Technische Universität München

Associations Between Perceived Risks And Travel Behaviors

A Mixed-Method Approach for the City of Munich

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I confirm that this master's thesis is my own work and I have documented all sources and material used.

Munich, 15th of April 2023

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MASTER'S THESIS

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Title: Influence of Perceived Safety on Mode Choices in Munich

Background:

In order to reduce the use of motorized private modes of transportation, which are harmful in regard to climate change, air pollution, congestion, etc. (David L. Greene and Michael Wegener 1998), there is a priority to push people to other modes such as public transportation, cycling and walking. Therefore, more knowledge is needed to understand urban commuters and how future choices can be moved to more environmentally friendly modes (Masoumi and Fastenmeier 2016). A.H. Maslow (1970) ranked the feeling of safety and security as a biological need second only to humans' basic physical and physiological needs. Several studies explored the role of perceived safety or perceived risks in choosing one's mode of transportation. Perceived safety is how people subjectively perceive risks, it is a complex social and psychological phenomenon (Rundmo and Nordfjærn 2019). Risks regarding transportation can be classified into two big categories: fear for one's own health or life due to the risk of a physical accident or virus infection; and fear of assault and harassment, which is associated with theft, inappropriate behaviours, transgression in an unknown environment with interactions with other people (Petříček and Marada 2022). All people are not concerned in the same way with security issues: gender, age, social class origin, and religion are factors of influence which must be studied. If the two first-cited minorities were studied in Germany already, the other needs to be explored within the German context (Masoumi and Fastenmeier 2016). Masoumi and Fastenmeier (2016) also suggest that north and central Germany were more studied than the south, making Munich a good place to study perceived safety in different modes of transportation.

Goals:

The aim of this thesis is to investigate the role of perceived safety in the use of different transport modes and how it can influence commuters' choices toward more sustainable modes. Public Transport (U-Bahn, S-Bahn, bus and tram), cycling, walking and private cars will be studied. It also aims to make a state-of-the-art of Munich's situation regarding safety in transportation to identify the area for improvement. It will be analyzed regarding gender, level of education, income, age, and origin/religion.

To comply with this intention, the following research questions are defined:

- How do different groups of people currently feel using different transport modes in Munich?
- How do perceived safety influence commuters' mode choices?
- What are the areas of improvement for the city of Munich in terms of safety?

Methodology:

To achieve those objectives, qualitative as well as quantitative methodologies are applied in this thesis.

- Literature review to obtain information about the concept of perceived safety in the field of transportation
- Literature review on studies that have been conducted about safety and risks in the different modes of transport that will be studied.
- Survey conducted within a representative sample of the city of Munich and data analysis
- Interviews to have a better insight into the psychological and social mechanisms which are relevant in mode choices and eventually other qualitative methods
- Identification of the most insecure places in Munich, finding the reason why those are more insecure and finding similar patterns in these places

Supervision:

The candidate will present to his supervisors Dr. David Duran and M.Sc. Maximilian Pfertner a draft of the structure for his master thesis and a work plan two weeks after this approval. Other supervision meetings will be planned with the candidate when necessary. The Chair of Urban Structure and Transport Planning supports the candidate with the contact to relevant actors and or experts if needed. After two weeks of the submission of his thesis, the candidate must defend it by means of a

presentation (20 minutes) and the following discussion. The results are responsibility of the author. The Chair does not take responsibility for those results.

Prof. Dr.-Ing. Gebhard Wulfhorst

M.Sc. Maximilian Pfertner

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Abstract

The time for the end of car-based planning has come for our cities. Individual vehicles are harmful with regard to climate change but also to our health and our comfort of life. While these findings are shared among the scientific community, the reality is more complicated and cities are struggling to shift to other modes of transport, the private car often remaining the main mean of travel. To better apprehend users, it is necessary to understand the reasons for the choice of mode. Perception of risk is one of the factors influencing transportation choice. Despite the importance of safety in transportation, previous research in Germany has poorly addressed the subject, prioritizing other factors associated with travel behaviors such as costs, accessibility, or flexibility. This study, using a mixed-method research design, aims to explore socio-psychological differences regarding risk perception towards unpleasant incidents and accidents and how it is associated with travel behaviors in the city of Munich. A survey was spread among 288 citizens of Munich to measure citizens' perception of risk and worry on the four principal modes of transport: walking, cycling, driving and public transport, as well as an evaluation of 5 personality traits and socio-demographic backgrounds. The participants were afterwards invited to participate in a workshop to support the results and discuss safety and mobility in Munich. Women, young and neurotic people have a higher perception of risk. One's previous experience with transportation in general also has a significant role to play in one's perception of risk and worry. Perceived risk has an influence on how people travel under specific circumstances, resulting in a reduction of the freedom of movement in certain situations. The city of Munich could improve its citizen's perception of safety in transportation by addressing the problem of unpleasant incidents, such as sexual harassment, discrimination, or violence thanks to improved communication on the subject, especially among the young generation. This study provides a first overview of the association between perceived safety and travel behaviors thanks to a mixed-method approach and can serve as a foundation for further research, which should aim at being solution-based oriented to suggest concrete policies to the City of Munich.

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1. Introduction

While the 20th century has seen the emergence of cities and increased the standards of living of citizens, 21st century's cities are facing a lot of challenges. Urban population is experimenting unprecedent growth. If today some 56% of the world's population live in city, urban population is expected more than doubling its current size by 2050 (World Bank 2023). Yet cities face an incomparable number of challenges and mobility is responsible for several of them.

Today we reach the end of an era, that of the car-base planning. Experts agree that the individual car is the enemy of the climate and well-being of citizens. It is time to turn this page of urban history, but the task is proving complicated. Cities are indeed designed for cars and it is difficult for the inhabitants to change their habits, as they are anchored in the history of the city. It is therefore necessary to understand the modal choice of users and the reasons that drive them to use polluting modes of transport. The perception of risks could be one of them.

1.1. Transport-Related Challenges faced by Cities

The first challenge to be identified is climate change. Literature identified climate change as the greatest challenge of all time (Carlo Fanelli 2014). The Intergovernmental Panel on Climate Change (IPCC) provides a comprehensive summary of the causes, effects and solutions against climate changes (IPCC 2023). Cities are both a victim and a culprit of climate change. With high CO2 emissions and sealed soils, cities deregulate the climate and the hydrological circle. But the anthropologisation also made cities more vulnerable to climate change because of the same sealed soils and because of the concentration of wealth and people. In Germany precipitations are going to rise with climate change and population already suffers from its effects (IPCC 2021). There is a need for mitigation and adaptation to climate change. Mitigation necessarily involves reducing drastically GHG emissions (IPCC 2022). Cities account for 70% of global CO2 emissions, most of which come from industrial and motorized transport systems, highly relying on fossil fuels (World Bank Blogs 2023). The role played by cities in mitigating climate change is crucial, and reducing GHG emissions from transportation has become an urgent necessity.

The second challenge is air pollution, emissions released by motorized modes of transport are not only harmful to climate change, but also to human health. The World Health Organization (WHO) reported that air pollution is associated with 7 million premature deaths annually in the world (WHO 2023). Combustion engines release Particular Matter (PM), nitrogen oxides (NOx) and undirectedly

Ozon (O3), which are respectively responsible for 28,910 (PM), 10,009 (NOx) and 4,628 (O3) premature deaths in Germany (European Environment Agency 2022). Although measures have been taken to reduce pollution levels in Munich, such as the Umwelt Zones, they still exceed the recommended limit set by the World Health Organization (WHO). Air pollution stations in Munich still report levels above threshold (Bayerisches Landesamt für Umwelt 2023).

The third main challenge is congestion. If private car allowed in the first place an increased accessibility, and the possibility to reach places in a reduced amount of time, congestion in cities has jeopardized this freedom. In Munich, drivers spend an average extra time of 67 hours driving due to congestion in 2022, it is 12 minutes more than in 2021 (TomTom 2023).

Most of cities were designed for the use of private cars and Munich makes no exception. Changing the lines of the city is a necessity for the environment, as well as for citizen's well-being. There is a priority to push people to other modes such as public transportation, cycling and walking.

1.2. Understand Commuter's Mode Choice

More knowledge is needed to understand urban commuters and how future choices can be moved to more environmentally friendly modes (Masoumi and Fastenmeier 2016). Maslow (1981) ranked the feeling of safety and security as a biological need second only to humans' basic physical and physiological needs. The Health Belief Model (Rosenstock 1974) and The Protection Motivation Theory (RW Rogers 1975) investigated safety as a factor for individual behaviors. Theories agree that an individual's perception of safety is important in one's behavioral intentions. It can be assumed that perceived safety will influence mode choice. Risk is inherent to transportation, even though technical progress tends to minimize the risk in every means of transportation. Risk is not just a matter of technical factors; it also includes human factors (Barjonet et al. 2010). The perceived safety benefits of less study than costs or accessibility as travel behavior's predictor. Rundmo and Nordfjærn (2019) showed that the priority of security was a significant predictor in the use of public transportation and Kummeneje and Rundmo (2019) investigated the role of perceived safety in the behavior of cyclists and pedestrians and also showed it was an important factor when it comes using use frequency of these modes. Perception of risk is associated with mode choice and travel behavior, thus it is necessary to understand how the perception of risk is constructed by individuals and how it influences travel behaviors.

1.3. Objectives

The car-friendly urban system reveals its limits, and it is time to adopt new modes of transport. However, changing mentality and habits is a real challenge. For this reason, this thesis focuses on

understanding citizens and getting closer to their security considerations. For this, several steps are important. First, to understand the socio-psychological phenomena related to risk perception and the resulting inequalities. Then, understand how the perception of risk influences the choice of transport mode in Munich. Finally, explore possible improvements for the city. To comply with these intentions the following research question are defined:

- What are the main perceived risk predictors in transport domain in Munich?
- How do perceived safety influence commuters' mode choices?
- What are the areas of improvement for the city of Munich in terms of safety?

The study uses a mixed-methods research design to answer these questions. The main data collection is done through citizen participation in the form of a survey about their perception of safety and their travel behaviors, as well as their socio-demographics background and their personality. Afterwards Munich's citizens were invited to participate in a workshop to discuss mobility and safety issues.

2. Literature Review

Literature research has been a crucial aspect of this study. By reviewing the structure and research approaches of other studies, it allowed to design a replicable study, comparable with previous and future research (Snyder 2019). As for this research, the literature review allowed the selection of a topic that represents a gap in existing research. This gap and the means used by this study to close it are explained in more detail in the methodology section. The literature review provides a foundation for the research and the design of the later survey and workshop. It will thereby support the research question proposed in the previous chapter.

2.1. Perceived Risk and Worry

To understand the concept of perceived risk, the concept of risk must be defined. When speaking about risk, it is often related to a bad event, for which the possibility to happen is not zero. There is a difference between subjective and objective risk. Objective risk means that an event can happen whereas subjective risk means that one think that the event can happen (Noland 1995). In the field of risk perception, researchers often focus on the subjective part of the risk (Douglas and Wildavsky 1982). In accordance with Hudspith (2004), perceived risk is a cognitive construct consisting of the subjective assessment of the probability of an event as well as the judgement of the severity of consequences if such an event should take place (Fig. 1). There are thus two major dimensions in risk:

the probability and the severity of a possible “bad event”. In the scope of this thesis, a distinction is made between worry and perceived risk as recommended by Backer-Grøndahl et al. (2009). Perceived risk will refer to as ‘risk as analysis’, whereas worry will refer to as ‘risk as feeling’ (Rundmo et al. 2011). ‘Risk as feelings’ implies fast, instinctive and intuitive reactions to danger while ‘risk as analysis’ adds logic, reasoning and reflection into the handling of risk (Slovic et al. 2007).

As for “perceived safety”, this expression usually does not mean that adverse events are believed to be impossible. Perceived safety, in this sense, would always be a misconception (Noland 1995). A place would be said “safe” only if the probability and the severity of a bad event happening is closed to zero, and it is almost never true, at least in the case of transportation. Perceived safety is thus how people subjectively perceive risks, it is a complex social and psychological phenomenon (Rundmo and Nordfjærn 2019).

Figure 1 : Dimensions in Perceived Risk

2.2. Perceived Risk Predictors

This chapter gives an overview of the different predictors for risk perception that have been identified by previous research and therefore that will be explored in this thesis. It aims at identifying differences between individuals that make them feel more or less safe in transportation.

2.2.1. Socio-demographics

There are socio-demographic predictors, studies have explored the role of gender (Sjöberg 1998; Chauvin et al. 2007; Bastide et al. 1989; Bouyer et al. 2001; Flynn et al. 1994), age (Bouyer et al. 2001; Chauvin et al. 2007; Hermand et al. 1999; Sjöberg 1998), ethnicity (Flynn et al. 1994), education (Lund et al. 2012) and income (Flynn et al. 1994; Vredin Johansson et al. 2006). Most of these studies have investigated risk from a wide array of area of life, not specifically regarding the transport domain. Slovic (2000) tried to explain the reason of these socio-demographics differences.

Gender wise, it could be explained by biologic factors, since women are responsible for birth and life, they are socialized to nurture and maintain life, therefore they perceive risks as higher than men. It could also be because of real risk is higher for women in modes with interactions to other people because they are more likely to be victim of sexual harassment. Last, they also are commonly perceived as weaker than men and have less resources for defense which make them, in common thoughts, more vulnerable than men (Slovic 2000).

Slovic (2000) also explains that perceived risk relates to the feeling of control one has over one's environment, which is why people with higher income or education feel safer than people that are more vulnerable (Barjonet et al. 2010). They have more power and control over what happens with them and their communities. As shown by Flynn et al. (1994), white males, compared to nonwhite males, white females, and nonwhite females, perceive hazards linked with industrial development as less risky than others do. In other words, well-trained and better-educated individuals, being politically more conservative, having higher household incomes, higher perceived control over risks to their health, and higher trust in government, authority, and industry (experts, engineers) see less risk in the world.

About age, there is not a consensus whether the younger generation feel safer that older one. For example (Bouyer et al. 2001) found that regarding public transportation and energy production young people scored higher risks. Lund et al. (2012) also made this statement for transport: the oldest age-group was significantly less concerned about risks in transport in general than the two younger age groups. This contrasts with most previous research where younger individuals were less concerned regarding accidents (Deery 1999; Glendon et al. 1996; Sivak et al. 1989). Lund et al. (2012) proposes to explain it with the following fact : younger individuals are over represented in transport accidents compared to older individuals, and they might be increasingly aware of it thanks to campaigns that contributes to reduce the optimism bias in young adults, giving them a more realistic perception about transport-related risks.

It would therefore be interesting to investigate perceived safety through the prism of intersectionality. According to Oxford (2022), intersectionality is the interconnected nature of social categorizations such as race, class, and gender as they apply to a given individual group, creating overlapping and interdependent discrimination or disadvantage. In this paper intersectionality in perceived safety will be explored, to understand which groups feel less safe using different modes of transport. Masoumi and Fastenmeier (2016) suggest that demographic groups like migrant or religious groups have not been in the center of research in the context or Germany, therefore they will be explored in the thesis

2.2.2. Psychological predictors

Risk perception is also related to emotions and feelings. People with different personality traits will not perceive risk in the same way and may not pay the same attention to it. According to Chauvin et al. (2007) personality facets are better predictors of risk perception compared to age, gender and educational level.

The past four decades have seen the emergence of the presence of five large personality, called the Big-5-Personality. An individual's personality can accurately be described by rating the individual on 5 personality traits (Spielman et al. 2020). The first one is neuroticism, the opposite of emotional stability. It is the tendency to experience negative emotions such as anger anxiety or depression. Those who score high in neuroticism are emotionally vulnerable to stress and are more likely to interpret ordinary situation as threatening, one can expect that they will therefore score higher in perceived risks.The second is extraversion, people who score high in extraversion create energy from external means, they like interactions with people. Reversed one, introverts tend to have lower social engagement and need more time alone. One can imagine that introverts will score higher in perceived risks when it comes to public mode of transport because it includes interactions with other people (Backer-Grøndahl et al. 2009). People who score high in consciousness are responsible and reliable, they have self-discipline and strive for achievement. Consciousness is the way people control, regulate, and direct their impulses; people who score high in consciousness might want to reduce risks in their everyday life. The fourth one is agreeableness which reflects social harmony. People who score high with agreeableness are considerate, kind, generous and trusting. They also have an optimistic view of human nature which could make them score lower on perceive risks. The last personality trait is openness to experience, people who generally appreciate art, emotion, unusual idea. They have a lot of imagination and curiosity: they tend to be more creative and aware of their feelings, this personality trait is not expected to have an impact on how people perceive risk.

Sjöberg and Wåhlberg (2002) correlated general risk assessment regarding a local depository of nuclear waste and three personality factors, they found out that risk perception correlates with neu-

roticism and opposite of conscientiousness. According to Backer-Grøndahl et al. (2009) extraversion and especially neuroticism are good predictors for perceived transport-related risks.This study will consider all Big-5 personality traits and will explore which ones correlates with risk-perception in the scope of the study.

2.2.3. Real Risk

Real risk is of course also a candidate to explore risk perception, even though risk is always a constructed vision, risk perception is also based on facts (Slovic 2000). Munich is considered to be the safest city in Germany (Crime Index by City 2022 Mid-Year 2022) but safety is not a given in the city. Police in Munich reported 46 intentional homicides in 2021 (Polizeipräsidium München 2021). Among those, 15 were completed and 31 were attempted. The location where these crimes took place in unknown, it is therefore not possible to know which part of them were transport related. In the area of the Munich, 1,657 sexual aggressions and 483 robberies were reported in 2021. In public transport, 15,363 incidents were reported in 2021. Most of them (49.4%) are property damages or insults; 12.5% are violent incidents; 11.6% are murders or sexual offences; 11.6% are robberies. The report also states where these events take place: 45.7% of the reported offences happened in U-Bahn, 29.6% at stations, 7.7% in buses, 4.2% in S-Bahn.

Regarding accidents, between 2017 and 2020, there were about 20,000 accidents with minor or severe injuries in Munich (Zeitung 2022). There is every year around 15 deadly accidents and 600 major accidents with severe injuries (Polizeipräsidium München 2019). On top of that there are thousands of minor accidents that are not reported to the police. Biking appears to be the most dangerous mode according to police reports. 41.3% of major accidents victims (fatal or severe injuries) happen to be with cyclists, 21.5% pedestrians, 19.4% car-drivers/passengers and 17.8% moto-drivers in 2019. 37.9% of minor accidents victims are cyclists, 43.1% car-drivers or passengers, 10.2% are moto-drivers and 8.8% pedestrians (Polizeipräsidium München 2019). Car-drivers are therefore more likely to be victims of a minor accidents than cyclists in Munich according to the police report. However, one can assume that small accidents while biking is less reported to the police than car minor accidents because of car damages and insurances.

2.2.4. Experience

Finally, experience is also an important predictor for risk perception. People who have experienced an unsafe situation will tend to score higher in perceived risk, especially for the mean of transport they have experienced an unpleasant experience in. According to Oris (2009), in the field of health, the experience influences one’s representation of risk. One can feel more vulnerable when one or someone one’s know have been experiencing a disease. We will explore the role of experience in

the field of transportation, even though Backer-Grøndahl et al. (2009) found it unsignificant to predict worry in transportation.

2.3. Perceived Risk and Travel Bahaviors

Real risk, socio-demographics, psychology, and personal experience can be predictor for risk perception predictors, and the perception of risk can be associated with travel behavior and mode choice (Fig. 2).

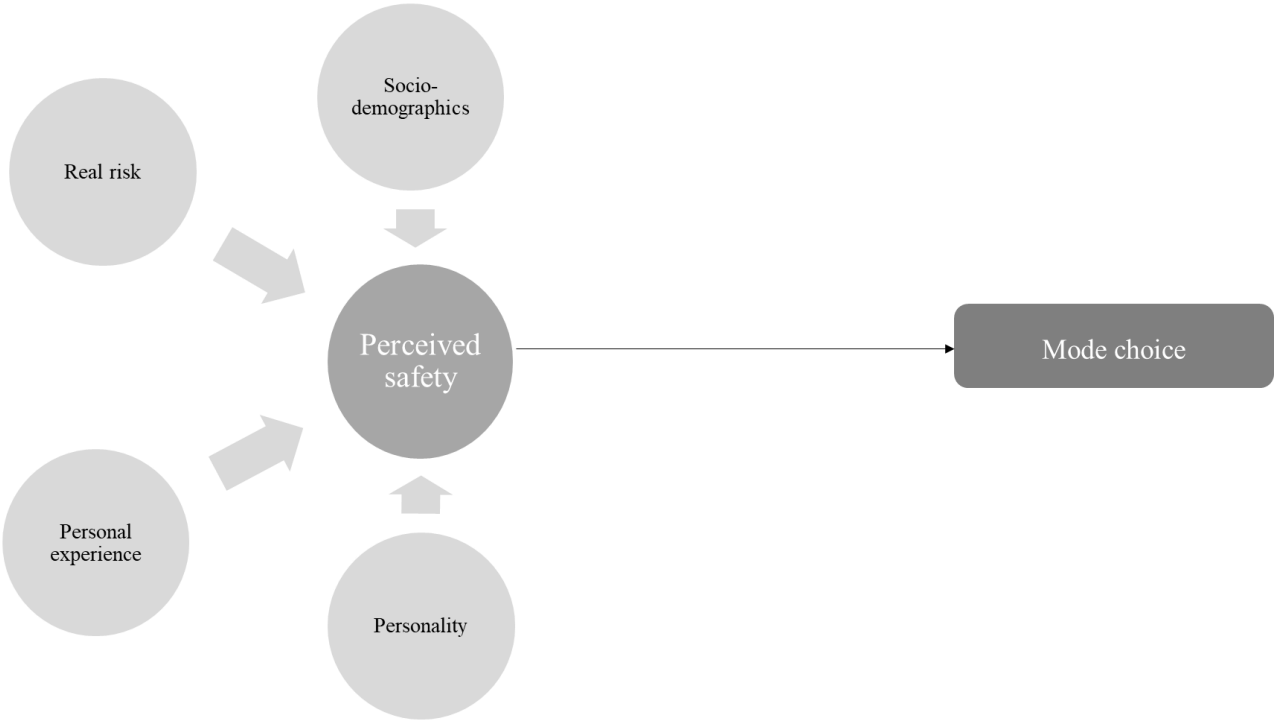

Figure 2 : Perceived Safety Predictors

Noland (1995) has been suggested that risk perception is an important factor when it comes to actual travel behavior. Most researches focused on perceived safety regarding one mode of transport, mostly public transport (Masoumi and Fastenmeier 2016; Nordfjærn et al. 2021; Rundmo and Nordfjærn 2019) but also cyclist and pedestrians (Kummeneje et al. 2019; Kummeneje and Rundmo 2020) or private cars (Deery 1999; Glendon et al. 1996; Sivak et al. 1989), but very few, apart from Backer-Grøndahl et al. (2009) aims at comparing how people feel in these different modes and how perceived safety influences mode choice in cities.

Travel time (Frank et al. 2007), travel costs (Frank et al. 2007) urban form (Frank et al. 2007; Maria Kockelman 1997; Cao et al. 2009; Khan et al. 2014) or accessibility (Maria Kockelman 1997; Khan

et al. 2014) were more often addressed as predictors for mode choice than safety. Yet safety is among the top-3 priorities when choosing a mode of transportation, as found by Rundmo et al. (2011) together with the flexibility (flexible times and routes) and convenience (punctuality, accessibility).

3. Methodology

The general aim of this research is to investigate the predictors of risk perception and explore how the perception of risk can be associated with travel behaviors in the City of Munich. Further, this research should give insights about areas of improvement for the city. It also sets the basis for further and more extensive research.

3.1. Research Gaps and Intentions

The purpose of this section is to relate the existing literature to the methodological intentions of this thesis. The literature review identified gaps in the existing research that this study attempts to fill. This section therefore explains the methodological choices with regards to what was identified as missing, as well as how this study builds on the results established by the existing research.

3.1.1. Private vs Public Transportation Modes

It was proven risk can be divided into two categories depending on if we are looking at private or public mean of transportation (Backer-Grøndahl et al. 2009). In private means of transportation, the risk is about physical accidents whereas in public mean of transportation unpleasant incidents like being threatened, harassed, or exposed to violence are more relevant. In the actual context virus infection will also be considered the risk of being infected in public modes of transportation. In this paper, driving is considered as a private mode of transportation, public transport as public and walking and cycling as a mix of both, because even though they are private modes of transportation, with accident risks, they also imply interactions with other people that refers to public mode of transportation.

3.1.2. Severity Dimension in Risk Perception

Rundmo and Nordfjærn (2019) suggest that the severity of the consequences is rarely taken into account when evaluating risk perception. Sjoberg (2000) pointed out that research have mainly focused on risks with small probability and large consequences, the so-called fatal risk, and less have been conducted on trivial risks, with higher probability but smaller or less serious consequences.

Risk with smaller consequences will be considered in this thesis. Therefore, a distinction will be made between major and minor accident. The first one being an accident, with severe or fatal consequences. Severe consequences refer to as injuries that need medical assistance. Minor accident is an accident without any severe issue. Concerning incidents, the study will also consider "uncomfortable but not harmful incidents", which are insults, staring, racism etc. They are incidents without any direct physical consequences but that make people feel uncomfortable.

This thesis will also try to the difference between worry and risk perception and the role of probability and severity of consequences in risk perception. It is an important dimension to truly understand one's perception of risk, and therefore be able to improve one's perceived safety.

3.1.3. Personality in Transport-Related Risk Perception

Rundmo and Nordfjærn (2019) also states that the association between personality variables and risk perception should be further investigated in the field of transportation. Even though there are some research about the association of personality trait and perceived risk in general (Chauvin et al. 2007; Sjoberg 2000), there are very few studies that focus on transportation when speaking of risk, and most of them were conducted in Norway (Backer-Grøndahl et al. 2009; Rundmo et al. 2011; Rundmo and Nordfjærn 2019; Nordfjærn et al. 2021). Studies rather focus on health or nuclear risks. However, transportation is a big part of one's everyday life in the modern world, and how people feel when using different mode of transport is a matter of great importance. Some studies compare socio-demographic and psychologic factors as risk perception predictors (Backer-Grøndahl et al., 2009; Chauvin et al., 2007; Sjoberg, 2000), but there is no consensus whether socio-demographic or psychological factors better predict risk perception.

3.1.4. Study Area

Masoumi and Fastenmeier (2016) underlines that there is no study about safety and public transport in the South of Germany, which make Munich a good city to conduct the survey, where the subject has not been addressed yet. Masoumi and Fastenmeier (2016) also consider that the question of sub-culture has not been addressed when looking at safety. Yet about 16 million people living in Germany have been born outside of the country or have foreign backgrounds (Masoumi and Fastenmeier 2016) . Therefore, this study will consider migration background as a predictor for risk perception.

3.1.5. Mixed Methods Research Design

All studies that have explored the socio-psychological inequalities in the field of safety and mobility has been focusing on quantitative analysis with a survey. However, as we are looking at a very complex psychological phenomenon, the quantitative approach shows some limitations (Backer-Grøndahl et al. 2009; Masoumi and Fastenmeier 2016). A mixed-methods approach will be used in this thesis, with a qualitative and a quantitative analysis to explore a maximum of dimensions.

3.2. Mixed Methods Approach

To comply with the intentions, a mixed methods approach was chosen, it is to say the “integration of qualitative and qualitative research in a research study” (Huyler and McGill 2019). It is a third research design after the qualitative and the quantitative designs. Mixed methods aims at overcoming the weaknesses of these two research design by the triangulating data sources, that is to say, seeking for a convergence of quantitative and qualitative databases (Huyler and McGill 2019). The results of one method can confirm or contradict the findings of the other one.

There are different procedures when using a mixed-method design (Huyler and McGill 2019). The first one is convergent parallel mixed methods where researchers collect quantitative and qualitative data simultaneously and merge the results to interpret better the overall results. The second one is explanatory sequential mixed methods, in which researchers first conduct the quantitative analysis, analyze the results, and then conduct the qualitative study to explain the results from the quantitative study. The last one is the reverse sequence from the previous one, the researcher begins with the qualitative analysis, and the results are used to build the quantitative phase, to best fit the sample for example. The second procedure is used in this thesis. The literature review was sufficient to build the quantitative analysis and design the survey questions. The results of the survey will be further investigated and interpreted thanks to a qualitative analysis. Participants will have the chance to participate in a workshop once the data are analyzed, to discuss the results given by the survey.

In the scope of this research, where complex socio-psychological mechanisms are on the table, this method allows the research to gain a more comprehensive understanding of the findings provided by the survey, which are not always obvious to interpret. The results of the qualitative analysis also prompt at better interpreting the results of the survey and conducting further data analysis which were not considered in the first place (Fig. 3).

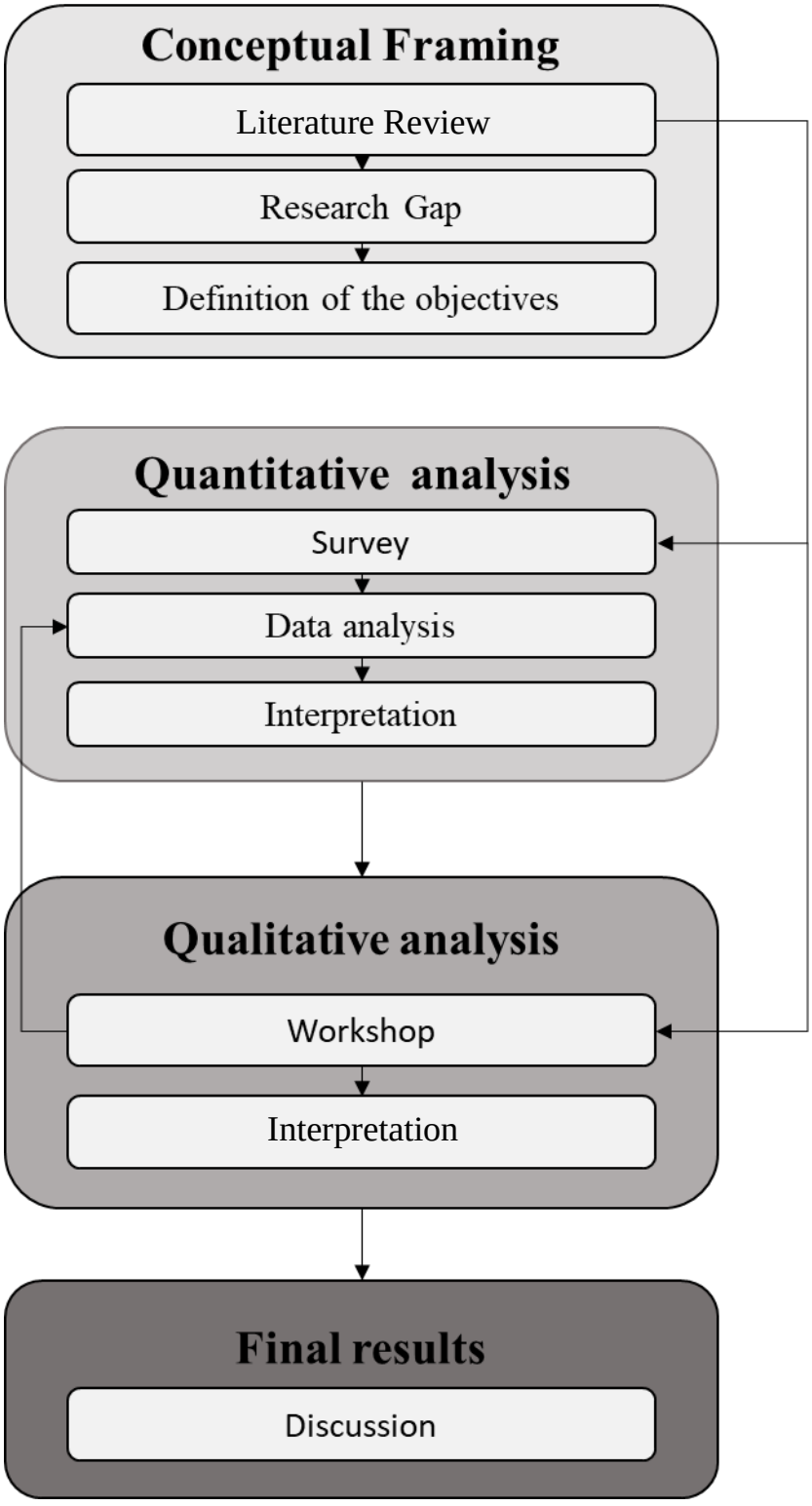

Figure 3 : Mixed-Methods Research Design

3.3. Quantitative Analysis

The following chapter presents the strategy for collecting quantitative data and provides details on the survey parameters, such as the target population and sampling method. It also describes the survey's structure, content, and design, and discusses the pilot survey and its implementation.

3.3.1. Justification

Survey is an effective way of collecting a large amount of data in a short period of time for a large area. Since the targeted population was the population of Munich and the aim to collect impression about safety in different means of transportation, reaching out the citizens of Munich was essential.

3.3.2. Sampling

As mentioned before, the targeted population is the entire Munich citizenship 1,487,708 individuals (Statistisches Bundesamt 2022). As it is impossible for researchers to reach each individual when looking at such scales, the sample survey method (SSM) is used. e of the This method allows to generalize the characteristics of a larger population based on data gathered from a smaller, representative sample of individuals, reducing cost, effort, and time required for the data collection. There are different types of survey sampling, the non-probability sampling method will be used in this thesis. It is a method of selecting people from a population using a non-random method. Since the survey is online, only people who have received the link to the survey are able to participate, the method of spreading is therefore subjective. However, this method assumes that the sample is representative of the population, which is a risky assumption. The study will aim at having as little bias as possible, in the limit of what is possible to do within the times and means available.

To calculate the target sampling size, the following formula is being used:

$$Sample\ size = \frac{\frac{z^2 * p * (1-p)}{e^2}}{1 + \frac{z^2 * p * (p-1)}{e^2 N}}$$

z : z-score

e : margin of error

N : population

p : population proportion

The sample's accuracy is determined by the level of confidence, the most used levels are 90%, 95% and 99%, which have their own corresponding z-scores based on the chosen confidence level (Sample Size Calculator 2023). The z-score is used in the above formula. p is the population proportion, which describes a percentage of value associated with the survey set to 0.5 for this study since the measurements we are looking does not have any proportion in the population. The confidence interval is an estimated range of likely values for a population parameter, it is usually set to 1 or 5%. To achieve a confidence level of 99% and a margin of error of 1%, which would be the ideal situation, the survey would require 16,473 responses, which is not achievable in the scope of this research. A more realistic number of responses can be achieved for a confidence level of 95% and a 5% margin of error, giving a 273-sample size (Sample Size Calculator 2023), which is what this study aimed for.

3.3.3. Material

The survey was divided into four sections: the first one is socio-demographics questions, the second one was questions about how people perceive risk in different transport mode in Munich, the third was about previous experience in the different modes of transport studied and the last one was about personality.

For the socio-demographics part, it was decided to ask, based on literature review, about gender, age, income, migration background and disability. Also, the ZIP code in Munich was asked, so one can see if there are any insecurity patterns in some region in Munich.

The section about the perceived risk was the longest and was itself divided into four parts for the four modes of transportation that were studied: public transport, cycling, walking and cars. Every sub-section started with a question about the frequency of traveling with the specific mode of the sub-section. The choices were the same as in the "Mobilität in Deutschland" report (BMDV - Mobilität in Deutschland (MiD) 2023): "Every day or almost every day", "From one to three times a week", "From one to three times a month", "Less than once a month", "Never or almost never". If the respondent answered "never or almost never" to the question they were atomically directed to the next mode of transport, so people that don't use the mode do not have to answer the questions about it.

Perceived risk about accidents (safety) and unpleasant incidents (security) was measured as "to what degree do you think about the possibility for an accident (or unpleasant incident) when you travel with (by, as) …?" in accordance with Backer-Grøndahl et al. (2009)'s formulation. Respondents were to answer on 5-point Likert scalers from 1 "not at all" to 5 "to a high degree". This will be named as "Perceived Risk Score" for the analysis. The different incidents throughout the survey

were: major accident, minor accidents robbery, physical violence, sexual harassment, uncomfortable but not harmful incidents (e.g. insults, staring) and virus.

There were some specificities for each mode based on their nature. It was proven by Backer-Grøndahl et al. (2009) that there is a difference between private modes and public modes, where one can have interactions with other people. In this study only the private car is considered as a fully private mode, and therefore questions about driving are only about accidents, not the unpleasant incidents. Biking and walking are considered as semi-private, semi-public therefore all questions are asked for these two modes, except from virus infection which was considered to be only relevant in public transport. Public transport is fully public mode, therefore there is only one question about accident in general (which merges minor and major accident), because, as underlined by Backer-Grøndahl et al. (2009) accidents is not the biggest part of worry in this mode. It was yet decided to ask about it because it was less obvious for buses than for trams and metro and since in this study "public transport" includes buses, it is still a dimension to consider.

After this series of question respondents were asked which of the incidents or accidents mentioned before worried them the most for each mean of transport; this question aims at focusing on the fear of people, what they worry about in order to be able to measure worry, the 'risk as feeling'. The idea was to explore if there are any contradictions between what people think of possible to happen, the 'risk as analysis' (which might be more objective, more related to the probability dimension of the perception of risk), with the first battery of questions, and what they are worried about (more subjective, where the severity of the consequences also comes to the fore).

The respondents were asked whether worry about accidents or unpleasant incidents would influence their travel behavior. More specifically they were asked it ever happened to them to change their trip on safety/security grounds, because they were afraid of an accident or unpleasant incident. Respondents had to reply yes or no to this question. If they responded yes, they were asked which alternatives they chose instead with a list of all the other modes (including taxi), change the time or the route of their trip or avoid it completely.

People were asked about their personal experiences, has one of the events mentioned above ever happened to them and in which mode of transport. They could tick any experience that has ever happened to them in any transport mode.

Personality-wise, it was chosen to use the Big-Five Theory, and the number of questions were shortened to not expand too much the time needed to fill out the survey. According to Rammstedt and John (2007), it is possible to reduce the numbers of items to 10 and still have a good overview of the person's personality. The questions developed are the one used in the survey. Each person-

ality traits out of the big-5 have 2 items (usually one normal and one reversed), and then the mean score (from one to five) of the two items is combined to have a personality score for each of the five personality traits.

The last question was about income. This question was put at the end of the survey even though it belongs to the socio-demographics part. Rea et al. (2014) states that the order of questions can significantly influence the results. It was chosen to ask about income at the end in order to minimize the number of participants who would drop out the questionnaire because they disliked being asked about income, which can be the case in Germany.

All questions were compulsory meaning that participants had to answer every question in order to access to next section. No questioned remained unanswered making the data analysis more efficient. Two “Attention check” questions were disseminated into the survey, to make sure people were reading and responding correctly to all the questions. These questions were “For this question, please select Cat”, it was a multiple choices question with 3 animals. People who did not select the right one were excluded of the analysis afterwards.

At the end of the survey people had a link to another survey to share their e-mail addresses if they wanted to participate in the qualitative part and discuss the issue of safety and mobility with the researcher. A second survey was created so the e-mail address could not be linked to the survey’s responses, remaining anonymous.

3.3.4. Design

The survey was designed through the survey provider ‘Google Form’. It an open-access survey provider, making the survey free of any cost. The survey tool provided all the services necessary to the elaboration of the survey. It was possible to create Likert-Scale questions and matrix of questions, to have multiple-answers questions or open-answers question. One can also chose to make the question compulsory or not.

The survey was conducted in German and in English. Munich being the study of area, conducting the survey only in English would have excluded many non-English speaking citizens. Yet Munich is also a cosmopolite city and a non-negligeable number of people do not speak German, conducting the survey in German would have excluded them. Thus, two surveys were created with the exact same questions and possibility of answers, so it was easy to merge the results afterwards.

As for data privacy, participants were informed about data handling and its analysis. The second survey was created so the responses of the first survey would remain anonymous, while being able to collect e-mail addresses. The second survey was designed on LimeSurvey so e-mail addresses

could be stored on the TUM professional server and not on the google account of the researcher. For the first survey there were no traceable personal data like name or address, so Google Form was adapted and more convenient than LimeSurvey to design the questions.

3.3.5. Pilot

To make sure that the survey was clear and readable for everyone, the survey was tested among a small number of people before it was officially lunched. The first survey that was tested was quite different from the final one. It included question about probability and severity of the incidents and accidents, making it unclear to the respondents who did not know about these two dimensions in the perception of risk. It was therefore decided to change the formulation and the content of the questions, using the one Backer-Grøndahl et al. (2009) used for their research. A second pilot survey was spread among people of different ages and different backgrounds to be sure everybody could clearly understand the questions. A total of 10 people with various backgrounds tested the final version of the survey before it was made public. The time necessary to fill out the survey was also controlled during this phase. After 15 minutes attention of the respondents tends to drop (Rea et al. 2014), therefore it was important to not exceed this duration. Results from the pilot survey showed that it took between 8 and 13 minutes for the respondents to fill it out.

3.3.6. Recruitment

The survey was spread through different means. The first step was to go at public transport stations and ask people to fill out the survey thanks to a QR code. A lot of different stops and different lines were covered to have a representative population from Munich. A particular attention was given to go at different times of the day to make sure to have a diversity in people's occupation and reasons of commuting: peak travel time but also weekends, very early mornings, or more quiet times. The second step was to post it on neurbaran.de, a neighborhood forum. Five different neighborhoods were covered: Giesing Bahnhof, Laim, Freimann, Poccistrasse and Isartor. People on this forum are from very different background which brings diversity to the survey. It was also shared on various platforms and instant messengers (Facebook, WhatsApp).

During the first phase of the recruitment, being in the public transport, the progress of the survey was monitored. The aim of the research being to be as representative of Munich as possible, the survey's results were checked daily to make sure that every age category, educational level, income status were represented in the survey. A particular attention was also given at having a representative share of women and men, as well as people with a migration background. The people targeted during the survey dissemination session in public transport was adapted in consequences when it was possible to do so, for example going to older people or specifically women because they were

underrepresented in the survey participants. However, it was harder to target specific social class, even though strategies like not being during the peak travel time (which is a peak travel time for executives), going earlier in the mornings or in the mid-afternoon allowed to reach people from lower social classes. When the survey was spread on the forum, this monitoring was no longer possible, this is why for example women are overrepresented in the sample. Between January 17th and February 21st 2023, a total of 288 people participated in the study which is very closed to the target sample population of 273.

3.3.7. Data analysis

Prior to data analysis it is crucial to conduct data preparation. The aim of data preparation and data cleaning is to obtain a comprehensive and consistent data set to ensure an important level of data quality. This step was also computed using R studio software, which was also used for the data analysis. Two data sheets were imported into R with the survey results. One with the responses of the German survey containing 241 observations of 60 variables and one for the English version of the survey, containing 47 observations of 60 variables. The first step was to make the data of both versions able to communicate with each other. The variables were renamed, and the answers all standardized into English. Merging the two data frame resulted in a data frame of 288 observations of 60 variables. Data were afterwards cleaned, observations that did not answered correctly to the "Attention check" questions were excluded, as well as the responses "prefer not to say" as gender and people who did not report their age correctly. After these step 280 entries remained for the data analysis.

The data preparation also included making the data ready to be analyzed. It involved transforming nominal data into numerical data. For example, for personality respondents had to choose between "Disagree strongly", "disagree a little", "Neither agree or disagree", "Agree a little" and "Agree strongly", these were transformed into 1 to 5. The personality scores were afterwards calculated by calculating the mean of the two scores (each personality traits had to items). The same methods were applied to every Likert scale in the survey. The perceived risk score was also calculated, as well as the experience score, that will be further explained in the survey results part.

After the data-cleaning process, an initial descriptive statistical analysis was performed. The sample was analyzed with regards to socio-demographics. Different descriptives analysis were computed to analyze risk perception and worry in different modes of transportation, to explore the travel behavioral adaptation. Afterwards, to identify the different predictors of perceived risk, multiple linear regression analyses were needed. Prior to multiple linear regressions, statistical tests were computed to analyze the collinearity between the different predictors. Stepwise regressions were then analyzed, first with the lens of different transport modes, then with the lens of different type of inci-

dents/accidents. To investigate the weight of different predictors and confirms the findings of step-wise regressions, a hierarchical regression analysis was also computed. Finally, comes a further descriptive analysis, enlightened by the results of the multiple regression analysis.

3.4. Qualitative Analysis

In the following subchapters, the qualitative part of the mixed methods approach - the focus group - will be further explained. The recruitment for this focus group as well as its practical implementation will be developed.

3.4.1. Justification

As this paper is looking at a complex socio-psychological phenomenon, it is difficult to address the subject only by a quantitative approach (Backer-Grøndahl et al. 2009; Masoumi and Fastenmeier 2016), which may overlook or occult some aspects because of the amount of data that is processed or because the scope of the survey was narrowed. Therefore, a qualitative approach is needed, to discuss different aspects of the study. First, the quantitative approach will allow for the interpretation of survey results that are not fully explained by the literature review. Second, it also enables to get feedback from the citizens of Munich on the survey, if they agree with the results. It is important to remember that these are the primary subjects of this study. Finally, the qualitative study will address the topic of concrete ways to make citizens feel safer in Munich's transportation system. Two methods were considered for this study: the one-to-one interview and the focus group.

The one-to-one interview would have allowed searching deeper into the psychological mechanisms that are involved in the perception of risk by exploring deeper people’s personalities more than with the 10 questions that were asked in the survey. Therefore, it would have allowed a better understanding of how personality would influence travel behavior. Participants of the survey would be interviewed afterwards based on their survey responses. However, this would have involved breaking the anonymity of the survey’s respondents and interviewing people with different socio-psychological backgrounds. Moreover, being completely unexperimented in this exercise was also a limitation to having relevant results. This method was decided to be out-of-the scope of this study because of means and ethics.

Therefore, a focus group was chosen. The focus group allows participants to interact with each other and therefore come up with ideas that may not have appeared in a one-to-one interview. Collective intelligence permit explaining complex mechanism, because everyone has their very own experience that they can share with other participants which lead to fertile discussions. This format was chosen to discuss the survey results and the way of improving safety in Munich.

3.4.2. Recruitment

At the end of the survey spread among the population of Munich, respondents had a link to another survey where they could leave their e-mail addresses. The e-mail addresses were collected thanks to the university LimeSurvey platform to assure high confidentiality of data. The second survey was not connected to the first one, therefore the responses to the survey remained fully anonymous.

In the end, 24 E-mail addresses were collected among the 288 respondents. These 24 participants were invited to participate in an online “Safety and Mobility Workshop” on Zoom. These participants were asked to share their availabilities to choose a date that would allow a maximum of people to participate in the workshop. 7 people were able to participate in this workshop on Monday 20th March.

3.4.3. Format

The focus group was an online workshop, which took place on Zoom. It was an interactive presentation, where everyone had the chance to talk and exchange. The seven participants had diverse backgrounds. Four of them were students from 23 to 26 years old studying engineering, informatics, and languages. One participant was a 37-year-old product engineer and new-mum. The last participant was 55 years old, a professor at the university. All participants were therefore high-educated people. The workshop took place in English, which could have been a problem for people with lower education. All participants have lived in Munich for at least 2 years. Three of them were German and four had a migration background. The workshop lasted one hour; particular attention was made so that everyone had a chance to talk during the workshop.

3.4.4. Content

The agenda of the workshop was to present and discuss some of the survey results and to brainstorm about how to increase safety for mobility in Munich. One hour of the workshop was dedicated to presenting and discussing the survey results. Presenting them to a group allowed a plurality of points of view and interaction with each other, and therefore a better interpretation of the results. The results were yet selected because the workshop was not supposed to last more than 1h30, thus it was not possible to cover the integrality of the results. The survey results presented were the ones that were not fully explained by the literature, and which were harder to interpret by a single person. Then 15 minutes were used to discuss the possible way of improvement for the city of Munich. It was important to talk about the improvements so the participants could also think about the future and not only state on the present situation.

4. Survey Results

The survey has been designed in such a way, that the two first research questions can be answered. The results of it are shown in the following chapter. Before presenting data, that is used to answer the research question, general information, such as socio-demographics, is shown. Subsequently, a descriptive analysis is conducted to analyze the differences between worry and perceived risk, to identify spatial inequalities regarding safety in Munich, and to identify travel behaviors. After that, the different predictors of perceived risk are analyzed by means of regressions. Finally, a new descriptive analysis is conducted considering the regression results.

4.1. Socio-demographics descriptive statistics

The sample aims at being as representative of Munich as possible, the recruitment method tries to be as little biased as possible. However, it can be observed (Table 1) that there are a majority of women in the sample (62.5%), they were more represented on neighborhood forum than men. People with a university degree are also over-represented in the sample (75.7%).

Table 1 Description of the Survey's Sample

	Variable	n(%)
Gender	Man	105 (37.5%)
	Woman	175 (62.5%)
Education	No university degree	68 (24.3%)
	University degree	212 (75.7%)
Income	<500€	49 (17.5%)
	>4,000€	49 (17.5%)
	1,300-2,000€	27 (9.6%)
	2,000-2,600€	36 (12.9%)
	2600-3,200€	37 (13.2%)
	3200 - 4,000€	27 (9.6%)

	Variable	n(%)
	Not Answered	55 (19.6%)
Migration Background	Yes	94 (33.6%)
	No	186 (66.4%)
Age	Mean (SD)	40(10)
	Median [Min,Max]	40[20,70]

In terms of migration background, the sample is quite representative. According to Wikipedia (2023), there a 23.3% of foreigners in Munich. Migration background being a wider concept (at least one parent born abroad: it can include Germans), having 33.6% seems reasonable.

Regarding age (Table 2), the population of Munich is good represented apart from the population above 60-year-old. 7% of the sample's population is 60 or older, whereas it is 32% of Munich's population. Therefore, people between 30 and 44 and people between 45 and 59 are overrepresented. The reasons are exposed in the methodology paragraph.

Table 2 : Age Categories

Age	**Munich**	**Sample**
15-29	22%	24%
30-44	28%	36%
45-59	23%	31%
>60	32%	7%

4.2. Descriptive analysis

A descriptive analysis is conducted to provide an overview of the survey results. First, a first analysis allows to compare the different modes according to the perceived risk and to the worry. Then these two indicators are compared to identify their differences. Then they are also compared to the

real risk. The different districts of Munich are also compared with regard to safety. Finally the association between perceived risk and travel behaviors is explored.

4.2.1. Perceived Risk Score

The different modes are compared regarding the “Perceived Risk Score”. This score is calculated for each mode by taking the mean value of the score for every incident or accident that were asked for the mode. Scale goes from 1 the risk is not perceived at all to 5, respondent think about the incident/accident to a high extent when they travel with the mode.

Table 3 : Comparison of Perceived Risk Score in Different Modes of Transportation

Mode		Perceived Risk Score
Bike	Mean (SD)	1.74 (0.562)
	Median [Min, Max]	1.67 [1.00, 4.00]
	Missing	49 (17.5%)
Public Transport	Mean (SD)	1.87 (0.600)
	Median [Min, Max]	1.67 [1.00, 4.17]
	Missing	8 (2.9%)
Walk	Mean (SD)	1.50 (0.543)
	Median [Min, Max]	1.33 [1.00, 4.00]
	Missing	3 (1.1%)
Car	Mean (SD)	1.88 (0.689)
	Median [Min, Max]	2.00 [1.00, 4.00]
	Missing	97 (34.6%)

The missing values are for those who do not use the mode at all. A first simple analysis (Table 3) shows that walking is perceived as the safest mode, with the lowest perception of risk whereas car is rated as the highest. The high rated risk towards cars can be explained by the fact that only acci-

dent was asked to be rated ant the absence of question about the incidents. Globally the perceived risk score is very low in Munich, always below 2 on a scale from 1 to 5.

4.2.2. Worry

To evaluate worry, people were asked which of the incidents/accidents worried them the most in the different modes of transport. The results (Fig. 4) draw the same conclusion as the perceived risk score, the mode people are the less afraid about is walking. It is the mode with the highest percentage of people answering “None” to the question, which means that among all the incidents and accidents cited, none of them worry them. The incident the most people are worried about is major accident while cycling.

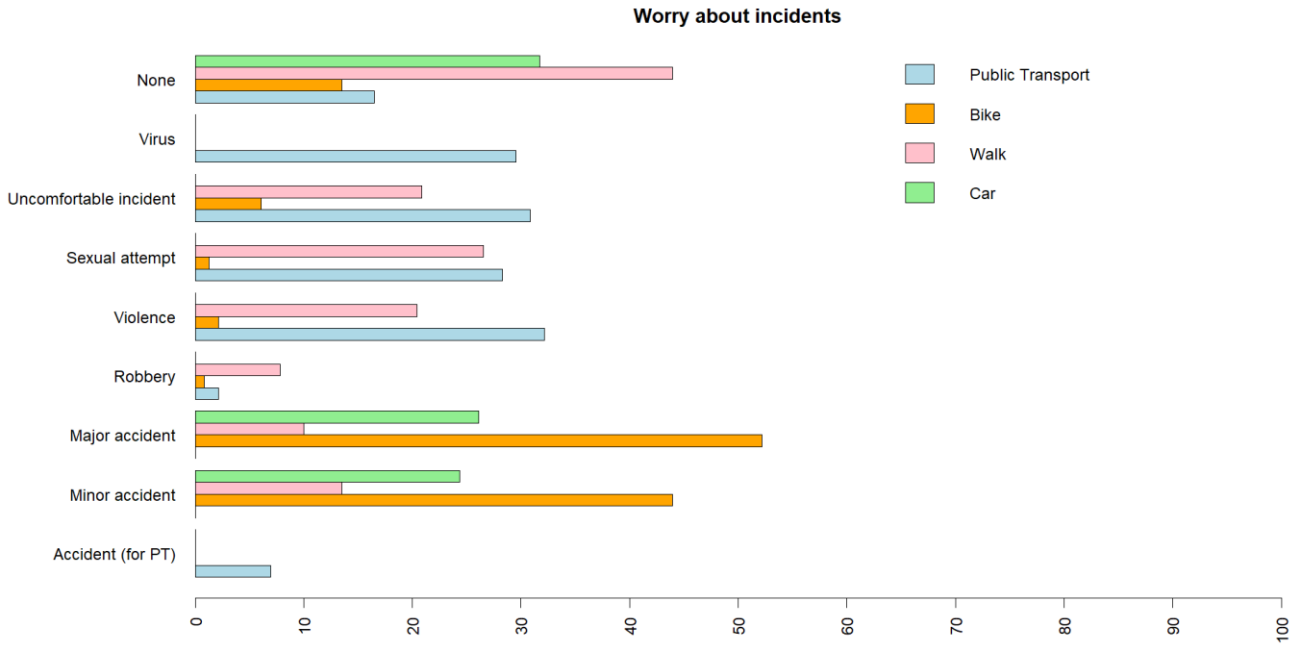

Figure 4 : Worry about Incidents/Accidents.

In public transport people are equally worried about violence, sexual harassment, uncomfortable but not harmful incidents and virus infection. Robbery is not an issue in Munich, even though it is while walking that people worry about robbery. When walking people are mostly afraid of sexual harassment, violence, and uncomfortable incidents. People also worry more about major accidents while driving than minor accidents. The statement made by Backer-Grøndahl et al. (2009) is also confirmed here, in modes with interactions with other people such as public transport and walking, people are more afraid of incidents whereas, in modes without those interactions, people are more afraid of accidents.

4.2.3. Comparison between Perceived Risk Score and Worry

In this study the Perceived Risk Score aims at measuring the “risk as analysis” whereas worry measures “risk as feeling”. Incidents or accidents with a high Perceived Risk Score are coherent with what people worry the most about (Table4): people worry less about incidents or accidents with a low score and more about incidents with a high score in general.

Table 4 : Comparison between Perceived Risk Score and Worry

Incidents	Public Transport		Bike		Walk		Car	
	Risk Perception Score	Worry	Risk Perception Score	Worry	Risk Perception Score	Worry	Risk Perception Score	Worry
Accident (for PT)	1.5	6.9%	-	-	-	-	-	-
Minor accident	-	-	2.6	43.9%	1.4	13.4%	2.0	24.3%
Major accident	-	-	2.2	52.1%	1.3	10.0%	1.74	26.1%
Robbery	1.3	2.2%	1.3	0.9%	1.4	7.8%	-	-
Violence	1.6	32.2%	1.31	2.2%	1.5	20.4%	-	-
Sexual attempt	1.7	28.2%	1.25	1.3%	1.60	26.5%	-	-
Uncomfortable incident	2.3	30.9%	1.8	6.1%	1.7	20.9%	-	-
Virus	2.7	29.5%	-	-	-	-	-	-

However, the perceived risk score for minor accidents is higher than the one for major accidents, yet a lower percentage of respondents worries about minor accidents than major accidents. Same observation is made for virus, even though it has the highest perceived risk score, it is not what people worry the most about in public transport. Incidents with high probability to happen, such as minor accidents or virus, with low severity of consequences worry people less than events with lower

probability to happen such as major accidents but with higher severity of consequences. It means that the dimension of the severity in worry is important.

4.2.4. Worry and Real Risk

In the case of public transport, there are precise data of which incidents are mostly happening, at least the ones reported to the police. Compared it to what people worry about, there are significant differences (Fig. 5).

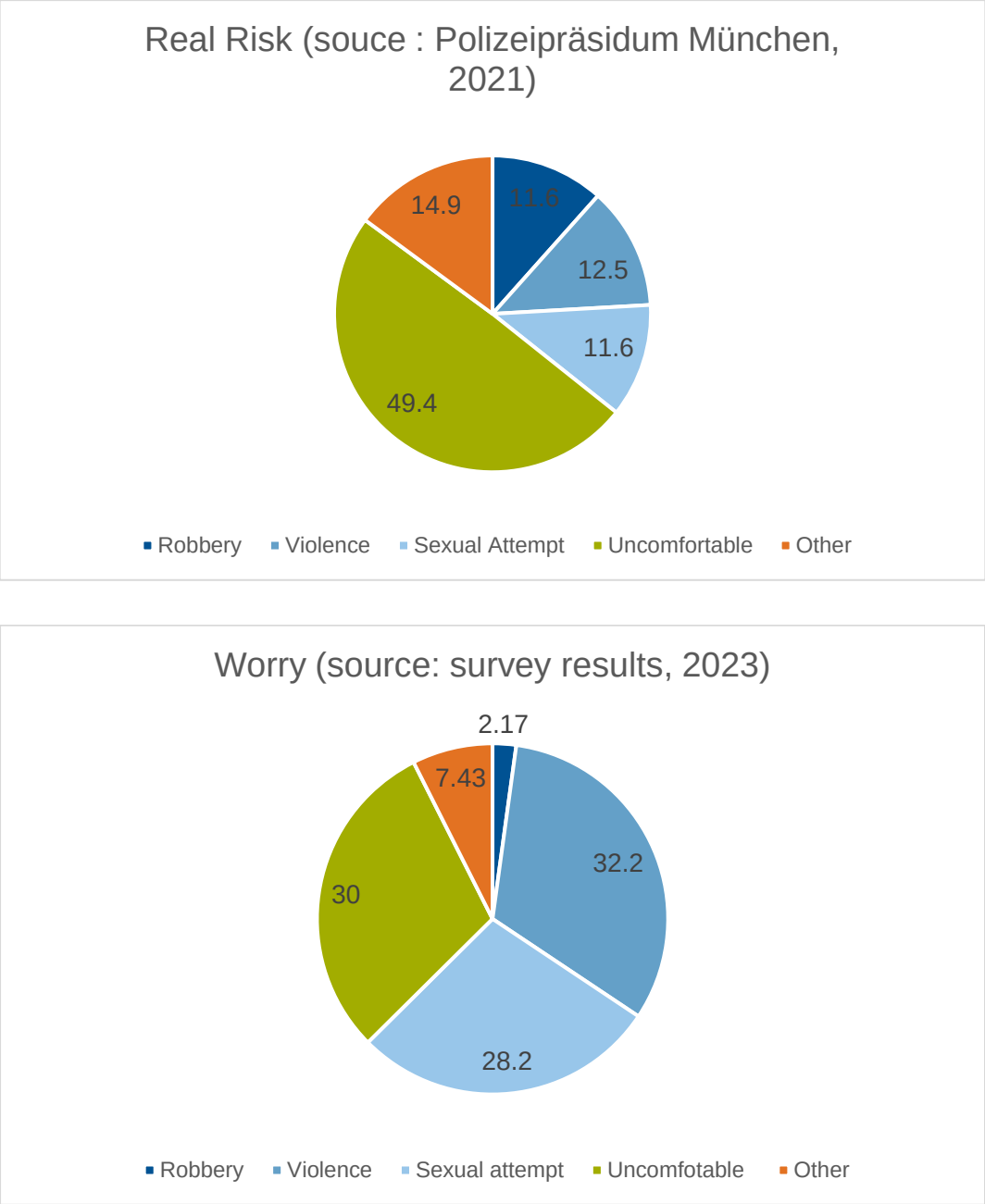

Figure 5 : Comparison between Real Risk and Worry

Uncomfortable but not harmful incidents happen the most in public transport, according to the Security Report (Polizeipräsidium München 2021), however people would worry more about sexual harassment or violence, that have more severe consequences. It underlines the important dimension of severity in worry. People also tend to worry more about major accidents while cycling and driving, with severe consequences rather that minor accidents that are, according to the data, more frequent.

4.2.5. Safety and Neighborhoods

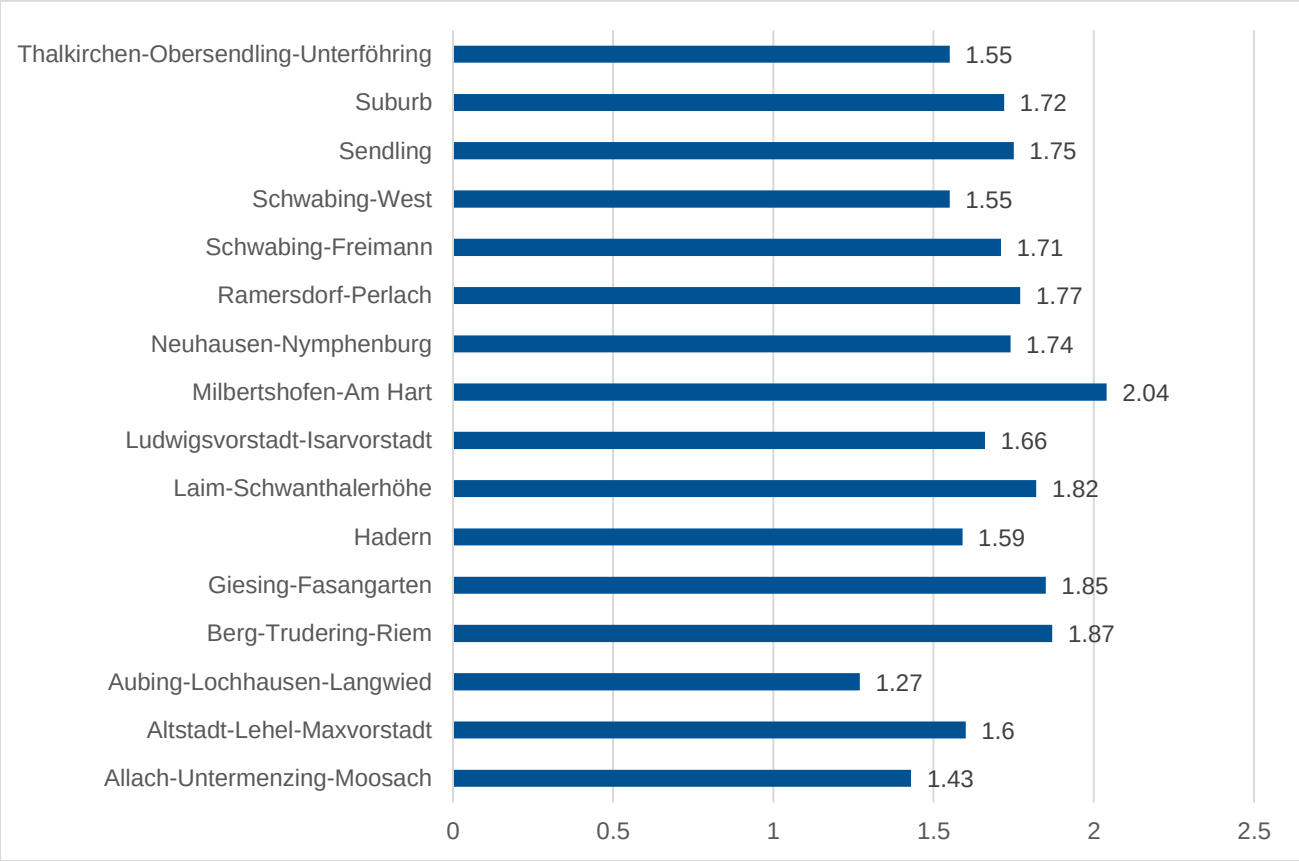

Figure 6 : Perceived Risk in Different Neighborhoods

The neighborhoods are not equally represented, because of the spacial bias of the neighborhood forum. One can observe that the perception of risk is different depending on the neighborhood one lives in (Fig. 6). People who live in Milbertshofen-Am Hart, Berg, Trudering, Riem or Giesing tend to feel less safe than people who live in Aubing, Lochhausen, Langwied or Allach for instance. Even though it is not because one lives in a neighborhood that he only travels through that neighborhood, however it is a place people come back to late at night for example. Therefore, it gives a first impression to see in which neighborhoods people feel less safe in.

4.2.6. Risk and Travel Behavior

To investigate if the perception of safety is correlated with the frequency of use in the everyday life, the respondents were categorized as user or non-user of a mode. If they travel with the mode more than once a week there are a user, if less than they are a non-user.

The results of the Wilcox-tests showed there is no significant correlation between perceived risk and frequency of use and the choice of mode. It is not because a mode is perceived as “unsafe”, that people will avoid traveling with this mode daily (Fig. 7). The tendency is the opposite of what was expected, user tend to have a perception of risk higher than non-user.

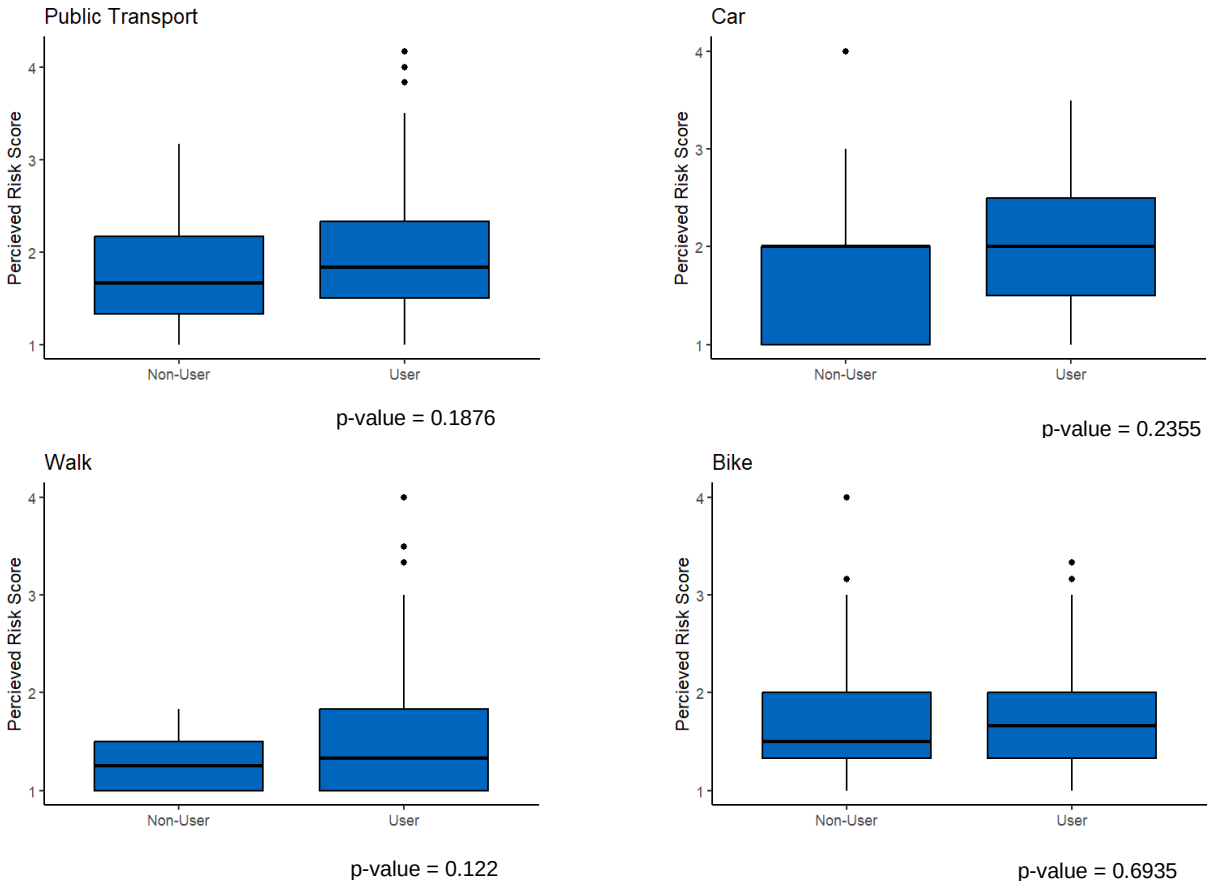

Figure 7 : Perceived Risk and Mode Choice

Besides, respondents were asked about mode shift is specific security-related situation if it ever happened to the changing their trip because they felt unsafe. People who perceived risk higher (with a higher perceived risk score), are more likely to answer yes to the question “Did safety ever prevented you to from traveling with ‘the mode’ (Table 6). People who feel more insecure, will have punctual behavioral adaptation.

Table 5 : Modal Shift and Perceived Risk Score

Public Transport		Bike		Walk		Car	
Prevent	Perceived risk score	Prevent	Perceived risk score	Prevent	Perceived risk score	Prevent	Perceived risk score
No	1.77	No	1.67	No	1.47	No	1.80
Yes	2.27	Yes	2.07	Yes	2.38	Yes	2.50

The respondents were asked, if they answered yes to the previous question, which behavioral adaptation they chose. They could only choose one response; therefore, it was asked to think of the worst time (Table 7).

Table 6 : Behavioral Adaptation on Safety Grounds

Transport Mode	Percentage who decided to								
	Avoid traveling	Change route	Change time	Use public transport	Travel by bike	Walk	Travel by car	Take a taxi	It never happened
Public Transport	2.5	0.7	2.9	-	14.6	3.9	8.6	7.5	59.3
Bike	0.7	3.9	0.7	15.4	-	4.3	7.1	1.1	66.8
Walk	5.0	4.6	3.2	7.5	3.9	-	4.6	4.6	66.4
Car	3.6	1.8	2.9	18.6	4.3	0.7	-	1.4	66.8

Concerning public transport, very few people decide to change their route, to avoid a certain U-Bahn station for example. Munich citizens feel safe at public transport stations. Few people decide to avoid (2.5%) or change the time of their travel (2.9%). The highest modal shift is interestingly towards bike, which means that under certain circumstances bike is perceived as a safer mode as

public transport. Car and taxi also benefit an important modal shift from public transport, combined 16.1%, it is the highest modal shift towards motorized mode of transportation. 7.5% of the respondents decide to take a taxi instead of using public transport. Some public transport trips cannot be replaced by walking or cycling because the distances are too big. Public transport is the mode with less people to whom it never happened not to travel on safety reasons (59.3%).

Cyclists are tempted to choose another route if the one they are supposed to take is too risky, however they almost never avoid their trip or decide to travel on a different time. The modal shift towards public transport is important (15.4%): bike and public transport seem to be interconnected modes they have an important modal shift towards one another. The modal report towards motorized mode of transport is not very important (7.1% for cars and 1.1% for taxi). Taxi is very rarely an option. 4.3% walk instead and 7.1% decide to drive.

5% of respondents avoid a walking trip on safety reasons, it is the highest percentage for this category. 4.6% change their route, which means that there are some streets and neighborhoods people tend to avoid when they walk because they feel insecure. 7.5% decide to use public transport, under some circumstances public transport are perceived as safer as walking. Driving or calling a taxi is also an option for 9.2% of people (4.6% decide to drive, 4,6% decide to take a taxi).

Among car-drivers, the percentage of people to whom it never happened to switch mode on safety reason is the same as for walking and cycling. Most people decide to use public transport instead (18.6%), 4.3% cycle instead. Very few people decide to walk instead, most likely because of distance reasons. 3.6% of the respondents decide to avoid their trip, 1.8% decide to adapt the route of their trip and 2.9% travel on a different time.

4.3. Risk perception predictors

This section is devoted to the analysis of predictors for risk perception It will be explored through different lenses. Which socio-demographic, psychological, and experiential predictors are significant in describing risk perception, and which are salient. Two regression methods are used: stepwise regression and hierarchical regression. Two prisms are also used: the first analysis is done through the lens of different modes of transport and the second through the lens of different types of incidents/accidents. Prior to regression analysis, the different predictors are tested to identify if some of them are correlated to each other.

4.3.1. Collinearity

To explore the different predictors of perceived risk, multilinear regression analyses were needed. Before computing them, statistical tests were made to find out if there was any correlation between the different independent variables. About the personality regression variables, the following hypothesis are tested:

H0: Personality variables are not associated with each other.
H1: Personality variables are associated with each other.

The correlation matrix (Fig. 8) does not reject H0, H1 is thus rejected.

As for the socio-demographics, as they were mainly categorical variables, independence tests were realized separately. Most of them were unsignificant, meaning that socio-demographics were not associated with each other, except for income. Income was converted into a numerical variable. For each category of the income variable, the upper value of the salary band has been allocated. For the last category “>4,000 euros”, the value of 6,000 was attributed, since the band could include a large variability in salary. The statistical tests showed that income was associated with age and education. A multiple-linear regression was computed based on the following hypothesis.

H0: Income is not associated with age and education.
H1: Income is associated with age and education.

The multiple linear regression rejects H0 (p-value =3.071e-09), thus H1 is not rejected. In order to avoid intercorrelation in the following study, income was not taken into consideration, it is assumed that it will be covered by age and education. Having a lot of participants who did not want to share their income in the survey supported the idea of choosing age and education over income.

Multiple linear regression analyses were computed afterwards to explore the different predictors for risk perception. Finally comes a discussion part where some new descriptive analyses are exposed about travel behavioral adaptations and worry enlightened by the results of the regression models.

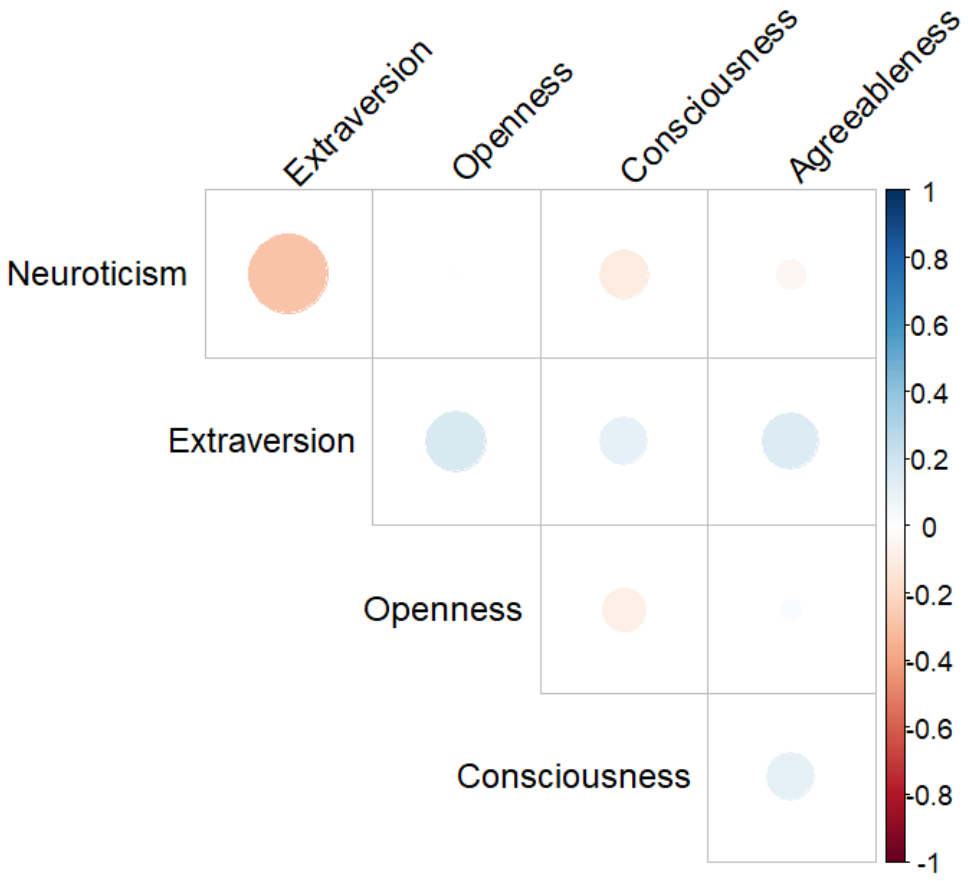

Figure 8 : Big-5 Personality Correlation Matrix

4.3.2. Lens of Different Transport Modes

In this section, the dependent variable is the mean score of perceived risk for each mode, being the mean value of all the scores for the incidents and accidents. This mean score goes from 1 to 5.

4.3.2.1. Multiple Linear Regression

A multiple linear regression was computed for each mode with the following independent variables:

- Socio demographics: gender, age, education, migration background
- Psychological: neuroticism score, extroversion score, openness score, consciousness score and agreeableness score
- Experience score: the experience score was calculated for each mode by considering that all incidents or accidents experienced by the respondents for the mode was valued one, the score was calculated by adding all the values. For instance, if one respondent has experienced sexual harassment and robbery in public transport, his experience score for public transport would be 2.

To escape the problem of multicollinearity and to filter the essential predictors for the model, a stepwise regression was performed.

Table 7 : Stepwise Regression in Public Transport

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Public Transport	Consciousness	0.05	1.76	.079	.01	[0.00, 0.03]
	Neuroticism	0.14	3.93	< .001***	.04	[0.00, 0.09]
	Gender	0.15	2.18	.030*	.01	[0.00, 0.04]
	Age	-0.01	-3.88	< .001***	.04	[0.00, 0.09]
	Experience	0.16	4.70	<.001***	.06	[0.01, 0.11]

$*p<0.05, **p<0.01, ***p<0.001.$

In public transport (Table 8) there is a correlation between perceived risk gender and age for socio-demographics. Women and younger people perceive risk as higher in public transport. Neuroticism is also strongly correlated with risk perception, the higher a person scores in neuroticism the higher is his perception of risk. People who have experienced more incidents or accidents also score higher. The strongest predictor appears to be experience, followed by age and neuroticism and last is gender.

Table 8 : Stepwise Regression for Biking

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Bike	Neuroticism	0.08	1.98	.048*	.02	[0.00, 0.05]
	Age	-0.01	-2.04	.042*	.02	[0.00, 0.05]
	Experience	0.22	4.20	< .001***	.07	[0.01, 0.13]

$*p<0.05, **p<0.01, ***p<0.001.$

When it comes to biking (Table 9), neuroticism, age, experience and neuroticism are correlated with perceived risk. Gender is no longer a predictor. Experience is by far the strongest predictor with the lower p-value and the highest sr², age and neuroticism do have the same weight in the model.

Table 9 : Stepwise Regression for Walking

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived risk score for Walking	Neuroticism	0.13	3.84	< .001***	.04	[0.00, 0.08]
	Gender	0.16	2.51	.013*	.02	[0.00, 0.05]
	Age	-0.01	-3.08	.002**	.03	[0.00, 0.06]
	Experience	0.19	5.01	< .001***	.07	[0.02, 0.13]

∗p<0.05,∗∗p<0.01,∗∗∗p<0.001.

For pedestrians (Table 10), experience is the strongest predictor with the lowers p-value and the highest sr², followed by neuroticism. Age and gender are also significant predictors. Gender is the weakest predictor.

Table 10 :Stepwise Regression for Driving

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Driving	Extraversion	-0.12	-2.08	.039*	.02	[0.00, 0.06]
	Consciousness	0.06	1.40	.162	.01	[0.00, 0.04]
	Neuroticism	0.13	2.39	.018*	.03	[0.00, 0.07]
	Age	-0.01	-1.96	.051	.02	[0.00, 0.06]
	Experience	0.21	2.37	.019*	.03	[0.00, 0.07]

$*p<0.05, **p<0.01, ***p<0.001.$

Finally for car drivers (Table 11), neuroticism, extraversion and experience are correlated to perceived safety. each of them has a similar weight, even though experience and neuroticism have a slightly lower p-value and higher sr^2. Age is not a significant predictor, yet it has a p-value very closed to 0.05 and the sr^2 is similar to the extraversion's sr^2. The less the respondents scored in extraversion the higher their perception of risk was, it is surprising for a mode without social interactions to have extraversion coming to the fore.

Globally, the hypothesis rejected are that migration background, education, agreeableness, openness, and consciousness are predictors for perceived risk. There is a clear distinction between modes with interactions to other people that are walking and public transport and mode without when assuming gender as a predictor.

4.3.2.2. 3-Step Hierarchical Regressions

Four three-step hierarchical regressions analyses were conducted to investigate the weight of the different predictors. Socio-demographics variables were entered at the first step, personality traits at the second step and previous experience at the third step.

In the first hierarchical regression analysis for walking (Table 12), socio-demographics variables explained 8% of the variance in perceived risk for walking. The R^2 increased significantly at the second step, suggesting that personality traits explain variance in perceived risk for walking. Having experienced an accident or incident included at the third step did also contribute significantly to the explained variance, resulting in a total of 19% explained variance. For walking the experience contributes the most to the explained variance.

The observation is very similar for public transport, with in the end a total of 21.1% of explained variance. Personality and socio-demographics contribute more to the explained variance for public transport than for walking, and experience less than for walking. However, for public transport there is no consensus whether it is socio-demographics, personality or experience which contributes the most to the explained variance. The three of them appear to be equivalent predictors.

For biking socio-demographics variable explained 0.5% of the variance in perceive risk. Personality contributed slightly to the explained variance and experience did contribute significantly to the explained variance up to 9%. It is undoubtedly experience that is the most significant predictors for perceived risk in biking.

In the fourth regression model, the one for driving, socio-demographics explained 2.7% of the variance. The R^2 doubled by adding the personality variables and increased also significantly at the third step. For driving the personality variables contributed to the most to the explained variance.

For driving and biking the explained variance in the end is two times smaller than for walking and public transport. The model fits walking and public transport than biking and driving, suggesting that other factors contribute to the perception of risk for these modes.

Table 11 : Three-Step Hierarchical Regression Analyses

	Walk			Public Transport			Bike			Car		
Step	R^2	ΔR^2	Step 4β	R^2	ΔR^2	Step 4β	R^2	ΔR^2	Step 4β	R^2	ΔR^2	Step 4β
1.Socio-demographics	0.081			0.10			0.0053			0.027		
Gender			0.25***			0.28***			0.087			0.15
Age			- 0.0078**			-0.011***			-0.0059*			-0.0081*
Education			-0.11			-0.075			-0.030			-0.11
Migration Background			0.004			-0.055			0.0060			0.14
2. Personality	0.13	0.045		0.15	0.053		0.022	0.017		0.067	0.040	
Extroversion			0.030			0.021			0.023			-0.13*
Consciousness			-0.011			0.032			-0.0094			0.056
Neuroticism			0.15***			0.18***			0.10*			0.12*
Openness			0.034			0.023			0.052			0.048
Agreeableness			-0.00044			-0.014			-0.040			0.0092
3. Experience	0.19	0.065		0.21	0.058		0.090	0.068		0.089	0.021	
Score			0.18***			0.16***			0.23***			0.20*

$*p<0.05$, $**p<0.01$, $***p<0.001$.

4.3.3. Lens of Different Incidents/Accidents

The lens of transport mode occulted the differences between the different kind of incidents. One can imagine that the perception is not the same from one incident or accident to another. Therefore, this analysis aims at better understanding the predictors for the different kind of incidents and accidents.

For this part, the dependent variable is the mean score of perceived risk for each incident in the different modes. For example, the perceived risk score for accidents is the mean value of the perceived risk score for minor and major accidents for driving, cycling, walking and public transport.

Table 12 : Stepwise Regression for Sexual Harassment

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Sexual Harassment	Neuroticism	0.11	2.84	.005**	.03	[0.00, 0.06]
	Gender	0.42	5.55	< .001***	.10	[0.03, 0.16]
	Age	-0.01	-2.87	.004**	.03	[0.00, 0.06]
	Experience	0.30	4.62	< .001***	.07	[0.01, 0.12]

$*p<0.05, **p<0.01, ***p<0.001.$

Regrading sexual harassment (Table 13), gender is undoubtedly the most significant predictor. Women think more about sexual harassment than men in general. Experience with sexual harassment also participates in 7% of the explained variance. Neuroticism and age are also significant predictors. Younger people and neurotic people tend to score higher risk perception for sexual harassment.

Table 13 : Stepwise Regression for Violence

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Violence	Extraversion	0.10	2.31	.022*	.02	[0.00, 0.06]
	Neuroticism	0.15	3.74	< .001***	.06	[0.00, 0.11]
	Education	-0.16	-1.91	.057	.01	[0.00, 0.04]
	Experience	0.20	2.49	.014*	.03	[0.00, 0.06]

$*p<0.05, **p<0.01, ***p<0.001.$

Regarding violence neuroticism is the most significant predictor (Table 14). Extraversion is also significant. Extrovert people are more afraid of violence than introverts, it is a surprising result. Experience is also a significant predictor. Education also comes to the fore, people with a higher educational degree perceive the risk of violence as lower than people without a university degree.

Table 14 : Stepwise Regression for Uncomfortable but not Harmful Incidents

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Uncomfortable but not Harmful incidents	Neuroticism	0.11	2.20	.029*	.02	[0.00, 0.05]
	Age	-0.01	-3.84	< .001***	.05	[0.00, 0.10]
	Education	-0.16	-1.58	.115	.01	[0.00, 0.03]
	Experience	0.25	6.29	< .001***	.14	[0.06, 0.22]

p<0.05, **p<0.01,*p<0.001.*

For uncomfortable but not harmful incidents (Table 15), which are for example insults, staring or racism, experience is the dominant predictor. Age is a strong predictor, with 5% of the explained variance. Neuroticism is also a predictor.

Table 15 : Stepwise Regression for Virus Infection

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Virus Infection	Neuroticism	0.32	4.68	< .001***	.07	[0.01, 0.12]
	Education	0.26	1.74	.082	.01	[0.00, 0.03]
	Migration Background	-0.19	-1.43	.153	.01	[0.00, 0.02]

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
	Experience	0.83	5.13	< .001***	.08	[0.02, 0.14]

∗p<0.05, ∗∗p<001,∗∗∗p<0.001.

Concerning the risk perception for virus (Table 16), neuroticism and experience are both strong predictors. Education also predicts the risk perception, participants with a university degree more likely to worry about virus infection than people with a lower educational degree. Germans also tend to worry more about virus infection than participants with a migration background.

Table 16 : Stepwise Regression for Robbery

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for Robbery	Extraversion	0.07	1.94	.054	.02	[0.00, 0.05]
	Neuroticism	0.11	3.51	.001**	.05	[0.00, 0.11]
	Openness	-0.06	-1.84	.067	.01	[0.00, 0.04]
	Age	-0.00	-1.46	.146	.01	[0.00, 0.03]

∗p<0.05,∗∗p<0.01,∗∗∗p<0.001.

When it comes to robbery (Table 17), something Munich's citizen perceived as a low risk, only neuroticism is a significant predictor.

Table 17 : Stepwise Regression for Accident

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Perceived Risk Score for	Neuroticism	0.11	2.94	.004**	.03	[0.00, 0.07]
	Openness	0.07	1.94	.054	.01	[0.00, 0.04]

Dependent Variable	Predictor	*b*	*t*	*p*	sr^2	95% CI
Accident	Age	-0.01	-2.27	.024*	.02	[0.00, 0.05]
	Experience	0.06	1.41	.159	.01	[0.00, 0.03]

$*p<0.05, **p<0.01, ***p<0.001$

Finally, regarding accidents (Table 18), neuroticism is again the strongest predictor. Age also participates up to 2% to the explained variance. Surprisingly, openness is also part of the model, the higher someone score in openness, the higher his perception of risk for accident is high.

Neuroticism is a predictor for every kind of incidents and accidents. Experience also participates in a significant part of the explained variance for sexual harassment, violence, uncomfortable but not harmful incidents and virus. However, it is not part of the model concerning robbery, most likely because very few people have experienced robbery in Munich (only 16 participants). Experience is also not a significant predictor for accidents, which is more surprising, especially because experience is the main predictors for perceived risk when cycling. Age is only a predictor for accidents, sexual harassment, uncomfortable but not harmful incidents. However, it is not when speaking about robbery, violence, or virus. Gender is only a predictor for sexual harassment.

4.4. Further descriptive analysis

In light of the results provided by the numerous regressions, the socio-psychological differences are again explored, particularly in relation to worry and behavioral adaptations. The aim is to investigate these differences and to see how they can influence the transport habits of the citizens of Munich.

4.4.1. Gender

The first multiple linear regression analysis showed that gender was a predictor for perceived safety only for modes with interactions (walking and public transport). It means that women and men feel equally safe when they cycle and when they drive but women feel less safe is public transport and when they walk.

The second multilinear regression analysis showed that gender was a predictor for perceived safety only when speaking about sexual harassment. For all other incidents and accidents, men and women have a similar perception of risk.

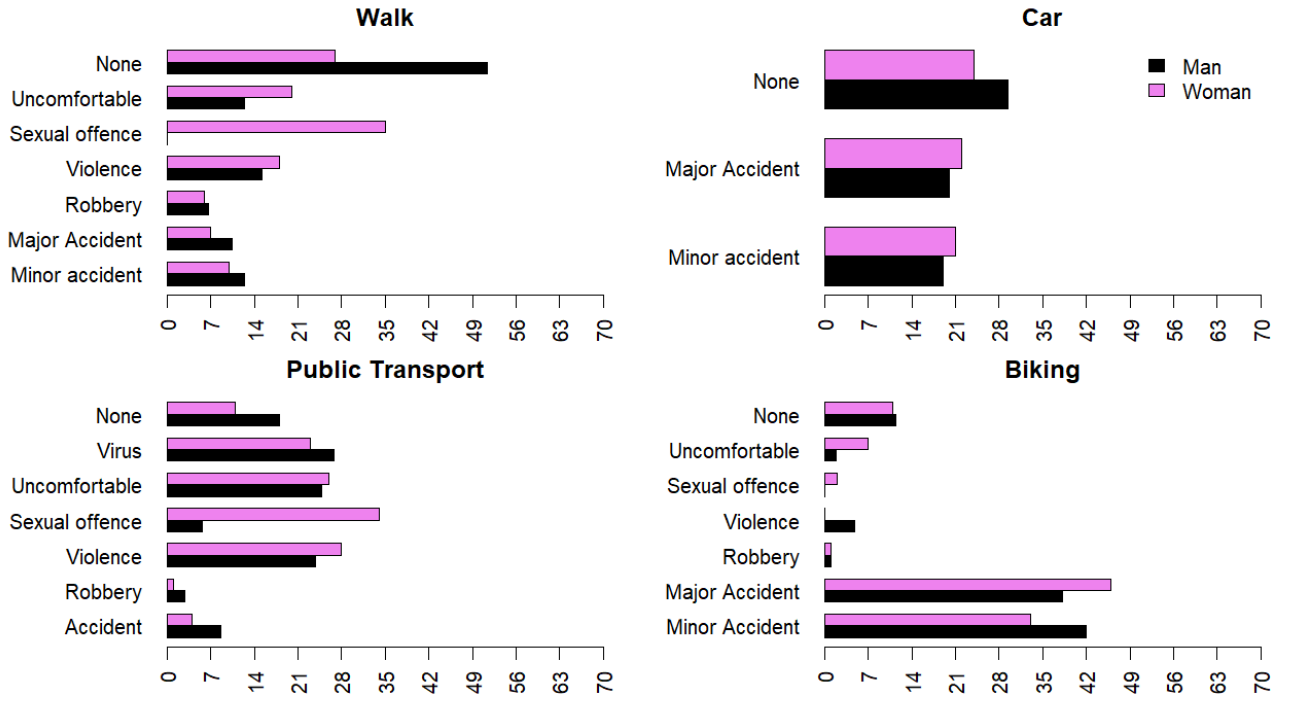

Figure 9 : Gender Differences in Worry for Different Modes

There are few changes compared to what was assumed before (Fig. 9). Walking does not appear as safe as before for women. The percentage of women afraid of none of the incidents while walking is much lower than the one for men. Women are afraid of sexual offences while walking, something men are not concerned about at all. The same observation is made for public transport. Women are also a bit more worried about violence and uncomfortable incidents than men. However, concerning accidents, it turns out that men are more worried about them than women while walking and using public transport, and minor accidents while biking. Women however worry slightly more about accidents when driving and about major accidents when they cycle.

When it comes to behavioral adaptation (Table 19), there significant difference between men and women for modes with interactions. The percentage of men who never had to avoid using one of these modes on safety reason is higher by more than 10 points than of women. Concerning public transport, women would mostly travel by bike (14,3%), travel by car (9,1%) or take a taxi (10,9%), this last solution, men do not use at all. 4% of women also decide to travel on a different time, so they probably avoid staying late at nights whereas this number drops to 1% for men. 3,4% of women avoid their trip (1% for men), which is not insignificant. Concerning walking, women are even more likely to avoid their trip (5.7% for women, 3.8% for men), they also tend to choose another route (5.7% against 2.9% for men) or time (4%, against 1.9% for men). 9.5% of women would use public transport instead of walking and 7,4% decide to take a taxi. There is a significant difference

concerning taxi. For modes with interactions, women decide to take a taxi, whereas men almost never do so.

Concerning biking, women will change the route of their trip, however they almost never avoid or change the time of their trip. Bike allows an increased freedom for women. They are less limited by the time of the day, they can for example easily cycle late at night. Adapting the route is less restrictive than having to avoid the trip or adapt the time of the commute. Men are more likely to use public transport instead of bike than women. However, women would rather walk instead. Men are a lot more likely to drive instead of cycle (11.4% for men and 4.6% for women). Neither men (1%) nor women (1.1%) consider taxi as a good alternative for cycling.

Concerning driving, the trend is reversed. The percentage of women who were never in the situation to avoid driving on safety reason (71.4%) is higher than for men (59%). A lot of men avoid traveling by car on safety reasons (4.8% for men, 2.9% for women) or use public transport instead (22.9%). Taxi is, however, not a probable alternative for men and women.

Table 18 : Gender differences in Behavorial Adapatation

Percentage of people who decided to … rather than using 'Transport Mode' :

Transport Mode	Avoid travelling		Choose another route		Travel on a different time		Use public transport		Travel by bike		Walk		Travel by car		Take a taxi		It never happened	
	men	women	men	women	men	women	men	women	men	women	men	women	men	women	men	women	men	women
Public Transport	1.0	3.4	0	1.1	1.0	4.0	-	-	15.2	14.3	6.7	2.3	7.6	9.1	1.9	10.9	66.7	54.9
Bike	0	1.1	1.0	5.7	0	1.1	17.1	14.3	-	-	2.9	5.1	11.4	4.6	1.0	1.1	66.7	66.9
Walk	3.8	5.7	2.9	5.7	1.9	4.0	9.5	6.3	2.9	4.6	-	-	4.8	4.6	0	7.4	74.3	61.7
Car	4.8	2.9	1.9	1.7	2.9	2.9	22.9	16.0	5.7	3.4	1.0	0.6	-	-	1.9	1.1	59.0	71.4

4.4.2. Psychology

The two linear regressions analysis showed that people who score high in neuroticism perceived risk as higher as non-neurotic people. In this analysis neurotic people are referred to as people who scored higher that 3 in neuroticism in the 10-items test, and non-neurotic people are people who

scored 2 or lower. Between these two scores people are considered as neutral, neither neurotic nor non-neurotic.

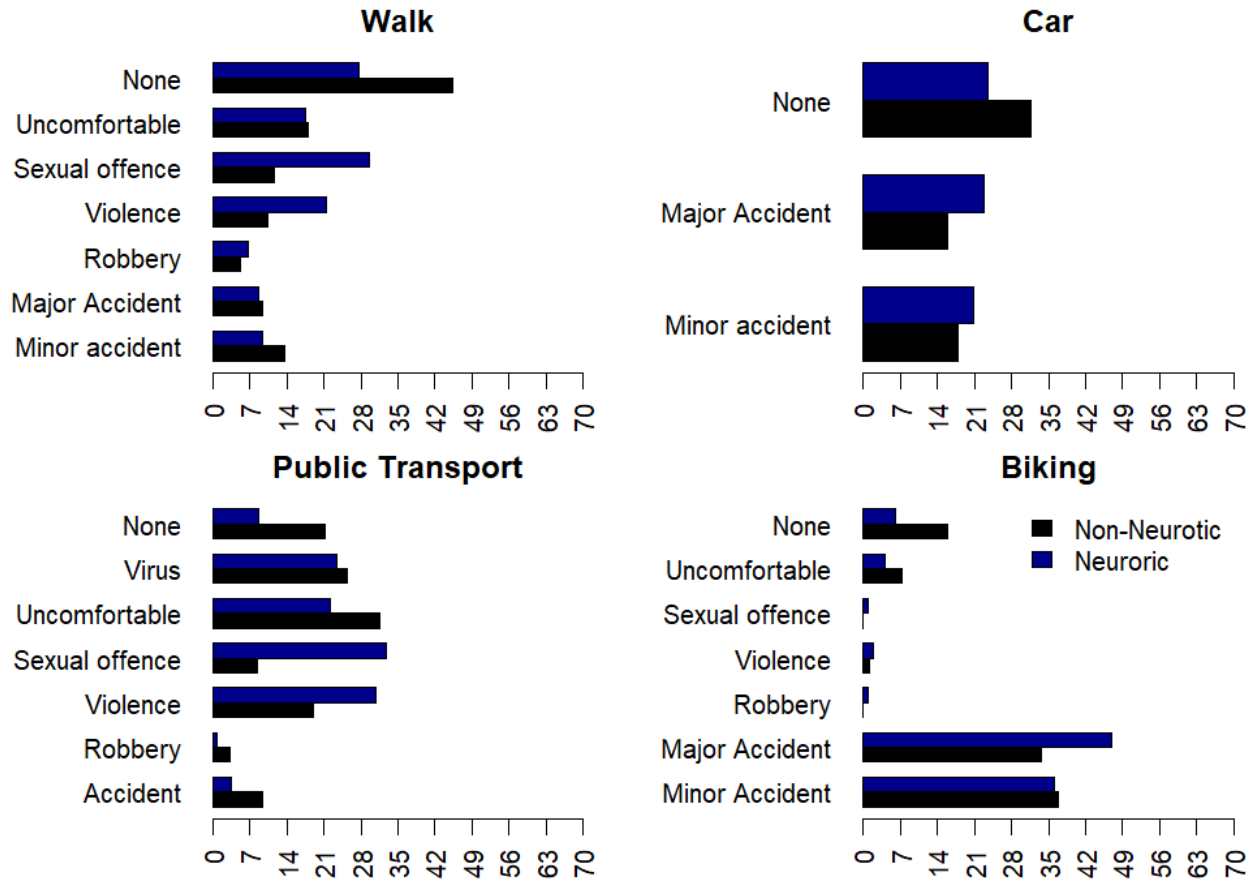

Figure 10 : Psychological Differences in Worry in Different Modes

Regarding what people are worried about (Fig. 10), there is a significant difference between the two groups. In general, non-neurotic people answered that none of the event mentioned worried them much more than neurotic people, this is true for every mode of transport. It is logical because neurotic people are more anxious in general, therefore they worry more about risks. This is especially true for incidents with serious consequences like sexual offences, violence, and major accidents. Non-neurotic people tend to worry more about incidents with small consequences but that are more likely to happen like minor accidents or uncomfortable but not harmful incidents than neurotic people that are more concerned about the one with severe consequences. Neurotic people would rather consider the 'risk as a feeling', whereas non-neurotic people rather focus on the 'risk as analysis.

Neurotic people also tend to have more travel behavioral adaptations because of safety reasons (Table 20). They are more likely to cancel their trip or change the time of their trip for every mode of transport. They will change their route more than non-neurotic people for walking and public

transport but not for driving and cycling. Non-neurotic people will tend to use their car more when they don’t travel by public transport, cycle, or walk, whereas neurotic people will rather take a taxi.

Table 19 : Psychological Differences in Behavorial Adaptations

Transport Mode	Percentage of people who decided to … rather than using 'Transport Mode' :																	
	Avoid traveling		Choose another route		Travel on a different time		Use public transport		Travel by bike		Walk		Travel by car		Take a taxi		It never happened	
	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic	Neurotic	Non-Neurotic
Public Transport	4.0	1.1	1.3	0	4.7	3.2	-	-	16.8	13.7	2.7	2.1	10.7	11.6	12.8	5.3	64.4	63.2
Bike	1.3	0	5.4	1.1	0.7	1.1	14.1	13.7	-	-	4.7	2.1	4.7	10.5	2.0	0	67.1	71.6
Walk	6.0	3.2	5.4	3.2	6.0		4.7	8.4	5.4	1.1	-	-	3.4	6.3	6.0	4.2	63.1	73.7
Car	4.0	2.1	2.0	1.1	2.7	3.2	17.4	22.1	5.4	3.2	0.7	0	-	-	2.0	1.1	65.8	67.4

4.4.3. Age

Age is a somewhat more complex variable to analyze because it is related to other variables. We have already seen that age and income are correlated. Moreover, experience and age could also be associated.

4.4.3.1. Income

Income was found as a predictor for risk perception in several research income (Flynn et al. 1994; Vredin Johansson et al. 2006). It was previously shown that income is strongly correlated to age and education, therefore it was excluded of the model. Older people having in general higher income, it could explain why older people feel safer in transportation. However simple linear regression showed that the relationship between income and perception of risk is unsignificant or almost unsignificant (p-value =0.1823 for public transport; p-value = 0.0456 for car, p-value= 0.411 for bike and p-value=0.03142 for walking). The hypothesis according to which perceived safety is associated with income is excluded. Yet the lowest Perceived Risk Score is always among the >4,000 category (Table 21). Income does not fully explain why age is a predictor for risk perception.

Table 20 : Income and Risk Perception

Income	Bike	Walk	Car	Public Transport
	Risk	Risk	Risk	Risk
<€500	1.79	1.68	1.90	2.11
€500-1,300	1.85	1.64	2.10	2.03
€1,301-2,000	1.72	1.50	1.77	1.78
€2,001-2,600	1.87	1.55	2.07	1.94
€2,601-3,200	1.74	1.57	2.05	1.87
€3,201-4,000	1.81	1.42	1.72	1.86

Income	Bike	Walk	Car	Public Transport
	Risk	Risk	Risk	Risk
>€4,000	1.56	1.24	1.57	1.67

4.4.3.2. Worry and Travel Behavioral Adaptations

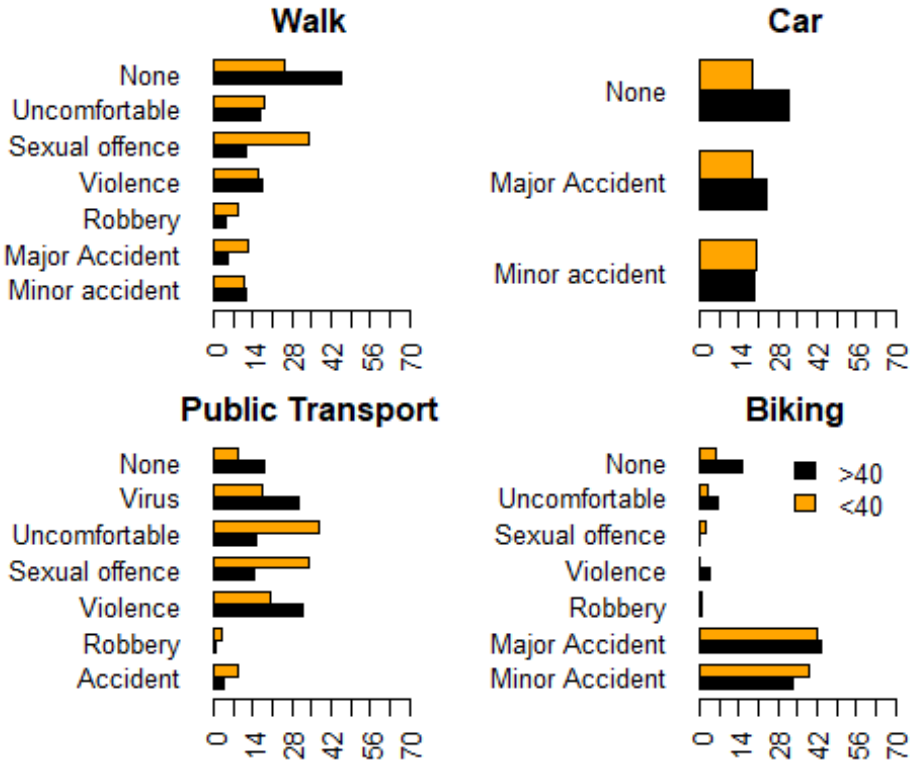

Figure 11 : Age Differences in Worry in Different Modes

As for what people worry about, Fig. 11 confirms that older people worry less in general about incidents and accidents in every mode of transport, they are more numerous to answer “None” to the question “Which of the accidents/incidents are you the most worried about?”. The global trend is that younger people worry more about everything, with an exception for violence and virus. Severity of consequences for virus -especially for COVID 19- are more important for people that are above 40 years old, it explains why they worry more about. Yet, younger people scored perceived risk for virus higher than older people, reinforcing the idea that worry is more about severity and perceived risk score about probability. Regarding accidents the two groups are equally worried.

Young people also reported more travel behavioral adaptions on safety reasons than older people for public transport and walking, public modes of transport (Table 21). They are more likely to cancel their trip, to change the time and the route of their tip in general, except for cars. Young people are more susceptible to pay for a taxi instead of walking and driving. Yet older people are more likely to drive to avoid traveling by bike. The results tend to show that young people are more afraid about incidents than older people in general and will have travel behavioral adaptations to avoid them.

Table 21 : Age differences in Travel Behavioral Adaptations

Transport Mode	Percentage of people of decided to … rather than using 'Transport Mode':																	
	Avoid traveling		Choose another route		Travel on a different time		Use public transport		Travel by bike		Walk		Travel by car		Take a taxi		It never happened	
	≥40	<40	≥40	<40	≥40	<40	≥40	<40	≥40	<40	≥40	<40	≥40	<40	≥40	<40	≥40	<40
Public Transport	1.0	3.4	0	1.1	1.0	4.0	-	-	15.2	14.3	6.7	2.3	7.6	9.1	1.9	10.9	54.9	66.7
Bike	0	1.1	1.0	5.7	0	1.1	17.1	14.3	-	-	2.9	5.1	11.4	4.6	1.0	1.1	66.9	66.7
Walk	3.8	5.7	2.9	5.7	1.9	4.0	9.5	6.3	2.9	4.6	-	-	4.8	4.6	0	7.4	61.7	74.3
Car	3.3	2.9	2.0	1.7	3.3	2.9	19.1	16.0	4.6	3.4	0.7	0.6	-	-	0.7	1.1	71.4	66.4

4.4.3.3. Experience

Experience and age might also be correlated. Survey's respondents were divided into 5 age categories (Table 23): under 25-years old (N=43), from 26- to 35-years old (N=61), from 36 to 45 years old (N=78), from 45 to 55 years old (N=52) and above 55 years old (N=46).

Even though the score for perceived risk decreases the older the categories have, it has an exception for the last category (older than 55), where the score increases compared to the previous category (45-55) for walking, biking and driving. This score remains lower than for the younger categories. The only exception is for public transport, where the lowest perceived risk score is among the oldest category (1.73/5).

There is no correlation between experience and age (except for cars, p-value= 0.0003955). In Munich older people have not experienced more incidents or accidents than younger people. This could confirm the theory developed in the workshop, according to which experience prevent people from doing mistakes again. People all experience (more or less) accidents or incidents in their young ages, and after that they try to avoid the dangerous situation. The age category in which people are the most likely to have young kids (26-35 and 36-45) perceived risk as higher as the two older categories, however the people younger than 25 perceive risk as even higher.

Table 22 : Experience and Perceived Risk for Different Age Categories

Age category	Public Transport		Walk		Bike		Car	
	Experience	Perceived Risk Score	Experience	Perceived Risk Score	Experience	Perceived Risk Score	Experience	Perceived Risk Score
18-25	1.02	2.06	0.67	1.69	0.40	1.79	0.19	2.12
26-35	1.05	2.02	0.46	1.57	0.51	1.88	0.28	2.09
36-45	1.14	1.82	0.64	1.43	0.83	1.74	0.41	1.83
46-55	1.17	1.75	0.71	1.38	0.71	1.61	0.56	1.68

Age category	Public Transport		Walk		Bike		Car	
	Experience	Perceived Risk Score	Experience	Perceived Risk Score	Experience	Perceived Risk Score	Experience	Perceived Risk Score
56-99	0.89	1.73	0.63	1.47	0.57	1.68	0.48	1.81

5. Qualitative Analysis

The qualitative analysis comes to complete de quantitative one, in order to better understand results that were not explained by the literature review, and to discuss the way of improvements for the city of Munich.

5.1. Discussing the Survey's Results

Some of the survey results were difficult to interpret with the available literature, sometimes contradicting it. For this reason, 7 of the survey participants were asked to discuss these results and express their agreement or disagreement with certain statements. Recommendations for the City of Munich and ideas for policy makers are also presented. The chapter closes with the limitations of the present study.

5.1.1. Walking as the Safest Mode

Different results of the survey agreed on considering walking as the safest mode. The participants were asked if they would agree to that statement. There is a very important distinction to make between day and night. During the day walking is indeed very safe, the infrastructures are very safe compared to other countries in the world and the risk of robbery is very low. At night however, everything becomes scarier, and especially when walking according to several female participants. It also depends on the neighborhoods, a participant explains "at night I heard that young people got robbed in the North of Munich, there are corners and streets I avoid during the night".

Some of the male participants agree that walking is the safest mode because, in comparison to public transport, one can chose the way when walking, it is possible to adapt to any kind of situation, for

instance avoid a group of shady people, take a street with more lights ect…However, in public transport there are always people around at any time of the day, which could be reassuring compared to being alone in the street at night.

But comparing public transport and walking may not be very relevant since one cannot replace a public transport trip by walking, and walking is part of a public transport journey, and it is very difficult to avoid it. Compared to biking walking have safer infrastructures which make people feel safer towards accidents.

It is very hard to say which mode can be considered as the safest since a lot of variables come to the fore, it very much depends on the situation and on which incident or accident we are looking at. For example, participants seem to be more afraid of sexual aggression and robbery when they are walking than in other modes.

5.1.2. Age as a Predictor for every Mode of Transport

The survey showed that older people feel safer in every mode of transport in Munich and for most accidents or incidents. One explanation discussed during the workshop is the nightlife. Young people are going out late at night. There two dimensions in this:

- First, at night, people are globally more concerned about safety than during the day.
- Second, people drink alcohol at night, drunk people are scarier, they have less control on themselves and can behave unsafely. This is true for safety reasons and accidents but also for security reasons, drunk people are more violent, they tend to talk more to strangers and are also more likely to harass women for instance.

A second explanation for this would be experience. Young people do not know what to expect so they tend to worry more, whereas experienced older people know that Munich is very safe, they have not or few experienced bad situations, and if they have, they know what to do to avoid being in this situation again. They can have more control on their own perception of safety by avoiding situation they know could be dangerous. One participant explains that she had a bike accident, but she knows what she did wrong so now she feels safer because she pays more attention to not being in a dangerous situation again. Perception can change throughout the time, one gets used to situation one used to feel unsafe about, but that now feel safer because one is used to it, “I used to struggle with narrow streets and bikes while driving in Munich, but I accommodated to it and now I feel much safer”.

On top of that young people are a generation that was born with social media. They are unexperimented and do not have their own experience, however they have heard and seen a lot on social media, and they create a “fake” experience based on things they saw on social media. Young people also tend to be more on their smartphones or listening to music while commuting, they are less focus on their environment, which make them more vulnerable, towards accidents but also incidents:“My 16-year-old daughter is always looking at her phone, she is not attentive and don’t care about traffic”. This unsafe behavior participates in making them feel unsafe. They can also have more dangerous behavior in general, cross at red lights or go faster than older people, risky behaviors while biking, driving, or walking are also important for your perception of safety.

One participant also explains that her perception of safety has changed since she has become a mother. Age of children is also something identified as a predictor for risk perception (Slovic 2000). The participant explains that when she cycles with her child, she is more afraid of cars and accident, and she adapts her behavior, “I only cycle with him in streets where there are very few or no cars”. It also is the case when she commutes alone, she has a responsibility towards her child which can also influence her perception of safety, because she must be safe for both of them, not only for herself anymore. She assumes that this feeling might go away when kids are older, therefore older people (with older child) could feel safer on that ground.

Some of the participants do not agree with the statement and think that above 60-year-old risk perception must be higher than for the younger generations, at least towards accidents. It is supported by survey’s results (Table 23): even though the score for perceived risk decreases the older the categories have, it has an exception for the last category (older than 55), where the score increases compared to the previous category (45-55) for walking, biking, and driving. This score remains lower than for the younger categories. The only exception is for public transport, where the lowest perceived risk score is among the oldest category (1.73/5). If one follows the statement made by one workshop participant, it could be that it is towards accidents that people feel less safe after a certain age.

Survey results showed there was no correlation between experience and age (Table 23). This could confirm the theory developed in the workshop, according to which experience prevent people from doing mistakes again. People all experience (more or less) accidents or incidents in their young ages, and after that they try to avoid the dangerous situation. The age category in which people are the most likely to have young kids (26-35 and 36-45) perceived risk as higher as the two older categories, however the people younger than 25 perceive risk as even higher.

5.1.3. Gender as a Predictor for Walking and Public Transport

All participants agree that women are afraid of modes with interactions because of sexual harassment. When a woman drives or bikes, she is not as “available” as when walking in the streets or using public transports “You are available, people can come to you, talk to you, steal from you, whereas when you are on your bike or in your car it is notthe case”. These two modes allow women to be more independent, they have more control one their environment and they can leave easier than when they walk or use public transport. It seems to be common for women to cycle at night to avoid public transport and walking, one participant noted “my female friends always rather cycle to go home after a party, they feel safer than in public transport”.

5.1.4. Other Predictors

Participants were asked if they would have expected other predictors to be significant for risk perception. Participants do agree that migration background should be a predictor as well. However, it can influence the perception of safety in both directions, that is why it is not shown in the quantitative analysis. People coming from other cities in the world, find Munich very safe in comparison to their other experiences, they even underestimate it they think “On the other hand, it can also make me underestimate the risk in Munich because I compare ir to other places”. One of them explains that he can leave his stuff a couple of minutes in the street and does not worry about it. But some participants that are coming from the countryside have the reversed impression, “I know everyone in my village, the problem in the city is that we don’t know people around us, we don’t even know our neighbor, so we don’t know what to except from them”. People with a migration background are also more likely to suffer from racism in the category uncomfortable but not harmful.

More than simply migration background it seems that the comparison with the place where one grew up has a significant influence on how one perceives safety in the actual place. Also, personal experience abroad or in other place can help putting into perspective your perception of safety in the place you live in.

5.1.5. Safety and Mode Choice

The survey showed that in the everyday life the perception of safety is not correlated with the travel behavior. It is to say it is not because one is more afraid of a mode that one will decide not to use this mode anymore. Participants do globally agree on this statement, they explain that even though they do not feel safe while walking (for women especially), they cannot avoid walking in their daily life. They explain that in a specific situation they can adapt their travel behavior on safety reasons, but in general there is no perfect solution for their everyday commute because they do not feel

100% safe in any of the modes: it is not a one-way solution. Therefore, safety is not the priority when it comes to mode choice for the everyday life, however it is in specific occasion. For example, one participant would not bike if it rained or snowed because he knows it is more dangerous.

5.1.6. Travel Behavioral Adaptation

The next part of the survey analysis was about the specific situations, a “one-time” situation, where people decided not to use a mode on safety reason.

5.1.6.1. Women and Taxi

During the survey analysis, it was shown that women were more likely to take a cab instead of walking and public transport. One participant explains that the action of taking a cab is “a very powerful indicator” for safety. Indeed, when one takes a taxi, it means that one is willing to pay extra-money to feel safe. It somehow gives a price to safety; it shows to extent one wants to increase one’s safety. Participants also wonder, in that case why would you not take a cab when being afraid of robbery or violence, things that men and women are equally worried about. There could be two answers to that question, people are not afraid of robbery and violence enough to pay for a cab, because de consequences are less damageable than sexual harassment. But also, because those incidents do not happen very often, it is possible but not very likely to experiment it, whereas sexual harassment (at night) is more systematic, every time a women commute at night, she thinks about it and worries about it, so to avoid this, women are more likely to take a taxi.

5.1.6.2. Men and Driving

It was observed in the quantitative analysis than men would avoid taking their car way more than women do and take public transport instead for instance. Workshop participants had quite varied explanations for this. One explanation to this observation would be alcohol related. If we assume that men drink more alcohol than women, it makes them have more situations where they decide not to drive because they are under the influence of alcohol, making them unsafe to drive. Another participant thinks that “men have a higher esteem of their car, because for men cars are symbol of succeed and good money”, therefore they do not want to damage their car, as it is a “big part of their personality”. It could also be because of environmental concerns, women are more engaged to the cause therefore they try to avoid using their car anyway, not on safety reasons but rather for environmental issues. Finally, one participant points out that “car is the safest mode for women, so why would they change it?”.

5.2. Measures to make Munich Safer

It was important that the participants of the workshop also had a chance to discuss the future and possible ways of improvement for the city of Munich. Some measures were presented, but the participants also had the possibility to present their ideas for a safer Munich. This section aims at putting forward a few ideas for considerations about policies for the city of Munich.

5.2.1. Effectiveness of Measures

Based on literature review (Sarah Mahmoud and Graham Currie; Vanier and d'Arbois de Jubainville 2017; ASTHO 2020) and some of the comments of the neubenan.de forum, it was decided to present 5 measures to increase safety in Munich. Most of the literature focus on one mode of transportation, therefore some of the measures presented aim at merging different measure to have a reasonable number of measures to present and discuss. The five measures presented were:

- Inform and educate people about bad and good behavior in the different transport modes;
- Car-free city;
- A better allocation of space between cars, pedestrians and bicycle, this measure implying better bicycle line, safer sidewalk, bicycle street or speed-calming measures;
- More police officers in the streets and in public transport;
- No alcohol when commuting and more control about it, as well for car drivers, bicycle as for public transport and in the street, banning the consumption of alcohol while traveling.

Participants had to rank the measures from the most effective to the less effective one according to them, without considering the feasibility of the measures.

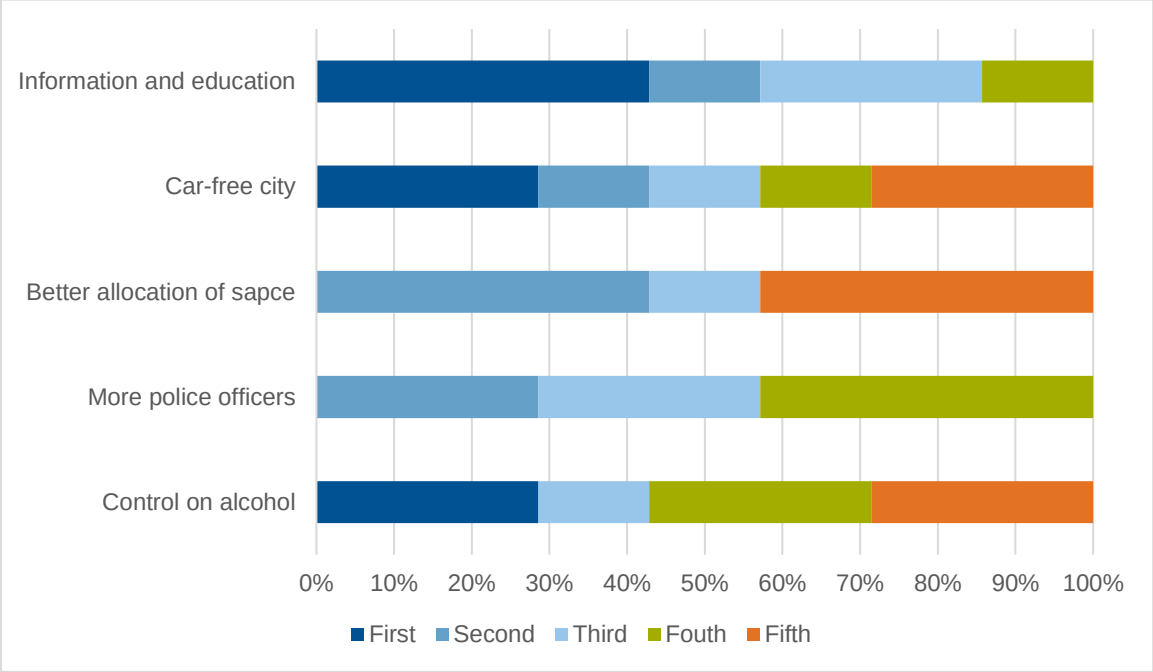

Figure 12 : Ranking of Measures to increase Perceived Safety in Munich

The results were quite different from one participant to another (Fig. 12). The first measure about education and information was ranked first for three participants, it was ranked second by one participant, third place by 2 participants and was considered not relevant (4th and 5th place) by 1 participant. The car-free city was chosen as the most effective measure by two participants, it was second place for one participant, and was considered irrelevant for 3 participants. The measure about better control alcohol consumption was ranked first by 2 participants as well, second by one participant and considered irrelevant by 4 participants. Having more police officer was never ranked first, it was chosen as second by 2 participants and third by 1 participant, 3 of them found the measure not relevant to the problem in Munich. A better allocation of space was ranked second by 2 participants, third also by two participants and found not relevant by 3 of them. According to the workshop participants, inform and educate people about behavior in transport would be the most effective measure in Munich, followed by excluding cars of the city.

5.2.2. Discussion on the measures

After ranking the measures, participants had a chance to talk about them or about other measures they thought would be relevant for the city of Munich.

According to some participants, alcohol is one of the major problems when it comes to travel by night. One participant proposed to have time limit in the sale of alcohol, for example forbid to sell alcohol after 10pm. This was experimented in Glasgow (United-Kingdom), which “used to be one of the unsafest places in Europe, the measure was very efficient and Glosgow is now way safer”. One

participant does not agree on that, she explains that it was also experimented in Munich, and at that time people were drinking even more at home and she had the feeling that in the end there were more drunk and drunker people in the streets than there are now. It is the culture there is around alcohol that must change but it takes a lot of time.

According to other participants, the problem is not really about alcohol. Indeed, if people knew how to behave, they would also have good behavior under the influence of alcohol, especially groups of people, there would always be some individuals who would make the group more reasonable. The problem is that people were not really taught what good and bad behavior are in transportation. Actually, they were, but only towards accidents. Everybody knows that one should not drive or cycle when they have drunk, and a very small amount of people do it now. So, if there was the same awareness about violence, sexual harassment, or discriminations it could have a significant effect. It would also make people feel safer to know that the other people around are educated and informed and that they know how to behave.

Therefore, there is a real need to think about how to inform and educate people on behavioral requirement for mobility and towards alcohol. “Funny videos from the MVG” one can find in the public transport are according to one participant very efficient. They show situations one would not have thought about or considered as a risky situation (for example reading the paper too closed from the trains or listening to music in the streets), so everyone is now aware of the risk it represents.

Lighting is also an option to increase safety. One participant underlined that having the lighting infrastructures hung above the middle of the street makes the sidewalk and some corner very dark, making him feel unsafe. One participant also stated that she avoids cycling in parks at night because there is no lighting.

One participant thinks that the most effective measure would be to have video recordings everywhere but is aware that in a country like Germany this measure is neither possible, neither a good ethical idea according to him. Yet, there are already video recordings at every U-Bahn stations (MVG; mvg.de 2022).

6. Discussion

In this chapter, the focus lays on reflecting and discussing the previously presented findings. It merges the results of the qualitative and quantitative parts. The perception of risk and worry in transport in Munich are analyzed and discussed. The differences between individuals for risk perception identified in the survey are interpreted and discussed with the light of literature review and workshop discussions, as well as their association with travel behaviors are presented. The chapter

closes with the assessment of the validity of the measures in this study as well as the methodological limitations it presents.

6.1. Perception of Risk in Different Means of Transport

In general, Munich citizens do not report high level of perceived risk in transportation. As the sample was somewhat biased in terms of age and education, it is possible that higher degrees of risk perception would have been observed with a more representative sample. However, education was not found out to be a significant predictor for risk perception, and age categories with the higher risk perception were overrepresented, whereas the age category with lower perception of risk were underrepresented. It is therefore unlikely that the bias of the sample influences the results.

It is very difficult to assess that one mode is safer than another for two main reasons. First, the survey showed that, depending on the transport mode, the concerns are very different. In private mode of transport, people worry about accidents, whereas they worry about unpleasant incidents in public modes of transport. The first one mostly implies one's own behavior, one can reduce the risk of accident by adopting a very careful behavior, whereas the second one implies interactions with other people, it is therefore harder to adapt one's behavior to feel safer since it depends on other people's behavior as well. Car was not rated as the safest mode as it would have been expected. The way the survey was designed could explain it. In the car section it was only asked about accidents and not about unpleasant incidents. Since the (real) risk about unpleasant incidents while driving is very closed to zero, one could imagine that all the unpleasant incidents would have been rated closed to 1 and therefore the Risk Perception Score would have dropped. This choice was made to reduce the length of the survey to maximize the number of answers. For further research, it would be recommended to ask about the same accidents and incidents for every mode to be able to compare them, even though it is acknowledged that unpleasant incidents are not relevant for cars and accidents not relevant for public transport. The second reason was highlighted during the workshop, there is no one-way solution. One cannot choose between walking and traveling by public transport, walking is somehow always part of the journey. Every mode has its own risk and advantages that are not always comparable.

6.2. Risk Perception and Worry

Backer-Grøndahl et al. (2009) explained that worry and risk perception should be two different variables, this is why this study had two questions. One was oriented towards 'risk as analysis', that is, "to what degree do you think about the possibility for an accident/incident?", whereas this question aimed at measuring worry in Backer's study. The other one was directly addressing worry "Which of

the mentioned incidents/accident do you worry the most about?", it aimed at capturing the 'risk as a feeling' of worry in a direct manner. This study allowed to compare worry and risk perception. The results were interesting, showing that people worry more about incidents or accidents with severe consequences and perceive risk higher for accidents and incidents with a higher probability to happen. It is exacerbated for neurotic people who worry even more of accidents and incidents with a high severity of consequences. Aiming at reducing the probability of event to happen will for sure reduce the so-called perceived risk, however it might not affect to the same extent what people are worried about. Reducing worry in transportation is a more complex task because the severity of consequences of accidents or incidents will always remain somehow the same.

6.3. Perceived Risk Predictors

Predictors of perceived risk were investigated by means of 10 multiple linear regression. The first four linear regression were computed for the different modes of transport. The models explained receptively 25% of the variance for public transport, 13% for cycling, 22% for walking and 14% for driving. This is equivalent to similar models presented elsewhere (Backer-Grøndahl et al. 2009; Chauvin et al. 2007; Slovic 2000).The model is more relevant for public modes of transport than for private ones. After conducting the workshop, it was realized that these models were not sufficient to explain perceived risk predictors because perception of risk is different between accidents and unpleasant incidents, therefore 6 new linear regression models were computed for the six types of incidents and accidents investigated in the survey. The explained variance for these models were 6% for accidents, 33% for sexual harassment, 12% for violence, 24% for uncomfortable but not harmful incidents, 20% for virus and 10% for robbery. It shows that the model is more relevant for unpleasant incidents than for accidents.

Most of the variance remains unexplained, indicating that further research should be conducted to find new variable able to predict risk perception. A first response to this question was found during the workshop, the previous experience, but experience in a wider term than the one used in the model, does influence one's perception of safety. This experience includes where one has lived before, where one has traveled before. The perception of safety, according to the workshop participants, is strongly based on comparison to other places and how one safe one has felt in different places. A deeper qualitative analysis on this subject could lead to new possible predictors that can be tested by a quantitative analysis afterwards. However, this experience might be hard to capture through quantitative analysis. Another hypothesis suggested by Backer-Grøndahl et al. (2009) is that in these models, predictors were linked to the perceiver and that factors connected to the transport mode in itself may be more important to explain risk perception than factors linked to the perceiver.

As for the predictors in the present models, the result support previous research that has shown a positive relationship between neuroticism and risk perception (Backer-Grøndahl et al. 2009; Chauvin et al. 2007; Sjöberg and Wåhlberg 2002). A higher score for neuroticism was related to a Perceived Risk Score. This was obvious for every mode of transport and every kind of accidents/incidents, even though it was more significant for walking and public transport than for biking and driving, which contradicts the results found by Backer-Grøndahl et al. (2009).

Concerning the socio-demographics factors, age is a strong predictor for every mode of transport, and for almost all the incidents/accidents except for robbery, violence, and virus. The younger the respondent was the higher his perception of risk was. It was a particularly strong predictor for sexual harassment and uncomfortable but not harmful incident.

Gender was a predictor for perceived risk when it comes to sexual harassment, it was therefore a predictor in public transport and while walking because they are the modes women are the most exposed to sexual harassment. It contradicts the hypothesis according to which women worry more because it is their nature to nurture and to protect life (Sjoberg 2000). If it was the case, then women would also be more worried about everything than men, gender would be a significant predictor for every mode and every kind of accidents and incidents. It is the interactions with other people, especially with men, since we are talking about sexual offences, that make them feel unsafe. Real risk plays an important role, since the women are more exposed to sexual harassment in practice, they worry more about it and perceive the risk as higher.

Having experienced an unpleasant incident was a strong predictor for uncomfortable but not harmful incident, sexual harassment, and virus. People who have experienced an incident before will have a higher perception of the risk. There was however no significant correlation between having experienced an accident and the perception of risk for accidents. This was explained through the workshop when one participant explained that having an accident actually helped her to feel safer because she knows how not to reproduce the same mistakes. However, for incidents such as uncomfortable but not harmful incident, sexual harassment or virus, the outcome does not depend on the perceiver, rather on other people's behavior. Thus, having experienced it does not make the perceiver feel safer, because he has no control over it.

6.4. Perceived Risk and Travel Behavior

The results suggest that the perception of risk does not influence mode choice in the everyday life. It supports previous research that have shown that other element such as reliability, flexibility or cost (Rundmo et al. 2011) would have a higher impact on mode choices. It was also confirmed by work-

shop's participants, even though it is a factor they think of their everyday life choices are not impacted by safety, especially in Munich, a relatively safe place to travel.

The percentage of people who made at least one behavioral adaptation are similar or somewhat lower than found by Backer-Grøndahl et al. (2009). In the survey, people could only choose one behavioral adaptation, they had to report what they did in the worst time. This was decided with the statistics consulting department of the TUM because in the first analysis plan a multi-nominal regression was supposed to be applied between the behavioral adaptations and the Perceived Risk Score. In was though decided to divide this analysis in two separate analysis, one regression between the Perceived Risk Score and the response to the question "Did it ever happened to you to avoid or modify your trip with X mode because of safety reasons?" which could be yes or no and a descriptive analysis of the response to the question "If yes which alternative did you chose?". Therefore, this last question could have been a multiple-answers question and would have provided better results. For coming research, this question should be a multiple answers question.

The results remained interesting and showed important differences between men and women in the behavioral adaptations. Women are more likely to take a taxi, avoid their trip or change the time of their trip making them less free in their mobility choices than men. To feel safe, they must pay for a taxi, to stay at home or to leave a party earlier because they are afraid for their safety. Women who took part in the workshop agreed on saying that their freedom was compromised because they are afraid of sexual harassment, which is a systematic thing when they travel according to one participant of the workshop. When they travel by night, they feel unsafe because of men's behavior. It does not have to be sexual harassment such as physical aggression or rape, it can be because of staring, comments or someone following them in the streets, there will always be something that make them feel unsafe.

6.5. Validity of the Measurements

We argue that perceived risk and worry were measured in the survey, however we cannot be completely sure that it is how people reported it in the survey. Several points are worth noting. Perceived risk and worry were both associated with neuroticism at every level of the study, which is coherent with other studies who also associated neuroticism with perceived risk (Chauvin et al. 2007) and worry (Backer-Grøndahl et al. 2009). Neuroticism is the tendency of experiencing negative emotions, it is therefore logical that neurotic people worry more about accidents and incidents and have a higher perception of risk. The means used to collect these two measurements were very different: one was based on several Likert-Scales, whereas the other one was a multiple-choice question. Perceived risk is thus a score from 1 to 5 whereas worry is a percentage of people. It makes the

comparison difficult and inevitably not completely accurate. Other questions formulations were tested through a pilot survey, where both were asked with Likert-Scales questions, however the difference between both was not understood by the participants, leading to a general confusion about question's meaning. Further research should aim at being able to compare these two variables in a more accurate way. It is however very difficult to capture the "feeling" of worry in a quantitative way, qualitative research is surely more appropriate. It was considered to talk about it during the workshop, but the subject was evaluated as too technical for the workshop format. It would have required more time or dedicate the whole workshop to the subject, which was not a priority in this thesis.

As for the validity of perceived risk in itself, which is the main core of this study, having the perceived risk score related to neuroticism and to travel behavioral adaptations suggest a high criterion validity (Backer-Grøndahl et al. 2009). Last, all the results of the survey were confirmed by the workshop, making the measurements consistent with practical reality.

6.6. Safety in Munich and Recommendations

Even though Munich is considered and perceived as a very safe city, the issue should not be overlooked in the city. Throughout the survey dissemination process and during the workshop, citizens of Munich showed an enthusiastic interest for this topic, suggesting that the situation is not perfect.

Munich citizens who participated in the workshop agreed that they would feel safer if they knew that people around them were informed and educated about adopting good behavior in public spaces. If people were taught how dangerous these behaviors are in the same way they are taught they should not drive when they drink, it would make people feel safer about incidents. The regression analyses realized throughout the study showed that the models chosen in this thesis are more relevant for modes with interactions than for modes without, suggesting that gender or psychologic inequalities are more relevant in these modes. These problems are not addressed by the city in the same extent as accidents are. If we look at the videos shared in public transport by the MVG, they deal about dangerous behaviors towards accidents. It would be interesting to have them also for incidents and to raise awareness towards violence, sexual harassment and small uncomfortable but not harmful incidents such as staring, racism or discrimination. In this way, every public transport user would know about these behaviors and that they are not supposed to act like that. However, it is necessary to target all the population and not only people who travel with public transport. Replacing publicity in the streets by safety awareness could be an idea. For example, having an emergency call possibility and communicating about it in the street on the publicity spots.

It does not mean that accidents must be overlooked by the city. Accidents are an important source of worry for a lot of people, especially when cycling. Developing safe cycling infrastructure is a key to have more people to cycle in the city.

Further studies could investigate which concrete measures would be the most efficient to increase Munich citizen's perception of safety. Solution-based research is needed to better understand the need of Munich's citizens.

6.7. Limitations

This study has methodological limitations. Indeed, the time and means available did not allow for a mixed research method to be carried out as rigorously as desired. Limitations are presented in the following chapter.

6.7.1. Quantitative part

With the recruitments methods used for the survey, it is exposed to a certain level of bias. The first recruitment was among public transport users, resulting in a high share of public transport users, 70.4% of the participants traveled with public transport at least once a week. Beside only 31.1% of the respondents reported to drive at least once a week. The cycling rate was also high 55.4% reported cycling at least once a week and 91.1% reported walking (more than five minutes) at least once a week.

Concerning socio-demographics the survey results showed a high share educated people, having a university degree (75.7%) which is not representative from the city of Munich. One feeling I had while approaching people at the public transport stations was that in general, people with harder jobs were tired and did not want to participate in the survey. The response-rate was lower in the very early mornings (around 6am) and in the mid-afternoon (around 3pm) than during the peak travel time (9am and 5pm). People with lower educational degree have harder jobs with hard schedules, they were not mentally ready to fill out the survey. People above 60 years old were also underrepresented in the study. It has to deal with the online form of the survey. A few people I approached told me they did not have a phone or could not scan the QR-code with their phone. Older people were also less likely to scan the QR-code because they were afraid it could be a scam. Even-though Covid-19 made people more familiar with QR-code, a lot of people did not want to scan it because of safety reasons. Yet some people were reassured when I said I was studying at the Technical University of Munich, mentioning it in the first place was necessary to gain people's trust. The second method of recruitment on the neubenan.de forum was not biased regarding the different

transport modes since it is not a transport-related forum. Yet there was a high a share of women in this forum, resulting in a high share of women in the survey results.

I also mentioned the subject of the study when sharing the link of the survey, so people who felt concerned by the subject were somewhat more likely to take part in it. It can also explain the high share of women among the participants, that are globally more involved in the subject of safety, even though I did not have this feeling when spreading it among public transport users, men and women seemed equally interested by the subject.

One can also regret the lack of gender diversity in the survey with only one respondent who did not to share iel's gender and no one identified as non-binary. This respondent was excluded of the survey analysis because of lack of significance. There were only 17 people who reported a disability, including one walking disability and 16 belonging to other health conditions, it is to say neither walking disability nor visual impartment. Thus, disability was not considered in the socio-demographics predictors.

The use of a convenience sample, with a limited number of participants limited the significance of the results. The lack of economical means and the time limitation of this study made it difficult to collect the number of participants required to have a smaller margin of error. It took a lot of time and energy to go directly to the people and talk with them to have them answering the survey, sometimes facing rude reactions. Sometimes, approaching people for 1h30 only resulted in 1 or 2 responses.

6.7.2. Qualitative part

Having people participating in the workshop was very challenging. It was impossible to predict in the beginning of the study if it would be possible to organize the workshop with Munich's citizens in the end. The strategy adopted to collect e-mail addresses via the survey was not ideal. Indeed, people had to go to another survey to share their e-mail addresses, only 24 participants did it out of 288. The choice was made to preserve the participant's anonymity, but it somewhat jeopardized the collect-rate of the e-mail addresses. The second crucial step was among the people who shared their e-mail addresses to have them to participate in the workshop, which means having several people (at least 5) available on the same day and at the same time and replying to my e-mail. It was decided to do an online workshop so the place would not be another condition for people to be able to participate. Seven people in the end met all these conditions.

People who participated in the workshop were all high educated people, one can regret a lack of diversity in the participants. It is the same problem as faced while sharing the survey, people with harder job do not have the will or the energy to participate in a workshop after work.

The format of the workshop was also limiting, I did not want it to be too long for two reasons. The first one being having seven people available at the same time for more than 1h30 seemed impossible. Second, the attention of participants might drop if the workshop is too long. It could already be observed that after one hour some of the participants were not participating as actively as at the beginning of the workshop. Limiting the length of the workshop forced me to do choices about what could be discussed during the workshop.

Organizing several workshops about different part of the study would have been interesting, especially to talk more about the psychologic mechanisms involved in the perception of safety. Unfortunately, I was not able to find enough participants to be able to do that. The workshop tried to be as exhaustive as possible within the limit of time and number of participants.

7. Conclusion

This study aimed at exploring the socio-psychological inequalities regarding risk perception and assess if there was an association between risk perception and travel behavior. The methodology used in this study was innovative. Previous studies which aimed at investigating perceived risk predictors chose a quantitative research design with a survey. This thesis aimed at adding a qualitative part in the study, which turned out to have some interesting aspects with regards to the subject. It allowed to interpret the survey results with perspectives that could have remained unexplored without the discussion with Munich's citizens. It is important for a researcher to be confronted with the ideas of his research's subjects because they often have ideas and interpretations the researcher would not have thought about or found in a literature review. The mixed-method research design should be further developed in future studies about risk perception.

One part of the research gaps this thesis aimed to fill in was whether it was socio-demographics, psychology or experience that better predict perceived risk in transportation. This study does not provide any consensus to this question. Depending on the mode and the kind of incidents we are looking at they don't have the same influence. Neuroticism and age are both strong predictors. Experience in general is also very important. The place people come from, previous incidents or accidents in transportation, places people have been, things heard or read on social media have a significant influence yet very hard to quantify.

The perception of risk does not predict mode choice in the everyday life. Every mode has its advantage and drawbacks regarding safety and there is never a perfect choice to feel perfectly safe. However, the perception of risk does make people have punctual behavioral adaptations in specific situations, such as bad weather conditions or traveling late at night. It very damageable that in a city

like Munich, which is referred to as one of the safest cities in Germany and in Europe, people must cancel their trip or change the time of their trip because they do not feel safe. Freedom of movement is somewhat jeopardized. Everyone is not equal facing these restrictions, they are more experimented by women, young and neurotic people. Sexual harassment is a big issue for women in Munich in public transport and as pedestrians and is poorly addressed by the city. It seemed that security (towards accidents) has been more addressed than safety (towards incidents) in Munich. Addressing the problem and raising awareness is crucial for the city, also about incidents, especially among the young generation.

Future research should focus on a solution-based approach for the city of Munich, considering the personal differences found by this thesis. Indeed, it is important to acknowledge the fact that the younger generation feels more vulnerable, that neurotic people tend to overestimate the risk when the severity is high or that women feel particularly vulnerable regarding sexual aggression. In terms of risk perception, the needs of individuals differ, so solutions must be both general and tailored to the individual as much as possible, so no one would feel left behind.

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A. Survey Questions

Wie sicher ist Mobilität in München?

Wie sicher füchlen Sie sich in den verschiedenen Verkehrsträgen in München? Welche Verbesserungen würden Sie sich für die Stadt wünschen?

Im Rahmen meiner Masterarbeit 'The Influence of Perceived Safety in Mode Choice in Munich' an der Technischen Universität München (TUM) führe ich diese Umfrage über Ihre Erfahrungen mit der Sicherheit in verschiedenen Verkehrsmitteln in München durch.

Ich möchte Ihnen versichern, dass alle mit diesem Fragebogen erhobenen Daten nur zu Bildungszwecken verwendet werden und weder persönliche noch vertrauliche Daten weitergegeben oder veröffentlicht werden. Die Beantwortung dieses Fragebogens dauert etwa 8 Minuten. Wenn Sie Fragen haben,
können Sie sich gerne an mich wenden:
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Soziodemografische Entwicklung

Geschlecht *

- ○ 1: Männlich
- ○ 2: Weiblich
- ○ 3: Nicht Binär
- ○ 4: Lieber nicht sagen

Wie alt sind Sie? *

Votre réponse

Was ist Ihr höchster Schul- bzw. Bildungsabschluss? *

- 1: (noch) ohne Abschluss,
- 2: Volks- oder Hauptschule, POS 8. Klasse
- 3: mittlere Reife, Realschulabschluss, POS 10. Klasse
- 4: Fachhochschulreife, Abitur, EOS 12. Klasse bzw. Berufs-ausbildung mit Abitur
- 5: Fachhochschul- oder Universitätsabschluss
- 6: anderer Abschluss

Haben Sie einen Migrationshintergrund?(mindestens ein Elternteil im Ausland geboren wurde) *

- 1: Ja
- 2: Nein

Sind Sie körperlich behindert oder dauerhaft gesundheitlich eingeschränkt? *

- [ ] 1: ja, eine Gehbehinderung
- [ ] 2: ja, eine Sehbehindering
- [ ] 3: ja, eine andere gesundheitliche Einschränkung
- [ ] 4: nein, keine Einschränkung

PLZ in München *

Votre réponse

Öffentliche Verkehrsmittel

Wie häufig benutzen Sie öffentliche Verkehrsmittel in München (U-Bahn, S-Bahn, Tram, Bus)? *

- ○ 1: täglich bzw. fast täglich
- ○ 2: an 1-3 Tagen pro Woche
- ○ 3: an 1-3 Tagen pro Monat
- ○ 4: seltener als monatlich
- ○ 5: nie bzw. fast nie

Sicherheit in öffentliche Verkehrsmittel

Inwieweit denken Sie über die Möglichkeit der nachfolgenden Vorfälle wärend der Nutzung von öffentlichen Verkehrsmittel? *

	Überhaupt nicht	In geringem Maße	In mittlerem Maße	In erheblichem Maße	In hohem Maße
Raubüberfall	○	○	○	○	○
Körperliche Gewalt	○	○	○	○	○
Sexuelle Belästigung	○	○	○	○	○
Unangenehmes, aber nicht schädliches Ereignis (z. B. Beleidigungen, Starren)	○	○	○	○	○
Virusinfektion (z. B. COVID 19)	○	○	○	○	○
Unfall	○	○	○	○	○

Welches der oben genannten Ereignisse beunruhigt Sie am meisten im öffentlichen Verkehrsmittel in München? *

- [ ] 1: Raubüberfall
- [ ] 2: Gewalttätigkeit
- [ ] 3: sexuelle Belästigung
- [ ] 4: unangenehmer, aber nicht schädlicher Vorfall
- [ ] 5: Virus
- [ ] 6: Unfall
- [ ] 7: keine

Hat Sie die Angst vor einem der oben genannten Ereignisse schon einmal daran gehindert, in München mit öffentlichen Verkehrsmitteln zu fahren? *

- ( ) Ja
- ( ) Nein

Wenn ja, welche Alternative haben Sie bei dem schlimmsten Vorfall verwendet?

- ○ 1: Auto
- ○ 2: Taxi
- ○ 3: Fahrad
- ○ 4: Zu Füss
- ○ 5: Ändern Sie die Zeit Ihrer Fahrt
- ○ 6: Ändern Sie die Route Ihrer Fahrt
- ○ 7: Vermeiden Sie Ihrer Fahrt

Radfahren

Wie häufig radeln Sie? *

- ○ 1: täglich bzw. fast täglich
- ○ 2: an 1-3 Tagen pro Woche
- ○ 3: an 1-3 Tagen pro Monat
- ○ 4: seltener als monatlich
- ○ 5: nie bzw. fast nie

Achtungskontrolle : Bitte wählen Sie "Stuhl" für diese Frage

- ○ Tisch
- ○ Stuhl
- ○ Tasche

Sicherheitsfahrradfahren

Inwieweit denken Sie über die Möglichkeit der nachfolgend genannten Vorfälle beim Radfahren in München nach? *

	Überhaupt nicht	In geringem Maße	In mittlerem Maße	In erheblichem Maße	In hohem Maße
Leichter Unfall (kleine Verletzungen: nicht schwere Verletzungen mit Krankheitsurlaub oder leichten Pflichten)	○	○	○	○	○
Schwerer Unfall (Schwerverletzung, tödlich)	○	○	○	○	○

Raubüberfall	○	○	○	○	○
Körperliche Gewalt	○	○	○	○	○
Sexuelle Belästigung	○	○	○	○	○
Unangenehmes, aber nicht schädliches Ereignis (z. B. Beleidigungen, Starren)	○	○	○	○	○

Welches der oben genannten Ereignisse macht dir am meisten Sorgen, wenn du in München Rad fährst? *

- [ ] 1: leichter Unfall
- [ ] 2: schwerer Unfall
- [ ] 3: Raubüberfall
- [ ] 4: körperliche Gewalt
- [ ] 5: sexuelle Belästigung
- [ ] 6: unangenehmer, aber nicht schädlicher Vorfall
- [ ] 7: keine

Hat die Angst vor einem der oben genannten Ereignisse Sie jemals daran gehindert, mit dem Fahrad in München zu fahren? *

- ◯ Ja
- ◯ Nein

Wenn ja, welche Alternative haben Sie bei dem schlimmsten Vorfall verwendet?

- ◯ 1: Öffentliche Verkehrsmittel
- ◯ 2: Zum Füss
- ◯ 3: Auto
- ◯ 4: Taxi
- ◯ 5: wählen Sie eine andere Route
- ◯ 6: wählen Sie ein anderes Zeit
- ◯ 7: vermeiden Sie Ihrer Fahrt

Laufen

Wie häufig gehen Sie zu Fuß (mehr als 5 Minuten) in München? *

- ○ 1: täglich bzw. fast täglich
- ○ 2: an 1-3 Tagen pro Woche
- ○ 3: an 1-3 Tagen pro Monat
- ○ 4: seltener als monatlich
- ○ 5: nie bzw. fast nie

Sicherheit zum Füss

Inwieweit denken Sie über die Möglichkeit der nachfolgend genannten Vorfälle beim Gehen (mehr als 5 Minuten) in München nach? *

	Überhaupt nicht	In geringem Maße	In mittlerem Maße	4: In erheblichem Maße	5: In hohem Maße
Leichter Unfall (kleine Verletzungen: nicht schwere Verletzungen mit Krankheitsurlaub oder leichten Pflichten)	○	○	○	○	○
Schwerer Unfall (Schwerverletzung, tödlich)	○	○	○	○	○

Raubüberfall	○	○	○	○	○
Körperliche Gewalt	○	○	○	○	○
Sexuelle Belästigung	○	○	○	○	○
Unangenehmes, aber nicht schädliches Ereignis (z. B. Beleidigungen, Starren)	○	○	○	○	○

Welche der oben genannten Vorfälle beunruhigen Sie am meisten, wenn Sie in München zum Füss gehen? *

- [ ] 1: leichter Unfall
- [ ] 2: schwerer Unfall
- [ ] 3: Raubüberfall
- [ ] 4: Gewalttätigkeit
- [ ] 5: sexuelle Belästigung
- [ ] 6: unangenehmer, aber nicht schädlicher Vorfall
- [ ] 7: keine

Die Angst vor einem solchen Ereignis hat Sie jemals daran gehindert, eine genaue Anreise zum Füss in München zu machen? *

- ◯ Ja
- ◯ Nein

Wenn ja, welche Alternative haben Sie bei dem schlimmsten Vorfall verwendet?

- ◯ 1: öffentlichen Verkehrsmitteln
- ◯ 2: Auto
- ◯ 3: Taxi
- ◯ 4: Fahrad
- ◯ 5: ändern Sie die Zeit Ihrer Fahrt
- ◯ 6: ändern Sie die Route Ihrer Fahrt
- ◯ 7: vermeiden Sie Ihrer Fahrt

Auto

Wie häufig fahren Sie mit dem Auto (oder sind Mitfahrer) in München? *

- ◯ 1: täglich bzw. fast täglich
- ◯ 2: an 1-3 Tagen pro Woche
- ◯ 3: an 1-3 Tagen pro Monat
- ◯ 4: seltener als monatlich
- ◯ 5: nie bzw. fast nie

Achtungskontrolle : Bitte wählen Sie "Katze" für diese Frage *

- ◯ Hund
- ◯ Katze
- ◯ Ente

Fahrzeugsicherheit

Inwieweit denken Sie über die Möglichkeit der nachfolgend genannten Vorfälle beim Autofahren in München nach? *

	Überhaupt nicht	In geringem Maße	In mittlerem Maße	In erheblichem Maße	In hohem Maße
Leichter Unfall (kleine Verletzungen: nicht schwere Verletzungen mit Krankheitsurlaub oder leichten Pflichten)	○	○	○	○	○
Schwerer Unfall (Schwerverletzung, tödlich)	○	○	○	○	○

Welche der oben genannten Ereignisse machen Ihnen beim Fahren in München am meisten Sorgen? *

- [ ] 1: leichter Unfall
- [ ] 2: schwerer Unfall
- [ ] 3: keine

Hat die Angst vor einem Unfall Sie jemals davon abgehalten, mit dem Auto zu fahren? *

- ◯ Ja
- ◯ Nein

Wenn ja, welche Alternative haben Sie bei dem schlimmsten Vorfall verwendet?

- ◯ 1: öffentlichen Verkehrsmitteln
- ◯ 2: Fahrad
- ◯ 3: Zum Füss
- ◯ 4: Taxi
- ◯ 5: ändern Sie die Zeit Ihrer Fahrt
- ◯ 6: ändern Sie die Route Ihrer Fahrt
- ◯ 7: vermeiden Sie Ihrer Fahrt

Erfahrung

Haben Sie schon einmal eine unsichere Situation erlebt, während Sie in München unterwegs waren? *

	Unfall	Raubüberfall	Körperliche Gewalt	Sexuelle Belästigung	Unangenehmer, aber nicht schädlicher Vorfall
im öffentlichen Verkehr	☐	☐	☐	☐	☐
Als Radfahrer	☐	☐	☐	☐	☐
Als Fußgänger	☐	☐	☐	☐	☐
mit dem Auto	☐	☐	☐	☐	☐

Erfahrung

Haben Sie schon einmal eine unsichere Situation erlebt, während Sie in München unterwegs waren? *

	berfall	Körperliche Gewalt	Sexuelle Belästigung	Unangenehmer, aber nicht schädlicher Vorfall	Virus	Keine
im öffentlichen Verkehr	☐	☐	☐	☐	☐	☐
Als Radfahrer	☐	☐	☐	☐	☐	☐
Als Fußgänger	☐	☐	☐	☐	☐	☐
mit dem Auto	☐	☐	☐	☐	☐	☐

Persönlichkeit

Jeder Punkt dieses Fragebogens ist eine Aussage, mit der eine Person entweder einverstanden oder nicht sein kann. Geben Sie für jeden Artikel an, wie sehr Sie mit dem, was der Artikel sagt, einverstanden oder nicht sind.

Inwieweit treffen die folgenden Aussagen auf Sie zu? *

	trifft überhaupt nicht zu	trifft eher nicht zu	weder noch	eher zutreffend	trifft voll und ganz zu
Ich bin eher zurückhaltend, reserviert	○	○	○	○	○
Ich schenke anderen leicht Vertrauen, glaube an das Gute im Menschen	○	○	○	○	○
Ich bin bequem, neige zur Faulheit	○	○	○	○	○
Ich bin entspannt, lasse mich durch Stress nicht aus der Ruhe bringen	○	○	○	○	○
Ich habe nur wenig künstlerisches Interesse	○	○	○	○	○
Ich gehe aus mir heraus, bin gesellig	○	○	○	○	○
Ich neige dazu, andere zu kritisieren	○	○	○	○	○
Ich erledige Aufgaben gründlich	○	○	○	○	○

Ich werde leicht nervös und unsicher	○	○	○	○	○
Ich habe eine aktive Vorstellungskraft, bin phantasievoll	○	○	○	○	○

Wie hoch ist Ihr monatliches Nettoeinkommen ? *

- ○ <€500
- ○ €500-1,300
- ○ €1,301-2,000
- ○ €2,001-2,600
- ○ €2,601-3,200
- ○ €3,201-4,000
- ○ >€4,000
- ○ möchte ich nicht angeben

B. Workshop Presentation

Presentation

Giulia Peaucellier

23-year-old

France

MSc. Environmental Engineering, TUM

giulia.peaucellier@tum.de

Context

- You replied to an online survey a few weeks ago
- The aim of the survey was :
  - To have an overview of safety in different modes of transport in Munich
  - To investigate perceived safety predictors
  - To establish the influence of perceived safety on mode choice in Munich

Agenda

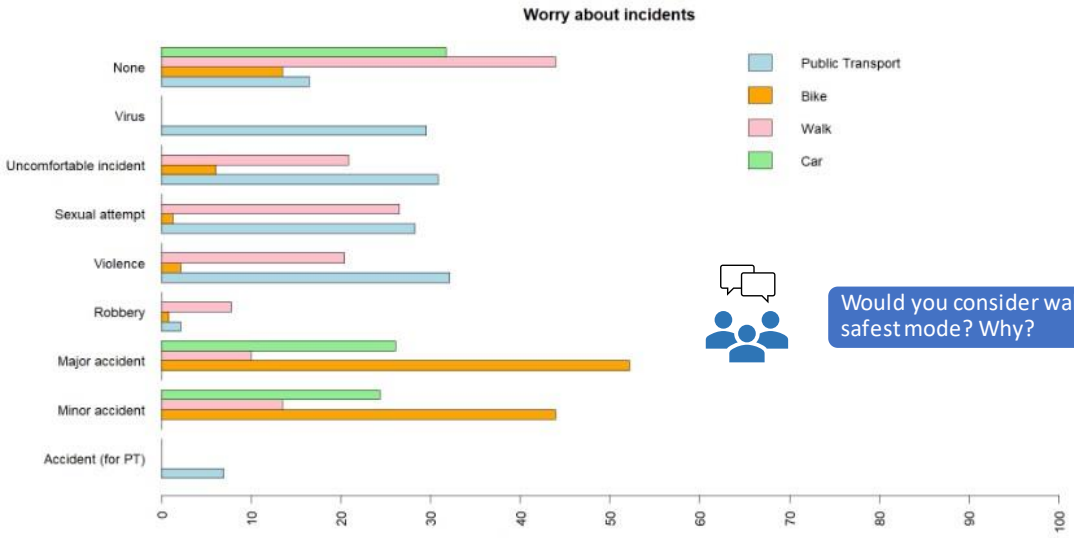
1. Present and discuss the survey results
   1. State of the art : how people feel in Munich?
   2. Socio-psychologic inequalities regarding percieved safety
   3. Safety and travel behaviour

2. How to increase safety in Munich?

Survey results

Survey results – State of the Art

Percentage of people who worries about :



Would you consider walking as the safest mode? Why?

Survey results – Perceived risk predictors

Socio-demographics

- Age
- Gender
- Education (University degree or no university degree)
- Migration background

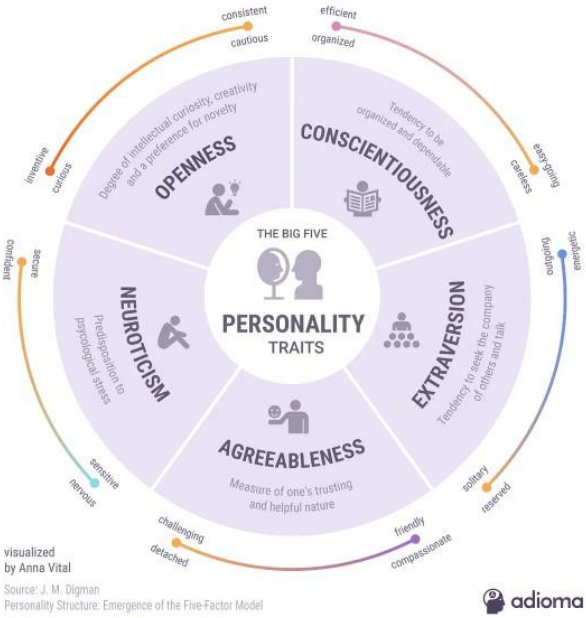
Personality (Big-5 theory)

- Neurotism
- Extraversion
- Openness
- Consciousness
- Agreeableness

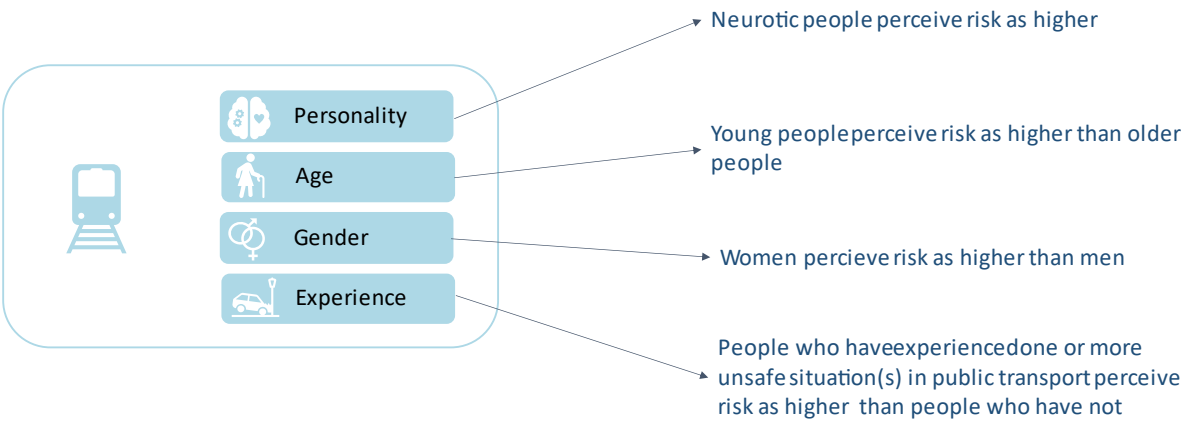
Previous experience

Personality

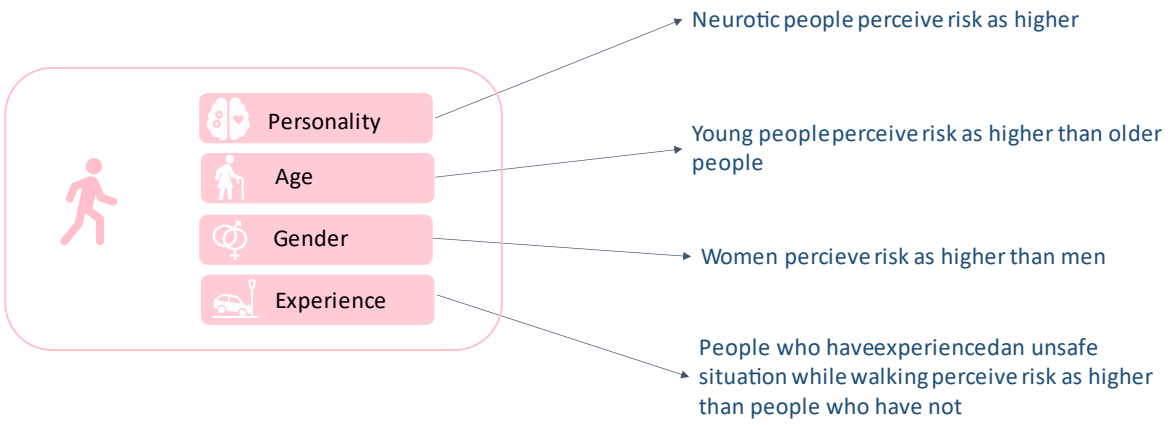
- **Openness** : imagination andcuriosity
- **Consciousness** : organizationand reliability
- **Extraversion** : sociability
- **Agreeableness** : trust inothers, generosity
- **Neurotism** : stress andanxiety



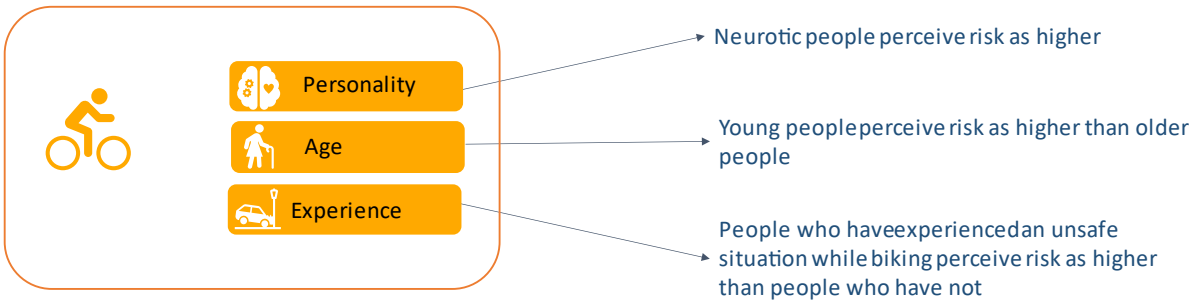
Survey results – Perceived risk predictors



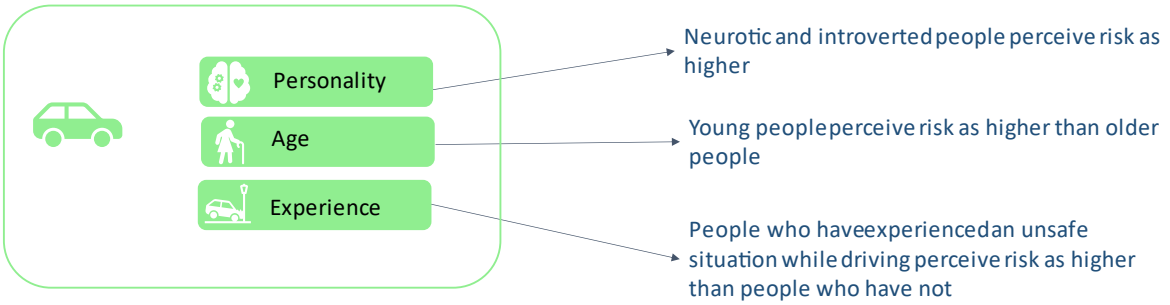
Survey results – Perceived risk predictors



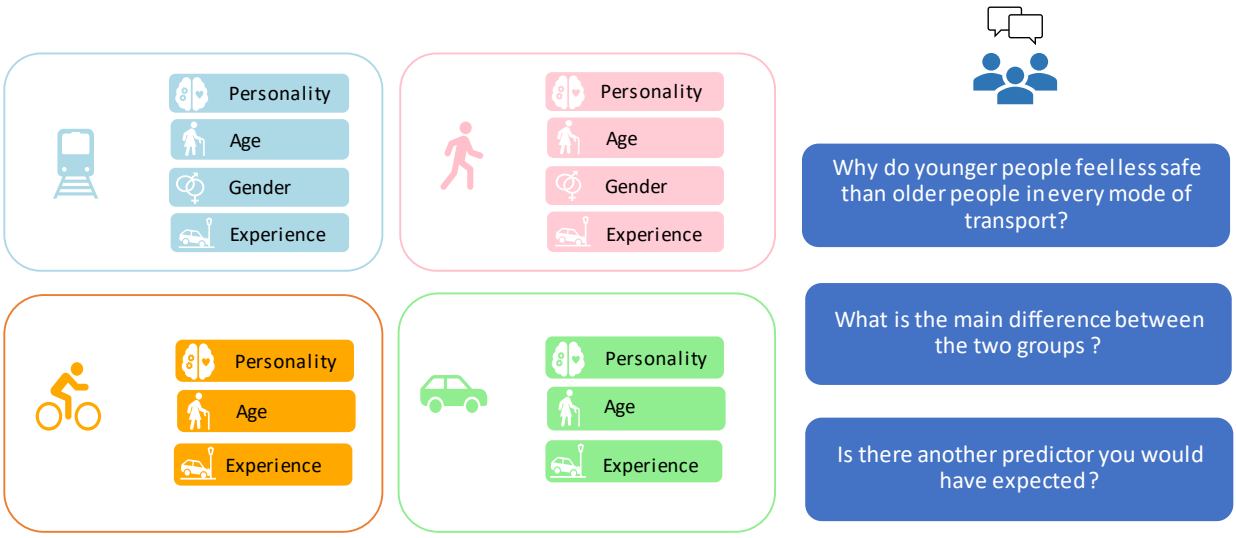
Survey results – Perceived risk predictors

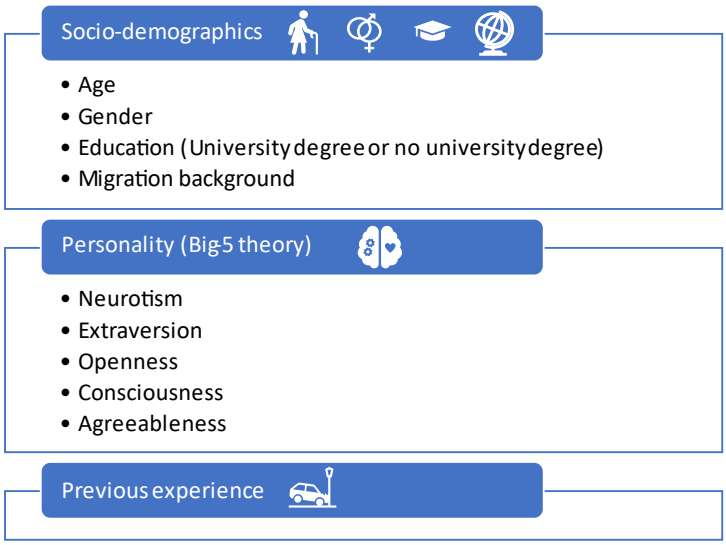


Survey results – Perceived risk predictors



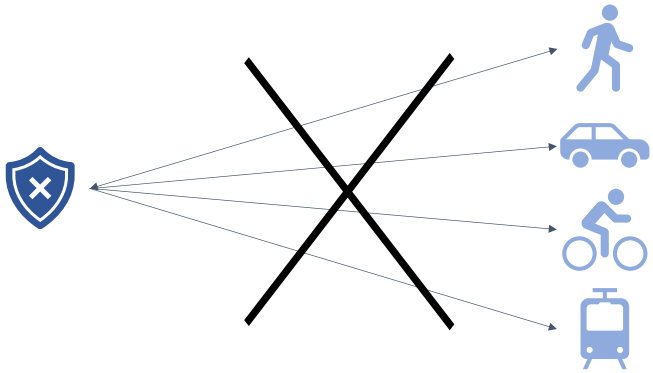
Survey results – Perceived risk predictors





- **Openness** : imagination and curiosity
- **Consciousness** : organization and reliability
- **Extraversion** : sociability
- **Agreeableness** : trust in others, generosity
- **Neurotism** : stress and anxiety

Survey results : mode choice and percieved safety



Perceived safety is **not a predictor** for mode choice : the perception of safety for a mode does not influence one's use of the mode in general (the mode frequency of use)

Do you agree that your perception of safety does NOT influence your choice of mode in the every day life?

Survey results - Modal shift

Percentage of people who decided to … rather than using 'Transport Mode' :

Transport Mode	Avoid travelling		Choose another route		Travel on a different time		Use public transport		Travel by bike		Walk		Travel by car		Take a taxi		It never happened	
	men	women	men	women	men	women	men	women	men	women	men	women	men	women	men	women	women	men
Public Transport	1.0	3.4	0	1.1	1.0	4.0	-	-	15.2	14.3	6.7	2.3	7.6	9.1	1.9	10.9	54.9	66.7
Bike	0	1.1	1.0	5.7	0	1.1	17.1	14.3	-	-	2.9	5.1	11.4	4.6	1.0	1.1	66.9	66.7
Walk	3.8	5.7	2.9	5.7	1.9	4.0	9.5	6.3	2.9	4.6	-	-	4.8	4.6	0	7.4	61.7	74.3
Car	4.8	2.9	1.9	1.7	2.9	2.9	22.9	16.0	5.7	3.4	1.0	0.6	-	-	1.9	1.1	71.4	59.0

To avoid an unsafe trip women are more likely to :

- Avoid their trip
- Change the route of their trip
- Change the time of their trip
- Take a taxi

Do you think women have less freedom in mobility than men? Why?

Survey results - Modal shift

Percentage of people who decided to … rather than using 'Transport Mode' :

Transport Mode	Avoid travelling		Choose another route		Travel on a different time		Use public transport		Travel by bike		Walk		Travel by car		Take a taxi		It never happened	
	men	women	men	women	men	women	men	women	men	women	men	women	men	women	men	women	women	men
Public Transport	1.0	3.4	0	1.1	1.0	4.0	-	-	15.2	14.3	6.7	2.3	7.6	9.1	1.9	10.9	54.9	66.7
Bike	0	1.1	1.0	5.7	0	1.1	17.1	14.3	-	-	2.9	5.1	11.4	4.6	1.0	1.1	66.9	66.7
Walk	3.8	5.7	2.9	5.7	1.9	4.0	9.5	6.3	2.9	4.6	-	-	4.8	4.6	0	7.4	61.7	74.3
Car	4.8	2.9	1.9	1.7	2.9	2.9	22.9	16.0	5.7	3.4	1.0	0.6	-	-	1.9	1.1	71.4	59.0

Why do we observe a reversed tendency for car ?

How to increase safety in Munich ?

Rank the measures!

1. Inform and educate people about bad and good behaviours in different modes of transport
2. Car-free city
3. Better allocation of space between cars, pedestrians and bikes
4. More police officers in the streets and in public transport
5. No alcohol when commuting (for every mode of transport :while driving, while biking but also walking in the street and on public transport) + more controls

How to increase safety in Munich ?

Other ideas/comments?

Thank you very much for paticipating in the workshop !

C.Notes of the Worshop

20.03.2023, 17h00

Participants:

Sindy, 37 product engineers, German, living in Munich for 4 years

Mathilde, engineering student, 23, French, living in Munich for 2 years

Irénée, engineering student 23, French, living in Munich for 2 years

Baris, informatics student, 24, from Turkey, living in Munich for 2 years

Kornelia, 55, university teacher, German, living in Munich for more than 20 years

Pia, 26 student to become a teacher (German and English), German

Jakob 25, engineering student, coming from Italy, living in Munich for 6 years

Do you also consider walking as the safest mode?

Mathilde: Walking is very safe; it is very rare to have an incident. What she worries the most about when she walks is sexual incident

Syndy and Pia agree that there is a difference to make between night and day : everything is scarier at night, especially when walking

Kornelia agrees that it depends on the time, but also the area of Munich, she heard that young people got robbed in the North of Munich. There are corners and streets to avoid during the night. Also she would avoid pedestrian areas very crowded, where it can be easier for to get robbed.

Irénée agrees that he walk safer than he uses public transport because when walking one can chose the streets you want to go to, you are flexible in your movements : you can adapt to any situation. Avoid a scary group of people, take another street, whereas you don't have this freedom when you are in public transport. Pia however thinks that comparing walking and PT is not relevant because you cannot walk instead of using PT, walking is part of a PT journey.

According to Baris, in PT you always have people around that make him feel safer than when he walks, there are less people than can make a situation become scarier.

Kornelia thinks that is also become on the lighting, she avoids biking in parks or some streets at night because there is no lighting.

Jakob think that walking is the safest way because the infrastructures are very safe compared to other places.

Why younger people feel less safe than older people?

Baris would say it is because of the night life that young people experience more than older people. People that are drunk are out of control and do not behave safely.

Pia thinks it is because of the lack of experience of younger people: they don't know what to expect whereas older people they know that Munich is very safe, they did not experience any bad situation, therefore they can feel very safe in Munich.

Kornelia agrees that it is about experience, for example she had a bike accident, and she knows what she did wrong, so she is more careful and feel safe BECAUSE of her own behavior. Again, a question of timing because would be different at night

Irénée is surprised he would have thought than young people in terms of accidents are more confident, they cross at red lights ect and still feel safe. Old people are more careful because of afraid BUT wouldn't make them feel safer?

If he had to explain it he would say that young people has a lack of experience and have heard stories. The experience is not their own, but stories from other people: it does not make them feel safer and scares them about thing that can have been misunderstood.

Syndy says that her perception of safety has changed since she has become a mum, she is way more afraid when she cycles with her kiddo, she tries to go only in streets without cars. Maybe old people do not have this responsibility anymore. Even though when you have a kid you have a responsibility towards him (even when he is not physically here) and this responsibility may go away when the kid grow up.

Pia thinks that young people are more aware because of social media, you hear about things that are not you own experience, but it can scare you about things you would not have thought without the social media, Mathilde agrees on this social media part.

Mathilde agrees on the social media thing, she also thinks that old people cycle more safely which make them feel safer. The way you are biking/walking/driving is also important.

Jakob would say that the 30-50 are more experienced so safer BUT that above 55 people are less safe when driving and cycling because their senses are less aware

Kornelia explains that her perception has changed throughout the time. For example, she used to struggle a lot with the narrow streets and he made her feel unsafe, whereas now she has accommodated to it and feel safer about it when she drives.

She has a 16-year-old child and she can tell that young people are always looking at their phone (while biking, while walking and while driving) : they are less focus, less attentive and they don't care about traffic (headphones), it makes their behavior very unsafe.

What is the difference between W+PT and C+B gender-wise?

Mathilde : It is because you have less interactions when you travel by car and bike than when you walk or use public transport. You are available, people can come and talk to you, rob you, whereas when you bike or drive it is not the case. Women are afraid of interactions.

Pia thinks that women are more independent while driving or cycling, when someone comes to you you can just decide to leave. Everything is under control; you go where you want.

Iréné: he knows female that rather take their bike than PT after a party to go home safely. He personally feels safe all the time in Munich.

Other predictors?

Irénée would have expected migration background to be a predictor, because when you know other cities conditions you find Munich very safe. On the other way around, it can also make you underestimate the risk in Munich because you compare it to other places. Baris agrees with that, he feels safer in Munich than in Istanbul, especially towards robbery, in Munich he can leave his stuff a few minutes he does not worry about them.

Jakob does not agree because he feels less safe in Munich than where he comes from in the countryside: he knows everyone in his village. Problem of the city we don't know the people: we don't even know our neighbor.

Kornelia agrees that perceived safety depends on your historic with other region: she went to France for a few months and agrees that culture is different there, she felt less safe, which in comparaison makes Munich safer.

She also comes from the countryside, and she thinks that driving-wise it is less safe.

Kids also influences the behavior.

Syndy also agrees that migration background could be a predictor, because when you have a migration background you are more likely to be victim of racism.

There is no relationship between perceived safety and mode choice in the everyday life.

Mathilde agrees on that because the mode she feels the less safe with is walking and she cannot avoid it.

Irénée disagrees : when it rains or snows he knows that cycling is not safe anymore, therefore he uses public transport. When he does not feel safe, he adapts his travel behavior.

Pia argues that in specific situation she can adapt her behavior BUT there is no perfect mode where she can feel 100% safe, it is not a one-way decision : therefore safety is not the first thing she thinks about when she chooses her commute.

Jakob feels less safe at nights but even though he does he does not change his mode choice. For example, when he sees a group of shady people in the streets, he continues walking anyway.

Women and freedom

Irénée thinks that taxi is a very powerful indicator because when you are ready to take a taxi to feel more safe and spend money for it, it means that you are willing to pay to increase your safety : how much you want to increase your safety, and he thinks it especially goes for sexual harassment that is why women are more ready to pay than men.

Kornelia : what about men and robbery? It seems that men do not feel enough unsafe to take a cab. Women have less freedom because of sexual harassment.

Mathilde think that robbery or violence can happen but it does not happen every time: therefore she would not take a taxi because of those reasons : come back to the indicator thing. Whereas sexual harassment at night is more systematic, so to avoid that she is more likely to take a taxi. It therefore explain why men don't: they are not as exposed as women to sexual harassment.

Why do we have the reverse trend for cars?

Jakob: men drink more alcohol than women and German don't drive when they drink

Irenée: men are more afraid of car accident because they value their car more and they don't want it to be damaged. Car is more of a social succeed symbol for men than for women. It depends on the importance you give to your car.

Mathilde thinks that since women are more concerned about the environmental impact they have, they will always try to chose another option than car

Jakob think the other way around since car appears to be the safest way of travel for women, why would they change it.

Increase safety

Kornelia : There is a reflection to have on the way to inform, she thinks that the funny video in the U-Bahn can be very efficient, they show us risky situation that we may not have considered as risky before seeing the video. Maybe we should do more about it.

Irénée think that sometime streets are very dark in Munich, the light hung in the middle of the street makes it ok for cars but not for sidewalk. Some corners are very dark and Munich would gain in increasing the lighting.

Jakob thinks that in Glasgow which use to be very unsafe, you cannot sell alcohol after a certain hour; having a time limit to sell alcohol made the city a lot safer

Kornelia thinks it is not the solution because it happened a while ago and people were drinking at home, and they were very drunk in the streets (more than they can be now). She thinks that culture has to change even though it takes time.

Pia thinks that people are drunk, but in a group if all the group knew how to behave, even under the influence of alcool they would behave, because in a group there are always people to come back to the reason. If people knew how to behave it would really change?

Kornelia agrees that we have to show people how to behave so they another feel more safe.

Jakob think that what would be efficient for sure is to have video recording everywhere, but he does not think it a good idea in Germany.