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The affordances of bike parking

An empirical study of cyclist behaviors at three distinct transport hubs in Copenhagen

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MSc in Mobilities and urban studies
Master‘ s thesis

Aalborg University May, 2024

AALBORG UNIVERSITY
STUDENT REPORT

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Title:
The affordances of bike parking - An empirical study of cyclist behaviors at three distinct transport hubs in Copenhagen

Project:
Master thesis

Project period:
Spring 2024

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Group:
1

Supervisor:
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Number of page:84
Appendices:A-E
Submission:30-05-2024

Abstract

The bike parking at the metro stations in Copenhagen constitutes a critical part of the infrastructure that supports intermodal journeys of riding a bike and metro. This study aims to investigate how the bike parking at Aksel Møllers Have, Enghave Plads and Nørrebro station transport hubs functions from a user point of view. This object comprises the different behavior that users perform while parking the bike, the users' attitude towards bike parking and how the hubs perform in the eyes of the users' behavior and attitude. To research the aforementioned object, different types of observation, including bike counting and structured interviews will be applied. The user behaviors shows preferences towards bike parking close to the metro/S-train entryways. As a result, the underground bike parking' capacity-related issues, fly-parked bikes in the way of the flows are fundamental issues with user the bike parking behavior at the transport hubs. These phenomena is supported by the culture of convenience and time-efficiency among the users. Hence, values such as security and order are undervalued by them. Designating a significant portion of the station area close to the metro/S-train entryways is then required to favor user demands which may in turn negatively effect other user groups at these transport hubs. In the eyes of the previously mentioned preferences of the users, certain restrictive and nudging measures can be applied.

Preface

This master thesis was written by Lenard Balint Maczo, a fourth-semester student at Aalborg University from the Master's program in Mobilities & Urban Studies. The primary focus of this thesis is to examine bike parking from the user's perspective. For this research, I have selected three major transport hubs along the M3 metro line in Copenhagen to analyze how these bike parking facilities meet user needs. I would also like to take this opportunity to say many thanks to my supervisor Claus Lassen for his support and guidance throughout this thesis project. Additionally, I would also like to give a thanks to Cecilie Breinholm Christensen for presenting me with an interesting problem from the metro that inspired me to choose this as my thesis topic, and for helping me with further insights along the way.

30-05-2024

Lenard Balint Maczo

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List of abbreviations

ANT	Actor-Network Theory
TPB	Theory of Planned Behavior
TTBPS	Two-tier bike parking system

1. Introduction

1.1 Research area

Environmental and urban challenges pressure the transportation landscape to operate in socially and environmentally more sustainable ways. Hence, the importance of understanding how transport behavior is constructed is growing (Donald et al., 2014). The importance of sustainable mobility is translated into city planning. The CPH 2025 Climate Plan outlines the municipality's objectives for future mobility enhancements. It aims for 75% of all Copenhagen journeys to be made by walking, cycling, or public transit (Københavns kommune, 2021). In addition, The Greater Copenhagen's Traffic and Mobility plan mentions intermodal trips and multimodal transport hubs as essential components for a green transition (The Capital Region of Denmark, 2021).

This is no coincidence. Multimodality and intermodality are key concepts that bring about a positive impact on sustainability. Therefore, it has been deliberately promoted by planning authorities (Goletz et al., 2020). According to the research by Goletz et al. (2020), more than 90% of the surveyed experts assessed intermodality in future transport planning as very relevant or relevant in Copenhagen. The share of intermodal trips is only at 4,3% of all trips in Copenhagen. (The share of intermodal travel of bike and public transport is as little as 1,8%.) However, experts expect a 15% increase in the number of intermodal trips in the future. Combined intermodal journeys of bike and train offer numerous user benefits. It enlarges the station's catchment areas, enhances travel options, and allows for greater journey customization, supporting seamless door-to-door trips (Cannon et al., 2024).

Transport hubs play a crucial role in these intermodal trips as 59% of the experts that were asked named transport hubs as a 'promotive' factor in the preference of users towards intermodality (Goletz et al., 2020). Likewise, bike parking was identified as an important component for enabling intermodal trips. However, this is an area which was recognized for improvement by the Copenhagen municipality as user satisfaction was low in the municipality's survey, especially, bike parking at stations (Cannon et al., 2024). This can be attributed to the numerous issues of Copenhagen's bike parking culture and infrastructure. According to Larsen (2017), inadequate bike parking capacity is an issue around Copenhagen. Moreover, improperly placed bikes both damage

the bikes themselves and bring disorder to the city. The relatively high-level risk of theft endangers the parked bikes as well (Larsen, 2017).

The aforementioned behaviors are the result of a complex decision-making process from the user that is influenced by the user's attitude, physical environment, social pressures, habits, and other factors (Götschi et al., 2017).

The Copenhagen metro with its four lines bears an important role in the public transport system in Copenhagen. The extension of the M4 line is set to open in the summer this year, and the proposal for a new metro line, M5 is discussed now (Københavns kommune, n.d.). With this in mind, it is a priority for the Metro company to draw conclusions on the bike parking infrastructure at the stations and establish a best practice which is not an easy task in the eye of the aforementioned issues.

1.2 Problem formulation

Following the introduction above, this research paper is set to provide an empirical investigation of how the bicycle parking infrastructure is used by cyclists and how the bicycle parking accommodates the different user behaviors. The location of this research is three different transport hubs on the M3 metro line in Copenhagen. The problem formulation aims to give an account of this complex relationship between the users of the bike parking and the affordances of the bike parking facilities. It states a comprehensive main research question and such sub-questions that cover the behavior of the users, their attitude towards bike parking, and the ability of the parking infrastructure to satisfy the users' needs. To be precise the main research question is regarding how the transport hubs in question allow for bicycle usage. Moving onto the sub-questions, the first one aims to unfold the different behaviors that users of the bike parking perform. The second one is about the users' perspective that motivates them in their behaviors. Lastly, the third sub-question is meant to connect the users' perspectives with the transport hubs' design that makes the different types of bike parking behaviors possible.

1.3 Research question

How do Aksel Møllers Have, Enghave Plads, and Nørrebro station transport hubs accommodate the use of bike parking?

Sub-questions

1. What different types of bike parking behavior can be identified?
2. What is the underlying attitude for the identified bike parking behaviors?
3. How do the different transport hubs afford for the needs of the bike parking users?

1.4 Delimitation

The scope of this project focuses on some objects and purposefully leaves out some others. Hence, in this section, the topics which are not dealt with in this paper are listed. This study is meant to include capacity and spatiality-related issues at the transport hubs, however, the scope of this research is not meant to deeply delve into the nuances of the changes in bike parking utilization in a positivist fashion. Its purpose rather lies in outlining how the bike parking capacity is utilized by the users and what behaviors cause the identified pattern. Furthermore, the involvement of different times of the year and weather might be able to highlight substantial changes in the bike parking users' behavior and capacity utilization, however, the influence of these factors is not studied in this research.

There is a complex psychological process behind travel behavior with a multitude of factors and their tangled interactions (Götschi et al., 2017). However, this study instead of conducting a deep research about these factors, is rather meant to explore only the relationship between the behaviors and attitudes of the users, as well as the affordances of the environment. Consequently, the role of habits and social influences are left out of this research.

On that note, bike parking at the transport hubs influences different and is influenced by many different user groups other than cyclists. Thus, the interaction of these users is part of the reality of bike parking (Petzer et al., 2021). However, these aspects are not dealt with here either. Similarly, the role of planning authorities in the bike parking design is an interesting research area. This is reflected in the insufficient collaboration of different authorities which a significant issue in the bicycle infrastructure planning in Copenhagen(Cannon et al., 2024). This is, however, an issue that is not included in this research.

1.5 Structure of report

The structure of the report consists of sections that provide a comprehensive overview of this study conducted on bike parking at three transport hubs in Copenhagen. The Literature review section examines the relevant literature and recent studies about intermodality, transport hubs, and bike parking, while the Theoretical framework section is set to provide a comprehensive account of the theoretical background for this research project which includes the mobilities turn, travel behavior, and affordances all connected to the research question at hand.

The Methodology section outlines the approach taken in the project. It discusses the philosophy of science guiding the research, and the research methods employed, including different observational methods and semi-structured interviews. The Results section presents the outcome of the applied methods, providing a comprehensive overview of the collected data regarding user behavior and attitudes. First, the results from the observations are presented, and then the interview results are combined with the insights from the observations.

Following the analysis, the findings of the research are discussed, and interpreted in the context of previous studies and theories. The conclusion section wraps up the project by answering the research question and by reflecting on the research process.

2. Literature review

2.1 Intermodality

Intermodality is one of the core concepts in the theoretical underpinnings of this paper. Intermodality is a subset of multimodality (Huang et al., 2023). While multimodality means the usage of multiple types of transport modes during a certain period of time, intermodality specifically refers to the occurrence of multimodality in a single trip (Olafsson et al., 2016). Policies have been increasingly advocating for multimodal transport options. Moreover, experts predict a rise in intermodal trips in European cities. Similarly, the increasing trend of the digital mobility planning solution, Mobility-as-a-service (MaaS), aims to facilitate intermodal travel. So, it can be said that from the planning side, there is an intent to advocate intermodal travel (Goletz et al., 2020). However, in the research of Goletz et al. (2020), only less than 10% of all travel is intermodal in the four major European cities where the research was conducted. The reason why planning authorities are pushing for intermodality is the valuable advantages it brings about. Multimodal transport systems can offer a competitive alternative in the form of intermodal trips to car-based transport modes, hence, giving rise to sustainable travel modes. One other advantage is the potential of intermodality to create a more efficient use of transport infrastructure by redistributing flows in the network, and at the same time, offering more personalized trips to travelers (Goletz et al., 2020).

Intermodiality can be prioritized by the physical and virtual integration of different modes of travel. In the case of the first, this means transport hubs, and in the case of the latter, digital solutions such as MaaS (Huang et al., 2023). Intermodality is influenced by travel behavior, so socio-economic factors, psychological factors, and the built environment (Goletz et al., 2020). In the research by Goletz et al. (2020), experts were asked about the main user motives for and against intermodal travel. In favor of intermodal travel, the top 3 answers were "*easy and fast access*", "*saving time*" and "*inconveniences of car travel*". The top 3 demotivating factors according to the experts are *"high number of transfers"*, "*lack of connection security, long waiting times*" and "*comfort/convenience*". Furthermore, the effect of "*lack of accessibility at stations*" which can be directly associated with transport hubs the subject of this research, was named as "*barely matters/doesn't matter*" by the majority of experts, however, 34% of them rated it as "*works strongly/very strongly against*" (Goletz et al., 2020).

2.2 Mobility hubs

Although multiple definitions exist for mobility hubs, in this study the following definition is used.

"transport hubs […]offer multimodal transportation alternatives that simplify intermodal transfers by offering different mobility options at close range" (Aydin et al., 2022, p. 1)

This definition offers an inclusive approach towards mobility hubs as it refers to it as a meeting point for multiple transport modes and it is not limited to shared mobility such as public transport. So, it includes micro-mobility options: walking, cycling, scooters, bike-sharing, as well as, car-sharing (Aydin et al., 2022). Mobility hubs play a crucial role in intermodal trips as a point of interchange between the transport modes (Aydin et al., 2022). From a transport planning point of view, the benefits of mobility hubs are improved connectivity, efficiency, and better articulation in the city (Hachette & L'Hostis, 2024). But as a mobility hub is placed in the fabric of the city, the social, physical, and urban dimensions of the mobility hubs are going to be unique based on the location. There is more than just the flow. Life, social interactions, and alternative uses occur at hubs (Geurs et al., 2023). With better integration into urban space, more benefits can be obtained. According to Geurs et al., (2023), most mobility hubs are results of top-down planning and lacking bottom-up inputs from users. Bottom-up co-creation can however bring benefits in the form of better user experience and greater societal impact. Moreover, inclusiveness and accessibility are major concerns for the design of mobility hubs. This goes hand in hand with democratic bottom-up planning practices, so the disadvantaged groups can convey their needs towards planners (Geurs et al., 2023).

According to Gøtzsche Lange, transport hubs inherently involve tension between the central role of the place and the movement that goes through it and moves people elsewhere. Hubs just like other places are built up of fixities and flows and depending on how a place is perceived from a sedentary or nomad point of view, either one or the other is more desirable (Gøtzsche Lange, 2021). From sedentary thinking, a sense of place is based on static entities, thus too much movement can bring disturbance to place and turn it into placelessness (Cresswell, 2006). Mobile entities are only motivated to move through places with little regard for their identity and culture. From a nomad perspective though, mobility is seen as positive and dynamic, accordingly, place is friction that slows down mobility. Mobility gives access to freedom and progress (Jensen, 2013).

These two perspectives rarely exist in their perfect forms in the real world, instead, they have an effect on the way we behave and the way we think about mobilities and spaces (Gøtzsche Lange, 2021). Not one or the other perspective is the right way to think about mobilities and places but useful tools to understand mobile practices (Jensen, 2013). In Gøtzsche's research, for example, the port town of Hirtshals functions as a transit hub. On the one hand, the many travelers that go through Hirtshals might exert a nomadic perspective on the place and regard it only as a transit hub or a non-place which they value for its role in their smooth travel. On the other hand, the locals might have a sedentary approach and view the flow of travelers as a disturbance to their city. Hence, this creates a conflict between the groups. However, with a sufficient strategy the different interests and metaphysical understandings can be mediated (Gøtzsche Lange, 2021).

2.3 Bike parking

"'Systems'of bike parking involve pavements, roads, stand props, racks, locks ,and municipality planners, street furniture, lock and rack companies, thieves, and cyclists" (Larsen, 2017, p. 58)

Bike parking is a crucial part of the bike infrastructure. It is inherently infused with mobility. Bike parking is the period of immobility wedged between two phases of mobility as bikes are halted, and then the cycling is resumed after parking (Larsen, 2017). The bicycle moorings are in constant interaction with the mobilities of the place. Consequently, well-designed bike parking needs to be compatible with the surrounding flows (Van der Spek & Scheltema, 2015). Bike parking can be understood as a system of a number of physical objects, users, and decision-making bodies. Physically, the pavement and a stand are needed to stabilize the bike and a lock is needed for securing the bike. The bike parking stands are designed and staged from above from the planners, while the cyclists use them according to their preferences (Larsen, 2017). In terms of the issues that bike parking can bring, the lack of proper infrastructure can create spatial and aesthetic disorder in the city (Cannon et al., 2024). Moreover, bikes can get stolen if there is a lack of security or if bikes are wrongly placed in front of shops they might be removed. The reason why bicycles are vulnerable to theft is their light weight and ease of use. Furthermore, as a result of their design bicycle components are also exposed to theft. Thus, locks are a crucial part of the system of bike parking. The fact that police handle bike theft cases further exacerbates the

problem. In addition, parked bikes face danger from vandalism and weather. The bike parking infrastructure is designed from above by planning, and it is enacted from below by cyclists (Larsen, 2017).

Egan et al., (2023) list the elements of good bike parking as Visibility, Protection, Accessibility, Proximity, Integration, and Diversification. Visibility means that the bike parking can be easily seen. Protection refers to the presence of elements that discourage theft such as CCTV cameras, physically protected facilities, and public visibility. Accessibility suggests a bike parking design that makes it physically easy for users to approach, especially in relation to non-typical users. Proximity refers to the distance between bike parking and the user's destination. The integration question is about how the policies, physical design of bike parking, and user preferences fit each other. And lastly, diversification points the focus to how the different needs of users require different designs (Egan et al., 2023). Van der Spek & Scheltema (2015) go beyond and put forward a hierarchical view by organizing the fundamental aspects of bike parking into Maslow's hierarchy of needs concept. On that note, Maslow's hierarchy of needs has been applied to different subjects in transport research, for instance, user experience research at the airport (Popovic et al., 2010), public transport satisfaction (Allen et al., 2019) and travel choice study on walking (Alfonzo, 2005). Safety is a pre-condition that comes before the other aspects of bike parking. It includes the pavement, visibility, and clear separation of the different modes of transport. However, safety should not be confused with security against theft. Moreover, in the model of Allen et al. (2019) and Alfonzo (2005) safety is a less fundamental aspect than utilitarian values such as accessibility which are synonymous with the next level: Directness. So, Directness comes next as a fundamental dimension for good bicycle parking. It refers to the proximity of bike stands to the destination, transfer distance, and bike parking capacity. And lastly, comfort and attractiveness are satisfier factors that come on top of the previous factors. They involve maintenance, good bike parking experience, and special bike amenities (Van der Spek & Scheltema, 2015).

Bike parking can come in a lot of different shapes and sizes. There are designated and purposefully designed bike racks, bike parking systems, and underground bike parking. The *grid rack* is a popular type of bike parking design but other designs such as the *inverted U* and decorative solutions exist (Larsen, 2017). The grid rack design is rows of integrated bike stands and inverted u is an inverted half loop paved into the ground. However, there are railings, road signs, and other

street furniture that are also utilized by bicyclists as bike parking. Or otherwise, bikes might just be leaned onto walls (Larsen, 2017). This kind of behavior is parallel to 'desire line' seeking where pedestrians make their own route through a certain place by avoiding planned or built pathways. The term 'fly-parking' refers to this kind of behavior just in terms of bike parking. People might urge to park their bikes in the closest proximity of their destination, even if a nearby rack is available (Larsen, 2017).

3. Theoretical framework

3.1 Mobilities

Mobilities are understood as acts that are loaded with a plurality of meanings, the reasoned motivation behind mobility is more than getting from A to B (Wind, 2014). However, Jensen (2015) argues against rejecting the quantitative approach of transport that mainly studies only the movement, instead, he sees mobilities as a point of view that goes beyond and investigates additional matters such as social, cultural, and environmental implications (Jensen, 2015). According to Cresswell, the definition of mobility is the sum of movement, meaning, and power. Movement is the act of getting from A to B. Meaning pertains to the drive or incentive to navigate through space and time, and the dimension of power conveys the capabilities acquired through such movements (Cresswell, 2006). These capabilities then translate into power disparities in the society as some have more potential to be mobile than others (Jensen, 2013). This is what the term 'motility' refers to, which was coined by Vincent Kaufmann and it describes the capacity for movement. Furthermore, motility can be thought of as a type of capital. It can enhance one's existing abilities or impair newly acquired ones (Kaufmann et al., 2004). Consequently, mobility may lead to societal problems including injustice, marginalization, or inequality (Jensen, 2013). Geography, sociology, anthropology, and urban studies are just a few of the academic disciplines in which mobilities are routed (Jensen, 2013). Thus, many theories and principles that are fundamental to studying mobilities are borrowed from other scientific fields. One significant theory that has a large impact on mobilities turn is ANT (Actor-Network Theory), a novel approach on the connection between humans and non-humans that places a strong emphasis on the non-human's involvement (Jensen, 2013). The intertwined network of human and non-human actors

creates then a complex and fluid assemblage. Non-human actors refer to the material sites, physical infrastructure, and technological system or in this case the metro as a transport system. According to ANT, these systems can affect people and form intricate networks with them in mobilities (Farías & Bender, 2013). The term 'urban cyborgization' specifically refers to a network between humans and non-humans where the boundary between human and non-human actors becomes blurred. Since ANT is not so much a specified theory rather it is a shared method of thinking among scholars, there is no unified definition for it (Farías and Bender, 2013). Nonetheless, radical relationality, generalized symmetry, and association are the three principles that stand out. Radical rationality refers to an extended form of relationality, not just in human domains such as communication and culture but non-living things such as objects, technologies, infrastructure, or the metro in this case. This entails that the metro or any other system or infrastructure might have been created and controlled by people, however, these non-human actors can influence people's behavior too. Generalized symmetry calls for a methodology that analyzes actors in a common way without differentiating between them. Lastly, association means that non-human actors can also partake in social connections. These methods saw the city or mobility as a stable entity or bounded unit or the interaction of bounded entities. ANT emphasizes the fluidity and blending of all kinds actors humans, systems and infrastructure (Farías & Bender, 2013).

In terms of the social sphere, mobilities are constructed from top-down and bottom-up influences. From the top-down various organizations and institutions provide affordances for mobilities as much as regulating it in the form of law, rules, and design. The bottom-up influence comes from people who experience, socially interact, and actively engage with mobilities (Jensen, 2013).

To give a summary, the non-human actors not only afford for the mobile experiences but also actively shape them. Hence, such assemblages should be analyzed as a whole that is the product of a complex network of actors and with regards to general symmetry (Jensen, 2013).

3.2 Theory of Planned Behavior in the context of travel behavior

On one hand, the underlying motivations driving movements can range from planned, such as traveling to destinations where certain activities take place like living, working, and recreation. On the other hand, the motivation can be rooted in personal habits, lifestyle choices, and even quick

impulses. Furthermore, it can be the result of the interplay between social and spatial structures (van Acker et al., 2010).

The Theory of Planned Behavior (TPB), conceived by Icek Ajzen aims to comprehend the complex network of the underlying motivations of human behavior. This theory is based on the premise that individuals are rational beings whose behaviors are conscious, planned, and reasoned. Such behaviors are primarily influenced by the intention driving them. The intention is shaped by three critical components: attitudes, subjective norms, and perceived behavioral control (van Acker et al., 2010). Attitudes pertain to the individual's beliefs or perceptions that cast the behavior in either a positive or negative light. In the context of transportation behavior, an individual may perceive certain modes of transport as environmentally sustainable, health-promoting, or pleasurable, leading to a predisposition toward using public transportation or cycling (van Acker et al., 2010). Subjective norms refer to the individual's perception of societal expectations and how this social pressure affects their actions. Perceived behavioral control means the people's capacity to carry out their behavior. This includes both the personal competencies including the availability of necessary resources to perform a behavior. This component also acknowledges that external factors may either force the individual towards a specific behavior or inhibit it (Ajzen, 1991).

3.3 Extending the Theory of Planned Behavior

As previously described, TPB is built on the assumption that people are conscious of their actions and engage in rational decision-making (van Acker et al., 2010). However, according to the dual process theory posits human decision-making is guided by two interrelated cognitive systems. While system 2 is in line with TPB as it makes conscious, slow, and accurate decisions, system 1 refers to a quick, intuitive, and subconscious decision-making (Bandsma et al., 2021). Thus the quick and impulsive decisions made by system 1 are not included in the TPB mode. This constitutes the foundation for significant critique, particularly when considering habits and impulses (van Acker et al., 2010). According to van Acker et al. (2010), habits are enacted automatically, without conscious deliberation, highlighting a dichotomy between attitudes and habits. In instances where habits are deeply ingrained, the influence of attitudes on behavior is less influential. Although habits initially stem from beliefs and attitudes, once they solidify, the individual's actions proceed without conscious thought and seldom involve a reassessment of the underlying intentions. This phenomenon has been documented within the sphere of travel

behavior research (van Acker et al., 2010). Habits, from an emotional perspective, often create a feeling of security and predictability. While conscious reevaluation of habits is possible, it is typically prompted by external disruptions or a spontaneous shift in perspective, leading to change in the established routines (Wind, 2014). Furthermore, Donald et al. (2014) advocate for an expansion of the TPB model to incorporate moral norms, arguing that this addition provides a more comprehensive understanding of the motivations behind environmentally conscious behaviors.

External factors

The model of TRB can made more complex by adding the environmental and social factors to the model. They can indirectly influence the intentions of people (van Acker et al., 2010). The social environment, comprising networks of family, friends, and colleagues, creates a web of destinations among which the individual travels. The household, being the primary social unit, exerts the biggest influence on travel behavior. Additionally, other forms of social structures with collective attitudes and behavior can affect individuals' travel behavior (van Acker et al., 2010). Returning to the role of habits, routine mobile behaviors often mirror and resonate with those within close social proximity. Unfolding the role of the social environment in travel behavior, when traveling is undertaken within a social group, such as a family, it can create a feeling of community, connectedness, and emotional bonds among the group members (Wind, 2014).

It is important to consider that people do not objectively comprehend their environment but rather subjectively interpret it. Kevin Lynch, in his influential work "The Image of the City" (1960), explores the question of how people make sense of their surroundings. Lynch categorizes the urban landscape into five elements: paths, edges, nodes, districts, and landmarks (van Acker et al., 2010). This conceptualization forms the basis of what is known as mental maps, whereby the travel environment is not only perceived and structured by individuals but also infused with personal significance. Research has provided empirical support for the assertion that these mental representations significantly influence daily travel behaviors (van Acker et al., 2010). While urban spatial configurations may be designed with utility and efficiency in mind, they also offer varied experiences, sensations, and emotional responses. The ambivalence of everyday mobilities is noteworthy, as they can elicit both positive and negative emotions and experiences. Moreover,

routine travel experiences, such as commuting by train, can become venues for meaningful social and emotional exchanges in daily life. These commonplace and habitual experiences frequently possess unexpected significance and value beyond the pragmatic reasons for choosing one mode of transportation over another. Such experiences may remain covert, unobserved, and unreflected upon by the individuals themselves (Wind, 2014).

3.5 Affordance theory

The concept of affordance emphasizes that the built environment such as the city, different types of places in the city, and bike parking have been designed with certain intent. As a result of that or not, they allow for certain behaviors, support certain activities, or discourage or ban other activities. From the user side, the user can decide what way they intend to engage with their environment. They interact in intended ways but also make use of their own ways. The interaction between the environment and users is a relational process. "*The role of the designed environment in those interactions is described as constantly interacting, supporting, and colliding with human bodies, whereas the role of human bodies in those interactions is to respond, go along with, or ignore the environmental affordances*" (Bendix Lanng & Jensen, 2022, p.42). There is a continuous interaction between the person and the environment (Bendix Lanng & Jensen, 2022).

3.6 Place Management

Place management concerns with among others how to integrate flows of mobility into the place. Mobilities and places can be not just moderated but may be brought into a synergy that holds new opportunities. In Agnew's definition of place, it is made up of three elements: location, locale, and sense of place. The first represents where the place is located. The second is about the materialities of the place. The last refers to the meaning of the place (Lassen & Laursen, 2020). So far in Section 2.2, it has been established how mobilities and place conflict with each other. However according to Cresswell, micro-scale mobilities play an important role in making a sense of place (Lassen & Laursen, 2020). According to Jensen (2013), mobilities carry positive and negative to places. Positive in the form of incoming goods and people to the place and negative in the form of bypassing human or non-human flows (Jensen, 2013). Places are also assemblages made up of complex relational networks and equally influenced by human and non-human actors. On the contrary, the term non-place by Augé stands for places that are deprived of meaning, identity, or

history. This term conveys how places are often designed for people but often rather end up being homogenized environments (Jensen, 2013). Dovey challenges prevalent perspectives on place that are anchored in the sedentary understanding, where attributes like 'sense of place,' 'character,' and 'identity' are perceived as relatively stable. His critique highlights daily life and human identities, which are in fact processes and constantly evolving (Lassen & Laursen, 2020).

3.7 Theoretical framing for the research

The following diagram was created to show how the relevant factors for this research influence bike parking behavior. Moreover, it aims to create the theoretical basis for this research. From one side the user with approach bike parking with their attitude towards bike parking. And from the other side, the spatial environment affords for certain uses. As it was described above, a wide array of factors influence travel behavior, however, as the main focus of this research is about the users' attitude and the capabilities that the environment affords for, only these influences are included in the model. In this diagram, both the user and the spatial environment play an active role in accordance with ANT which states that non-human actors have an active role in influencing people's behavior.

Figure 3.1: Theoretical framing (Own production)

4. Methodology

4.1 Philosophy of science

"By a series of common-sense constructs they have pre-selected and pre-interpreted this world which they experience as the reality of their daily lives. It is these thought objects of theirs which determine their behaviour by motivating it. The thought objects constructed by the social scientist, in order to grasp this social reality, have to be founded upon the thought objects constructed by the common-sense thinking of men [and women!], living their daily life within the social world."(Schutz, 1962, cited in Bryman, 2015, p.30)

This study follows the phenomenological traditions of Schutz. Hence, it is founded on the premise that people's action is established in social reality. It refers to a reality that people share and has a meaning for them. Hence, they act based on the meaning. Furthermore, the social scientist needs to access the meaning of the people and their social reality to be able to interpret their actions. Observations are key for this strand of philosophy. Observing is the basis for the concept of 'typification', which refers to the categorization of experiences and observations into types or patterns that help the social scientist understand and predict social behavior (Kim & Berard, 2009). The social scientist is an integral part of this process as they make sense of the observations with their rationale. At the end of the process, 'rational puppets', in other words, rational actors are constructed, who act based on their motivations. Hence, as the motivation behind the behavior is obtained, future actions can be predicted (Kim & Berard, 2009).

Schutz's understanding of social scientific constructions boils down to three postulates. *Logical consistency* means that the concept developed by scientists needs to exhibit a high level of logical consistency free of contradictions. *Subjective interpretation* entails that social phenomena should be interpreted from the point of view of the people involved. *Adequacy* implies that the understanding of the social scientist needs to be consistent with the social reality. Thus, it should be understandable to the social actor and its social surroundings (Eberle, 2014).

Based on the aforementioned, this study bases its data collection on different observational methods which are intended to capture the bike parking behavior. Then, in the second phase of data collection, the subjective meaning of the cyclists is explored. Lastly, in the Discussion section the behavior, the meaning of the cyclists, and the scientific knowledge are triangulated.

4.2 Methods

In terms of methods, this research aims to capture the behavior of bike parking users from an outside point of view, while also capturing the viewpoint of users. To capture the complexity of mobilities that bike parking brings to the transport hubs and users' meaning regarding bike parking a mixed-method research design was applied with structured observations and short semi-structured interviews. Using both quantitative and qualitative approaches helps to gain a comprehensive understanding of the phenomenon (von Zweck et al., 2015. The adoption of qualitative research methodologies is increasingly acknowledged as an instrumental tool to investigate travel behavior, particularly, the underlying motivations, attitudes, and lifestyles (Lucas, 2013). Such methodologies are adept at uncovering determinants of travel preferences and choices that extend beyond the conventional metrics of travel time and cost, despite the significance of utilization maximization behavior in shaping these choices (Götschi et al., 2017).

The aim of the observations is to pick up on patterns of behavior of bicycle parking. The purpose of the semi-structured interviews is to build on the observations and to understand the observed patterns with the attitude of the users. Thus, other than the subjective reality of the researcher the social reality of the users are also accessed. So, the interviews are used to investigate the underlying perspectives and the satisfaction of the users. Both the observations and interviews have quantitative and qualitative aspects. In other words, the research employs a sequential explanatory design, which is particularly suited for understanding complex social phenomena (Saunders & Lewis, 2019).

4.2.1 Observations

The observations phase is a multi-method stage that employs structured observations with qualitative unstructured observations methods which are meant to gather descriptive data about the usage and functionality of the transit hubs. This stage aims to establish a baseline understanding of how these hubs support intermodal trips involving bicycles and the metro. Pre-observations were utilized prior to the structured observations to explore the different types of behaviors that take place in the domain of bike parking. Based on this phase, then a structure was developed for the actual observations. Two types of structured observations (bike counting and flow mapping) and an unstructured observational method (observation of interchange) were used.

Parked bike counting

This method involved the counting of the different types of bikes, different types of locks, and the location of the parked bikes together with the way the bikes were parked, all location-specific. The purpose of this method was to get an overview of the bike stand capacity and the way people use them. Some of the locations where the bike stands might have been crowded and some others might have been underutilized. Furthermore, this method was used to get an understanding of what the different bikes are parked at the hubs. For this method, pre-observations were conducted to establish a picture of the conditions of the transport hubs. Then, the bike counting itself was carried out on the 13,15,18th of March between 13-15 o'clock. This timeframe were chosen as the pre-observations showed that this is the time when the most bikes are parked at the transport hubs.

Flow Mapping

This type of observation were applied to detect the different mobile flows that goes through the hubs on street level. The premise of this method is to show if the location of bike stands are comply with or conflict the flows of people at the hub. This method was used using video recordings of the hubs, and then based on the recordings the different type of mobile flows were mapped out spatially.

Observation of interchange

This method were applied with the purpose of outlining the different ways people approach the bike parking, park their bikes and then the way they continue their journey. Although, there has a range of different behaviors while parking the bike. Such behaviors were categorized, so the most prominent types can be quantified.

4.2.2 Interviews

This phase were used to interpret the observations together with the users themselves. The interviews are built on the hypothesis from the observations and it meant to goes beyond the explorative nature of the observations. Structured interview design were chosen to ensure that all the hypotheses are touched upon. Furthermore, opposed to sent-out surveys the option of face-to-face interviews guaranteed to collect responses from participants who use the bike parking at the hubs in question. In addition, this type of data collection offered benefits such as the possibility for follow-up questions or further clarification of the predefined categories. Both closed and open questions are employed to get an understanding of the cyclists' perspective of the bike parking infrastructure at the hubs in question. More precisely, this method is designed to get a general statistical overview of the cyclists' journeys, their behavior regarding bike parking, their needs in relation to bike parking and their level of satisfaction of the current bike parking infrastructure. Moreover, the open questions meant to capture the perspective of the cyclists on bike parking qualitatively.

The interview questions can be divided into four sections: Demographics part, Travel behavior, Perspectives on bike parking, Perspectives on underground bike parking. The first section is a short demographics part including data on age and gender. This is followed by Travel behavior which aims to capture what bikes the cyclists have, for what purpose they park their bikes there and how often, when, how long the cyclists' leave their bikes at the hubs. The third section is intended to investigate three factors: what behavior the users perform when parking their bikes, what the most prioritized needs of users are regarding bike parking and how satisfied they are with the bike parking infrastructure. In addition, this section aims to connect behavior with the needs of the users. The options for the question of "*How important are the following values for you in bike parking?*", which are '*Convenience*', '*Order*', '*Security*' and '*Time-efficiency'*, were based on the research of Larsen (2017). Additionally, the options for "*How satisfied are you with the following factors at the station?*", which are '*Accessibility*', '*Distance to destination*', '*Order*', '*Security*' and '*Wayfinding*' were based on the research of Egan et al. (2023), in which they listed the following elements as fundamental for good bike parking. ('*Integration*' and '*Visibility*' were not included as they fall outside of the scope of this research. Furthermore, '*Diversification*' was left out since

during the interviews each participant had the chance to express their opinion individually.)(See Appendix D for the definitions of the options provided to the participants.) The last section is proposed to specifically explore the users' perspective on underground bike parking. The reason for specifically investigating the user's attitude towards underground bike parking in the last portion of the questionnaire is that the underground parking was identified as extraordinarily underutilized during the observation phase.

In total, the questionnaire consists of 14 questions, out of which 12 are closed-ended questions with multiple choice options or Likert scales as the options for responses and 2 open-ended questions which meant to capture detailed responses on bike parking. The closed-ended questions aim to measure the variables that were based on the observations. While the open-ended questions seek to apprehend answers that are not bounded by the predefined variables. Furthermore, the closed-ended questions have been provided with an 'other' option which enables participants to supply answers that falls outside the predefined categories. On average, it took around 2-3 minutes to conduct the interview with the participants.

The interviews were conducted at three different hubs on three consecutive days between Wednesday and Friday in the timeframe between 3 and 5 pm. (The exact dates are 24,29-30.04.2024). This timeframe were chosen as it coincides with the rush hour, thus it gave access to a larger pool or possible participants who use the bike parking, while the afternoon hours had the premise of less busy participants who might be more willing to stop for an interview. The participants were selected randomly and in total 35 interviews were conducted.

5. Framing

In this section, the settings of this research including intermodal travel in Copenhagen, the bicycle parking landscape of Copenhagen and the locations of this research are described.

Intermodal trips in Copenhagen made up just 4,3% of all trips according to a 2015 dataset. Specifically, the combined trips of bike and public transport trips made up only 1,8% of all trips. However, transport planning experts anticipate a 15% increase in the number of intermodal trips. Convenient interchanges between the different modes of transport is an important point in such journeys, especially, bicycle parking in bike and public transport trips(Goletz et al., 2020).

Copenhagen's plan with future bicycle parking is comprised of three goals. One is to support intermodal travel. Another is to increase passenger satisfaction with bicycle parking. And lastly, to create a good urban environment (Cannon et al., 2024). Based on the TU (The National Travel Survey) data between 2015-2019, on average, 6-7% of all passengers approached the metro stations on bike. However, this number can vary based on what type the station in question is. The most passengers (60%) however walk to the stations (Gehl & Moe, 2022). The satisfaction of cyclists with bike parking at stations in Copenhagen lies at 47%. This number have increased since 2012, however, it falls short of the Copenhagen municipality's year 2025 goal of 70% satisfaction (Københavns kommune, 2022).

5.1 Bike parking in Copenhagen

According to the Copenhagen municipality, the number of bike parking stands in Copenhagen were at 180 thousand in 2017, from which 100 thousand stands are taken up by bikes. Another 100 thousand bikes are parked outside of bike stands in their approximations. So, same racks are used a little and some other spots there are way less bike stands than enough for the demand (Københavns kommune, 2018). Specifically, in terms of cargo bikes, there has been rise in the recent years, and consequently there is a lacking parking capacity for cargo bikes which the Copenhagen municipality seeks to resolve by allowing cargo bikes to be parked in car parking places (Leck Bachmann, 2023). In terms of stands, Copenhagen is dominated by grid stands, as it works well together with o-locks which, however ,do not allow for securing the bike to the stand

but only stabilize it by the fork. This design has inherent issues such as the lacking stability of the rear end of the bike which can result in the bikes being pushed over or tipped over by the wind (Larsen, 2017). Hence, bikes can be broken or scratched this way(Larsen, 2017). Moreover, overcrowding is often the case at these bike stands in Copenhagen, which can fuel this issue. Many bikes are, however, fly-parked in the presence of too few and overcrowded racks on the streets of Copenhagen. This show how time-efficiency and convenience are major drivers of bike parking in Copenhagen. Bike theft is also a big issue in Copenhagen. Thus, it discourages people from owning expensive bikes. Furthermore, the grid rack design together with the o-locks does not greatly secure the bikes (Larsen, 2017). First, the grid rack does not make it possible to secure the bikes by the frame. Second, the o-locks are not most secure type of lock. Overall, the presented bike parking landscape in Copenhagen influence people's behavior by dissuading them from owning expensive bikes and maintaining them. Hence, the bikes become easily replaceable (Larsen, 2017).

Bike parking is a burden for the municipality as the installation and maintenance of bike parking only accumulate costs without a source of revenue. This is in contrast with car parking which is a profitable business as in many cases only some road painting need to be done to receive parking fees (Larsen, 2017). This might be the reason that the different authorities like municipalities, the metro and the train company (DSB) in Copenhagen pass the responsibility of bike parking onto each other (Cannon et al., 2024).

5.2 Locations

The locations of this study were chosen with the intent of having a variety of transport hubs which do not just represent these locations themselves but the wider context of bike parking at the transport hubs in Copenhagen. The chosen locations are: Aksel Møllers Have, Enghave Plads and Nørrebro station. In the following the particularities of each location is presented.

Aksel Møllers Have

In the categorization of Gehl & Moe (2022), this is a local station. The neighborhood, in which the hub is located, is high density with 5-6 story high buildings. The hub is connected to a football-pitch sized park with a playground and community building in the middle of the station area. On the front end of the station, the station is bounded the busy road of Godthåbsvej. In terms of

passenger number this station is one of the least busiest transport hubs on the M3 metro line with 4130 passengers a day in the weekdays and 3300 in the weekend days (Breinholm Christensen, 2024). In terms of public transport connections, the hub is linked into the network with the M3 metro line and the 2A, 74 bus lines. According to the calculations of the Copenhagen municipality's traffic model, only 1% of the passengers approach a local station such as this one by bicycle (Gehl & Moe, 2022). Furthermore, the average bike trip to the station were less than 500 meters in 2021 according to the calculations of the same traffic model (Gehl & Moe, 2022). Regarding bike parking, while on the front-end of the station, there are 11 grid stands and 2 inverted U stands, on the rear-end, there are 4 grid stands and the staircase leading to the underground parking. (See Appendix A for images of this transport hub).

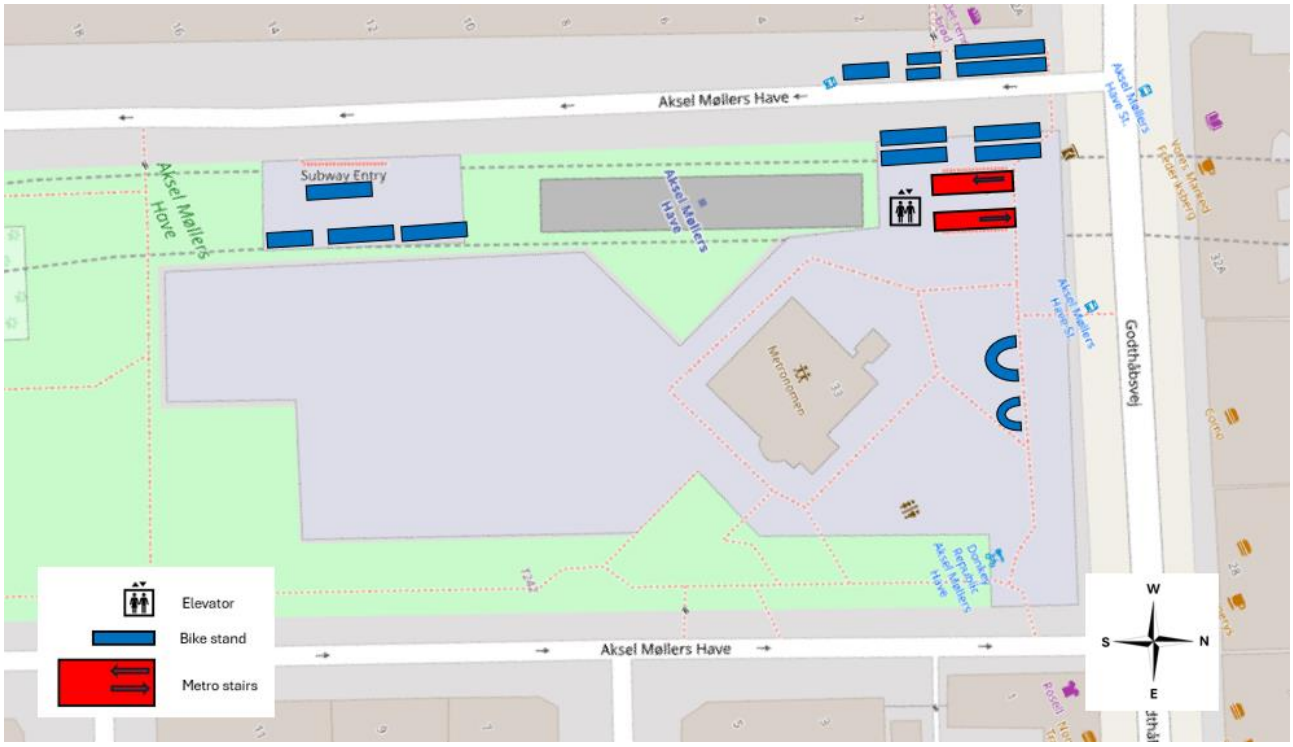


Figure 5.1: Map of Aksel Møllers Have (Own Diagram from bike counting)

Enghave Plads

This hub similarly to the last is local station (Gehl & Moe, 2022). It is nested in a football pitch sized square that is characterized by liveliness, multitude of flows and people doing different activities. The square is surrounded by shops, cafes and restaurants. The west-end of the square is neighbored by a park like area with trees, playground and a skateboarding area. Regarding

passenger numbers this station is at the higher end of the scale with 8090 passengers a day in the weekdays and 6670 a day in the weekend (Breinholm Christensen, 2024). This hub plugged into the public transport network with M3 metro line and bus line 23. While the proximity of Enghave road offers other more frequent bus connections such as 1A. As a consequence of the busy life at this hub, much of the bike parking capacity is taken up by non-metro users. To be exact, only 6 out of 39 people, who use the bike parking, are passengers of the metro, according to the analysis of Gehl & Moe (2022). The average length of the bike trip that brings passengers to the station were just over 500 meters in 2021 (Gehl & Moe, 2022). In terms of bike parking, this station has only grid stands with one cargo bike stand with capacity for two bikes. The grid stands are organized into rows on the Northern side of the square, taking up a considerable area, while leaving the Southern end of the square free for other activities. (Only the bike stands inside the area bounded by the bike lanes on the Eastern and Southern ends of the square were mapped. There are further bike stands outside this area close to the stand. However, they were deemed as irrelevant since it is unlikely that they are used by a high degree of public transport users.) (See Appendix A for images of this transport hub).

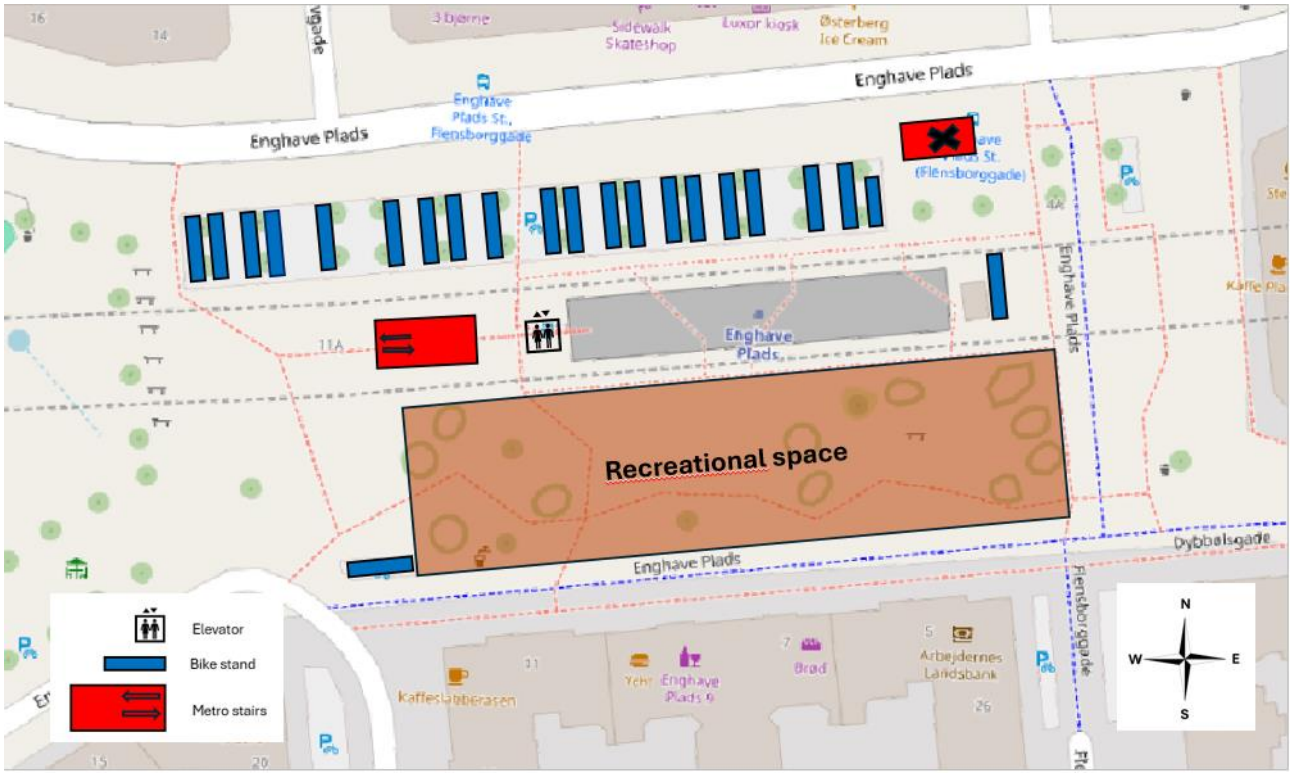


Figure 5.2: Map of Enghave Plads (Own Diagram from bike counting)

Nørrebro station

This station is a 'switching station' as it has both an S-train station and metro station. But in the same time it can be also categorized as an 'end station' since it has a big catchment area north of the hub. Both of these two type of stations brings more cyclists on average than the local type of station, 22% of the passengers come with bike to a switching station and 12% of the passengers approach an end station with bike (Gehl & Moe, 2022). This hub is higher in the number of overall number of passengers too as it has 9980 passengers a day in the weekdays and 7450 passengers a day in the weekend (Breinholm Christensen, 2024). In terms of public transport options, there is the M3 metro line, F S-train line, the busy bus line of 5C and other bus lines like 4A, 250S, 350S, 12. The train station part of the hub is overground with escalators leading up to it and attached to the train station building while the metro station is underground with two entrances. Concerning bike parking, the middle of station (east end of the station), there is a lack of bike stands, while parallel to the S-train station there is a two-tier bike parking system (TTBPS) with a large capacity of 672 stands. The front metro entrance does not have bike parking. However, the rear end entrance is equipped with both grid stands and underground parking. (Further areas with bike parking, primarily referring to the southern end of the station, were excluded from this research because of their distance from the station.) (See Appendix A for images of this transport hub).

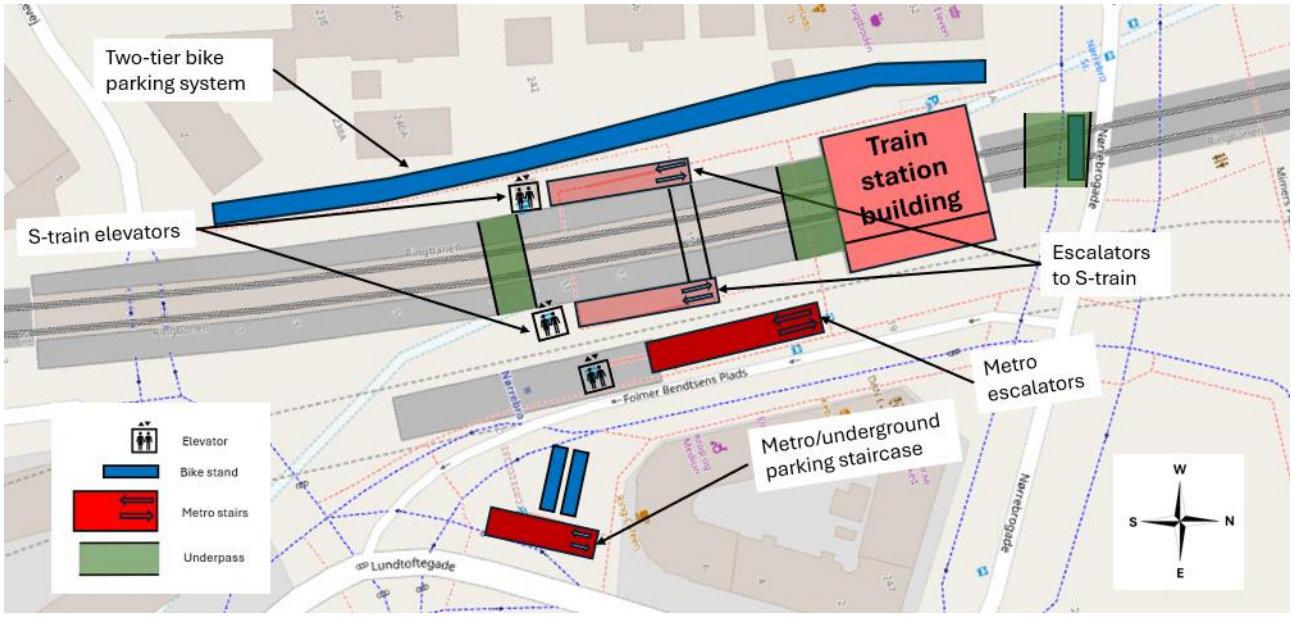


Figure 5.3: Map of Nørrebro station (Own Diagram from bike counting)

6 Results

6.1 Results of observations

Parked bike counting

The observations had an explorative role in the research design. In the following, the results of the observations are presented. The structured observation of the counting parked bikes has served the role of revealing details about the capacity, the type of parked bikes and spatial distribution of the parked bikes.

Capacity

Let us start with the question of capacity and number of bikes parked at the three hubs in question. These two metrics show how the number of bike stands and number of parked bikes relate to each other. As Figure 6.1 shows there are enough number of bike stands at all three stations for the number of bikes parked there. In terms of the number of bike stands, Aksel Møllers Have and Enghave Plads have a similar number, while Nørrebro station exceeds them by a large number, more than twice as much. Regarding, the number of bikes there is slight difference between Aksel Møllers Have and Enghave Plads. There are around 60 more bikes parked at Enghave Plads than at Aksel Møllers Have. At Nørrebro station there is 219 more bikes parked than at Enghave Plads.

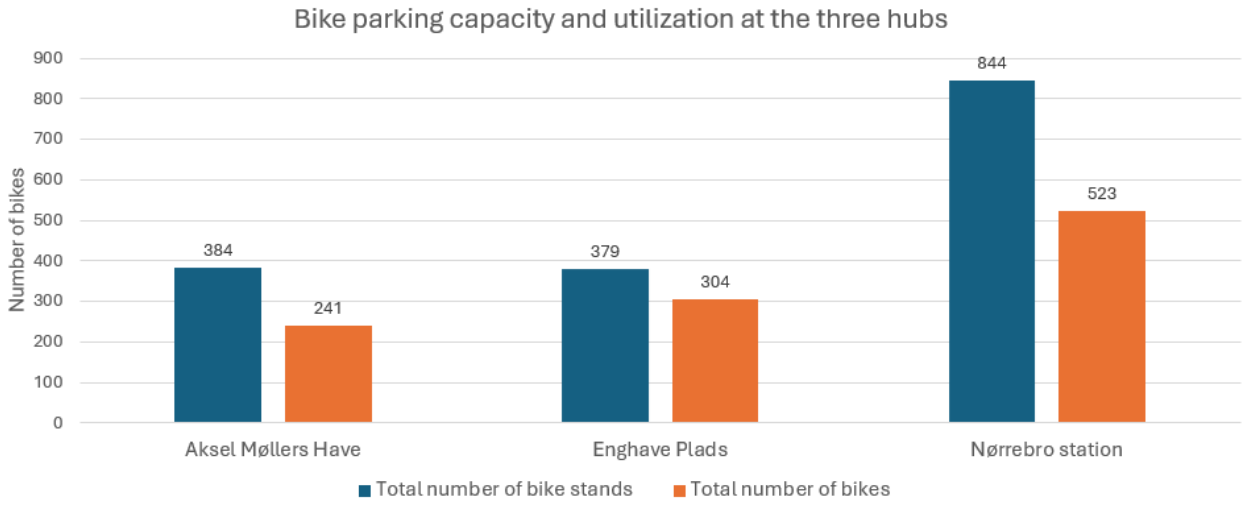


Figure 6.1: Bike parking capacity and utilization at the three hubs (Own Diagram from bike counting)

Now, let us take a closer look at capacity. The capacity of bike parking at the hubs can be broken down into three different metrics: the number of free bike stands, the number of bikes parked in the bike stands and the number of bikes parked outside of bike stands. These three dimensions show how many bikes stands are not utilized, how many bike stands are used and how many bikes are fly-parked. If the first two metrics are added up, the number of bike stands is revealed. If the last two metrics, then the number of parked bikes is obtained for each transport hubs. Figure 6.2 shows that while at Aksel Møllers Have there is slightly more unutilized bike parking than at Enghave Plads, 55 more to be exact, at Nørrebro station there is way more unutilized bike stands, more than 3 times more than at Aksel Møllers Have. In terms of used capacity, there is around the same number of bike stands used at the three hubs. Comparing the two aforementioned metrics at Nørrebro station, the number of used capacity is dwarfed by the number of unutilized parking which is more than three times more. Lastly, concerning the number of bikes parked outside of the bike parking areas, Enghave Plads has slightly more bikes than Aksel Møllers Have with 13 bikes, while Nørrebro station has more than five times more than Enghave Plads.

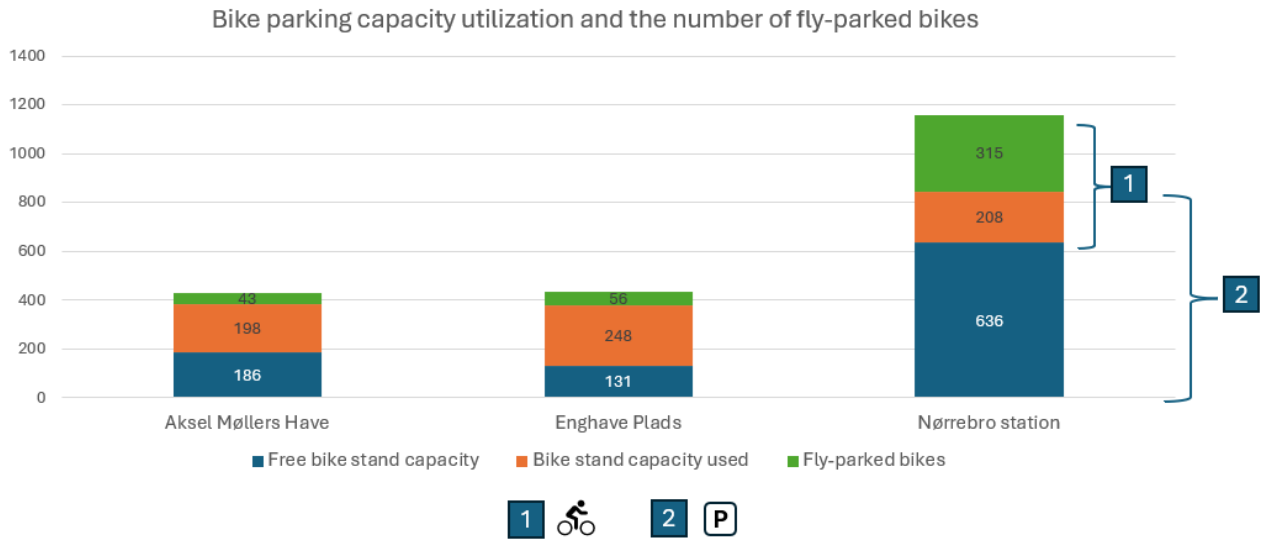


Figure 6.2: Bike parking capacity utilization and fly-parked bikes (Own Diagram from bike counting)

Next, let us look at how the different types of bike parking perform against each other in terms of used capacity. As Figure 6.3 shows, the bike rack design is highly utilized in all three of the hubs, while the underground parking and the two-tier bike parking system are way less used. More precisely, the underground parking is way underutilized as at Aksel Møllers Have there were only 4

bikes parked and at Nørrebro station only 5 bikes. Compared to this, the two-tier bike parking system is better, especially at the ground level of racks.

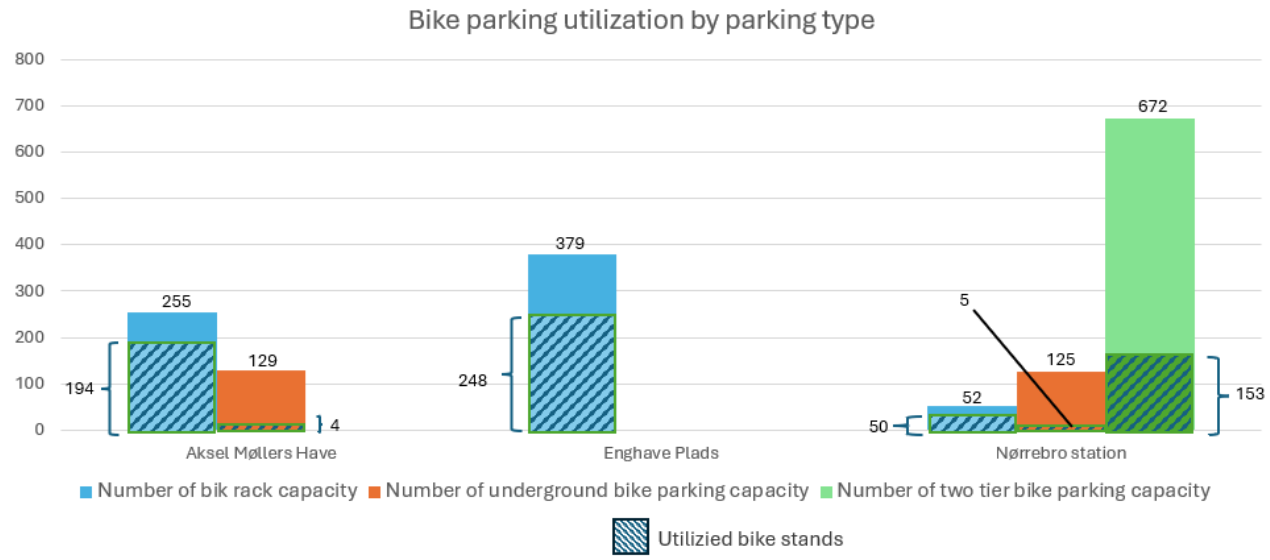


Figure 6.3: Types of bikes (Own Diagram from bike counting)

Types of bikes

During the observations, the bikes were differentiated based on type. The following categories were used: city bikes (female and male types), shared vehicles (Donkey bike (Donkey bike is a company that makes it possible to rent electric and non-electric shared bikes), electric shared bikes, and electric shared scooters), electric bike, cargo bikes (front-load bikes and front-load tricycles), Swapfiets bike (Swapfiets is company that makes it possible to rent both electric and non-electric bikes monthly), road bike, mountain bike, kids bike, bikes with child seat, fixie, camping bike, wrecked bikes.

In the following the distribution of these types of bikes is presented. As Figure 6.4 shows the most common bikes were the female city bikes followed by the male city bikes and then Swapfiets, family bikes and shared types of vehicles.

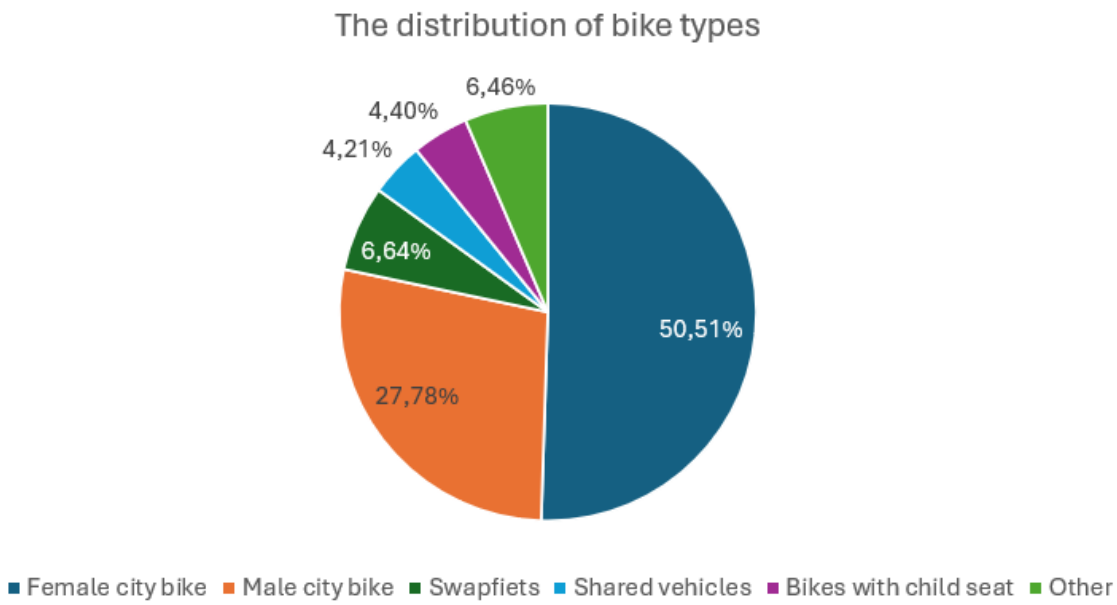


Figure 6.4: The distribution of bike types (Own Diagram from bike counting)

When looking at the differences in the distribution of the different types of bikes through the different hubs, it can be said that there is a significant difference in the distribution of certain types of bikes at the different hubs. At Aksel Møllers Have, there is a slightly more male city bikes,

however, not significantly. Regarding the other bike types at this station, there is not a significant percentage difference. At Enghave Plads, there is a substantially higher percentage of bikes with child seats at 7,21% compared to the average of 4,40% at all the stations. Moreover, there are also way more cargo bikes at Enghave Plads with 7 cargo bikes to only a couple at the two other stations. Hence, most of these cargo bikes are parked in the normal bike stands, taking up more space than a normal bike would (See Appendix A for the image). At the other stations, there are no significant differences in the distribution of the types of bikes.

Improperly placed bikes

Other than fly-parking, two other types of transgressive behavior were observed. One is putting the bike to the bike stand but without pushing the bike into the wheel-holder. Another is putting the bike in between two bike stands without having sufficient space for it. The following figure shows what percentage of the parked bikes carry these transgressive behaviors for each transport hub.

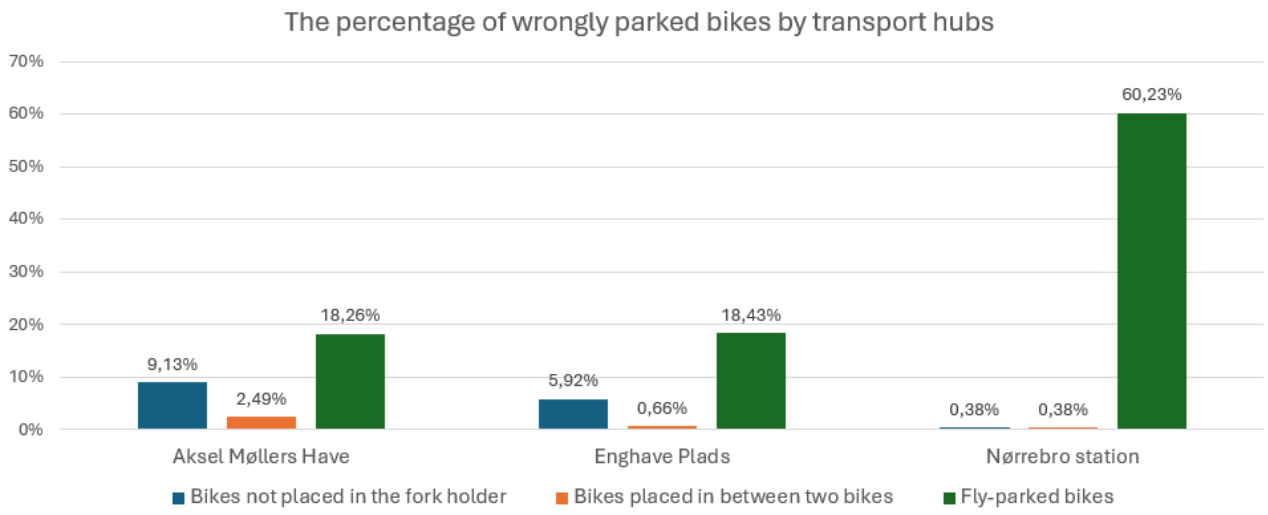


Figure 6.5: The percentage of wrongly parked bikes by transport hubs (Own Diagram from bike counting)

Distribution of the different types of improperly placed bikes

To see if there is a difference in the distribution of the types of bikes through the improperly placed bikes, it needs to be compared to the distribution of the bike types among all bikes at Aksel

Mølles Have and Enghave Plads. Only these two hubs are considered since Nørrebro station was ruled out from the analysis. As it was established previously, Nørrebro station has substantially more bikes placed fly-parked bikes even though the capacity of bike stands would be able to accommodate the number of bikes at the station. However, the users refuse to use the bike parking stands at Nørrebro station. Since placing bikes is so normalized as this station, it does not make sense to involve this station in this analysis. The following figure compares the distribution of the bike types of all bikes at the two stations compared to the distribution of the improperly placed bikes. It can be concluded that the order of the categories from most common to least is identical. However, looking at the percentages of the shared rental vehicles and Swapfiets bikes, there is a significant difference as there are almost twice as many of these types of bikes that were not parked properly.

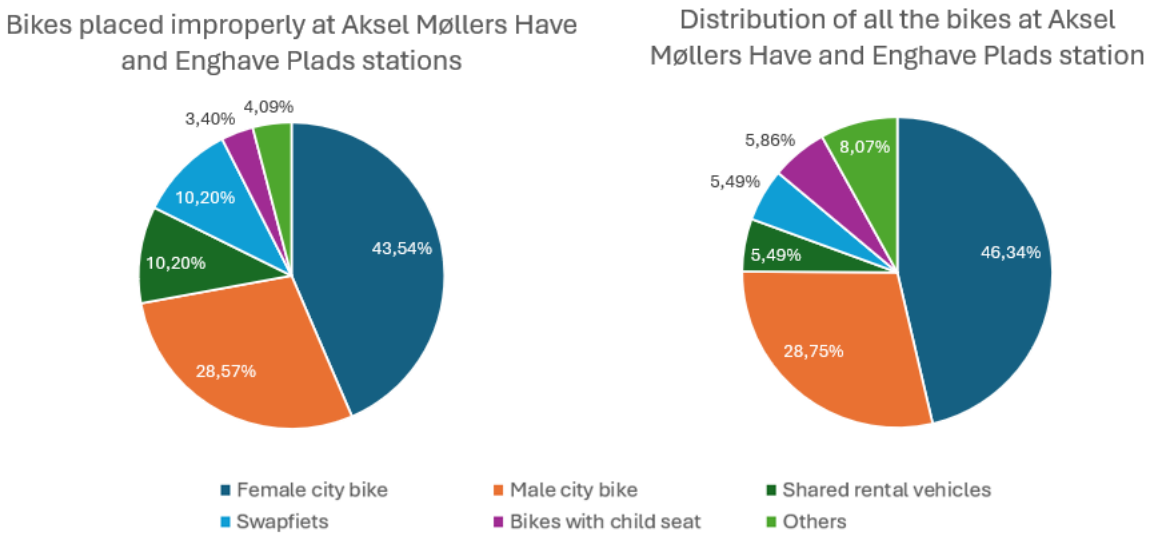


Figure 6.6: The distribution of bike types against the distribution of bike types of the improperly parked bikes (Own Diagram from bike counting)

As described in Section 2.3, bike parking is a system, and as such locks are considered integral parts of bike parking. Figure 6.7 shows the breakdown of the types of locks that the bikes are secured with. As expected, O-locks by far are the most common type with 72,58%. This is followed by chain locks with 16,13% and the combination of the O-lock and the chain lock have 4,84%. The other types of locks such as Low-budget locks, U-locks, and Wire locks make up less than 7% in total. Furthermore, if the number of bikes, that are secured to the bike stand, is considered, then

it can be concluded that this option is not much utilized by users since it is only at 2,49% of the parked bikes.

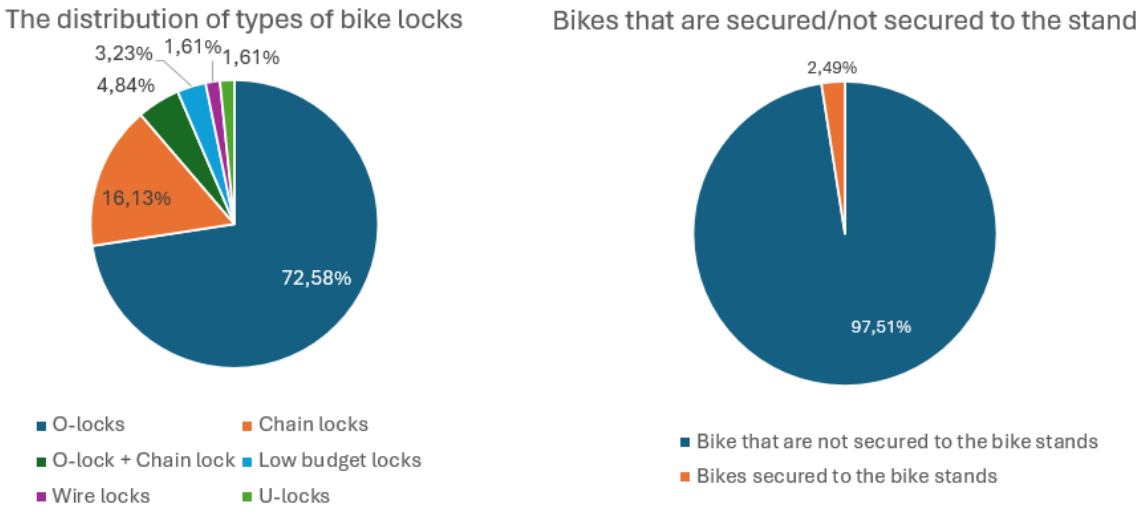


Figure 6.7: The distribution of the bike lock types (Own Diagram from bike counting)

Spatial maps of bike parking at the three transport hubs

The used capacity and the fly-parked bikes were spatially mapped. The following maps are the visualizations of this data. The maps are meant to capture which spaces of the hubs are used or unutilized, and where the fly-parked bikes are.

Aksel Møllers Have

Starting with Aksel Møllers Have, as the metro escalator and elevator are placed on the northern-westmost corner of the square, the stands in the proximity of these metro entryways are highly utilized. The two half-circle-shaped stands are distanced from the metro entrances, but given the scarcity of bike stands on the northern east side of the station, are similarly highly utilized stands. Moving south direction towards the garden part of the station, the stands close to the southern staircase entrance of the station are underutilized compared to the previously mentioned stands.

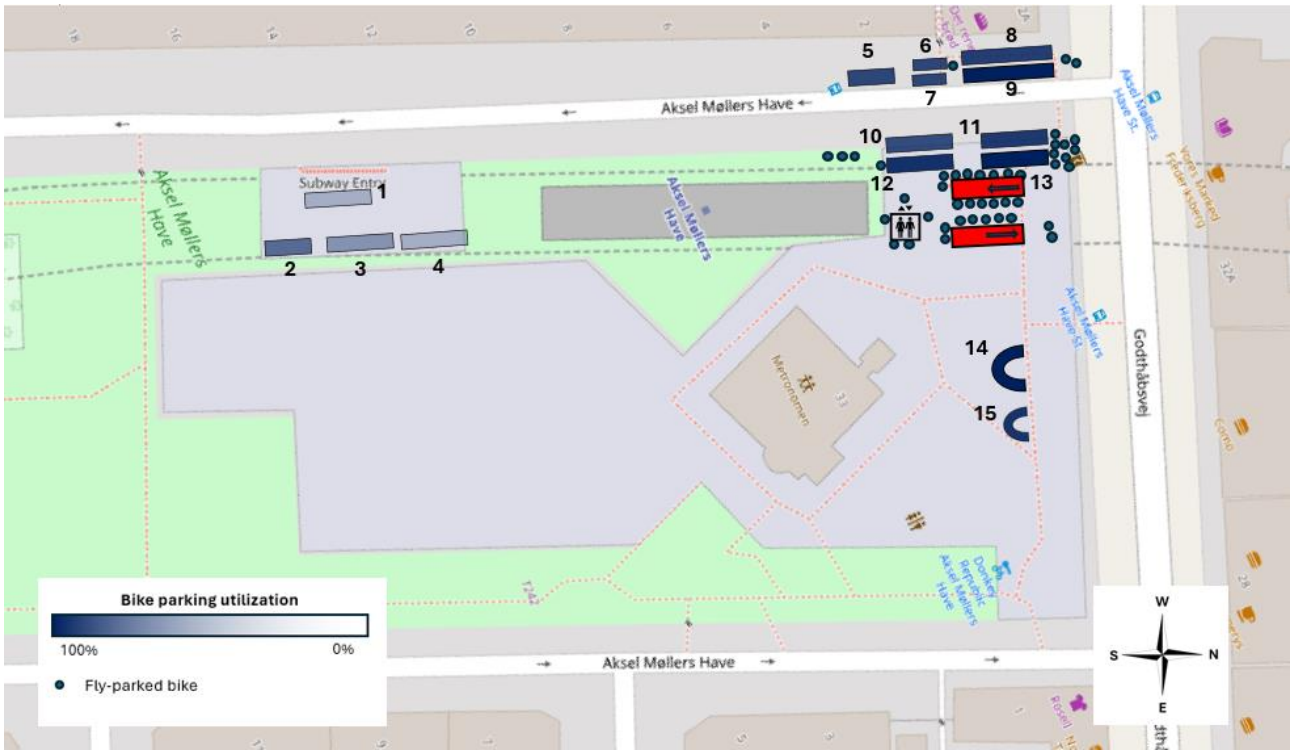


Figure 6.8: Spatial map of the bike parking at Aksel Møllers Have (Own Diagram from bike counting)

In terms of the fly-parked bikes, the square is populated with fly-parked bikes in between the stands, metro escalators, and the elevator. These fly-parked represent the high demand for bike stands on this end of the station as the bike stands are highly utilized and missing the capacity for the fly-parked bikes.

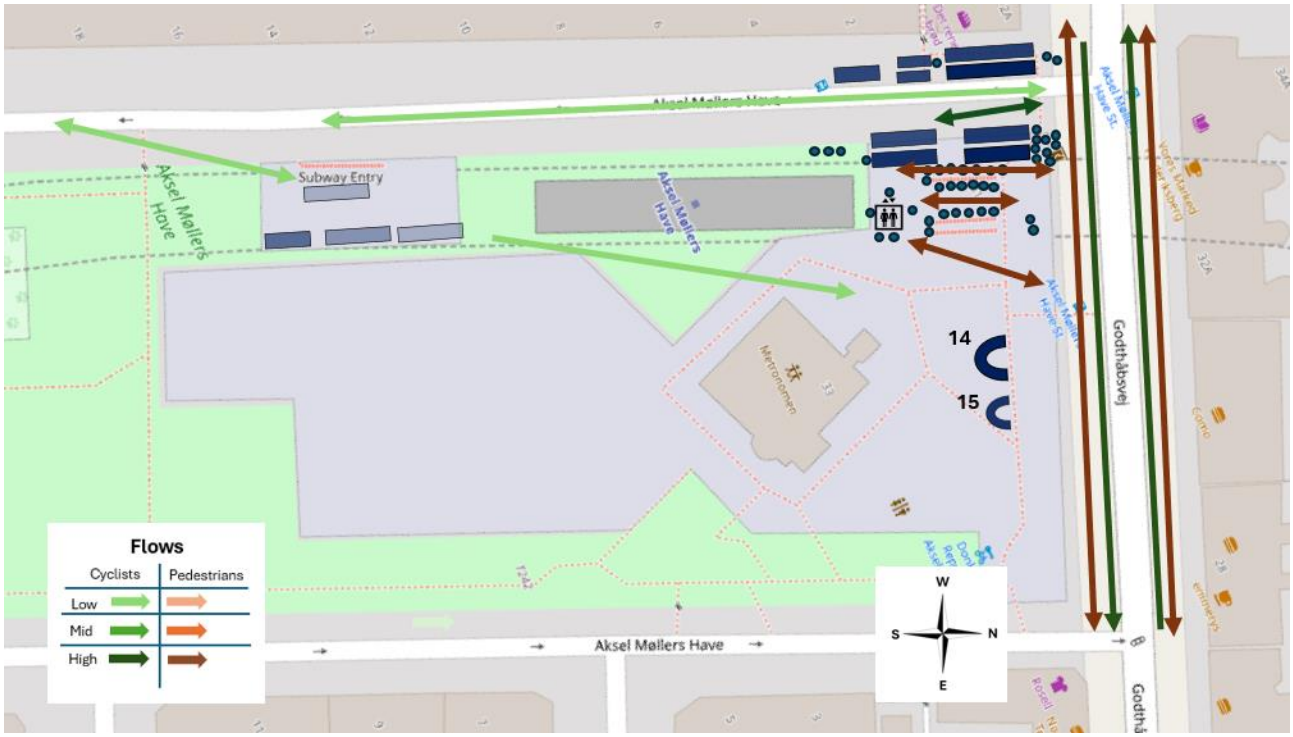
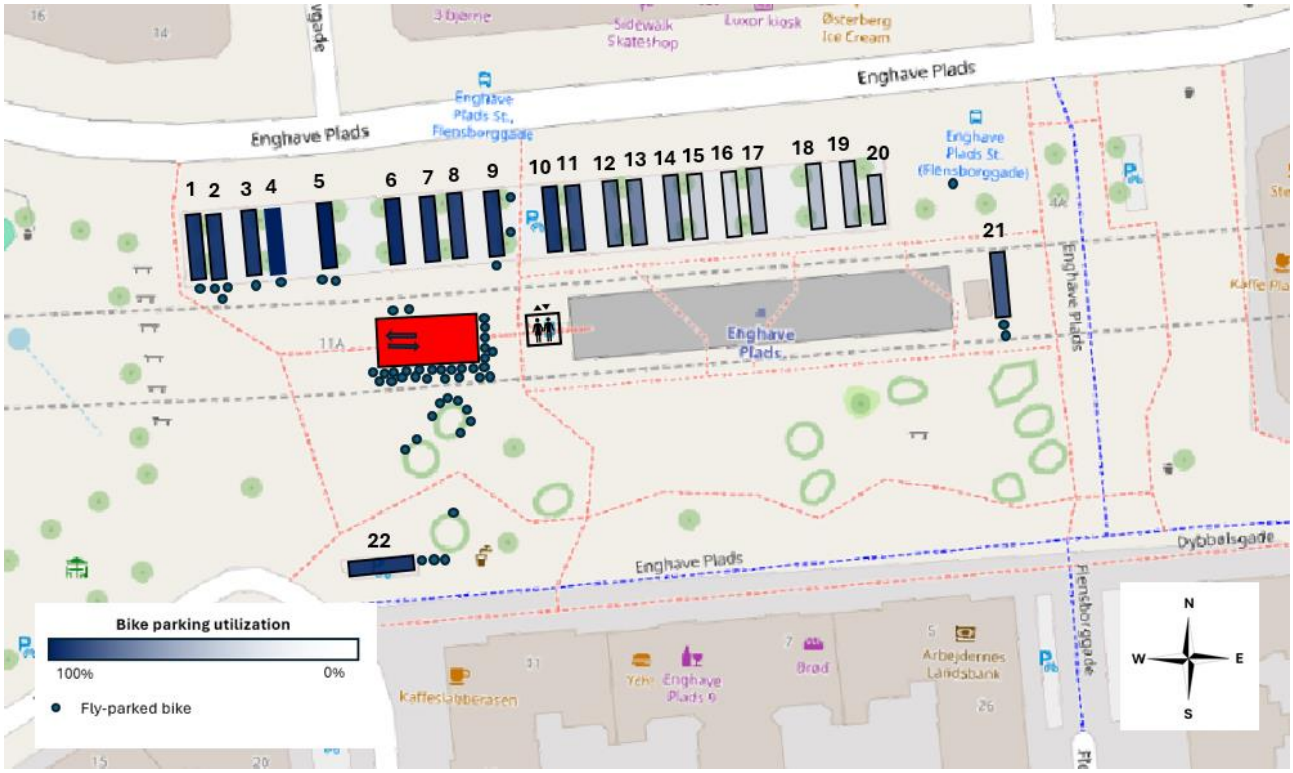


Figure 6.9: Spatial map of the bike parking at Aksel Møllers Have with the flows (Own Diagram from bike counting)

Now consider the flows of cyclists that bring them to the hub. Godthåbsvej brings the majority of the cyclists to the hub. The southern end of the station, where the garden is, is way quieter in terms of cyclist and pedestrian flows. Moving onto the pedestrian flows of the station, a large number of pedestrians are brought to the transport hub from Godthåbsvej. The flows connected to the elevator lead through a few meters wide passages between the escalators, the bike stands, and the pillar that holds the roof over the escalators. These passages are often overloaded with fly-parked bikes colliding with the pedestrian flows.

Enghave Plads

Next, Enghave Plads, when considering this hub, it is important to be reminded that it is embedded in a square with a lively character and surrounded by commercial units. The commercial zone around the square have also bike parking stands, however, the hub's bike parking is also expected to have a high number of non-metro-related users.



Bike stand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Capacity	20	10	20	20	2	2	22	22	22	22	25	25	5	5	10	14	9
Utilizied	5	6	8	5	2	0	20	17	26	19	25	21	4	4	8	15	8
Percetange	25,00%	60,00%	40,00%	25,00%	100,00%	0,00%	90,91%	77,27%	118,18%	86,36%	100,00%	84,00%	80,00%	80,00%	80,00%	107,14%	88,89%

Figure 6.10: Spatial map of the bike parking at Enghave plads (Own Diagram from bike counting)

The entrance to the metro is located at the western end of the square with a west-facing staircase leading down to the metro and an elevator behind the staircase. Accordingly, if looking at the used capacity of the stands, it can be said that the stands on the west end of the square in the proximity of the staircase and the elevator are the most utilized. Behind the staircase and the elevator, as moving down towards the eastern end there is gradually less and less used capacity in the stands. The easternmost and southernmost ends of the square have one-and-one stands. Given this limited capacity in these areas of the square, both of these stands are highly utilized.

Moving onto the fly-parked bikes, as the southern half of the stand is rather scarce of stands with only one stand, fly-parked bikes are concentrated in this area, close to the metro staircase and scattered between the bushes on the southwest corner of the square. The rest of the fly-parked bikes are placed next to the most utilized stands close to the metro entrance.

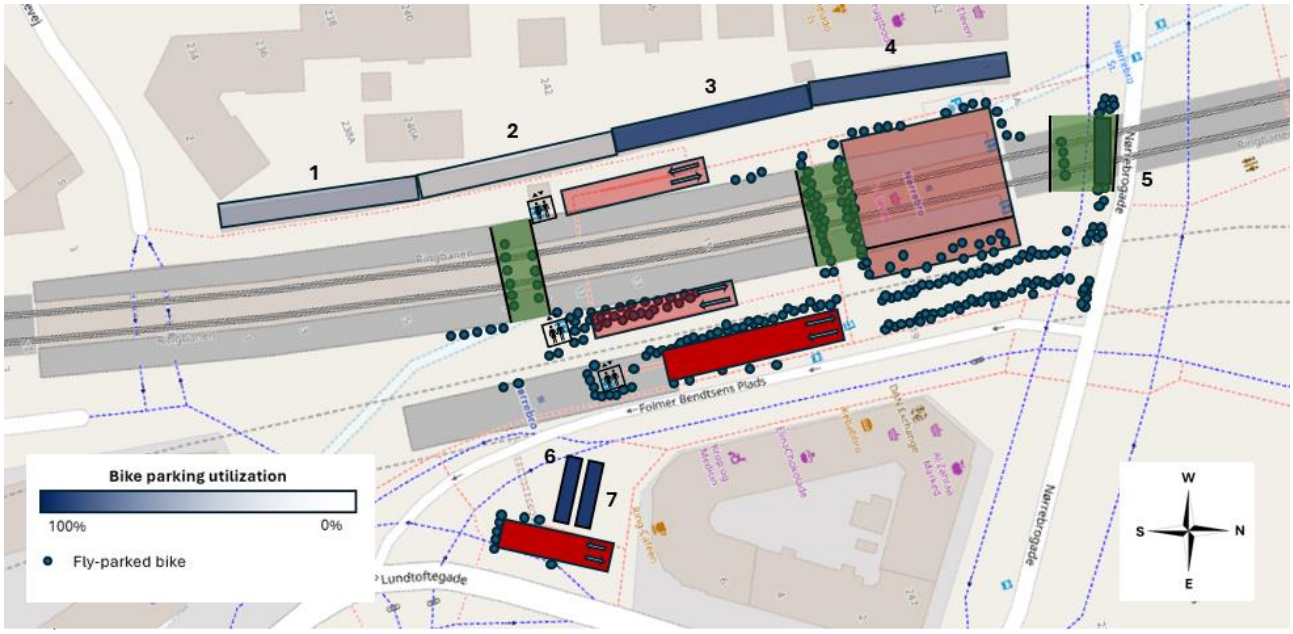
Bike stand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Capacity	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	7	15	17
Utilizied	15	15	15	17	17	16	15	14	15	15	13	10	9	8	3	2	5	4	4	7	2	11	15
Percentage	88,24%	88,24%	88,24%	100,00%	100,00%	94,12%	88,24%	82,35%	88,24%	88,24%	76,47%	58,82%	52,94%	47,06%	17,65%	11,76%	29,41%	23,53%	23,53%	41,18%	28,57%	73,33%	88,24%

Figure 6.11: Spatial map of the bike parking at Enghave Plads with the flows (Own Diagram from bike counting)(See Appendix C for resulotion)

The location of the fly-parked bikes are in line with the cyclist flows in the square since there are not many stands for the cyclists that come from the southern direction. Moreover, the locations of the fly-parked bikes are in conflict with the pedestrian flows around the metro entrance, and at the corner of the bike stands where a great deal of the cyclist and pedestrian goes by.

Nørrebro station

As described in Section 6.1, at this transport hub there is an issue with the underutilized underground bike parking and two-tier bike parking system, as well as a large number of fly-parked bikes.



Bike stand	1	2	3	4	5	6	7
Capacity	18	72	72	96	96	17	17
Utilizied	16	53	48	11	26	15	19
Percentage	88,89%	73,61%	66,67%	11,46%	27,08%	88,24%	111,76%

Figure 6.12: Spatial map of the bike parking at Nørrebro station (Own Diagram from bike counting)

There are three bike stands at this hub. Two are located on the north eastern metro entrance and one is located on the side of Nørrebrogade. All three of these bike stands are highly utilized. Moving on to the TTBPS, it is a more than 100 meter long bike parking system with two levels and it runs along the S-train tracks on ground level. Starting with the top level of the bike parking, it can be said that it is far more underutilized than the bottom level as the top level has 1,49% utilized, while the bottom level has 44,05% utilized. For the sake of analysis, let us brake the this system of bike stands is broken into four pieces, so then it can be spatially seen which parts of the bike parking is utilized and which are not. The two fourths that are between Nørrebrogade and the escalator leading to the S-train are most utilized with 73,61% at the first and 88,89% at the second. The two other fourths are less utilized as the third has only 11,46%, and the fourth has only 27,08%. The underground bike parking is significantly underutilized with only 1,49% used capacity.

Next, fly-parked bikes are a prominent issue at this hub. Looking at the map, it can be concluded that the main area where bikes are fly parked is the eastern side of the hub where there is a total

lack of bike stands. So, the cyclists that come from the eastern direction on Nørrebrogade and wish to park their bikes in a convenient manner may choose to fly-park as there are no bike stands on this side of the station. In the sea of fly-parked bikes at the eastern section of the hub, one noteworthy observation were that even though the high number of fly-parked bikes, a clear order was possible to recognize. These fly-parked bikes were in placed in two rows, instead of pure chaos (See image in Appendix A).

Figure 6.13: Spatial map of the bike parking at Nørrebro station with the flows (Own Diagram from bike counting)

Considering the flows together with the fly-parked bikes, the flows visibly outline the area of the fly-parked bikes. This applies to the eastern side of the hub in font of the metro escalators and the S-train building, and the underpasses that leads to the opposite side of the S-train. Overall, the fly-parked bikes take up a substantial portion of the space at this hub, but they leave just enough space for the flows go through.

Results from observation of interchange

This method was applied to gain insight into what different types of behaviors are performed by the people who park their bikes at the hubs. As a result, there were observed eight different types of behaviors. Some of the users approached the parking by pushing their bikes, while others cycled there, moreover, other cyclists were observed riding through the pavement of transport hubs. The

former type of behavior reflects rule-following and promotes order while the latter rejects the traffic laws and brings disarray. During the interchange, some of the users exhibited hurrying while others took their time. Furthermore, a fraction of the users put a cover on their bike seat to shield it from rain. In terms of where the parked bikes are set, some bikes were parked properly in the stand and some outside the stands. While the first promotes order and prevents the damaging the bike, the latter brings disorder. And finally, some people lock their bikes to the bike stand for higher security.

6.2 Results of interviews

The interview phase was designed as a follow-up to the observations, supplementing the observations phase and opening up the phenomena from the observations. So, in the following section, the interview data is analyzed and combined with the insights from the observations. Hence, it aims to unfold background data, journey-related data, and data regarding the needs and preferences of the bike parking users.

Demographics

There was only limited demographic data collected, namely age and gender as these factors can greatly influence travel behavior. The average age of the participants was at 32,4 years with a standard deviation of 13,7. In terms of gender, 20 participants were female, 13 male, and 2 wished not to answer this question. (See Appendix B for the distribution of age of the participants)

Travel behavior

This section is meant to explore the participants' journeys and their travel choices that resulted in the usage of bike parking. The first question aims to investigate the distance that participants have biked to the hubs. The mean distance has been at 1,62 kilometers with a standard deviation of 1,28. This mean distance is slightly higher than the distance indicated in the calculations of the Copenhagen municipality's traffic model, however, this number includes users who park their bikes at the hubs for different purposes than traveling further with the metro. In terms of travel purpose, 69% of the interviewed parked their bike at the hubs to further with public transport (metro, S-train, or bus), 17% parked their bikes there as they were guests in cafes, restaurants, or shops in the surrounding area and the rest 14% parked their bikes their since they live, work or

study in the area. If only the public transport users are considered, the average distance biked comes down to 1,375 kilometers.

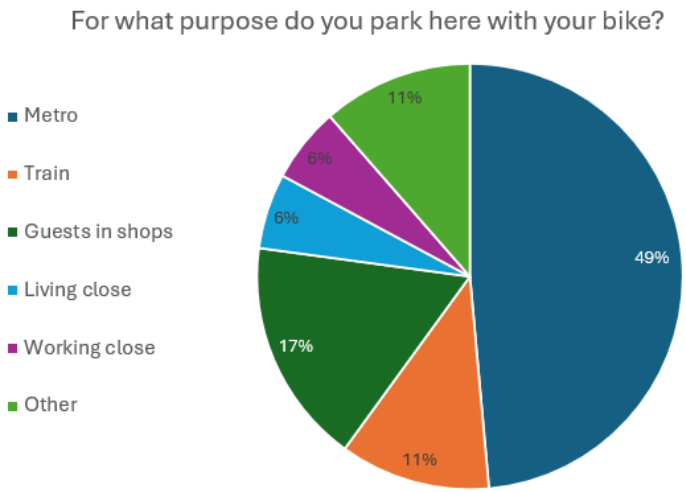


Figure 6.14: Travel purpose (Own Diagram from interviews)

In addition, the rest of the questions were directed towards when the users parked their bikes at the hubs. One question targets how often they park their bikes at a certain transport hub. Most of the participants (29%) answered that they park their bikes at the transport hubs in question 7-5 times a week. This is followed by 20% who park their bikes 2-4 times a week and 23% park there once a week. The rest 28,58% park their bikes at the transport hubs less than once a week.

The next question investigates what time of the day the participants park their bikes at the transport hubs. The most common answer was *'In the morning'* (between 6-8:59 AM) with 37%, followed by '*Afternoon*' (between 12-4 PM) with 31%, then '*Early evening'* (4-6 PM) with 20% and '*Before noon'* (9-12) with 11%. ('*Late evening and night'* did not receive any responses.) The distribution of these responses needs to be considered in mind with that interviews were conducted between 3-5 p.m.

Regarding the duration of the parking, most participants (40%) answered that they park their bikes at the hubs for 2-4 hours. This is followed by 26% of the respondents who park their bikes at the hubs between 4 and 8 hours. Then, 11% -11% reported that they use the bike parking for 1-2 hours and 8-24 hours . The respondents who parked their bikes at the hubs for more than a day

only received 9% and the respondents who parked their bikes at the hubs for less than an hour received 3% of the answers.

Perspectives on bike parking

Behaviors that the participants perform

The following part unfolds what behaviors the users perform, and what the participants' perspective on bike parking in general and specifically on the transport hubs in question. Starting with the behaviors, the following question explores what behaviors the participants do when parking their bikes. The options for the answers are based on the observations. The most common answers were split between '*Parking close to the destination'* and '*Parking their bike orderly*' with 43-43%. These two answers are followed by 'Hurrying' and '*Pushing bike to the stand'* with 40-40%. The next were *'Biking to the stand'* through the station with 34% and '*Parking outside the bike stands'* with 26%. Not any of the rest three options, namely, '*Taking good time'*, '*Locking the bike to the stand'* and '*Putting cover on bike seat'* were performed by more than 20% of the participants.

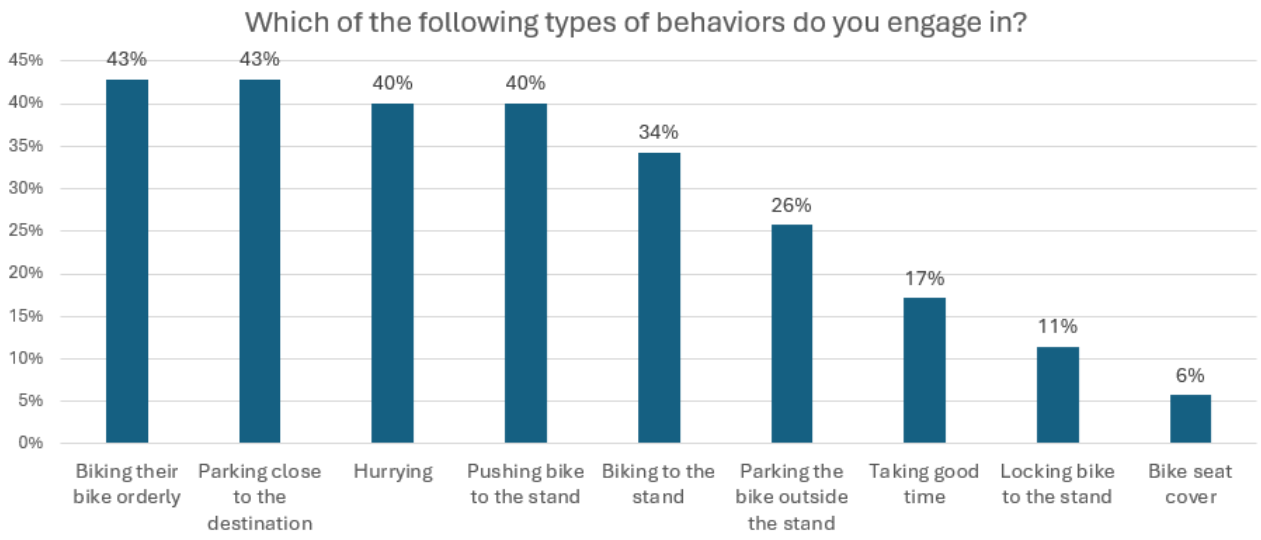


Figure 6.15: The distribution of behaviors that the participants perform (Own Diagram from interviews)

Satisfaction with the bike parking infrastructure

Regarding the participants' perspective on the bike parking infrastructure at the transport hubs, the first question is regarding the general satisfaction with the bike parking at the hubs. The

following diagram shows that no participants answered that they were *'Very satisfied'* with the bike parking and only 14% answered that they were '*Satisfied*'. Most of the participants (60%), however, answered that they are either '*Dissatisfied*' or '*Very dissatisfied'*.

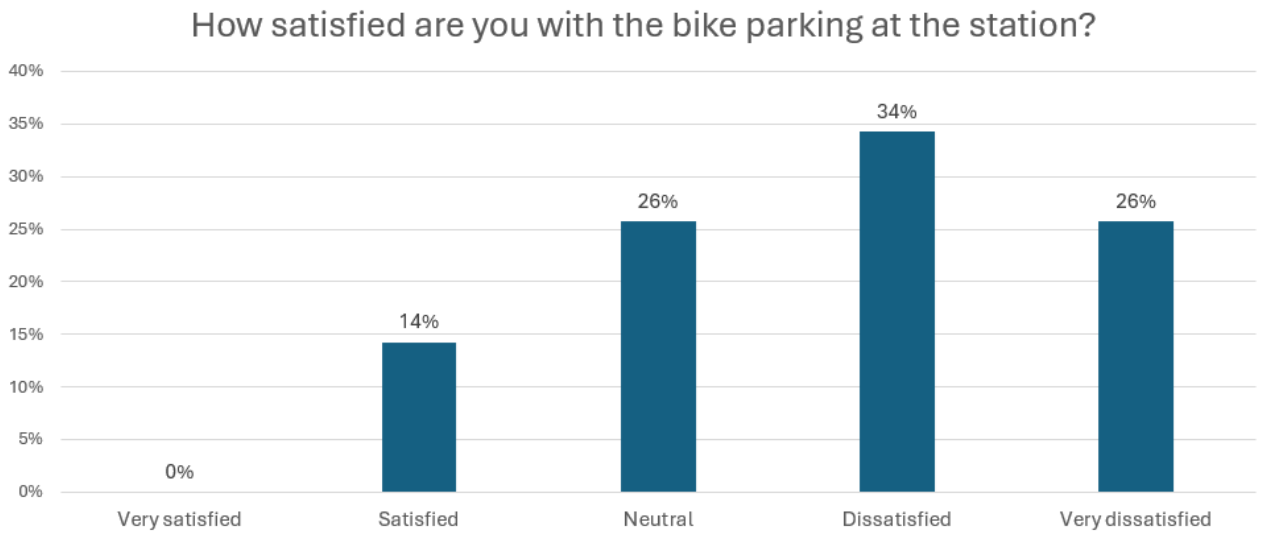


Figure 6.16: The distribution of the participant's satisfaction with the bike parking facilities at the transport hubs (Own Diagram from interviews)

In the Copenhagen municipality's research, they have recorded a far better result with 47% of the users being satisfied with the bike parking at the stations in Copenhagen (Københavns kommune, 2022). However, it is worth bearing in mind that Nørrebro station is a problematic station, hence it may exacerbate the general mean satisfaction of the three transport hubs.

The next set of questions is meant to unfold which of the different factors, that makes up the satisfaction, users are satisfied or dissatisfied with, specifically, "*Accessibility, Distance to destination, Order, Security, Wayfinding"*. If translating this Likert scale to numbers (5 = Very satisfied, 1 = Very dissatisfied), the average score can be calculated for each factor. By doing that, the users were most satisfied with wayfinding and least satisfied with the distance to the destination. The following diagram is meant to open up the satisfaction score of each factor in the order of the average satisfaction score. Starting with Distant to station, the diagram reveals that this factor has the most *'Very dissatisfied'* ratings with 26%, together with the least number of '*Very satisfied'* or '*Satisfied*' ratings (only 28%) making this factor the one that the participants are the least satisfied with. The next is Security as it has the second highest percentage (17%) '*Very dissatisfied'* and the least (6%) '*Very satisfied'* participants. The next factor is Order. Most

participants (55%) were either '*Dissatisfied*' or '*Very dissatisfied'* with the order at these transport hubs. This is matched with a low satisfaction rate, namely, 28% in total of *'Very satisfied'* or '*Satisfied*'. Accessibility has also a high dissatisfaction rate, 42% in total, however, this is complemented by a high 37% satisfaction rate in total. The participants were the least dissatisfied with Wayfinding since it received only 17% '*Dissatisfied*' and no "*Very dissatisfied*". This outcome though needs to be weighed up by taking into account that a large part of the pool of these participants travel through the transport hubs in question regularly. Hence, this research lacks the novel users that are key for researching wayfinding (Bubric et al., 2021).

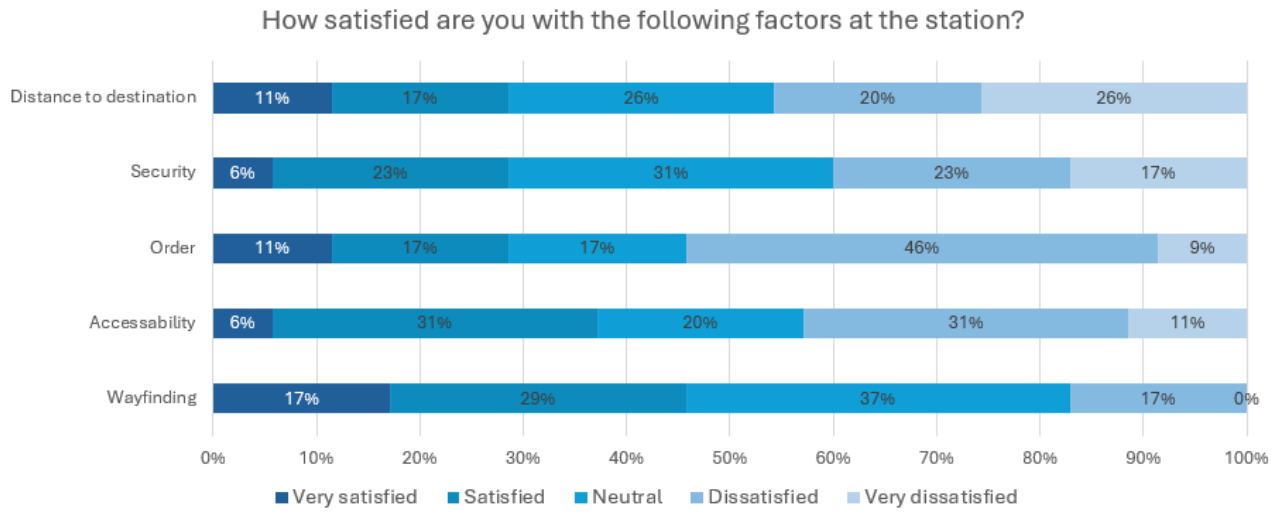
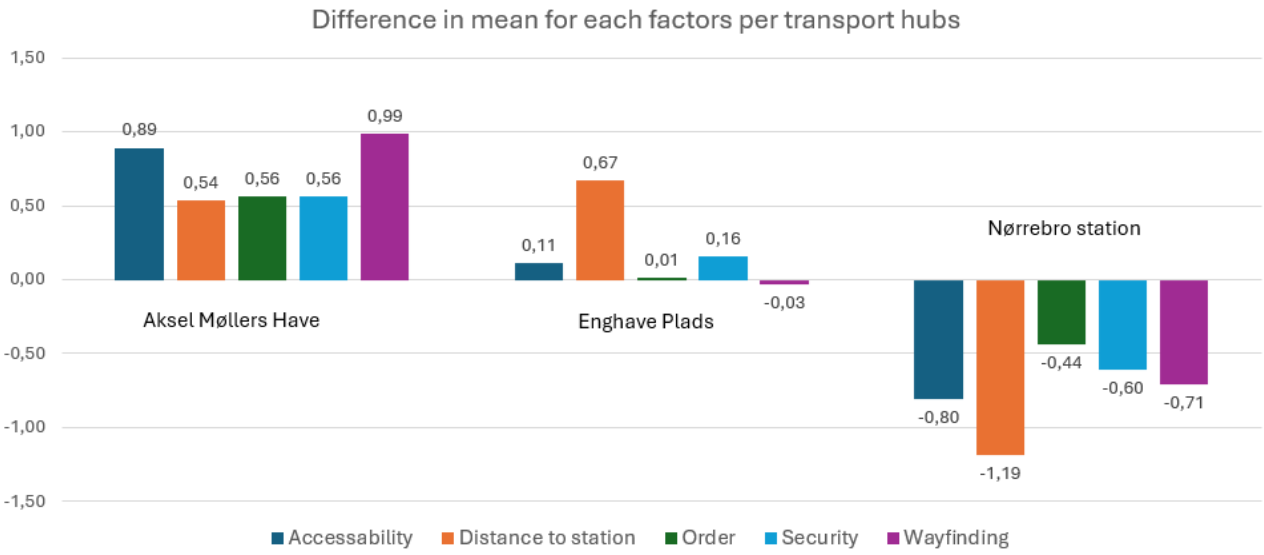


Figure 6.17: Participant satisfaction with the different bike parking quality factors (Own Diagram from interviews)

If these factors are analyzed for each of the station separately, substantial differences are revealed. The following figure shows the differences in the mean for each factors by transport hubs.



Factors	Accessability	Distance to station	Order	Security	Wayfinding
Mean satisfaction	2,886	2,686	2,771	2,771	3,457

Figure 6.18: Difference in mean for each factors per transport hubs (Own Diagram from interviews)

As seen previously, Aksel Møllers Have have a higher mean satisfaction rate than at the rest two stations. This is also reflected in the key factors. As the diagram shows mean user satisfaction with Wayfinding and Accessibility is higher by 0,99 and 0,89, while the other factors are only higher by a lower degree. In terms of Enghave plads, user satisfaction is slightly lower than at Aksel Møllers Have. The users rated Distance to destination higher by 0,67 than the mean, while the other factors are the mean value. Nørrebro is by far the hub which the users are the least satisfied with. This is also mirrored by these key factors. Users are the least satisfied with Distance to destination and Accessibility.

Motivating factors

The next section focuses on the factors that are important to the users of bike parking. Four factors were identified, in the order the average score from highest to lowest: Time-efficiency, Convenience, Security, and Order. Now, if these scores are unfolded into distribution of the ratings of the participants, then it can be seen that Time-efficiency was rated as “Very important” by slightly less than the half of the participants (49%) and together with the “Important” ratings they make up 75% of the participants. Moving on to Convenience, it has also a high percentage of “Very

important" ratings (40%), and together with “Important” ratings they account for 71% of all the ratings. “Security” just like the two aforementioned factors has a high total (Very important and Important) ratings, however, the distribution of the “Very important” and “Important” ratings is different as it is in favor of the “Important” ratings by 30%. Order compared to the previous factors have received less “Very important" and “Important” ratings. Moreover, substantially more participants has named it as either “Not important” or “Not important at all”, in total 25

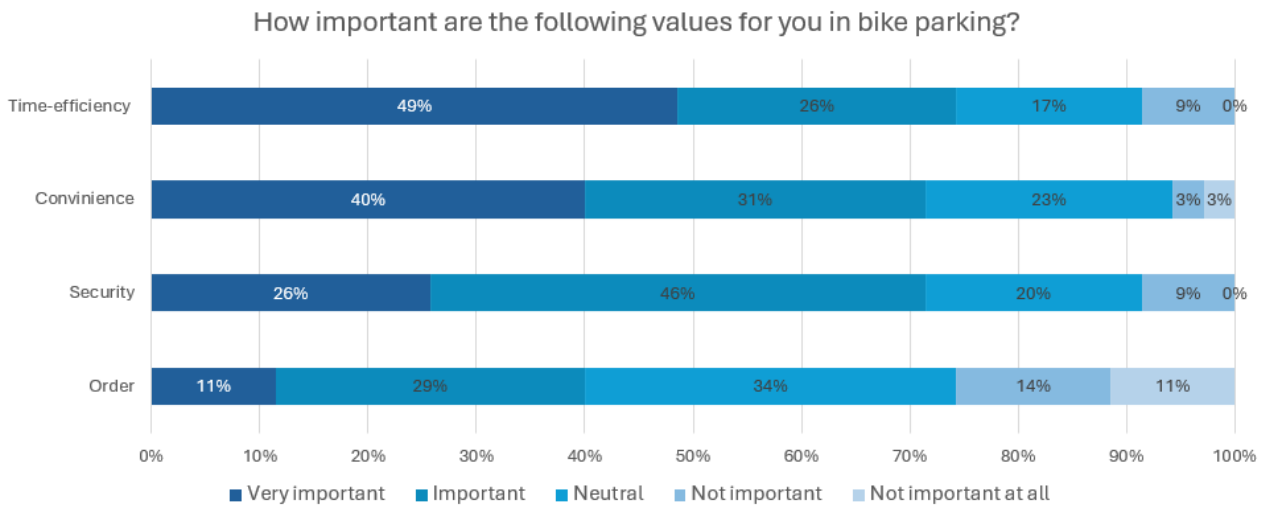
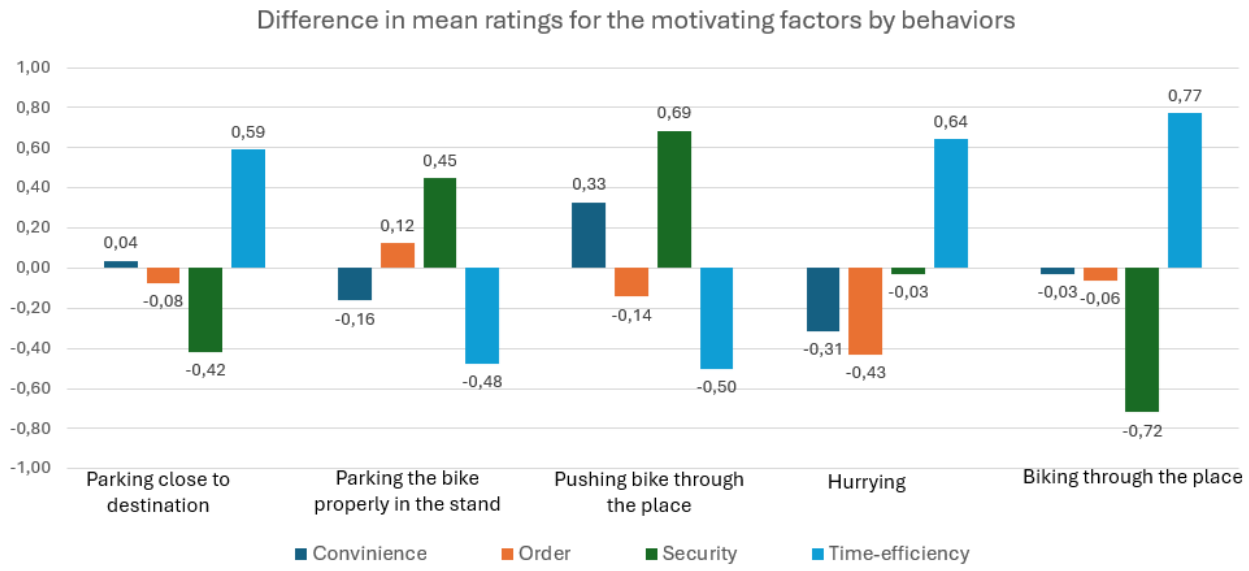


Figure 6.19: User perspective on the different motivating factors of bike parking (Own Diagram from interviews)

Connecting behaviors and motivating factors

By analyzing the different behaviors together with the motivating factors, it can reveal which behaviors might be associated with which motivating factors. So, in the following, those participants’ preferences regarding the motivating factors are analyzed who reported to do certain behaviors. The Likert scale is translated into numbers, so “Very important” equals 5 and “Not important at all” corresponds 1. Only the top 5 behaviors are considered for this analysis as the rest of behaviors were performed by less than 10 participants, thus does not live up to validity concerns. The participants, who parked close to the destination (performed by 15 participants), rated Time-efficiency 0,59 higher than the mean ratings. Moreover, they rated Security as less important by 0,42 points than the mean. The participants who performed “Parking their bike properly” valued “Security” more by 0,45 than the mean. However, they devalued “Time-efficiency” by 0,48. Participants with the “Pushing bike through the place” behavior value Security

by 0,69 higher than the mean and value Time-efficiency 0,50 lower than the mean. Furthermore, the participants with “Hurrying” value Time-efficiency 0,69 higher and devalue Order by 0,43 points than the mean. The participants who perform “Biking through the place” value Time-efficiency substantially higher by 0,77 points and devalue “Security” similarly by a large 0,72 points compared to the mean.



Motivating factors	Convinience	Order	Security	Time-efficiency
Mean rating	4,029	3,143	3,886	4,143

Figure 6.20: Difference in mean for each factors per transport hubs (Own Diagram from interviews)

Perspectives on underground bike parking

At the two stations where there is an underground bike parking (Aksel Møllers Have and Nørrebro station), the participants where asked if they are aware of that there is the underground parking. The majority of the participants reported that they were aware of it, 71% of them to be exact.

The second question aimed to explore that reasons behind why users normally do not use this infrastructure. (This question were asked from the users of Enghave Plads, even though there is not an underground parking at that transport hub.) The most common answer were “*Inconvenient*” with 69%, followed by “*Time-consuming*” with 57% of the participants and “*No benefits*” with 51%. Between these answers and the rest, there is a notable gap as “*Feels unsafe*”

received only 17%. There has been 11% of the participants who answered differently, than the premade options and only 6% answered that it was difficult to get around down there.

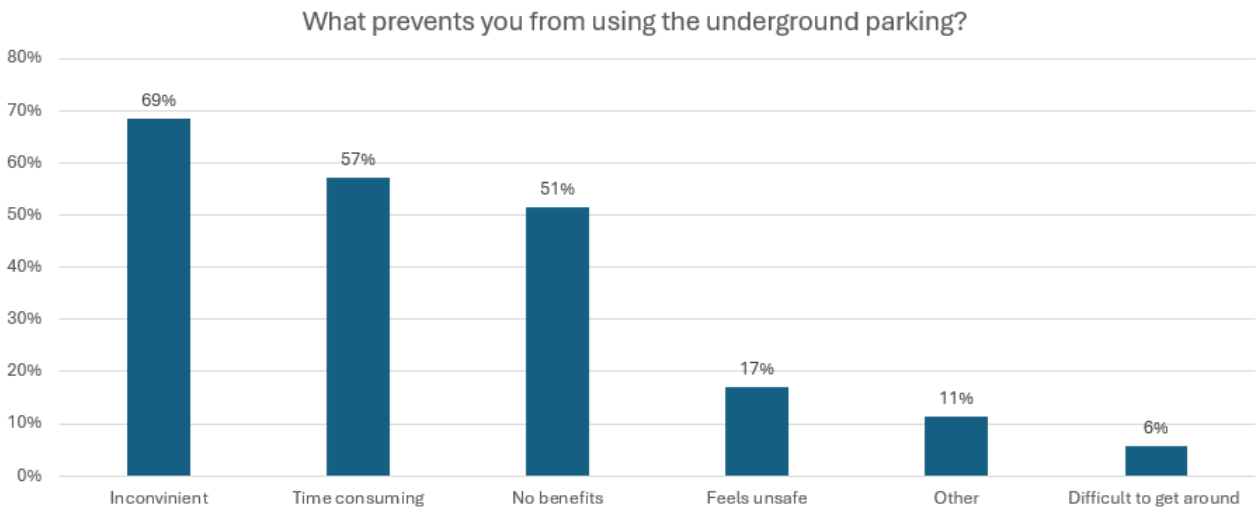


Figure 6.21: The factors that prevent participants from using the underground bike parking (Own Diagram from interviews)

In terms of the other option, the few opinions, that were voiced, pointed out issues that have not been touched upon in the premade options. One says that the underground parking does not accommodate atypical users such as cargo bikes. Furthermore, another participant directed to the issue of steep stairs which go beyond inconvenience and pose a serious difficulty for some user groups.

User suggestions for improvements

The participants were presented with an open question at the end of the survey to let them freely voice their suggestions regarding improvements at the transport hubs. Out of the 35 participants 14 have answered this question. The answers were rooted in the attitude that was revealed in the previous section.

Lack of bike parking capacity

The majority of the answers were focused on the capacity issues and wished to get it resolved. Some of the answers pointed simply towards the problem of not having enough capacity and wished for improvements there. As the following quote represents: ” *…here are a lot of bike stands missing, especially from in front of the station building…”.* Other opinions directed the focus towards the location of bike parking and the distance between the metro/S-train entryways. As it was seen in Section 6.1, the bike parking capacity is utilized to a higher degree at these entryways, and as moving away they are utilized to a lesser and lesser degree. Likewise, as time-efficiency and convenience were named as major motivating factors for the participants, this area for improvement fits into the picture. As one participant puts it ”I am wondering why they can't put stands next to the metro stairs”. These suggestions aim for bike parking in the direct proximity of the metro/S-train entryways, such as next to the metro stairs.

Lack of security

As it was discussed in Section 6.1, in the wider context of Copenhagen bicycle theft represents a widespread problem. As 40% of participants said that they were either dissatisfied or very dissatisfied with security at the transport hubs. At the same time, 72% of the participants reported that security at the transport hubs is either important or very important for them. The combination of these factors foreshadows that some participants named security as an area for improvement. This participant, for example, says that “*I wouldn’t mind more security here, my bike got stolen multiple times”.*

Other issues

Other than the aforementioned wishes for improvements. Some participants named the issue of lack of diversification, specifically in regards to the parking of rental bikes or in regards to cargo bikes in the case of another participant. Another participant emphasized that at Nørrebro station the fly-parked bikes take up too much space, and are in the way of the flows. A third participant points out that at Enghave Plads pathways for bikes are missing on the West end of the square.

7 Discussion and findings

7.1 The culture of time and convenience maximization

The observations showed that the distance from the metro/S-train entryways together with cyclist flows were two strong determinants of where the bikes are parked. The proximity of the entryways is a favored area by users to park their bikes. This is well demonstrated by the distribution of bike stand capacity utilization at Aksel Møllers Have and Enghave Plads. The stands close to the entryways were the most utilized and moving away from the entryways they were less and less utilized. Similarly, the fly-parked bikes were the most prevalent close to the entryways at Aksel Møllers Have and Enghave Plads, typically on the side walls of stairs or elevators leading to the metro/S-train. At Nørrebro station, this was slightly different as the station does not have any stands on the East side of the station. This is important because of the flows, which similarly to the distance from the entryways shows a connection with where the bikes are parked. Hence, at the East side of this station, a large flow of cyclists goes through which results in a high number of fly-parked bikes. Similarly, at the rest two stations there was a similar pattern revealed. The importance of the distance to the entryways and the cyclist flow reveals a discrepancy between the users' behavior and the layout of the bike parking stands. Hence, this results in empty bike parking and fly-parked bikes. However, parking bikes close to entryways comes with an issue that has prevented planners from placing bike stands at the entries and that is pedestrian flows that surround the entries as it was described in Section 6.1. Consequently, Gottlieb Paludan Architects & Rambøll (2022) advise setting up bike-free zones around the entries.

The interviews helped to shed light on the attitude of the users, hence, offering some explanation for the observed pattern of bike parking. It was revealed that the most important values for the users were time-efficiency and convenience, which are in line with the observed behavior. Time-efficiency (with a mean value of 4,143 on the Likert scale) and convenience (with a mean value of 4,029) were named as the most important values for bike parking by the interview participants. This aligns well with Larsen's analysis of the bike parking culture in Copenhagen since he also names time-efficiency and convenience as fundamental factors for users (Larsen, 2017). Moving from the small scale of bike parking to the level of journeys, a similar picture is revealed. Minimizing distance, time, or effort in non-motorized travel are major motivating factors (Næss, 2012). This rational behavior can be regarded as utility maximizing. Such rationale is the

foundation of user needs in transportation according to Allen et al. (2019). Additionally, one of the findings of The National Science Center for Cycling Promotion reveals that 80,06% of their survey participants choose active transport such as cycling because they think 'It is fast and easy' (Det Nationale Videnscenter for Cykelfremme & Syddansk Universitet, 2023).

An alternative explanation for why cyclists might choose to park their bikes in the proximity of large flows of pedestrians or cyclists is that they hope to have their bikes surveilled by by-passing people (Buehler et al., 2021).

7.2 The compromised culture of security

Security of the parked bikes was rated as the third most important value by the interviewees with a mean of 3,88 and with 72% of them rating it a "Very important" or an "Important" factor. This in conflict with Larsen's understanding of the importance of security which deems security as a less significant value for the bike parking in Copenhagen. He bases his argument on the fact that bikes are rarely locked to bike stands and mainly low-security O-locks are used for securing the bikes (Larsen, 2017). This is something that has incidentally been observed in this research as well. So, then a discrepancy is revealed between the observed behavior that the users do to secure their bikes and their attitude towards security. Furthermore, the fact that the users reported low satisfaction regarding the level of security at the three transport hubs implies that most users see security as not their own responsibility to improve.

An effective tool to mitigate the security concern of users is to deploy video surveillance at the bike parking areas as users prefer to park their bikes in areas with video surveillance (Buehler et al., 2021). According to Larsen, however, bike theft is a complex social problem instead of an issue that is not easy to solve with new design interventions. From the thieves' side, many of them do not feel discouraged from stealing a bike as only a few are punished for it. Bicycle theft is not treated as a serious crime by authorities and often goes without consequences. From the users' side, in Copenhagen, the majority of bikes are cheap and poorly maintained which are suitable for shorter bicycle journeys (Larsen, 2017). Hence, these bikes in most cases are only secured with an O-lock. 72,58% of the bikes were secured this way according to the bike counting. This makes bikes easy targets for theft as thieves can disable these locks with ease compared to more robust locks such as chain locks which were observed on only 16,13% of the parked bikes. Moreover,

there were only a few bikes locked to the bike stand, only 2,49% of the counted bikes. At Nørrebro station, there is a lack of enough bike parking stands, or for that matter, in other parts of Copenhagen according to Larsen (2017). The lack of adequate parking infrastructure goes hand in hand with these low-value bikes as they are in danger of being damaged by being knocked over in case of overcrowded stands, or being scratched or bent. This environment in turn can contribute to the hegemony of cheap bikes and discourage the parking of expensive bikes such as road bikes, electric bikes, and cargo bikes (Larsen, 2017). The bike counting of this study can back this as only 2,34% of the counted bikes fit one of these categories. According to Larsen (2017), this is in contrast with the practices in Amsterdam where most users lock their bikes to the bike racks even if bikes are indeed low-value.

7.3 Hierarchy of the needs of bike parking users

As it was described in Section 2.3, the needs of the users regarding transport can be ranked in hierarchical order just like in Maslow's hierarchy of needs model. Based on the models of Alfonzo (2005), Allen et al. (2019), and Van der Spek & Scheltema, (2015), as well as the findings of this research, a hierarchy of needs model was developed specifically concerning the bike parking needs. As the utilitarian factors of time-efficiency and convenience were rated the highest among the motivating The observations and interviews together showed in the forms of fly-parked bikes and answers aimed towards the improvement of the bike parking's location. Accessibility, capacity, and proximity to the station are the components that can satisfy these needs. Next, is security of the bikes was rated as a less important factor, however, still is a fundamental value for the users. The specific measures that can improve the protection of the bikes have been dealt with in the previous section. Order and the services that can raise the comfort level of the users are the least essential for the users.

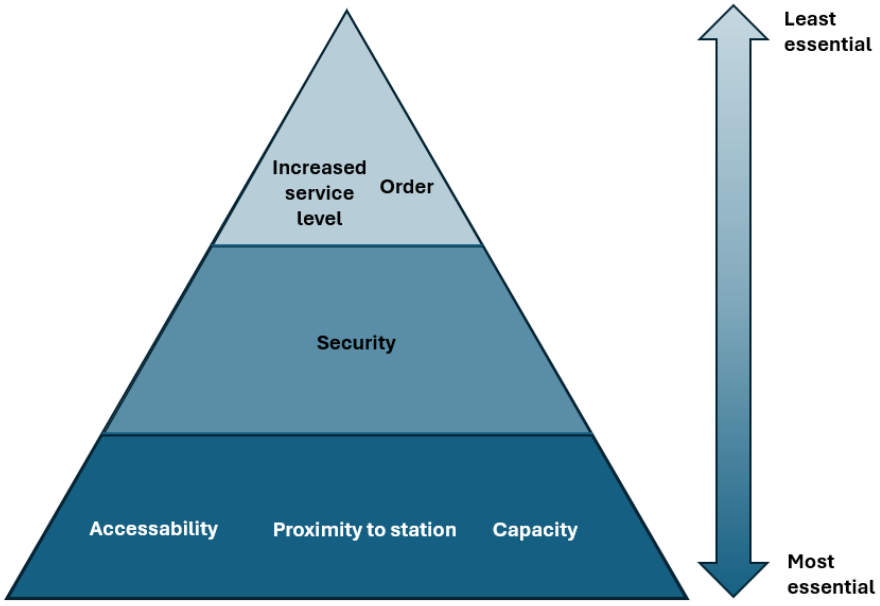


Figure 7.1: Ways to distribute the place between the different uses (Own Diagram from bike counting)

7.4 Bike parking as a scene for the conflict of fixities and flows

On the one hand, bike parking is intertwined with mobilities as parking the bike is the absence of movement between two phases of mobility (Larsen, 2017). On the other hand, bike parking is embedded in place (Lassen & Laursen, 2020). As described in Section 2.2, for mobile people place and fixities can be experienced as obstacles for their mobility (Jensen, 2013). If the bikes are fly-parked in the way of the flows of people, they can create hindrance to mobile flows of cyclists and pedestrians. The bike counting showed that fly-parking is a widespread issue at the three transport hubs. The most prominent one is at Nørrebro station where 315 bikes (corresponds to 60,23% of the bikes parked there). In terms of spatiality, this issue is the most notable in the proximity of the entryways of the metro and S-train. This, however, is not unique to these transport hubs, but rather a common problem all around Copenhagen. As it was previously discussed, this behavior is motivated by convenience and time-efficiency (Larsen, 2017).

The distribution of shared vehicles such as shared bikes and e-scooters was significantly higher among improperly placed bikes (including fly-parked bikes and bikes wrongly placed in the bike stands). This might be explained by the notion that users tend to take less ownership of shared products which results in lower responsibility and higher misuse towards them (Zhao et al., 2023). The fly-parked e-scooters made a chaotic scene in Copenhagen in 2019 which resulted in new laws regarding the parking of e-scooters (Nathan & Holmen, 2019). Nonetheless, shared vehicles often come with more misbehavior (Zhao et al., 2023).

The scope of this study focused on the problems of the bike parking infrastructure at the three transport hubs from the perspective of the users. Actors and their interactions have a crucial role in constructing place. However, different actors have different claims for their own uses over place (Petzer et al., 2021). As such, bike parking influences a great deal of different stakeholders, other than just the users, with different roles and attitudes towards the issue of bike parking (Petzer et al., 2021). Fly-parked bikes present an issue for other groups of users who might not park their bikes at the transport hubs (Petzer et al., 2021). For that matter, bike parking itself takes up a significant amount of space at the hubs, hence, taking up the space from other uses. This is the most visible at Enghave Plads where the square is often filled with people, especially in case of good weather. The street furniture is often occupied. Families and playing kids utilize the space at the square.

The current situation relies on the notion of space appropriation between fly-parking, pedestrians and people who use the place for other purposes. This way the usage of the urban space is negotiated by occupying it for the different uses. Moreover, from this point of view, place is not just a physical space but a construct that is shaped by actors and institutions. Space is a finite resource in an urban environment so when space is taken up by one socio-technical system like bike parking it takes it away from another like walking (Petzer et al., 2021).

7.5 The reason why underground bike parking is underutilized

One premise of underground bike parking is that it can free up valuable public space. Another is that it can offer higher security for parked bikes. Furthermore, it might bring order as opposed to the chaotic conditions at Nørrebro station for example (Gottlieb Paludan Architects & Rambøll, 2022). However, the bike counting revealed that these facilities are immensely underutilized. Then, mapping of flows revealed that the entryways to the underground parking are at secluded areas of the transport hubs. In other words, they fall outside most of the cyclist flows. Additionally, the interviews showed that the participants' opinions coincide with their general perspective toward bike parking. Precisely, they problematized the time-consuming nature, inconvenience, and lacking benefits of the underground bike parking. Furthermore, some of the participants pointed out that the accessibility of the underground parking is problematic for cargo bikes, other atypical forms of micro-mobility, or for weaker users who might have issues with pushing up and down the bike the steep stairs. However, certain underground bike parking or bike parking systems are successful in the Netherlands. The examples mentioned in the research of Van der Spek & Scheltema (2015) underground parking or other parking facilities were matched with enforced restrictive measures, so the users are compelled to use the underground parking. More on this in the next section.

7.6 Possible measures to alleviate the downsides of bike parking at the three transport hubs

As of now, the different user groups appropriate the space that they use. Consequently, if fly-parked bikes are placed in a certain space at the transport hubs, that space cannot be used for other purposes. As an alternative spaces can be allocated for different uses. In other words, the space for bike parking can be restricted (Petzer et al., 2021). Or another tool to alleviate the downsides of the bike parking at three transport hubs is nudging. Considering the concept of

affordance, the physical environment allows for or even guides behavior (Bendix Lanng & Jensen, 2022), so by altering these affordances, the new environment can bring new behaviors. Nudging can theoretically guide users not to fly-park or to use the underground parking by changing the affordances of the transport hubs.

The following diagram shows the different ways of how space can be divided between the different uses. The different types of nudging techniques are discussed further on.

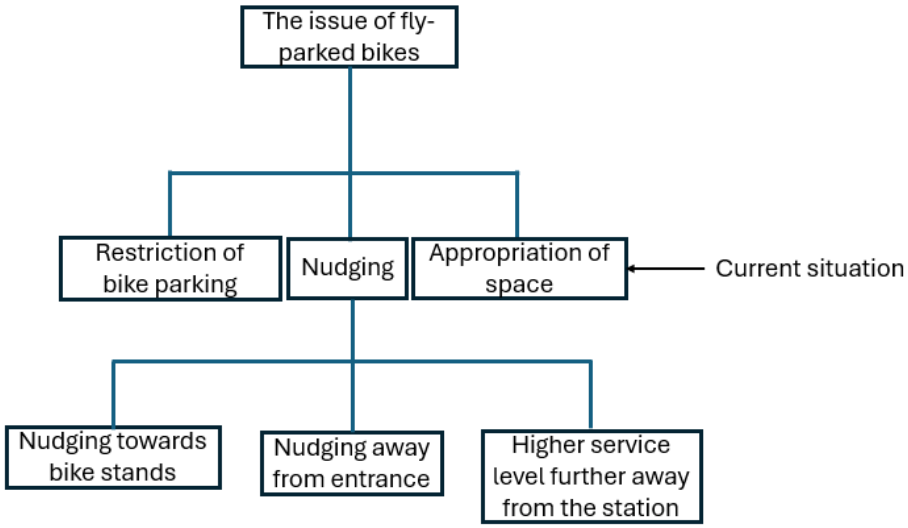


Figure 7.2: Ways to distribute the place between the different uses (Own Diagram from bike counting)

In terms of space allocation, there are examples that proved to work in other contexts. In case of street-level bike parking, the bike parking area can separated from the rest of the environment with lines and signs indicating the boundaries of the area which are the applied solution in multiple spots in the Netherlands (Van der Spek & Scheltema, 2015). Or in the presence of bike parking systems or underground bike parking informal bike parking can be banned altogether (Buehler et al., 2021). This is done by putting up signs and enforcing the rules in the area (Van der Spek & Scheltema, 2015).

Regarding nudging, there are different types that can be considered. The types of nudging can be differentiated based on which brain function they communicate with. Decisions regarding behavior are taken by either using cognitive system 1 or 2. In the case of system 1, the decisions are intuitive, fast, and not well-considered. System 2 however refers to a slow and conscious

process of thinking (Bandsma et al., 2021). Regarding this research, it can be said that the user attitude such as being motivated by time-efficiency is the result of the longer thinking process of system 2. Nonetheless, system 2 can be also targeted by nudging (Bandsma et al., 2021). According to Wind (2014), a change in the environment, such as a nudge can stop the loop of a habit and initiate the rethinking of the habit. Additionally, educative nudges can be also applied to system 2, which informs the users about the results of their behavior, thus anticipating that the user considers these information when making their decisions (Bandsma et al., 2021).

Let us consider now, specific nudges that have proven to guide the bike parking in a more organized manner, thus decreasing the number of fly-parked bikes, especially around the metro/S-train entryways. Most nudging is aimed at system 1 since then the user just acts on quick stimulus (Bandsma et al., 2021). These nudges often materialize in small changes to the environment that alter how much effort it takes for the user to do a behavior. If it takes more effort to conduct a behavior, the subconscious decision of the user might guide them not to do the behavior. This type of nudging is relevant since convenience was the second most highly rated motivating factor. According to Gottlieb Paludan Architects & Rambøll, (2022), this can be done in multiple ways. One way is to raise the pavement height around the metro/S-train stairs, escalators, and elevators. This way it takes more effort for the users to take their bike to the entries. At the same time, it is important to nudge the users towards the bike parking areas. This can be achieved by creating clearly defined and separated bike parking areas. A good example of this in Copenhagen is Nørreport station where the bike parking areas are clearly defined. Moreover, the bike parking areas are sunken slightly lower than the level of pavement to nudge the users towards them (Gottlieb Paludan Architects & Rambøll, 2022). Another significant aspect of this solution is the bike parking pollutes the landscape less as it is slightly sunken below the normal level of the pavement. There is another type of nudges that works by making it more beneficial for the users to take their bikes further from the entryways. Incentive nudges specifically refer to positive experiences that reward users who conduct a certain behavior (Bandsma et al., 2021). This can be done by offering better bike parking services at the bike stands that are further away from the metro/S-train entryways. One solution for this is constructing bike parking areas with roofs further from the metro/ S-train entry (Gottlieb Paludan Architects & Rambøll, 2022). This is relevant since weather can significantly damage bikes (Larsen, 2017), and at the same time, it raises the comfort level for

users (Gottlieb Paludan Architects & Rambøll, 2022). Another solution is to establish lockable bike parking as security is a high concern of the users and only 29% of the users were satisfied with the current level of bike parking security at the three transport hubs. Yet another option is to put up bike stands with more space between them since it was observed that 8,81% of all parked bikes at Aksel Møllers Have and Enghave stations were not correctly placed in the bike stands. Additional services can be also placed at bike parking areas further from the stations such as charging points for electric bikes or reparation points for bikes (Gottlieb Paludan Architects & Rambøll, 2022).

7.7 Quality of research

The quality of research is built up of two main components: reliability and validity. Reliability means both internal and external reliability. Internal reliability refers to the ability to ensure consistency in the research process through transparent and consistent data collection and analysis practices, while external reliability is the capacity to replicate the research results by repeating the study under the same conditions. Validity refers to the accuracy and appropriateness of the research methods and analysis as well as the generalizability of the findings. Validity can be divided into internal and external validity. Internal validity is the degree to which the findings can be attributed to the variables being studied, rather than other factors. External Validity is the extent to which the research findings can be generalized to other contexts, settings, or populations. Furthermore, ethical standards including obtaining informed consent from participants, ensuring confidentiality, and minimizing harm need to be ensured (Saunders & Lewis, 2019).

The aforementioned criteria were considered during all stages of this research including planning, data collection, data analysis, and interpretation of the findings. In the following an account is provided of what measures were taken to ensure a high quality of research.

Starting with internal reliability, as only one researcher conducted this study. It is irrelevant to discuss consistency between multiple researchers. There has been special attention paid to consistent data collection across the observations and interviews. More precisely, regarding the observations clear and well-defined categories were applied. Similarly, the categories and the terms in the interviews questions were defined based on the theories, thus an overall consistency was sought. In terms of external reliability, this research aims to give an accurate and detailed

documentation of the research structure, methods, and analysis, as well as the conditions of this research. Hence, making the research possible to be replicated. Internal validity was established by being careful about establishing causal relationships as well as being consistent with using the same methods for all observations and participants, hence, ensuring comparability across them. Regarding the questionnaire, special care was taken to translate the theoretical terms and concepts into the wording of the questionnaire. External validity was pursued by conducting the research across three different transport hubs with bike parking and choosing participants randomly for the interviews. This way the findings of this research are applicable to a wider context than only this research.

In terms of biases, the researcher bias was considered and accounted for during the research process. The research was conducted with the participant bias in mind and measures were taken to mitigate this bias by randomizing the options for the questions during the interviews. Furthermore, participant error, namely, the settings of this research is something that might have influenced the participants' answers since many interview participants were hurrying as they were stopped in the middle of their travels.

7.8 Limitations

Several limiting factors were come across with during the research. It is crucial to recognize and address the limitations that may have affected the data integrity and quality of research. Hence, they put a constraint on the interpretation and generalizability of the findings.

During the literature review phase of this research, a great deal of factors were identified that can influence travel behavior including habits and social influence. While it could have been beneficial to incorporate these factors into the research to gain a more comprehensive understanding of travel behaviors. However, researching habits involves a fair amount of challenges (De Houwer, 2019). Moreover, this research design may not have been suitable for such research.

The timeframe of this research project has posed a restriction on how many rounds of bike counting were possible to be conducted. This is relevant as the number of bicyclists can fluctuate in a year. In the summer for example there are more people cycling than in the winter (Tin Tin et al., 2012). So, if there were a study that has conducted the bike counting across different months

of the year or different seasons of the year, the could be revealed different degrees of bike parking utilization.

Similarly, weather can influence the number of people who cycle in a day. According to The National Science Center for Cycling Promotion, 32,05% of the cyclists in Copenhagen experience bad weather as a barrier to cycling (Det Nationale Videnscenter for Cykelfremme & Syddansk Universitet, 2023). Hence, this weather might have influenced how many parked bikes were counted in the days when the counting took place.

The circumstances of the interviews posed a constraint on how many people this research was able to recruit as participants for the interviews. Many potential participants opted not to take part in the interviews. This might be the result of the hurrying during the interchange between bike and metro. Consequently, they did not have time to stop and participate in the interviews. On this note, the length of the questionnaire was also kept relatively short, 2-3 minutes to conduct to interviews to be exact. Nonetheless, as already mentioned, this length was already too extensive for some potential participants.

8 Conclusion

This research investigated how the design of Aksel Møllers Have, Enghave Plads and Nørrebro station supports bike parking. By conducting the research a multifaceted picture was unfolded. To investigate the primary research objective, a three-fold focus was applied with the user point of view in focus. More precisely, the different types of bike parking behavior that the users perform, the attitudes underlying these behaviors, and the extent to which the transport hubs meet the needs of bike parking users.

Types of Bike Parking Behavior

The research identified several distinct types of bike parking behavior at the three transport hubs. Firstly, proximity to entryways and the flows of cyclists emerged as a key determinant, with cyclists favoring spots close to metro and S-train entrances. This preference was evident in both the formal use of bike stands and informal 'fly-parking' against walls and staircases. Furthermore, the bike stands further from the entryways and the underground bike parking were underutilized. Nørrebro station, which lacks stands on its east side despite high cyclist flows, highlighted a

different pattern where a substantial number of bikes were fly-parked. Overall, the majority of the observed and reported behaviors reflect rule-following and orderly behavior. While a small fraction of behaviors foster disorder by not properly parking their bike in the stands or by fly-parking their bikes.

Underlying Attitudes for Identified Bike Parking Behaviors

The interviews with users revealed that time-efficiency and convenience are the most critical values influencing bike parking behavior. They are the underlying motivations for the users to hurry, bike through the station, and to park their bikes close to the metro/S-train entryways. Regarding security, although the most interview participants rated it as important, it did not significantly influence the choice of locks, as the widespread use of low-security O-locks was observed. Hence, despite security being rated highly in the interviews, the actual behavior showed a lower priority for more robust security measures, suggesting that users expect authorities to provide a secure environment. Concerning order, fly-parking and other transgressive behaviors have been widely observed. This is also reflected in their preferences as the interview participants see order as a less important factor.

Accommodating the Needs of Bike Parking Users

The three transport hubs demonstrate varying levels of effectiveness in accommodating the needs of bike parking users. Aksel Møllers Have and Enghave Plads have bike stands near entryways that are well-utilized but stands further away are often empty. Moreover, fly-parked bikes are often parked close to the entryways which can interfere with important pedestrian flows. Nørrebro station is a dissimilar transport hub compared to the two other as it faces a more significant challenge with a lack of bike stands on its eastern side, resulting in a high number of fly-parked bikes. Additionally, the lack of diversification of the bike stands were also named by participants as a favored area for improvement. In terms of underground parking, the users choose not to use it as it was deemed time-consuming and inconvenient as well as accessibility and diversification-related issues were revealed. In addition, several measures were considered for the improvement of the bike parking facilities and its surroundings based on the described situation and wider theoretical insights. By either allocating clear boundaries for the different domains of the

transport hubs or by incorporating nudging elements into the bike parking design, new behaviors can arise.

8.1 Outlook

Building on the findings of this study, several avenues for future research opens up. So, in this section, the potential areas are further research are explored. In addition, the particularities of this research's design are contrasted with alternative approaches as several aspects could have been addressed differently.

In terms of the scope, a multitude of different areas could have been insightful to research. Bike parking is a complex object to research as it is intertwined with a complex network of human and non-human actors. However, the scope has been limited to the users' behavior, attitude, and the affordances of the bike parking facilities. Thus, leaving out other human and non-human entities that influence of influenced by bike parking. This includes urban planning practices which are particularly challenged by unclear responsibilities between different organizations. Or other user groups such as pedestrians or users who socialize or recreate in these urban environments. The involvement of a wider array of user groups can be potential future research as it can provide a more comprehensive overview how bike parking affects other users. In addition, a deeper analysis of the nudges and their effects can be a direction for future research.

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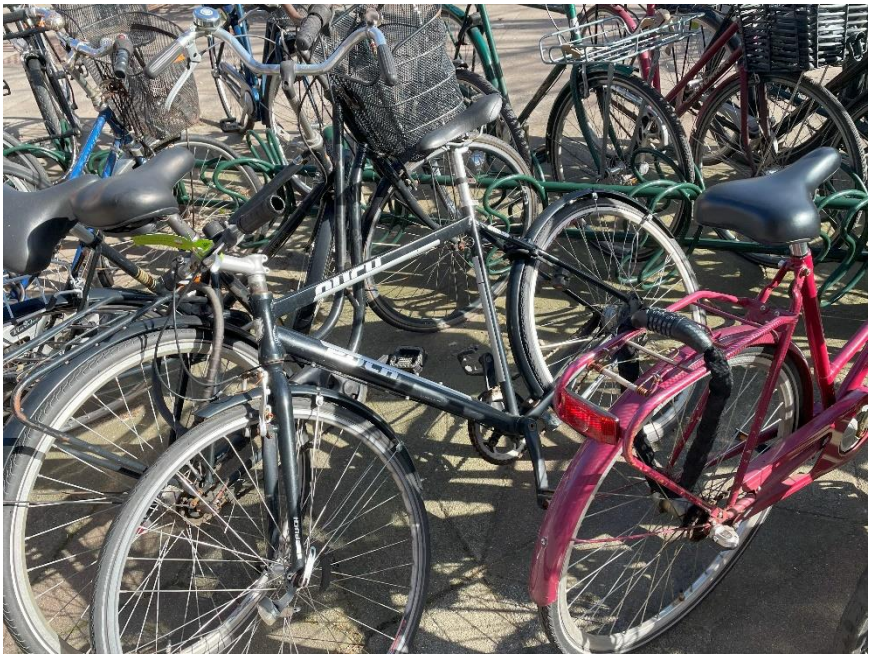
Appendix

Appendix A: Images of the transport hub

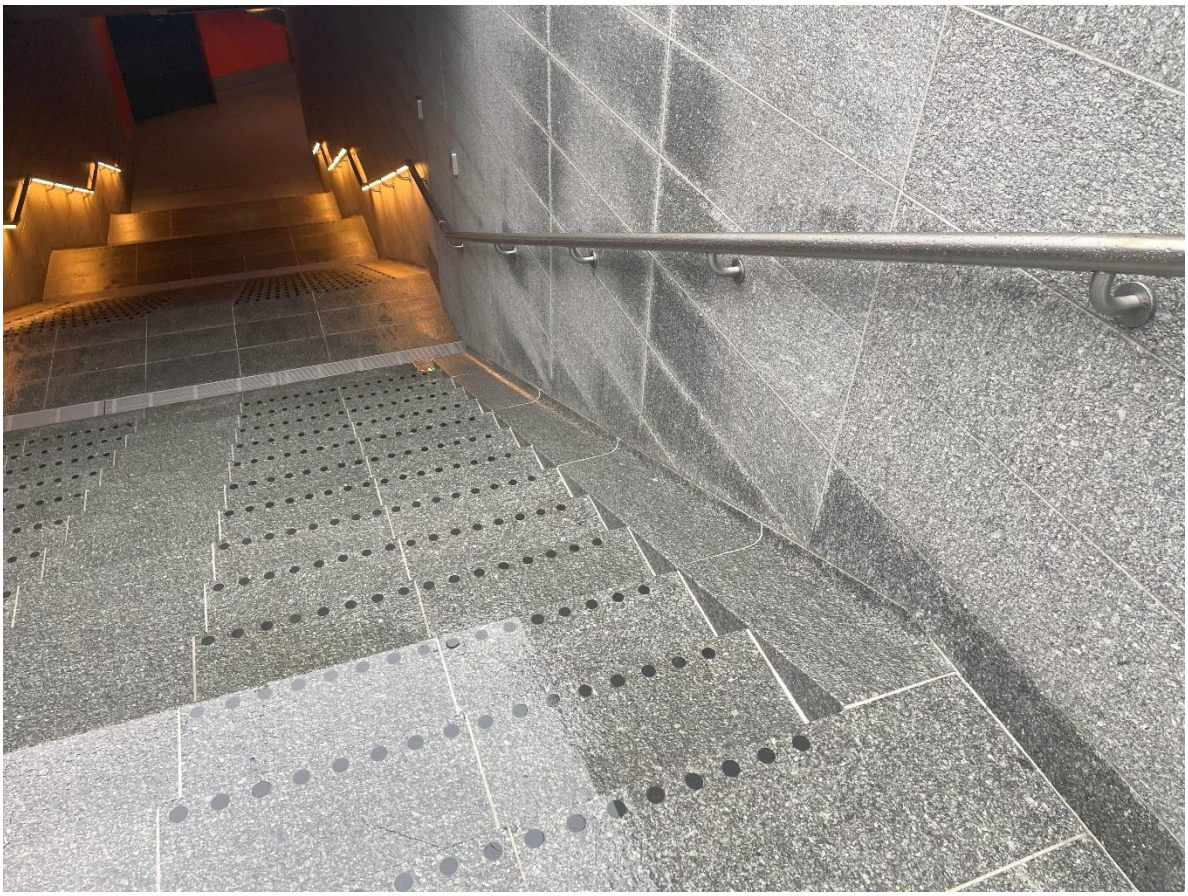
Images of Aksel Møllers Have:

Narrow and fly-parked alleyway between the bikes

Bikes tipped over at Aksel Møllers Have



Another example of the same issue



The stairs leading to the underground bike parking

Limited signage regarding the underground bike parking

Images of Enghave Plads:

Many fly-parked 'Donkey' rental bikes at Enghave Plads

More fly-parked bikes at Enghave Plads

Lively urban life at Enghave Plads

Cargo bike parked at the normal bike stands at Enghave Plads

Nørrebro station

View from the S-train station at Nørrebro station

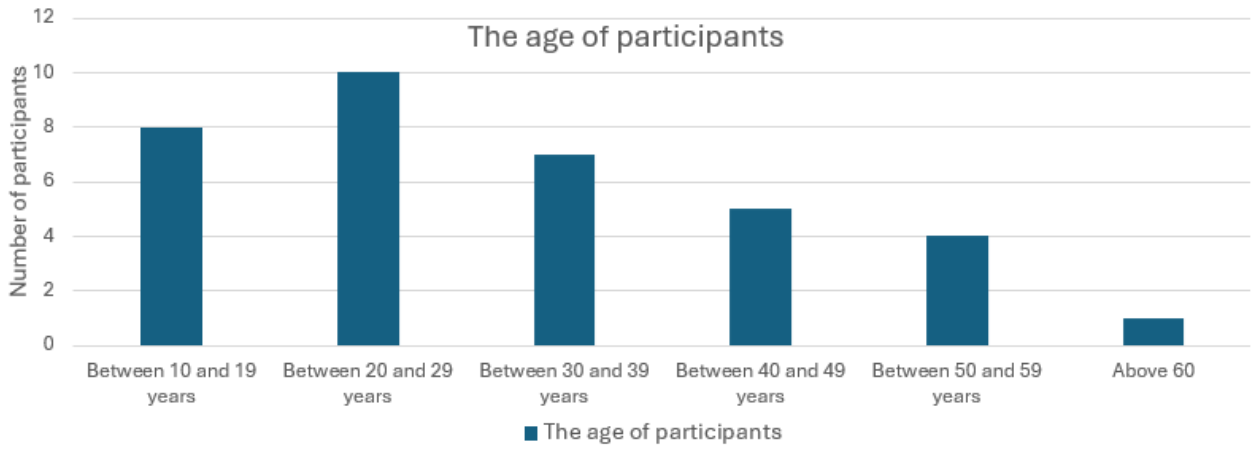
Fly-parked bikes organized into two orderly rows by users

Appendix B: Additional diagram for interview results

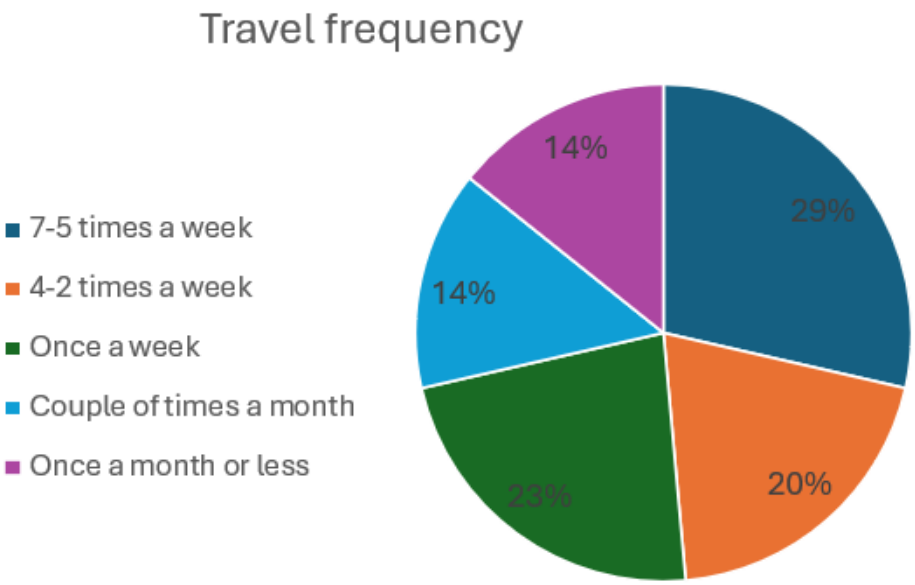
Daily passenger numbers of the three transport hubs (Breinholm Christensen, 2024)

Station	Passagertal pr hverdag	Passagertal pr weekenddag	Samlet passagertal 2023
Nørrebro	9980	7450	**3240101**
Enghave Plads	8090	6670	**2711630**
Aksel Møllers Have	4130	3300	**1434077**

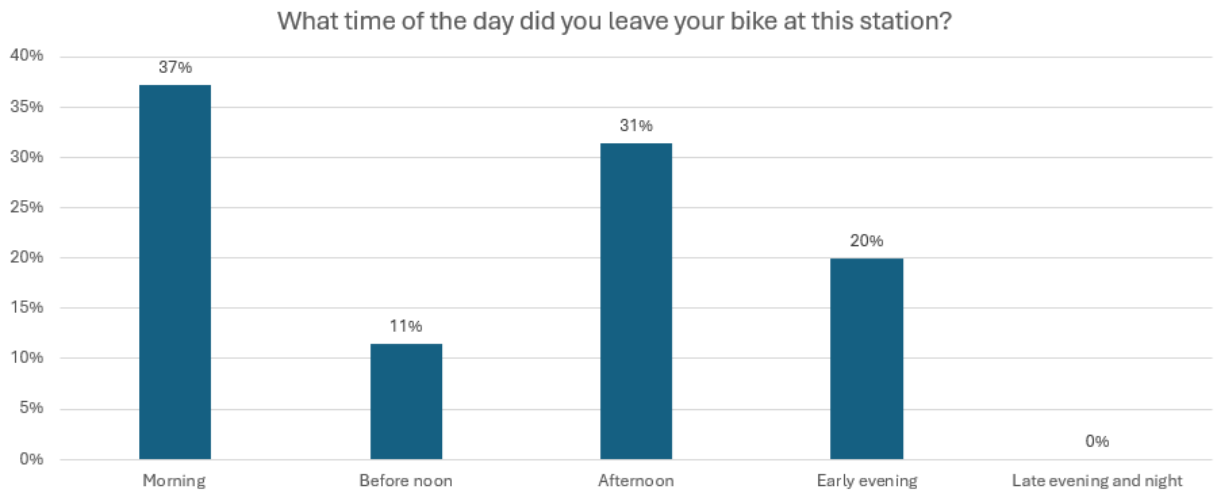
The distribution of the age of the participants (Own Production)



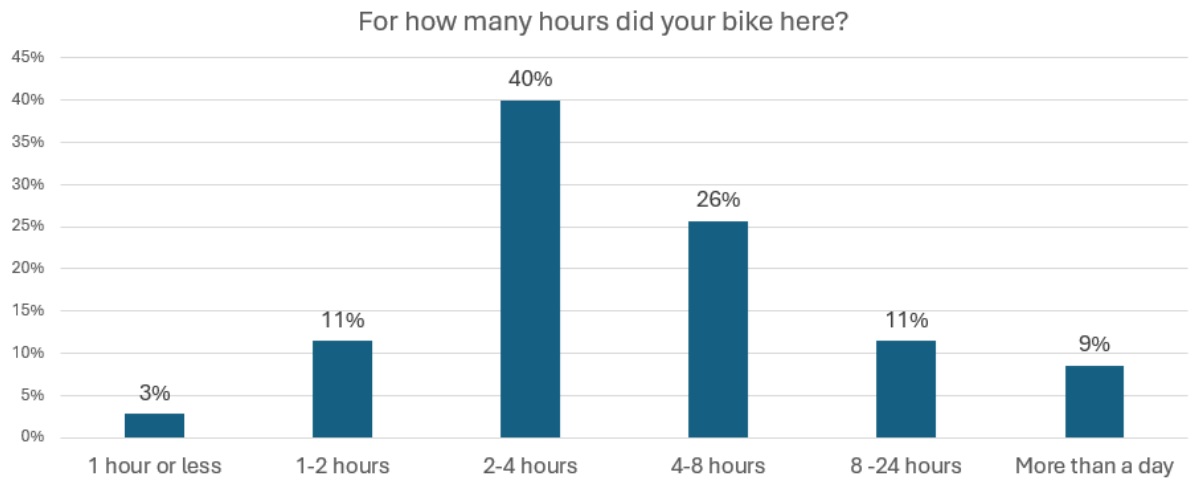
Travel frequency (Own production)



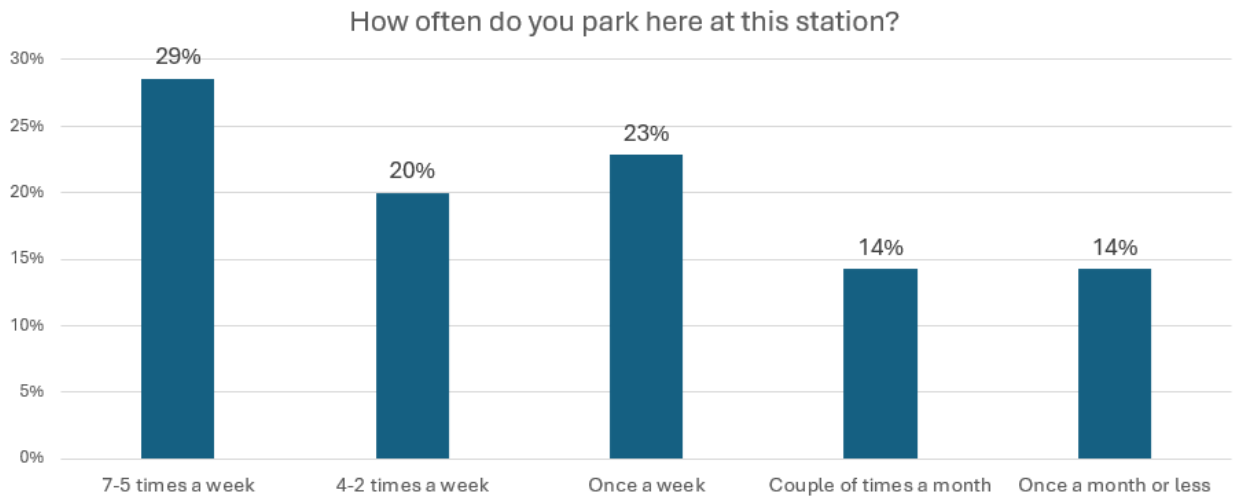
Which part of the day do cyclists park their bikes at the transport hubs? (Own production)



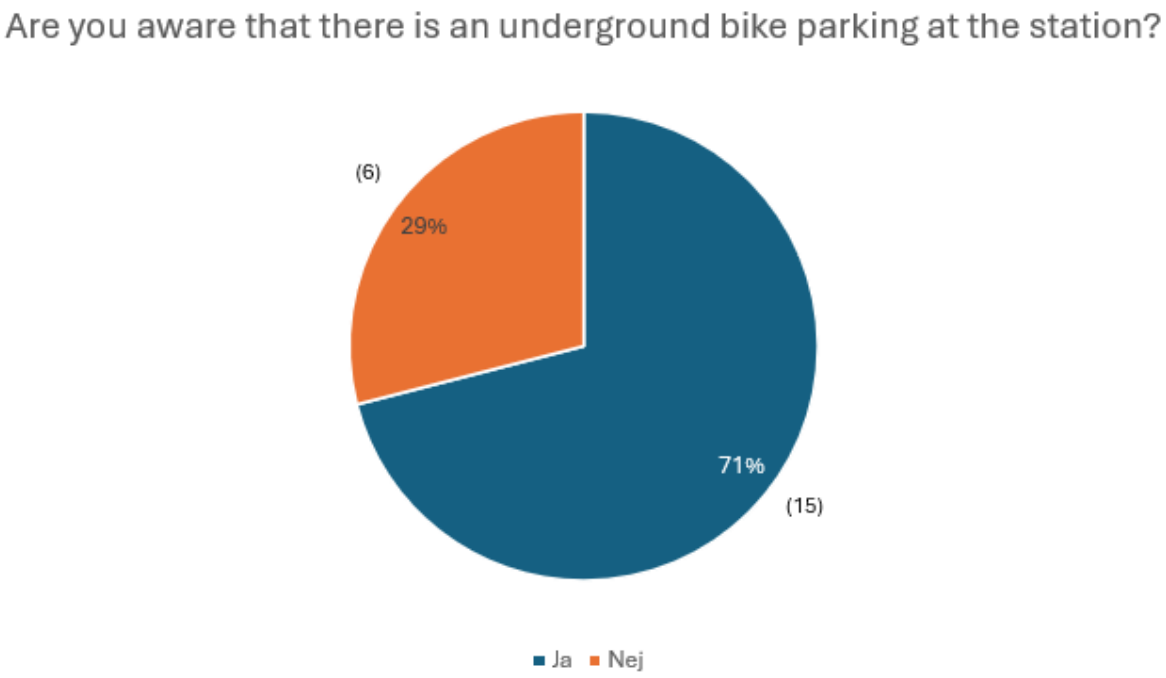
For how many hours do participants park their bikes at the transport hubs? (Own production)



How often do the participants park their bikes at the transport hubs? (Own production)



Are the participants aware of the underground bike parking? (Own production)



Behavior matrix (Own production)

Bike parking behavior matrix				
Observed behavior	Time maximization	Security	Rule-following/Order	Convinience
Cycling through the place	X			
Putting cover on bike seat				X
Putting bike in stand properly		X	X	
Parking close to destination	X			
Hurrying	X			
Taking time				X
Pushing bike though the place		X	X	
Locking bike to the stand		X		

Appendix C: Data from observations

Table for bike stand utilization at Enghave Plads:

Bike stand	1	2	3	4	5	6	7	8	9	10	11	12
Capacity	17	17	17	17	17	17	17	17	17	17	17	17
Utilizied	15	15	15	17	17	16	15	14	15	15	13	10
Percentage	88,24%	88,24%	88,24%	100,00%	100,00%	94,12%	88,24%	82,35%	88,24%	88,24%	76,47%	58,82%

13	14	15	16	17	18	19	20	21	22	23
17	17	17	17	17	17	17	17	7	15	17
9	8	3	2	5	4	4	7	2	11	15
52,94%	47,06%	17,65%	11,76%	29,41%	23,53%	23,53%	41,18%	28,57%	73,33%	88,24%

With the following link the data table with the interview results can be accessed: https://docs.google.com/spreadsheets/d/1Q5AdBIhnIdshTDR2lZNOkz2qfSKc6Eip/edit?usp=sharing&ouid=115940806326771540155&rtpof=true&sd=true

Appendix D: Interview structure

Demographics part

1. How many kilometers have you biked to this station or will you bike from this station to your destination?
2. What is your gender?

- Male
- Female
- Other:
- I don't want to say

3. What is your age?

Travel behavior

4. For what purpose do you park here with your bike?

- Living close
- Working close
- Need to go further with the metro
- Need to go further with S-train (only for Nørrebro station)
- Guest in cafes, restaurants and shops
- Other:

5. What kind of bike do you use to get around?

- Male city bike
- Female city bike
- Rental bike
- Electric bike

- Bike with child seat
- Cargo bike
- Other:

6. How often do you park here at this station?
- 7-5 times a week or more
- 4-2 times a week
- Once a week
- 3-2 time a month
- Once a month or less

7. What time of the day did you leave your bike at this station?
- In the morning (6-8:59 am)
- Before noon (9-11:59 am)
- Afternoon (12-15:59 pm)
- Early evening (16-17:59 pm)
- Late evening (18-night)

8. For how many hours did your bike here?
- 1 hour or less
- Between 1 and 2 hours
- Between 2 and 4 hours
- Between 4 hours and 8 hours
- Between 8 hours and 24 hours
- More than 1 day

User perspectives on bike parking

9. How satisfied are you with the bike parking at the station?
- Very satisfied
- Satisfied
- Neutral
- Dissatisfied
- Very dissatisfied

10. Which of the following types of behaviors do you engage in? You can choose multiple options
- Putting cover on bike seat
- Parking the bike orderly: putting the bike in the bike stand properly in the wheel-holder
- Parking close to the destination
- Hurrying
- Taking time
- Pushing bike to the stand
- Locking bike to the stand
- Biking to the stand
- Parking bike outside of bike parking area

11. How important are the following values for you in bike parking? Give a value between 1-5 to each. 1 is not important at all, 2 is not important, 3 is neutral, 4 is important, 5 is very important
- Convenience: Minimizing effort and inconveniences
- Time-efficiency: Reaching the destination as quickly as possible
- Security: Protecting the bike against theft
- Orderly parking: Promoting order in the bike parking

12. How satisfied are you with the following factors at the station? Give a value between 1-5 to each. 1 is Very dissatisfied, 2 is Dissatisfied, 3 is Neutral, 4 is Satisfied, 5 is Very satisfied 3
- Accessibility: Ability to conveniently make it to the bike stands
- Orderly bike parking: The bikes at the station are parked orderly
- Security: Perception that their bike is protected at the station
- Wayfinding: Easy to locate the desired destination at the station
- Distance between bike parking and destination at the station

13. Are you aware that there is an underground bike parking at the station?
- Yes
- No

14. What prevents you from using the underground parking?
- Inconvenient: Takes too much effort to bring the bike down and up from the underground bike parking.
- Timely: Takes too much time to go to and from the underground parking
- No benefits: Not enough benefits of using it
- Feels unsafe down there: Unsafe feeling down there. Not enough visibility
- Difficult to get around down there:
- Other:

15. What would you want to improve regarding the bike parking? Open question
16. Any other comments regarding bike parking? Open question

Appendix E: Data from interviews

With the following link the data table with the interview results can be accessed: https://docs.google.com/spreadsheets/d/1iXcB6fvPGDO8NInsMVrAHguXEaw6U2BC/edit?usp=sharing&ouid=115940806326771540155&rtpof=true&sd=true