
- One day per week
- 2 - 3 days per month
- One day per month

For what purpose do you use the public transport system?
Please select at least one answer
The sum must equal 100.

To/From Work, School, University
(To/From Work, To/From Meeting, To/From School, To/From University, Library, etc.)

Personal Errands
(Shopping, Family Obligations, Doctor's Appointment, Veterinarian, Bank, Administrative Errands, etc.)

Social and Recreational
(Visit Family/Friends, Cinema, Restaurant, Bar, Sports, etc.)

Remaining: 100
Total: 0

The sum must be 100%.

*
Do you use a tool like www.wienerlinien.at to plan your trip?

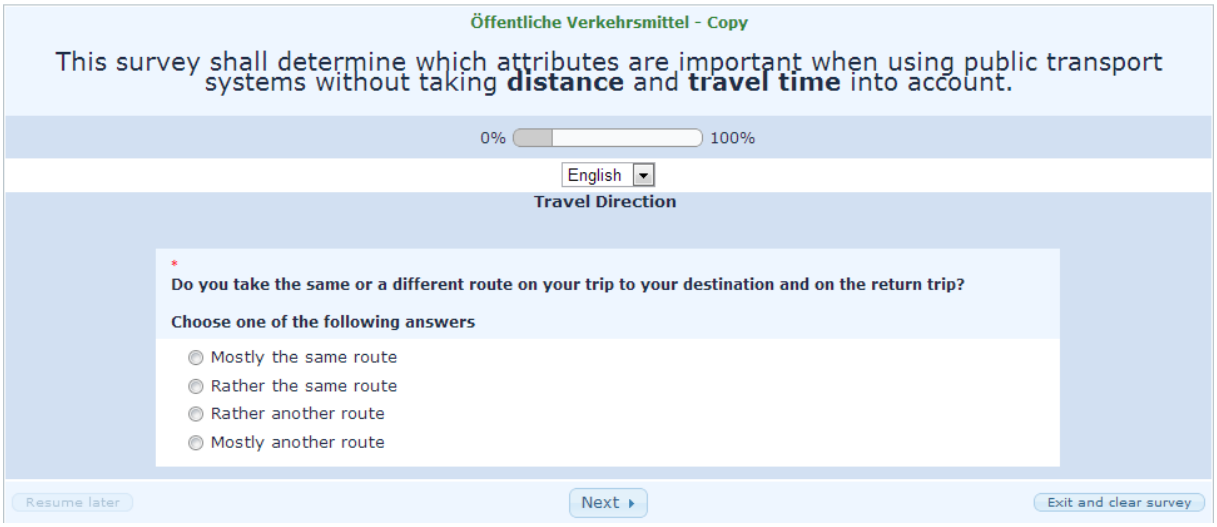
Yes No

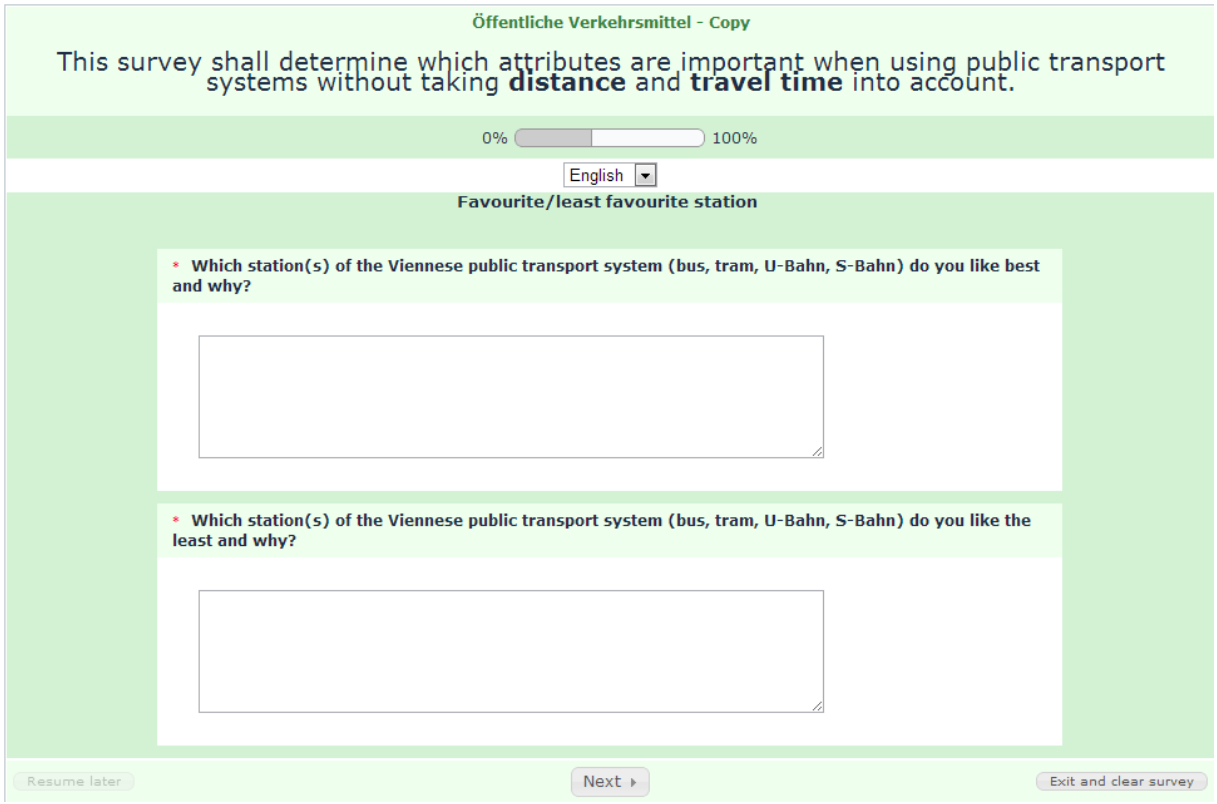
*
How important is it for you to reach your destination as fast as possible? (1 - not important 5 - very important)

	1	2	3	4	5
To/From Work, School, University (To/From Work, To/From Meeting, To/From School, To/From University, Library, etc.)					
Personal Errands (Shopping, Family Obligations, Doctor's Appointment, Veterinarian, Bank, Administrative Errands, etc.)					
Social and Recreational (Visit Family/Friends, Cinema, Restaurant, Bar, Sports, etc.)					

1 - not important 5 - very important

Resume later Next Exit and clear survey


Öffentliche Verkehrsmittel - Copy
This survey shall determine which attributes are important when using public transport systems without taking distance and travel time into account.
0%
100%
English
Travel Direction
*
Do you take the same or a different route on your trip to your destination and on the return trip?
Choose one of the following answers
Mostly the same route
Rather the same route
Rather another route
Mostly another route
Resume later
Next
Exit and clear survey


Öffentliche Verkehrsmittel - Copy
This survey shall determine which attributes are important when using public transport systems without taking distance and travel time into account.
0%
100%
English
Favourite/least favourite station
* Which station(s) of the Viennese public transport system (bus, tram, U-Bahn, S-Bahn) do you like best and why?
* Which station(s) of the Viennese public transport system (bus, tram, U-Bahn, S-Bahn) do you like the least and why?
Resume later
Next
Exit and clear survey

Öffentliche Verkehrsmittel - Copy

This survey shall determine which attributes are important when using public transport systems without taking **distance** and **travel time** into account.

0% 100%

English

Attribute

On this page you will find a list of attributes of a station (stop). Which of these attributes influence your decision for or against a station in the following 3 situations?

*

Work, school or the university **(e.g. Trips To/From Work, Meeting, School, University, Library, etc.)**

Please select at least one answer

- ☐ **Shops in or around the station** (Clothing, Groceries, Drug Store, etc.)
- ☐ **Food in our around the station** (Takeaway, Bakery, Restaurant, etc.)
- ☐ **ATM**
- ☐ **Condition of shops in or around the station**
- ☐ **Air quality in the station**
- ☐ **Weather** (protected vs unprotected stop, below ground vs above ground)
- ☐ **Environment** (Trees, Flowers, Green Field vs. U-Bahn Tunnel)
- ☐ **Means of transportation** (U-Bahn, S-Bahn, Tram, Bus)
- ☐ **Walking time to the station**
- ☐ **Walking time in the station when changing lines**
- ☐ **Beggars**
- ☐ **Number of people in the station**
- ☐ **Condition of the station** (newly built, worn, dark, damaged seats, etc.)
- ☐ **Smell**
- ☐ **Layout of the station** (simple and clear vs. complicated and angled)
- ☐ **Temperature** (or perceived temperature)
- ☐ **Possibility of ticket inspection**
- ☐ **Cleanness** (Trash on the Floor, Dirty Seats, etc.)
- ☐ **Safety** (e.g. Bad Environment, at Night, etc.)
- ☐ Other:

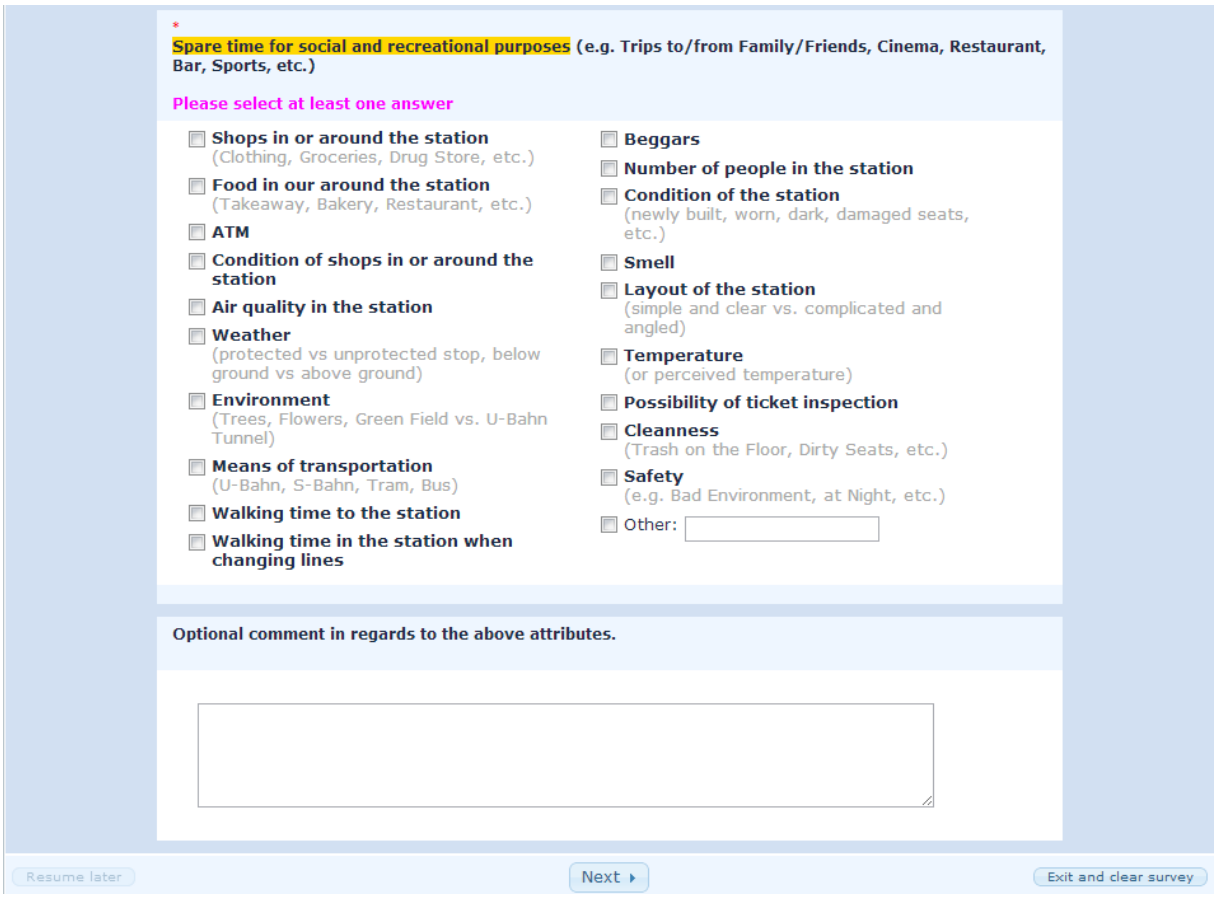
*

Personal errands **(e.g. Trips for Shopping, Family Obligations, Doctor's Appointment, Veterinarian, Bank, Administrative Errands, etc.)**

Please select at least one answer

- ☐ **Shops in or around the station** (Clothing, Groceries, Drug Store, etc.)
- ☐ **Food in our around the station** (Takeaway, Bakery, Restaurant, etc.)
- ☐ **ATM**
- ☐ **Condition of shops in or around the station**
- ☐ **Air quality in the station**
- ☐ **Weather** (protected vs unprotected stop, below ground vs above ground)
- ☐ **Environment** (Trees, Flowers, Green Field vs. U-Bahn Tunnel)
- ☐ **Means of transportation** (U-Bahn, S-Bahn, Tram, Bus)
- ☐ **Walking time to the station**
- ☐ **Walking time in the station when changing lines**
- ☐ **Beggars**
- ☐ **Number of people in the station**
- ☐ **Condition of the station** (newly built, worn, dark, damaged seats, etc.)
- ☐ **Smell**
- ☐ **Layout of the station** (simple and clear vs. complicated and angled)
- ☐ **Temperature** (or perceived temperature)
- ☐ **Possibility of ticket inspection**
- ☐ **Cleanness** (Trash on the Floor, Dirty Seats, etc.)
- ☐ **Safety** (e.g. Bad Environment, at Night, etc.)
- ☐ Other:

?



*

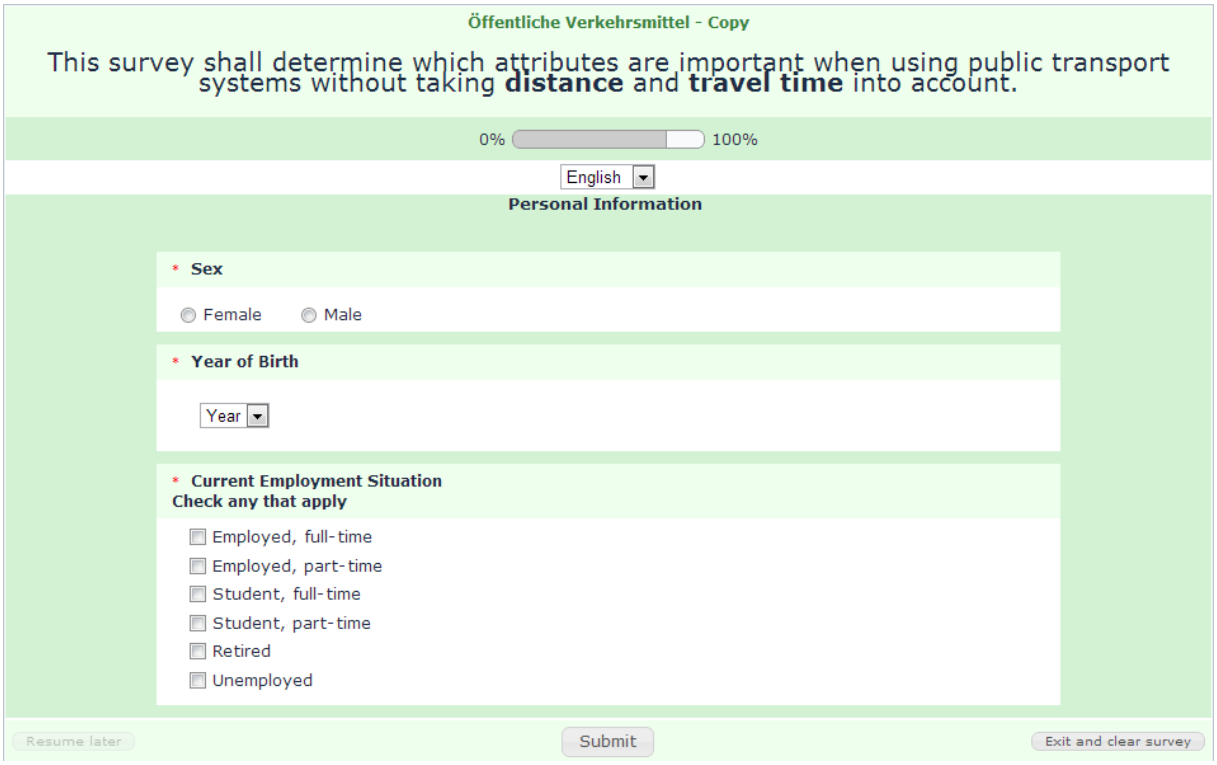
Spare time for social and recreational purposes (e.g. Trips to/from Family/Friends, Cinema, Restaurant, Bar, Sports, etc.)

Please select at least one answer

- Shops in or around the station (Clothing, Groceries, Drug Store, etc.)
- Food in our around the station (Takeaway, Bakery, Restaurant, etc.)
- ATM
- Condition of shops in or around the station
- Air quality in the station
- Weather (protected vs unprotected stop, below ground vs above ground)
- Environment (Trees, Flowers, Green Field vs. U-Bahn Tunnel)
- Means of transportation (U-Bahn, S-Bahn, Tram, Bus)
- Walking time to the station
- Walking time in the station when changing lines
- Beggars
- Number of people in the station
- Condition of the station (newly built, worn, dark, damaged seats, etc.)
- Smell
- Layout of the station (simple and clear vs. complicated and angled)
- Temperature (or perceived temperature)
- Possibility of ticket inspection
- Cleanness (Trash on the Floor, Dirty Seats, etc.)
- Safety (e.g. Bad Environment, at Night, etc.)
- Other:

Optional comment in regards to the above attributes.

Resume later | Next | Exit and clear survey



Öffentliche Verkehrsmittel - Copy

This survey shall determine which attributes are important when using public transport systems without taking **distance** and **travel time** into account.

0% 100%

English

Personal Information

* **Sex**

Female Male

* **Year of Birth**

Year

* **Current Employment Situation**
Check any that apply

- Employed, full-time
- Employed, part-time
- Student, full-time
- Student, part-time
- Retired
- Unemployed

Resume later | Submit | Exit and clear survey