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Department of Information and Computing Science

Human-Computer Interaction Master Thesis

Empowering Temporary Mobility-Impaired Travelers with Technological Accessibility Features for the Dutch Railway Systems

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Abstract

This thesis investigates the challenges and technological solutions for empowering travelers with temporary mobility impairments within the Dutch railway systems. Despite the extensive use of railways in the Netherlands, accessibility issues persist, particularly for those with temporary disabilities resulting from injuries, surgeries, or short-term health conditions. The research highlights the significant barriers and travel needs of these individuals, captured through interviews. Using a user-centered design approach that incorporates these challenges and needs, this study identified technological accessibility features to enhance perceived accessibility and independence for temporarily mobility-impaired travelers, thereby improving their overall travel experience. Key solutions include real-time updates on station crowding and elevator functionality, and a location-based immediate assistance button. By implementing these features, the redesigned NS Planner aimed to provide a more accessible and autonomous travel experience. The evaluation of these features through vignette studies showed significant improvements in travel autonomy and promising enhancements in perceived accessibility and travel experience. This research not only contributes to the field of Human-Computer Interaction but also offers practical insights for developing accessible transportation systems globally, ensuring that public transport becomes more inclusive for all individuals with mobility impairments.

Keywords: temporary mobility-impairment, accessibility features, perceived accessibility, independence, travel experience, dutch railway systems

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1. Introduction

In the Netherlands, over 1 million people use the railway system daily [63]. Trains are the most utilized mode of public transport in the country, with each resident traveling an average of 610 km by rail in 2021 [17]. However, within those, a number of individuals face challenges during their travels, confront barriers, or even avoid traveling due to mobility-related difficulties. There is an estimation of 130 million people worldwide with a physical disability that requires a mobility device (e.g. wheelchair, crutches) [30, 102] and this number is still increasing [13].

Limited or absent ramps, non-functional elevators or escalators, overcrowded trains, and platforms are among numerous challenges that may have minor or no impact on some, though they can pose significant barriers for people with mobility issues [74, 86, 102]. This situation leads to over half a million mobility-impaired individuals remaining restricted to their homes [102]. This results in facing barriers in education, employment, transport, and other areas, significantly limiting their activities [53]. This implies that accessibility is crucial for social inclusion and well-being [48, 78, 98], emphasizing that global goals extend beyond just mobility [77].

Therefore, it is crucial to empower mobility-impaired individuals using public transportation to ensure their journeys are more accessible to enable their independent participation in society.

1.1 Problem Statement

Current research focuses on individuals with permanent mobility impairments, examining their barriers/challenges [30, 32, 64, 72, 75, 79, 84], accessibility [3, 7, 22, 30, 32, 33, 37, 46, 49, 52, 53, 77, 78, 88, 93], and the importance of independence [19, 24, 32, 47, 52, 53, 59, 64, 68, 89, 91]. However, there is a significant gap in understanding the needs of individuals with temporary

mobility impairments, who may have different requirements due to their lack of experience with such disabilities. Keeping the focus on a specific group of individuals is important as it encourages research and development on their specific needs and as a result, solutions that are optimized for these specific needs [37]. When referring to temporary mobility impairments we consider results from various causes, such as injuries, surgeries, pregnancy, or short-term health conditions.

Although existing technological solutions that aim to enhance independence or accessibility exist, they have not yet been thoroughly evaluated to determine their actual effectiveness in achieving these goals. Furthermore, their focus extends beyond the public transportation system, specifically, encompassing various other areas that may have different requirements. Meanwhile, in the Netherlands, technological solutions in this area primarily facilitate human assistance [4, 10, 40, 66, 80] rather than fostering independence and forcing those individuals to pre-plan their journeys extensively.

To address this gap, we propose focusing on the specific needs of people with temporary mobility impairments through technological solutions. We believe this approach can significantly enhance their perceived accessibility and independence, thereby improving their overall travel experience on the Dutch Railway System.

1.2 Contributions

The aim of this research is to investigate how a technological solution in the form of accessibility features can empower individuals with temporary mobility impairments in the Netherlands. Our research will contribute to this empowerment in the field of HCI by designing accessibility features that enhance perceived accessibility, promote independence, and improve travel experience for those individuals.

By focusing on user-centered design and addressing the unique needs of these individuals, we expand the scope of assistive technologies in the

Netherlands, providing solutions and valuable insights into creating inclusive technologies for diverse users. While we specifically concentrate on individuals with temporary disabilities, the insights and solutions can facilitate more accessible and independent travel experiences for all individuals with mobility impairments. Furthermore, these findings can eventually have global applicability by transforming public transportation systems worldwide, making them more accessible to diverse mobility needs.

1.3 Research Question

Based on the aforementioned goals, we aim to answer the following research question:

*How can technological accessibility features be designed based on the user needs of individuals with temporary mobility impairments to enhance both **perceived accessibility** and **independence** within the Dutch railway systems, thereby improving their overall **travel experience**?*

The research question will be answered based on three subquestions. In the first one, their main challenges and travel needs will be explored. Then in the second one, the specific accessibility features they need will be investigated and lastly in the third one it will be evaluated if those needs are fulfilled through the accessibility features and if this leads to enhanced perceived accessibility, independence, and overall travel experience.

*SQ1: What are the specific **travel needs** and **barriers/challenges** of individuals with temporary mobility impairments when traveling with the Dutch railway systems?*

*SQ2: What are the main **technological accessibility features** temporary mobility-impaired people desire ?*

*SQ3: How do the additional technological accessibility features impact **perceived accessibility**, **independence** and **overall travel experience** among users with temporary mobility impairments ?*

1.4 Contents

Following the introduction, Chapter 2 discusses the current state of accessible public transportation, identifying the barriers and challenges faced by mobility-impaired individuals, and exploring the role of technological innovations in improving mobility and accessibility. Chapter 3 outlines the design process, detailing the methods used to gather insights from temporarily mobility-impaired individuals, the steps taken to develop the initial design, and the results and analysis of these findings. It further explains the design requirements, initial design, user feedback, and the adjustments made to arrive at the final design. Chapter 4 presents the evaluation of the final design, explaining the steps taken through the chosen methods and the subsequent analysis. Chapter 6 discusses the results of this evaluation. Finally, Chapter 7 interprets the results in relation to the initial research subquestions, offers design recommendations, and discusses the limitations of the study along with suggestions for future research.

2. Literature Review

The literature review begins by identifying the barriers that affect the accessibility of public transportation for mobility-impaired individuals. These barriers lead to the need for accessible public transportation, which is central to defining accessibility. The following section discusses travel autonomy as it can significantly improve perceived accessibility, by empowering individuals to navigate the transport system more independently. Ultimately, improved accessibility positively impacts the overall travel experience, highlighting the critical connection between travel autonomy, perceived accessibility, and the overall accessibility of public transportation services. The structure of this section can be seen in Figure 2.1.

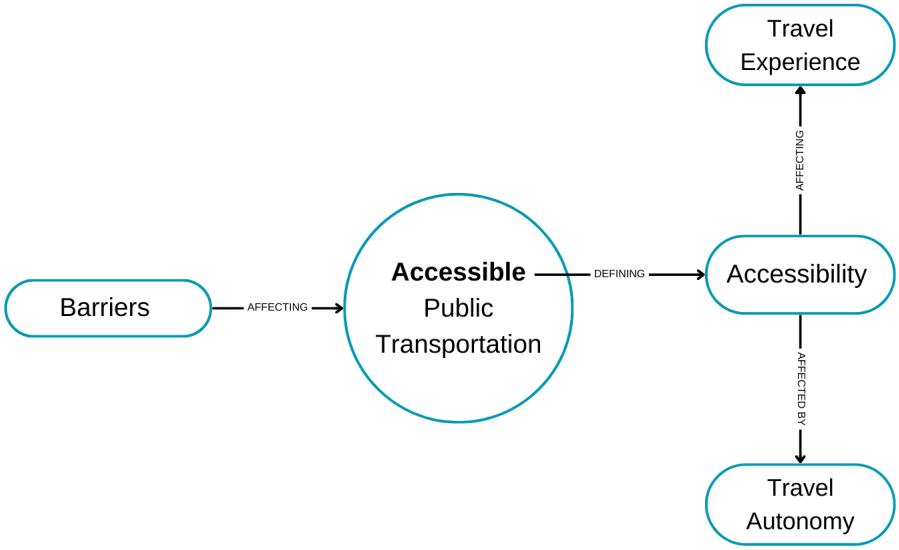


Figure 2.1: Concepts discussed in Literature Review

2.1 Barriers Faced by Mobility-Impaired People

In general, disabled people face more barriers than the overall population, in transportation due to physical and cognitive limitations [28, 90]. Based

on the World Health Organization [102], a barrier refers to any obstacle that prevents equal access to services or information for an individual or a group. They could be defined as environmental/physical factors that restrict a group of people by their presence or absence, as negative attitudes of people against a demographic with their emotional and psychological impact, and as lack of appropriate assistive technologies (tools designed for assistance, adaptation, or rehabilitation) [86]. Several studies are focusing on the difficulties experienced by individuals with mobility impairments who travel by public transportation. Overall they are categorized into the following (See Tables 2.1 ,2.2, 2.3, 2.4).

The most common challenges involve physical barriers (See Table 2.1) at stations, stops, and vehicles. These include unfriendly layouts for wheelchairs, malfunctioning elevators, unreliable ramps, uneven pavements, and limited space within buses or trains. Additionally, inadequate waiting areas, steep or poorly designed ramps, and insufficient toilet facilities further aggravate these issues, making public transport less accessible and safe for mobility-impaired individuals.

Except for physical barriers, mobility-impaired individuals often face negative human interactions and behaviors (See Table 2.2), such as discrimination, conflicts over accessible seating, unwanted physical help, verbal abuse, and neglect by bus drivers. There is also a lack of awareness of accessibility features among transport operators, leading to impolite treatment and hesitation to ask for help, which diminishes confidence and independence.

Both physical and attitudinal challenges result in emotional distress, including stress, anxiety, frustration, feelings of worthlessness, and fear of unpredictable journey aspects (See Table 2.3).

Lastly, preparation and travel times are significantly longer for people with disabilities (See Table 2.4), involving extensive planning and waiting periods. High travel time costs and associated difficulties result in reluctance to travel, causing significant delays and reduced mobility.

Barrier	Description	Examples	Refs
Physical	Challenges related to the physical environment and infrastructure.	• Unfriendly layouts • Malfunctioning elevators • Unreliable ramps • Uneven pavement surfaces • Limited space within buses or trains • Narrow aisles • Steps or uneven levels between platforms and vehicles • Misaligned or absent curbs • Lack of proper waiting areas • Gradient or inadequate ramps • Insufficient toilet facilities	[8, 21, 34, 71, 74, 97, 102, 103]

Table 2.1: Examples of physical accessibility challenges faced by individuals with mobility impairments in public transportation.

Barrier	Description	Examples	Refs
Attitudinal	Negative human interactions and behaviors affecting mobility-impaired individuals.	• Interpersonal discrimination • Conflicts over accessible seating • Unwanted physical help • Intimidation and verbal abuse • Neglect by bus drivers • Lack of awareness of accessibility features by operators • Overcrowding leading to impolite treatment • Hesitation to ask for help	[8, 64, 71, 93, 99, 102]

Table 2.2: Examples of Attitudinal challenges faced by individuals with mobility impairments in public transportation.

Barrier	Description	Examples	Refs
Emotional	Emotional and mental health challenges arising from transportation issues.	• Stress • Anxiety • Frustration • Annoyance • Feelings of worthlessness and heartbreak • Fear of unpredictable journey aspects • Feeling unsafe • Reduced confidence • Decreased independence • Impact on overall well-being and life satisfaction	[24, 32, 50, 79]

Table 2.3: Examples of Emotional challenges faced by individuals with mobility impairments in public transportation.

Barrier	Description	Examples	Refs
Time	Increased time and effort required for trip planning and execution.	• Longer preparation time • Longer time to reach access points • Extended waiting times • Higher travel time cost leading to reluctance to travel	[12, 52, 73, 84]

Table 2.4: Examples of Time-related challenges faced by individuals with mobility impairments in public transportation.

However, all these studies focus on the difficulties experienced by individuals with mobility impairments who travel by public transportation, in general. This study aims to explore specifically the barriers and challenges people with temporary mobility impairments face while traveling with the Dutch Railway System. Those could be different due to lack of experience or similar due to the general needs of people who face any kind of mobility difficulty.

2.2 Accessibility in Public Transportation

All the challenges mobility-impaired people face indicate the inaccessibility of the public transportation system. Indeed, there are universal transportation accessibility challenges that affect people worldwide [62]. Urban mobility data indicate that around one-fifth of individuals living in the European Union face difficulties using public transport services, highlighting the widespread nature of this issue [29]. To address these challenges and create truly accessible systems, it is crucial to understand the concept and definition of accessibility. By comprehending what constitutes accessibility, we can better identify and implement the necessary changes to improve public transportation for all users.

To be able to understand and measure accessibility, several different approaches can be used. It can be seen as a way to enable a physical approach to services or goods and reaching destinations [43, 87]. Kwan [42] and Geurs and van Wee [33], define it differently: as a property of space and individuals. They refer to it as the possibility to interact with various opportunities or activities that are available geographically, including jobs, services, or social interactions.

Other well-known definitions are: 'the accessibility of a specific land-use activity from a given location through a particular transportation system' [22], 'the autonomy of individuals in choosing whether or not to engage in various activities' [14], 'the advantages offered by a transportation and land-use system' [7].

Some studies separate the term more precisely, into objective and perceived accessibility and mention that to be able to access it is important to consider both [45, 49]. Objective accessibility determines the actual travel options available, which include the built environment, characteristics of transportation modes, travel times, costs, and distances [45]. Another study also names this concept as calculated accessibility because it is evaluated using calculated indicators based on spatial data [77]. Moreover, the same study argues that objective accessibility does not exist, as accessibility is inherently influenced by individual perceptions. Therefore, perceived accessibility refers to the primary factor influencing decisions about activity [77] and reflects individuals' sentiments about their living conditions [44].

Specifically for transportation systems, perceived accessibility is a subjective assessment of how effectively they can enable people to lead a satisfactory life [44]. This encompasses the ease of using and reaching the transport system and the extent to which the system allows them to access desired activities and opportunities [45]. Unlike objective accessibility, perceived accessibility does not rely on predefined important indicators because these can vary among individuals, groups, cultures, and contexts [44].

In a study about how those perceptions of accessibility are shaped [77], a combination of individual, land-use, transport, and temporal factors is mentioned. Individual factors include socio-demographic characteristics, capabilities, attitudes, preferences, and context. Land-use factors involve the perceived distribution of activities and destination attributes. Transport factors encompass perceptions of transport supply and travel resistance. Temporal factors relate to perceived variability in travel time and constraints for activities. These components interact with the physical environment and personal experiences, ultimately influencing decisions about mobility and accessibility.

The focus is on understanding the term accessibility to be able to enhance it specifically in public transportation and more specifically in the Dutch Railway System. We are focusing on the perceived accessibility of

this system rather than the objective as the aim is not to change the objective aspects of it. Instead, we aim to identify and address the barriers temporary mobility-impaired encounter and their feelings about them, to eventually enhance their perceived accessibility. By measuring accessibility from individuals' perspectives we are not only capturing their assessment of their personal ability to function or travel behaviours but also their assessment of the barriers encountered when accessing facilities [95].

Therefore, it is reasonable to believe that perceived accessibility, which incorporates the perspective, knowledge, and travel horizon of the individual, offers a more comprehensive and user-centered understanding of accessibility [45]. This approach captures dimensions of accessibility that conventional measures, which rely solely on standardized criteria, often overlook [44]. The emphasis on prioritizing users' needs over travel possibilities and traditional objective indicators of transport disadvantage (such as age, physical mobility, income, and vehicle access) is further reinforced by other studies [20].

The idea is that even if the Dutch Railways have accessible features if a person with a mobility impairment feels anxious about the possibility of a malfunctioning elevator or finds the information on accessibility unclear, their perceived accessibility is going to be low.

2.3 Travel Autonomy and Independence

To achieve enhanced perceived accessibility, it is essential to consider the concept of travel autonomy, as research has shown that stronger travel autonomy leads to stronger perceived accessibility [46]. Studies further break down travel autonomy into two distinct concepts: decisional autonomy, which is the freedom to make decisions without external constraints, and executional autonomy, which is the ability to carry out those decisions [19, 47]. Another study by Friman [32] refers to it as the ability of individuals to travel independently without relying on others, and encompasses control over various aspects of daily travel. This definition refers to travel independence which is the broader concept of travel autonomy and focuses on the

practical aspect of being able to travel without assistance. In terms of public transportation, independence is identified as a critical need [59], while more broadly it is strongly correlated with enhanced feelings of joy, fulfillment, and an overall better quality of life [89].

In general, the disability movement has expanded the understanding of independence beyond the ability to perform daily tasks unaided, emphasizing the importance of travel autonomy [91]. Therefore, our research focuses on enhancing travel autonomy for mobility-impaired individuals, aiming to help them feel more independent while also empowering them to seek assistance when needed. This approach is based on the understanding that true independence involves both self-sufficiency and the ability to request help as required [59, 68, 83].

By improving travel autonomy, we can directly address the practical and psychological barriers to independence, promoting a sense of accessibility and empowerment among mobility-impaired individuals.

2.4 Travel Experience

The sense of accessibility directly impacts the overall travel experience of individuals. As Woldeamanuel and Cygansky [101] highlight, poor accessibility negatively affects the travel experience, indicating how critical accessible transport systems are. Similarly, Brons et al.[11] found that lower accessibility can reduce the frequency of public transport use, showing the direct correlation between accessibility and travel behavior. So by improving travel autonomy for mobility-impaired individuals not only accessibility is enhanced but also the overall travel experience can be influenced.

In general, the travel experience is influenced by attributes like the quality of public transportation, cleanliness, punctuality and regularity of services, the on-board travel time (e.g. how much time and with what comfort/pleasure [25], staff attitudes, security and ease of ticket-purchase [16, 27, 35]).

However, especially for individuals with special needs most of the is-

sues that impact their overall travel experience are related to accessibility challenges [72] [8], distressing situations, like being carried over train tracks [74], or attitudinal barriers [8].

Measuring travel experience is complex due to its multidimensional nature [85] that includes a broad range of attributes. Whereas, Travel satisfaction is a subjective evaluation of these experiences [94]. Specifically for rail accessibility, research [104] has shown that its enhancement can lead to higher travel satisfaction by reducing barriers and making travel more convenient and enjoyable for all users. This aligns with findings from Bezyak et al. [8] and Park et al. [72], which indicate that addressing accessibility challenges — such as attitudinal barriers and physical obstacles — can significantly improve the overall travel experience and satisfaction for individuals with disabilities.

2.5 Technological Innovations and Systems for Enhancing Mobility and Accessibility

Assistive technology for mobility-impaired individuals is essential for enhancing accessibility and independence. Despite significant advancements in accessibility through existing apps, there is still considerable potential for developing innovative assistive technologies specifically designed to address various disabilities and conditions more effectively [3]. This research indicates a clear need for the development of assistive technologies that assist to the specific needs of individuals with disabilities. By addressing these unique challenges, applications that significantly enhance the quality of life for these individuals, can be developed, offering more tailored and effective solutions.

Current technologies largely facilitate providing human assistance at stations, but 41 percent of users emphasize the need for independent travel [26]. Significant barriers affecting independent travel, include the lack of guidance systems to avoid wheelchair-unfriendly routes and the need for personal assistive devices [32]. Studies highlight the importance of a holis-

tic approach considering all elements of public transport systems [92].

The "Mobility-for-All" project [76] used GPS to aid cognitively disabled individuals by providing real-time navigation alerts. The WheelScout project [36] advanced this with interactive, personalized navigation that identifies and reroutes around obstacles, including both permanent and temporary barriers, and offers customization for different wheelchair types. Further innovations include prototypes like the personal travel assistant and Memory Aiding Prompting System [6], which use GPS and mobile technology to support navigation and communication for users with cognitive disabilities. Furthermore, Evelity [56], a mobile application, provides indoor navigation in public spaces, aiming to enhance safety and autonomy for users with various disabilities. However, its effectiveness and feature development based on disabled community feedback require further research.

The EasyWheel project [55], specifically designed for wheelchair users, enhances independence by providing geo-tagging for points of interest (POIs) and barriers, personalized routing based on user-specific mobility parameters, and fostering a social community through Facebook integration. These features collectively help wheelchair users navigate cities more independently and efficiently, illustrating the potential for tailored assistive technologies in improving urban accessibility.

The Wegoto [60] project also aims to enhance wheelchair accessibility by using a smartphone-based approach to assess and improve accessibility. It records sensor measurements such as acceleration, deceleration, inclination, orientation, speed, and GPS position, allowing for detailed analysis of route accessibility. This information is then used to create an accessibility index, helping wheelchair users find the most suitable routes based on their specific needs and capabilities

In Table 2.5 those technological solutions that were developed globally to assist people with disabilities are presented. It outlines the technologies used, their primary focus, and the types of disabilities they target.

As can be seen, GPS and real-time information are the most commonly used technologies, however, these solutions are not exclusively focused on

individuals with mobility impairments, particularly those with temporary mobility disabilities. Additionally, there is a lack of research evaluating the effectiveness of these technologies in meeting the travel needs of disabled individuals. Furthermore, none of these solutions are specifically tailored to address the unique requirements of public transportation.

Nevertheless, none of these technologies have demonstrated clear results in promoting independence or accessibility, nor do any of them specifically focus on public transportation. In the Netherlands, the railway operators [4, 10, 40, 66, 80] just provide information about accessibility services such as the availability of elevators and the option to book travel assistance. They all emphasize planning ahead by just searching for information in their respective apps.

Consequently, none of these offerings effectively promote independent and accessible travel for individuals with temporary mobility impairments in the Netherlands. This study aims to address these gaps by designing and evaluating technological solutions that foster independence, perceived accessibility, and overall travel experience in the Dutch Railways, for temporary mobility-impaired individuals.

Feature	Mobility-for-All [76]	Travel Assistant Device (TAD) [6]	WheelScout [36]	WayFinder App [38]	Evelity App [56]	EasyWheel [55]	Wegoto [60]
GPS	✓	✓	✓	✓	✓	✓	✓
Real-time Info	✓	✓	✓	✓		✓	
Step-by-Step Directions				✓	✓		
Alerts	✓	✓					
Customizable			✓		✓	✓	
Indoor Navigation					✓		
Independence	✓	✓		✓	✓	✓	✓
Cognitive Disabilities	✓	✓		✓			
Mobility Impairments			✓		✓	✓	✓
Special Needs		✓			✓		
Geo-tagging POIs						✓	
Crowdsourcing						✓	
Sensor Measurements							✓
Accessibility Index							✓

Table 2.5: Comparison of Projects

3. Design

To address the research question and the three subquestions, a mixed-method approach was employed. Semi-structured interviews were conducted with individuals with temporary mobility impairments to identify the specific needs and challenges they face (SQ1) and the features they desire (SQ2). Based on these insights, accessibility features were designed. These features were evaluated to determine their impact on perceived accessibility, independence, and overall travel experience (SQ3). This approach ensured a thorough understanding and development of targeted solutions to enhance the travel experiences of individuals with temporary mobility impairments. The study design is visualized in Figure 3.1. The Ethics and Privacy Scan of the Utrecht University Research Institute of Information and Computing Science was conducted (See Appendix C). It classified this research as low-risk with no fuller ethics review or privacy assessment required.

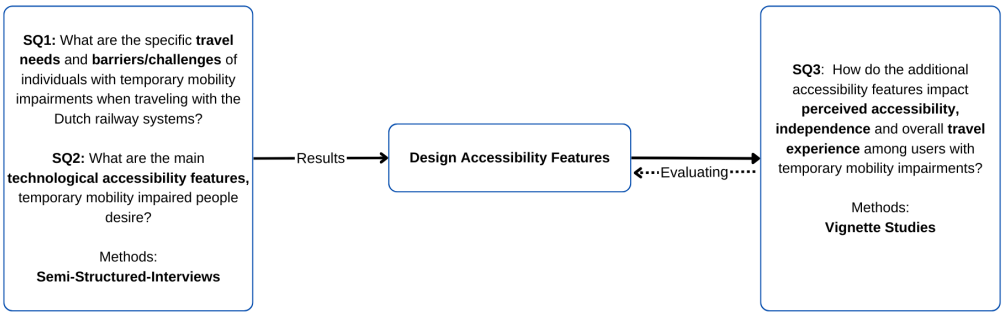


Figure 3.1: Study Design

3.1 Interviews

Initially, semi-structured interviews were conducted to identify the primary barriers and challenges faced by individuals with temporary mobility impairments when using Dutch Railways. Qualitative semi-structured interviews are an effective method in the early stages of a study, uncovering in-

depth insights and narratives that can reveal the complexities of individuals' experiences [41]. A semi-structured interview served as a step to understand the barriers encountered, the emotions experienced, and the degree of independence perceived by respondents during travel. Feelings, thoughts, and daily realities are easier to capture through this approach which provides the flexibility to follow conversational leads and probe deeper into responses.

That facilitates a comprehensive understanding that structured methods might not easily achieve. It also prompts participants to reflect on past experiences, thereby evaluating the current state of accessibility and independence offered by Dutch Railways to this demographic. This format also encourages follow-up questions and the exploration of new topics that may not have been initially anticipated. This adaptability allows for a more dynamic conversation, uncovering valuable insights that structured interviews might overlook. Moreover, this method also served as a way to evaluate the current approach of the Dutch Railway systems, with the travel facilities they are offering to mobility-impaired people until now. After conducting these interviews, additional dimensions within the research topic were revealed, leading to the formulation of more sub-questions.

3.1.1 Participants

Participants were recruited via WhatsApp [100] and in-person contacts. They had to be older than 18, with a current or past experience of a temporary mobility disability.

Eventually, seven individuals with temporary mobility impairments were recruited in total. Three used crutches while accessing the Dutch Railways, one utilized both crutches and a wheelchair, another only a knee brace, and the last two used a wheelchair exclusively. The ages of participants ranged from 23 to 31 *(M = 27.0, SD = 2.7)*.

3.1.2 Materials

The study was conducted remotely in a discussion-friendly manner, through Microsoft Teams [57].

An information sheet (See Appendix A.1) and a consent form (See Appendix A.2) were developed in Qualtrics XM [82], outlining the study's purpose, their rights as participants, the confidentiality measures, and how their data would be used. Moreover, a script with the introduction and a list of questions divided into 5 categories were developed (See Appendix A.3). The open-ended interview questions were designed to elicit responses directly related to the core research topics without leading participants. By focusing on past experiences, such as their last journey, the questions encouraged participants to reflect on the barriers, challenges, and emotions they encountered (See Appendix A.3).

The interviews were recorded and transcribed by the Microsoft Teams [57] feature. The interviewer was also taking notes to complement the automatic transcriptions. Moreover, coding was done in NVivo [81] and Miro [58] was utilized to organize the coding process and enhance comprehension to eventually interpret the data.

3.1.3 Procedure

After participants agreed to join the interview through the recruitment process, they were provided with an information sheet and a consent form (See Appendix A.2, A.1) to sign. Once these were completed, we sent them a link to the scheduled online meeting.

The interviews took approximately thirty to forty minutes. First, the moderator introduced themselves and the research. Then the participants were asked again to give their verbal consent before the audio recording started. They were asked for any possible questions they may have before the session started. The rest consisted of the interview questions (See Appendix A.3). Eventually, we asked them if they had any additional comments or questions and thanked them for their participation.

3.1.4 Analysis

The first step involved carefully reviewing the interview transcripts generated and transcribed by Microsoft Teams [57], ensuring clarity and accuracy by referencing them with the notes taken by the interviewer and the recorded audio. Eventually, an edited transcription method was utilized, combining the elements of both the automated transcripts and the notes to an accurate record of the interviews.

Subsequently, the transcripts were read multiple times in order to become familiar with the content, recognize the patterns, and make sure that the data was comprehensive enough, to support conclusions.

The final interview transcripts were analyzed using Thematic Analysis and inductive coding to identify key themes based on participants' experiences. Information about the participants' context of injury and train traveling can be seen in Table 3.1. The final analysis is illustrated in Figure 3.2. Transcripts were coded for key ideas, and similar codes were grouped into broader themes.

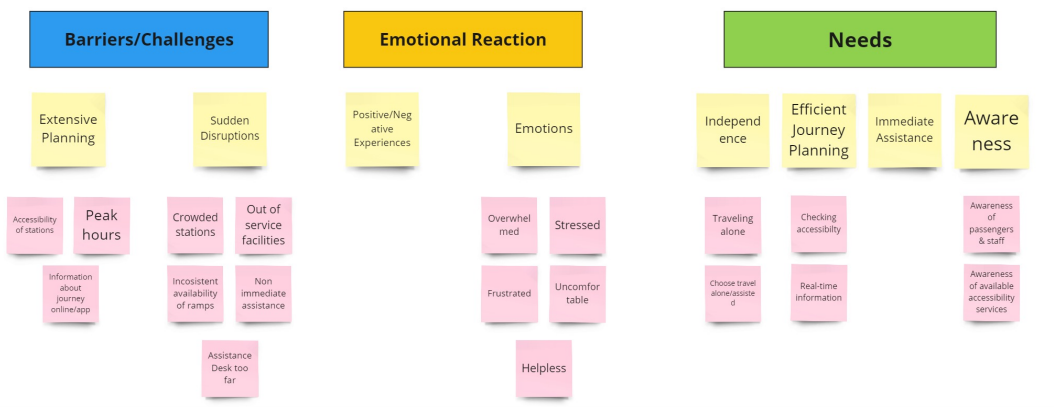


Figure 3.2: Interview Data Analysis

3.1.5 Results

Participants in the semi-structured interviews thoroughly discussed the targeted topics, primarily emphasizing the barriers and challenges they face. They also articulated their needs and desires for technological solutions.

Barriers/Challenges: Six participants highlighted the physical barriers

P(i)	Travel Freq	Overall Experience	Injury
1	2-4 times/week	Generally fine, occasional delays not significantly affecting leisure travel	Broken leg bone
2	Weekends	Generally okay, reliable but not a daily traveler	Neurological malfunctioning
3	Often due to not having a car	Quite reliable, functional	Knee ligament injury from scooter accident
4	Weekends	Generally okay, simple	Ankle fracture and dislocation
5	2 times/week	Generally positive, not very bad experience	Knee injury from skiing accident
6	3 times/week - work and visiting family	Good, efficient but with challenges due to mobility impairment	Leg injury
7	2 times/week leisure	Mixed experience, generally reliable but with occasional issues	Leg injury from bike accident

Table 3.1: Context about Injury and Train Traveling

they encountered suddenly when traveling. Non-functional services (escalators, elevators) were the most mentioned ones. Some participants had experiences where they had to ask for physical help, like Participant 3 who mentioned:

> *"I had to ask a fellow passenger to carry me down the escalators because they were out of service."*

The second most mentioned barrier was also part of the sudden disruptions happening while they traveled, it was the crowdedness of the station that was mentioned by 3 participants. Participant 2 mentioned:

> *"It was hard for me to navigate in the crowded station with my wheelchair, it took extra time and when I was on crutches it was also hard to keep my stability between all those people"*

Following those two, the non-immediate assistance was mentioned by two participants. Participant 1 mentioned:

> *" I was late for an important appointment because I asked for help from the operator staff and they did not come fast"*

All the participants mentioned the extensive planning they needed to do as something challenging for them. This planning included: (1) searching information online or through a planner app, (2) checking the peak hours to avoid, and (3) checking the accessibility of the station. Three participants were unaware of the accessibility services available or where to find them, while two believed these services were only for those with severe disabilities.

By six participants extensive planning was also mentioned as a strategy to overcome any possible barrier that may arise suddenly. Participant 5 mentioned:

> *" I was preparing my journey very well, checking the schedules, how crowded it is going to be, the stations I am going to visit to be able to avoid or even overcome any sudden disruption that may happen. But that required time because it was not that easy to find the information online or in the app either. "*

Emotional Reaction: Participants frequently reported experiencing significant emotional impacts due to the barriers and challenges they faced. They recounted numerous incidents that left them feeling overwhelmed and helpless due to these sudden disruptions. Three participants mentioned that relying on assistance from nearby passengers was often challenging in busy stations where everyone was occupied. Particularly participant 6 mentioned the difficulty of asking strangers for help in person:

> *"For me it was really stressful and uncomfortable to go ask help from someone in person, of course, I did it when I had no other choice but I would prefer If I did not have to"*

The challenging preplanning of the journey that was already mentioned caused considerable stress and frustration to four participants. Participant 2 expressed this frustration accordingly:

> *"It is too frustrating sometimes having to pre-plan everything in advance, and it is time-consuming trying to find all the information online. That is demotivating for someone with a mobility disability that is thinking of traveling"*

Six out of seven participants reported negative experiences while traveling with temporary mobility disabilities on the Dutch Railway Systems. These issues were primarily due to sudden disruptions that could not even be mitigated despite their extensive pre-planning that caused stress. Additionally, three participants felt negatively about the dependency on others for travel.

However, participant 1 mentioned a positive experience, more specifically :

> *"At first I thought traveling independently with my temporary mobility disability would be impossible. However, my experience was positive because I realized that with enough information on accessibility services and functional facilities, traveling independently can be easy."*

Travel Needs and Technological Solutions: Based on interview data, several key travel needs emerged for individuals with temporary disabili-

ties. These needs include (1) independence, (2) efficient journey planning, (3) immediate assistance, and (4) awareness of staff/passengers/available services. All of those needs were articulated as technological solutions by the participants. The connection between the travel needs and the technological solutions can be seen in Figure 3.3.

All the participants mentioned the real-time updates as crucial for their journey planning and their feeling of independence. Participant 2 specifically mentioned:

> *"It would be helpful to know beforehand if the elevator for my platform is not working, that would mean for me to ask for someone to come over with me, choose another option, or go there earlier. Adjusting my trip accordingly helps me feel less dependent on others"*

More specifically, the need for independence was highlighted by six participants, all of whom expressed a preference for traveling alone and only seeking assistance when necessary. They emphasized the importance of not feeling overly dependent on others and desired the flexibility to choose between traveling independently and requesting help when needed. The importance of this was articulated by Participant 7 accordingly:

> *"It should be obvious that whatever condition I have, I am traveling alone"*

The need for immediate assistance was emphasized by 5 participants, who suggested a button that could be pressed to ask for help at a specific location. This feature was highlighted by five participants, with Participant 3 specifically stating:

> *"I would prefer to have the option to ask for help through the application immediately where I am located rather than booking someone in advance or asking someone in person because people are busy and it makes me feel uncomfortable and too dependent"*

Conclusions: The data revealed a strong preference for independence among individuals with temporary mobility impairments. Participants emphasized the need for travel systems that support solo travel without as-

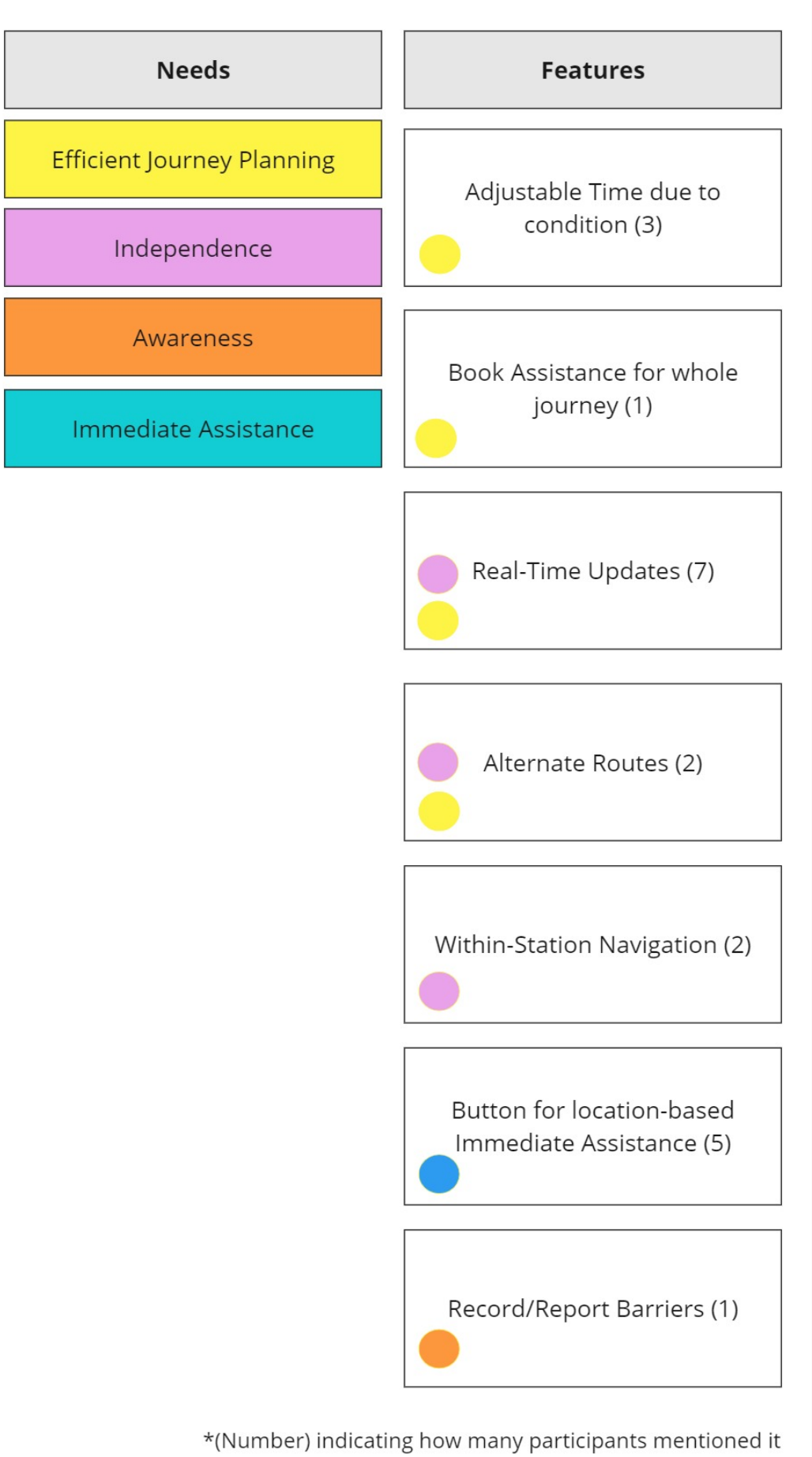


Figure 3.3: Travel Needs and Accessibility Features Connection

suming assistance is required at every step, highlighting the importance of minimizing direct human assistance. They expressed a desire for systems that offer the choice between independent travel and requesting help, with quick and reliable access to staff assistance when necessary. This capability enhances confidence in traveling alone while providing an immediate way to request location-based help when needed. Efficient and informative journey planning tools are also crucial, offering accessible routes and real-time updates to reduce planning time and effort, thereby improving perceived accessibility and independence. Access to up-to-date information helps travelers make informed decisions and avoid unexpected challenges, reducing anxiety and enhancing the overall travel experience. While there are significant challenges, one out of seven participants reported a positive travel experience, suggesting that proper accessibility services can lead to satisfactory journeys.

3.2 Design Requirements

The NS Planner [65] was chosen as a baseline because interview data showed it is widely used by participants when preparing their journeys. Moreover, by not developing a separate application for individuals with temporary mobility impairments, we are promoting inclusivity as all users have equal access to the same resources and benefits. They will not need to adapt to an additional application and can continue using the NS Planner [65] with which they are already familiar. The focus remained on one specific aspect of the journey: the preparation phase. It was chosen because participants in the interviews frequently emphasized its importance, which aligns with the literature findings. According to the literature, extensive preplanning is necessary and often time-consuming [12, 52, 73, 84] for mobility-impaired individuals. This approach aims to address gaps and areas for improvement identified through research, specifically benefiting users with temporary mobility disabilities. Leveraging the strengths of an established platform, the re-design incorporates features mentioned as crucial by participants during interviews.

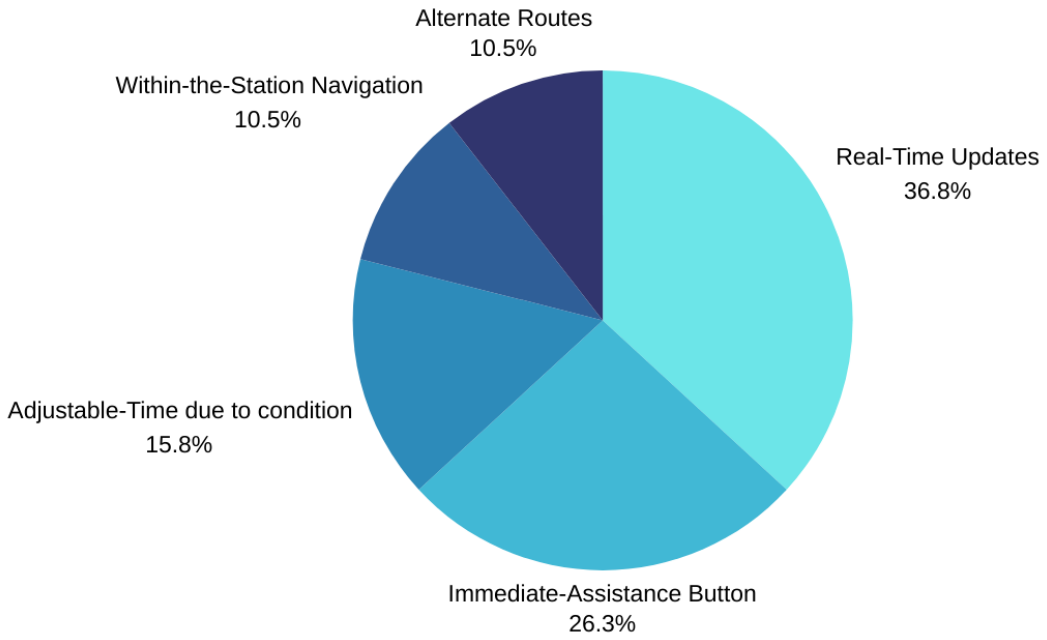


Figure 3.4: Features mentioned in the Interviews

Due to time constraints and numerous suggestions, three key features were selected to be designed, based on the most preferred features (See Figure 3.4).

1. **Real-time information about the station crowdedness**: The NS Planner [65] currently provides train crowding data but lacks station crowding information, which participants highlighted as important. The new feature offers real-time station crowding updates, complementing existing data on punctuality and train crowding. This allows travelers to make informed decisions, such as traveling during less busy times, choosing alternative routes, or adjusting arrival and departure times to avoid large crowds. It supports thorough travel planning and enhances independence by enabling travelers to navigate stations confidently and autonomously.
2. **Real-time information for elevator functionality**: The second feature is a real-time indicator of elevator functionality, as this was the most requested feature in the interviews. If a particular elevator is

out of service, real-time updates can help users find alternate routes promptly. This reduces the need to ask for help from strangers, thereby fostering a sense of autonomy. Also, knowing about potential barriers in advance can reduce the fear and frustration associated with unexpected obstacles. This aligns with participants' concerns about sudden barriers causing significant stress and negatively impacting their travel experience.

3. **Location-based immediate assistance buttton**: Additionally, participants frequently mentioned the need for immediate assistance and the discomfort in seeking help from strangers, leading to the inclusion of an instant assistance button for users to get help at their current location. Knowing that reliable help is just a button press away can boost travelers' confidence and encourage users to travel independently, reducing the hesitation caused by potential barriers. This is particularly important for those who prefer to travel independently but need occasional support, as mentioned in the interviews.

3.3 Initial Design

After deciding on the features to be incorporated, the next step was to design the app screens. All screens were created using Figma [31]. First, the screens for the NS planner [65] were designed to be used (See Figures 3.5, 3.6, 3.7).

3.4 Feedback Icons and colours

Various approaches were explored for integrating the new features, including different colors and icons. To determine the optimal design, feedback was requested from potential users. Different versions of the screens were sent to nine participants. We asked them if they understood what the icons (See Figures 3.10, 3.11, 3.12) represent, then which one they preferred and their opinion on the colours (See Figures 3.8, 3.9) that must be used to display the accessibility features. Based on their feedback, the most preferred

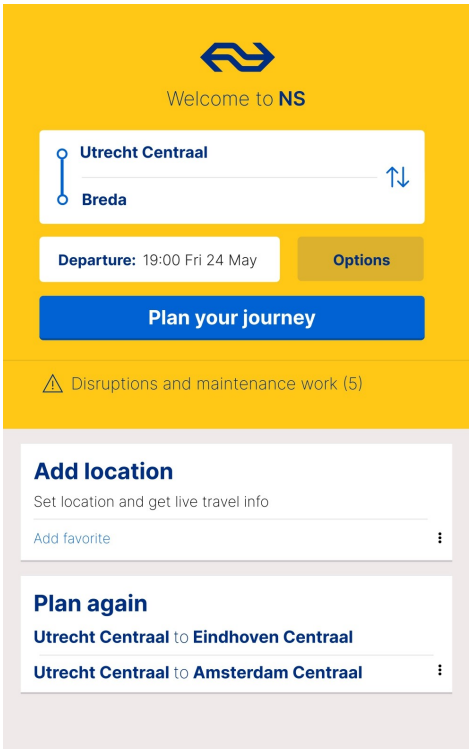


Figure 3.5: Main Screen

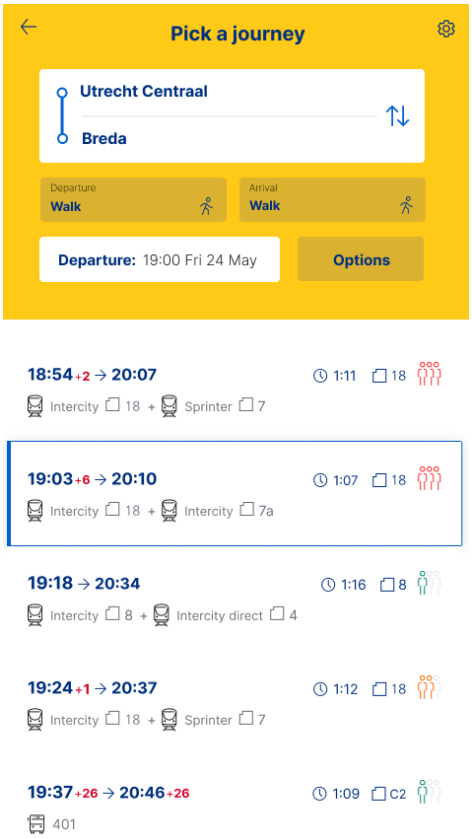


Figure 3.6: Possible journeys

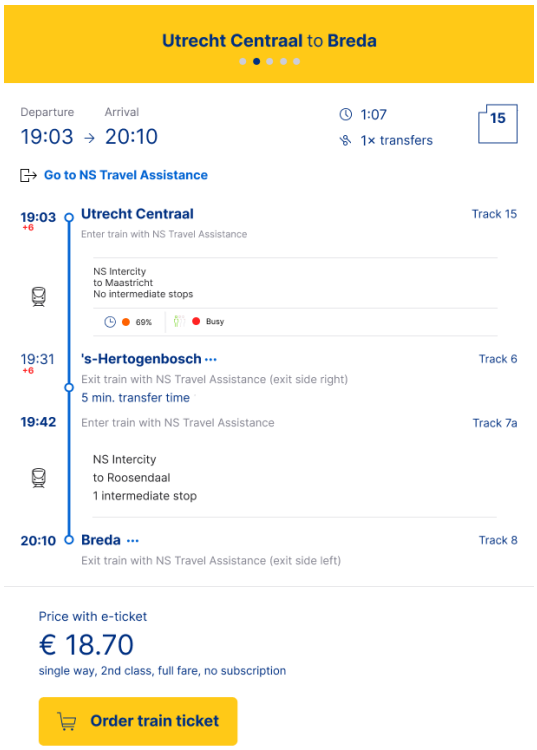


Figure 3.7: Journey with the NS

designs were selected for the final implementation.

The use of the color red to indicate something out of service or requiring attention was found to be repulsive by some participants. However, others felt that it was necessary and made important information stand out. When presented with an orange alternative, all participants agreed that this option effectively served its purpose. For the icons, all nine agreed that the most accurate representation of an elevator is in Figure 3.11.

3.5 Final Design

Aside from the added features, the overall design of the app remained consistent with the baseline NS Planner [65]. Based on their feedback, the most preferred designs were selected for the final implementation that can be seen in Figures 3.13, 3.14, 3.15.

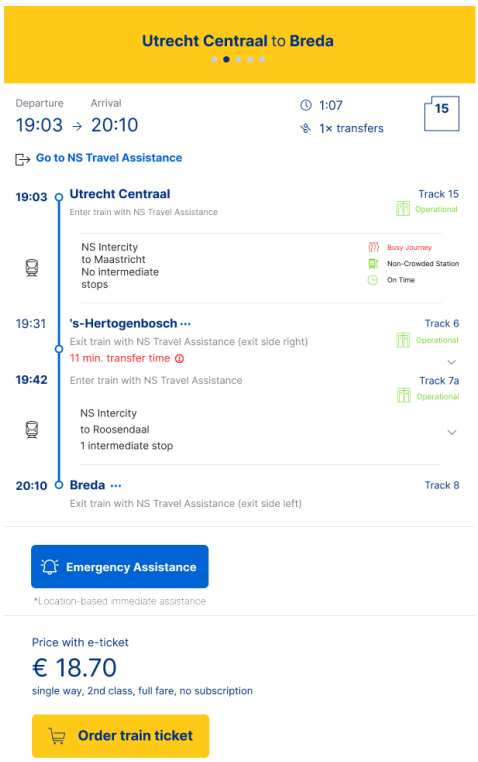


Figure 3.8: Font colour choice 1

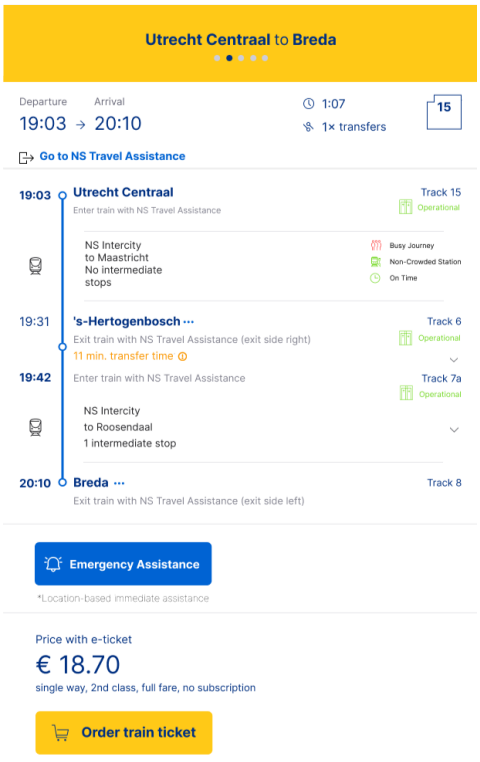


Figure 3.9: Font colour choice 2

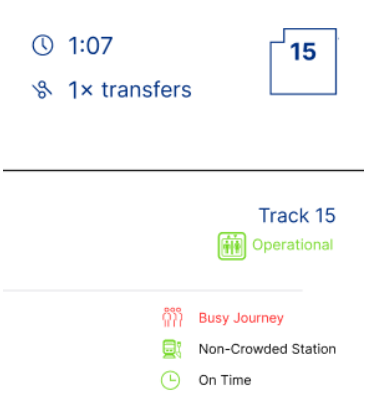


Figure 3.10: Option 1 for the elevator icon

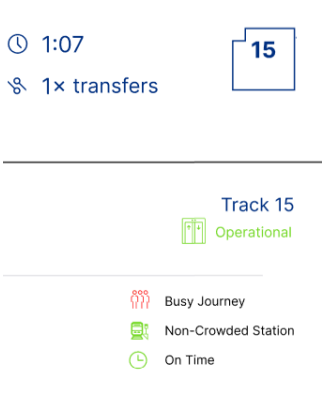


Figure 3.11: Option 2 for the elevator icon

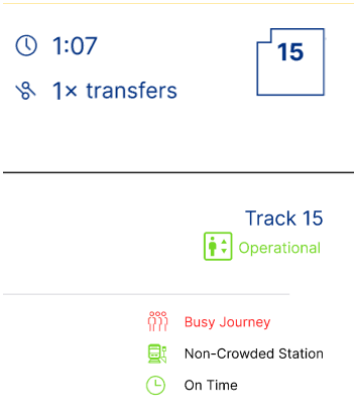


Figure 3.12: Option 3 for the elevator icon

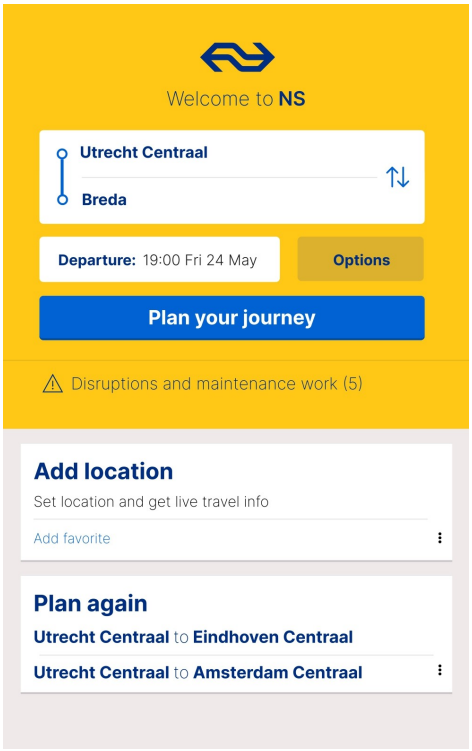


Figure 3.13: Main Screen

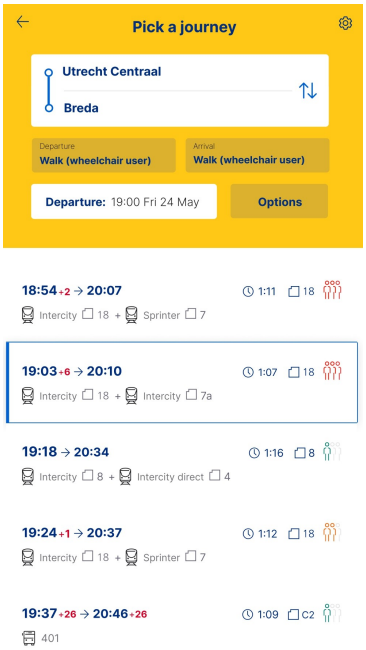


Figure 3.14: Screen of the possible journeys

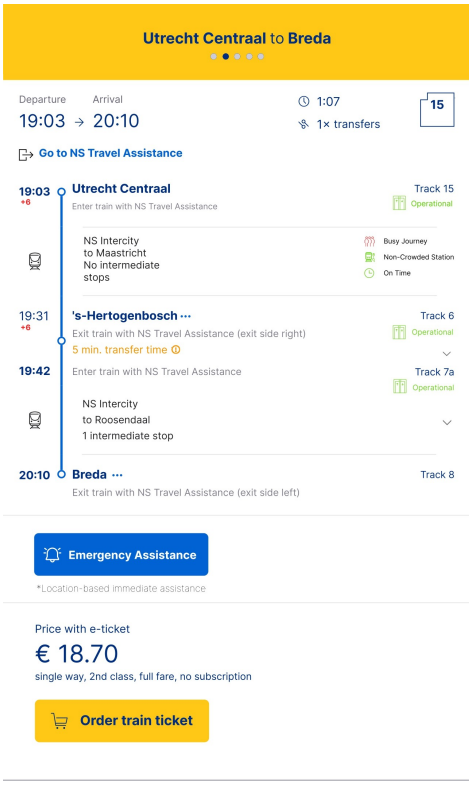


Figure 3.15: Screen of the journey with the RE Planner

4. Evaluation

In order to evaluate the final design, Vignette studies were conducted. They involve using brief scenarios or descriptions, known as vignettes, presented to survey participants to gather their reactions and opinions about those situations [5]. This method was chosen as it can allow users to create realistic scenarios that can simulate various situations [2] to evaluate how users perceive their accessibility, independence, and travel experience. In Figure 4.1, the experimental design of the Vignettes is shown. The dependent and independent variables, as well as the within-subject and between-subject factors, can be seen and are further discussed in subsection 4.4.

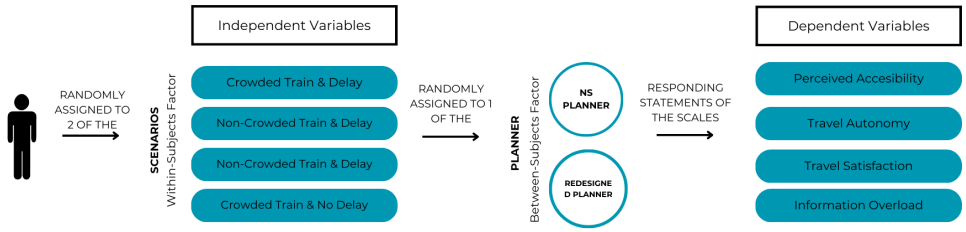


Figure 4.1: Experimental Design

4.1 Participants

Participants were recruited via WhatsApp [100] and via in-person contacts. They had to be older than 18. Eventually, 78 individuals were recruited in total. The average age of participants was 31 years (SD = 17). Out of the total of 78 participants, 31 had experienced a temporary mobility disability (SD = 0.49) in the past and 51 had used the NS Planner [65] before (SD = 0.47).

4.2 Materials

The Vignette study was developed using Qualtrics [82]. An Information Sheet and a Consent Form outlining the study's purpose, procedures, and ethical considerations were included there.

Since all interview participants emphasized the importance of preparing their journey in advance and this was also indicated in the Literature [12, 52, 73, 84], the Vignette focused on this step. Given that the planner is a redesign of the NS planner [65], the Vignette Study aimed to compare the two versions. The current NS planner [65] provides information on train punctuality and crowdedness, so the scenario (See Appendix A.6) was built around these aspects. This approach was chosen to ensure a fair comparison between the two planners. By focusing on variables like train punctuality and crowdedness, rather than unique features of the redesign, participants would not be biased towards the redesign simply because it provided additional useful information. This way, the evaluation would be based on how well each planner helps in preparing for the journey, without the influence of extra features that could skew the results. Consequently, four scenarios were created to evaluate the redesigned planner's effectiveness in providing this information. The screens designed in the previous step for the extra accessibility features and for the original NS Planner [65] were utilized.

4.3 Measurements

Four different scales were used to formulate the statements that were asked to be responded to in the vignette study.

1. **Perceived Accessibility Scale:** Perceived accessibility was assessed using the Perceived Accessibility Scale (PAC) created by Lättman [45] that is validated. This scale includes four statements that reflect various aspects of travel ease: Ease of travel, Ability to live one's desired life, Access to preferred activities, and Quality of access to activities (See Appendix A.7.1). The tense of the questions was the only change made to fit the idea that the participants are immersing themselves in

the preparation for the journey of a temporary mobility-impaired individual. So a present continuous tense with a future intention was used and the questions were changed to "How I am going to travel today" instead of "How I travel today". Participants rated their agreement with these statements on a scale from 1 to 7 (1 = Completely disagree, 7 = Completely agree).

2. **Travel Autonomy Scale**: In order to measure independence, a travel autonomy scale that was based on the self-determination theory [23] was developed and validated as a reliable measure [32], was used. The reason this scale was chosen was because travel autonomy is a significant component of overall independence, and part of its definition [69]. The travel autonomy scale includes quantifiable and measurable criteria to test, making it easier to quantify levels of independence. Whereas, independence is often considered a non-quantifiable concept because it encompasses a broad range of subjective experiences and personal capabilities.

   This scale assesses four aspects of daily travel autonomy: **capability, prerequisites, freedom, and possibilities** (See Appendix A.7.2).

   Each statement begins with '*To what degree do you have...*' and continues with (1) 'the ***capability*** *to travel as you wish*,' (2) '*the* ***prerequisites*** *to travel independently without help from others*,' (3) '*the* ***freedom*** *to travel as you wish*,' and (4) '*the* ***possibility*** *to travel as you wish.*' Each of the four statements was measured on a seven-point scale ranging from 1 to 7 (1 = To an Extremely Small Extent, 7= Ton an Extremely Large Extent).

3. **Travel Satisfaction Scale**: To measure if the overall travel experience is enhanced by the redesign of the NS planner [65], the travel satisfaction scale was utilized (See Appendix A.7.3). It evaluates both **cognitive** and **affective** components, and was used to measure travel experience as this is a very broad concept while travel satisfaction is more specific and can be seen as a subset of the broader travel experience. Moreover, travel satisfaction is a more immediate, short-term assessment of how well a specific trip met the traveler's expectations

and needs, impacting their immediate perception and feedback of that journey [39]. Thus that helps to effectively measure how well the redesign of the NS Planner [65] meets user needs and expectations in a hypothetical setting.

Participants had to answer this type of questions: *To what extent would you feel the following emotions while preparing for the journey using the planner*: *enthusiastic/bored, engaged/fed up, and alert/tired* for positive activation/negative deactivation; *calm/stressed, confident/worried, and relaxed/hurried* for positive deactivation/negative activation. And, to what extent would you feel that the preparation of this journey: was *high/low standard*, *worked out well/not well*? Respondents rated their experience on 7-point scales, ranging from -3 (minimum/negative emotions or evaluation) to 3 (maximum/positive emotions or evaluation).

4. **Information Overload Scale**: The concept of information overload is crucial to understanding how users interact with digital platforms, particularly in contexts where a significant amount of information is provided, such as e-commerce environments or travel planning applications [18]. In e-commerce, it has been shown that when users are presented with too much information, it can lead to poor decision-making and negative subjective experiences [18]. This can similarly apply to users of travel planning applications, especially those with temporary mobility disabilities who rely heavily on these tools for accessible travel routes. For individuals with temporary mobility disabilities, the travel planning tool must deliver information in a manageable way to enhance the travel experience without causing stress or confusion. By incorporating an information overload scale, this research can systematically assess and address potential overload issues, ensuring that the travel assistant is both effective and user-friendly. Particularly in this redesign, where additional information has been included, it is crucial to ensure it enhances the user experience without overwhelming the user. Thus the goal is, to deliver information in a manageable way that will promote a more accessible and inclusive travel experience for individuals with temporary mobility disabilities.

As a result, to measure the perceived information overload, the Vignette Study included a validated scale based on a study for information overload on consumers' subjective state [18], that was adapted for the purpose of the research (See Appendix A.7.4). Each of the statements was measured on a five-point scale ranging from 1 to 5 (1 = Strongly Disagree, 5= Strongly Agree).

4.4 Procedure

The survey was sent to the participants through WhatsApp [100]. Participants opening the survey read the information sheet and the consent form (See Appendices A.4, A.5). After reading and signing a consent form, they were randomly assigned to one of four scenarios (See Appendix A.6). Screens from one of two planners were then randomly displayed (See Figure 4.1). Participants completed statements for four scales related to the first scenario. Subsequently, they were assigned a second scenario and completed the same four scales for the new scenario.

4.5 Analysis

Using Python, we began by removing columns containing redundant information(e.g. the start date) to streamline the dataset. We then created new columns labeled "Scenarios" and "PlannerType" to facilitate later identification of these factors in the analysis, such as for Friedman tests. For each scale question, the program identified the scenarios and planner type that each participant had reviewed, storing this information in a list formatted as a combination (e.g. "SC1SC2RE/ NS"). This information was extracted from the question IDs (e.g.TA-prereq-SC3-RE). Finally, we populated the "Scenarios" and "PlannerType" columns with the appropriate values (e.g. SC1SC2 or RE/NSRE/ NS) for each participant's response, based on the specific naming conventions of each question.

Initially, descriptive statistical analyses were conducted to summarize the central tendencies, dispersion, and overall distribution of the responses for each scale, both for the normal planner and the adapted planner. This involved calculating measures such as the mean, median, mode, standard deviation, and range for each planner, providing a foundational understanding of the data's basic characteristics and variability. Descriptive statistical analyses were also conducted for individual questions of each scale for both the normal planner and the adapted planner. Additionally, the difference in mean responses between the planners was calculated. Furthermore, Cohen's d was calculated to understand the practical significance of the differences in responses.

To better understand the results from the descriptive statistical analyses, statistical tests were utilized to check if there was a significant difference between the planners. More specifically, a mixed model ANOVA was used to investigate the effects of both between-subject (Planners) and within-subject factors (Scenarios). The Shapiro-Wilk and Levene's test statistics were used to test the assumptions of normality and homogeneity of variance. The assumption of normality for a mixed model ANOVA was violated. Therefore, we opted for the Mann-Whitney U test, to compare two independent groups (Planner Types), as the assumption of homogeneity of variances was confirmed from Levene's test statistics.

To examine the relationships between the dependent variables (perceived accessibility, travel autonomy, travel satisfaction, and information overload), a correlation analysis was conducted. Pearson's correlation coefficients were calculated to assess the strength and direction of the linear relationships between the variables. This analysis provided insights into the extent to which changes in one dependent variable were associated with changes in another.

Descriptive statistical analyses were conducted on perceived accessibility, travel autonomy, and travel satisfaction, categorized by sce-

nario and planner type. This approach enabled a clear comparison across the different scenarios. To determine if significant differences existed in the Travel Autonomy, Perceived Accessibility, and Travel Satisfaction, across the different pairs of scenarios, a Friedman two-way ANOVA was conducted, as the assumptions were not violated.

The impact of the scenarios on information overload was not evaluated in this study because information overload is more closely related to the quantity and complexity of information provided by the planners, rather than the scenarios themselves. Each scenario's primary function was to simulate different travel contexts, whereas the information presented within each planner is what directly influences the cognitive load experienced by the user.

5. Results

In this chapter, we present the results from the analysis of the vignette study. The findings are divided into two main parts. First, we discuss the responses for each scale (Perceived Accessibility, Travel Autonomy, Travel Satisfaction, Information Overload), providing their descriptive statistics and the results of the statistical tests. Second, we present the scenario-based results, including the associated descriptive statistics and outcomes of the statistical analyses.

5.1 Effect of the re-designed planner on the subjective ratings

This section presents and compares the effects of the redesigned planner and the NS Planner [65] on subjective ratings for each scale. It includes descriptive statistics, percentage responses for individual scale statements, and overall differences in results between the two planners.

5.1.1 Perceived Accessibility:

PlannerType	mean	std	min	25%	50%	75%	max
NS	3.773026	1.210126	1.125	2.9375	3.75	4.75	5.75
RE	4.322368	1.349935	1	3.5	4.375	5.34375	6.125

Table 5.1: Perceived Accessibility Descriptive Statistics

As can be observed in Table 5.1, the RE group generally perceives better accessibility compared to the NS group, as evidenced by higher mean and median values, as well as higher values at the *25th* and *75th percentiles*. The wider range in the RE group, indicated by a higher standard deviation and a broader spread between the minimum and

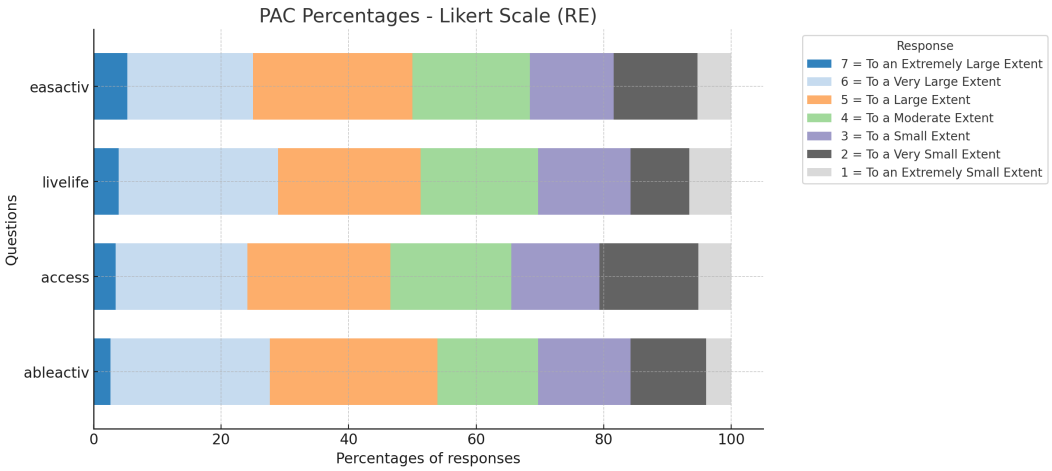


Figure 5.1: PAC - Responses for the Re Planner

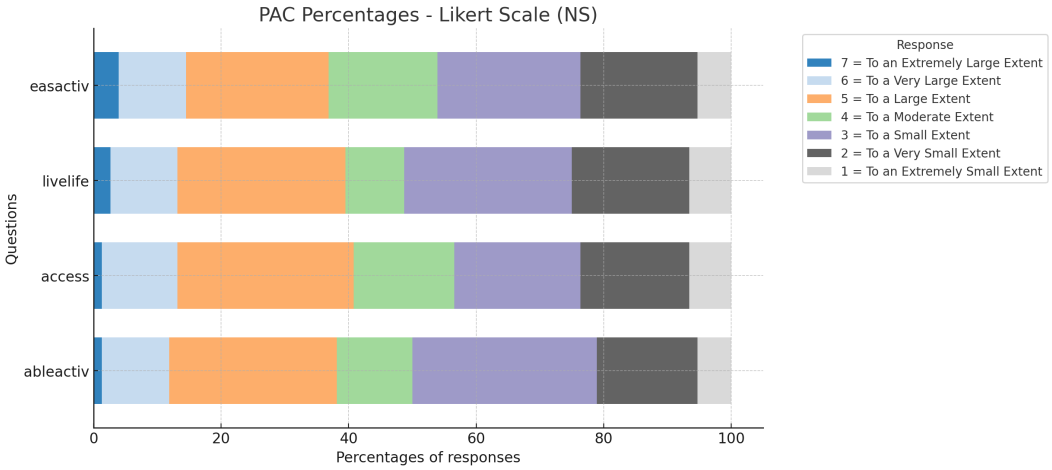


Figure 5.2: PAC - Responses for the NS Planner

maximum values, suggests more variability in their perceptions of accessibility. The coefficient of variation calculated (*For NS: CV = 1.210126 / 3.773026 0.32, For RE: CV = 1.349935 / 4.322368 0.31*), suggests that this relative variability compared to the mean is not drastically different. The low minimum values (*min perceived accessibility NS = 1.125 and min perceived accessibility RE = 1*) do not necessarily indicate outliers by statistical definitions, but they do show a significant deviation from the central tendency (mean and median) and quartiles. This suggests there may be a few respondents who rated perceived accessibility very low compared to the majority, but they are not extreme enough to be classified as outliers.

PAC_Scale_Question	Mean_NS	Std_NS	Mean_RE	Std_RE	Difference
able to do all the activities I like to do	3.753	1.210	4.360	1.350	0.6067
access to all the things I want to do is very good	3.815	1.210	4.401	1.350	0.5859
easy to do (daily) activities	3.800	1.210	4.271	1.350	0.4716
able to live my life as I want to	3.720	1.210	4.339	1.350	0.6194

Table 5.2: PAC Scale Questions, Means, Standard Deviations, and Differences

Cohen's d	Effect Size
0.473	Medium
0.457	Medium
0.368	Small
0.483	Medium

Table 5.3: Cohen's d and Effect Size for PAC Scale Questions

The results from the individual responses on the perceived accessibility statements (See Figures 5.1, 5.2) show that both groups generally have a positive outlook across all questions. However, the RE group consistently shows a higher percentage of responses in the highest satisfaction categories. Most responses with the RE planner fall between 5 and 6 on the Likert scale, while responses with the NS planner [65] are typically either 5 or 3. Especially for questions related to living life as desired, participating in activities, and accessing activities, the majority of responses for the RE planner were concentrated in the upper categories of the scale ("7" and "6"). In contrast, the NS planner [65] had more spread-out responses, with fewer high ratings and a larger proportion of moderate responses.

To determine if the differences in responses to each question between the two planners are significant, we examined *Cohen's d* values (See Table 5.3). They suggest effect sizes ranging from small to medium, highlighting the differences in means between the NS and RE groups.

The Mann-Whitney U test indicated that the perceived accessibility levels of the participants did not differ significantly between the groups, *U = 540.5, p = 0.059, two-tailed*. However, the p-value is very close

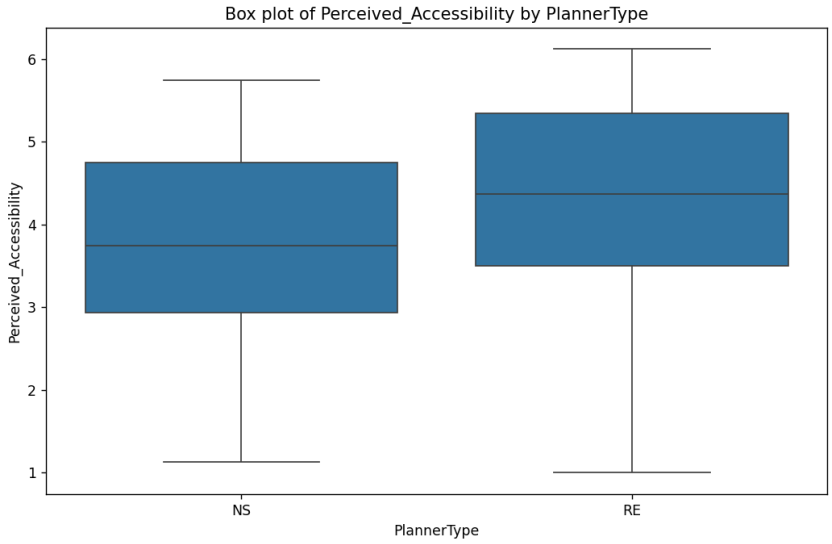


Figure 5.3: Median Scores for Perceived Accessibility

to the *0.05 threshold*, suggesting that the results are nearly significant. This difference can also be observed from the median scores in Figure 5.3.

5.1.2 Travel Autonomy:

As can be seen in Table 5.4, the RE group generally perceives greater travel autonomy across all measures (mean, median, quartiles) compared to the NS group. The distribution of scores in the RE group is slightly more spread out (higher standard deviation), indicating more variation in responses. The coefficients of variation calculated (*CV (NS) = 1.208118 / 3.664474 0.33, CV (RE) = 1.326035 / 4.286184 0.31*), are not close to the mean or over 1, indicating moderate variability. The higher median and quartiles in the RE group suggest that not only do they rate their autonomy more positively on average, but a greater proportion of the group also perceive higher autonomy.

PlannerType	mean	std	min	25%	50%	75%	max
NS	3.664474	1.208118	1.625	2.78125	3.6875	4.65625	6.125
RE	4.286184	1.326035	1.125	3.5625	4.25	5.46875	6.25

Table 5.4: Travel Autonomy Descriptive Statistics

The results from the individual responses on the travel autonomy state-

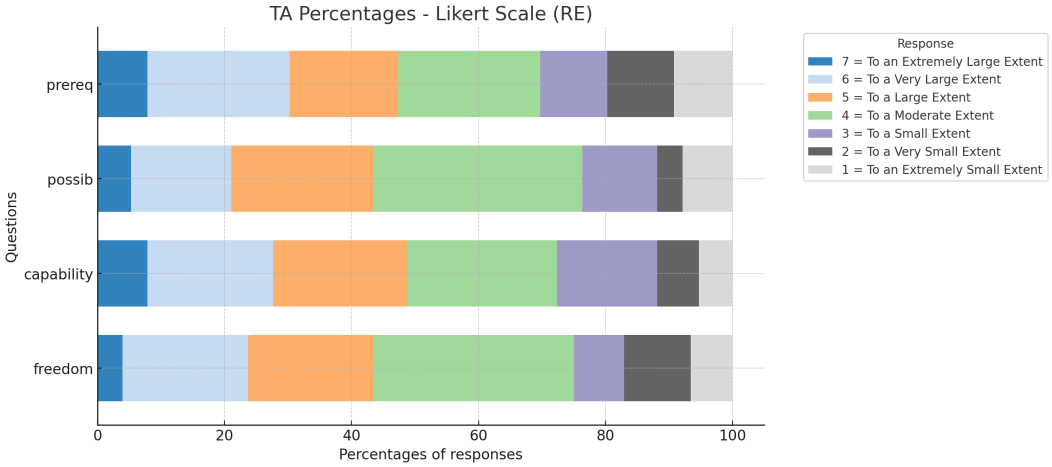


Figure 5.4: TA - Responses for the Re Planner

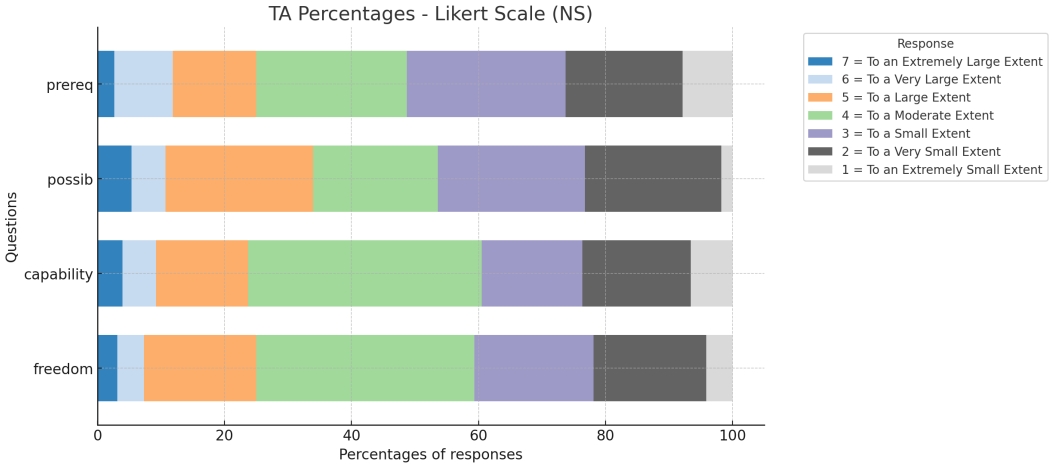


Figure 5.5: TA - Responses for the NS Planner

ments (See Figures 5.1, 5.2) show that both groups tend to respond mostly moderately (around 4). However, the RE group shows a noticeable difference compared to the NS group, with responses clustering more around the higher ratings. More specifically, for the RE Planner (See Figure 5.4), the "prerequisite" and "capability" statements exhibit a relatively even distribution across all ratings with a noticeable indication of responses at the highest rating. The question about having the prerequisites to travel independently though, shows more responses on the upper ratings. The responses to the question about having the prerequisites to travel independently show a tendency toward higher ratings ("6" and "7"). The "possibility" and "freedom" statements predominantly cluster around the mid-range rating of 4 (Moderate), with the "freedom" aspect having the most varied distribution, indicating differing levels of agreement among respondents.

For the NS Planner [65] (See Figure 5.5), the "freedom" and "capability" questions are mainly rated as moderate, whereas the "prerequisite" and "possibility" statements show a more balanced distribution across all rating levels. Overall, responses for the NS Planner [65] include a higher frequency of low ratings (2-3) compared to the responses for the RE Planner.

TA_Scale_Questions	Mean_NS	Std_NS	Mean_RE	Std_RE	Difference
capability	3.662135	1.2081	4.415497	1.3892	0.753
freedom	3.683743	1.0990	4.242105	1.6455	0.558
possibility	3.787524	1.3717	4.278728	1.6348	0.491
prerequisite	3.539401	1.3869	4.282237	1.3464	0.743

Table 5.5: TA Scale Questions, Means, Standard Deviations, Differences, and Cohen's d

Cohen's d	Effect Size
0.579	Medium
0.399	Small
0.326	Small
0.544	Medium

Table 5.6: Cohen's d and Effect Size for TA Scale Questions

To determine if the differences in responses to each question between

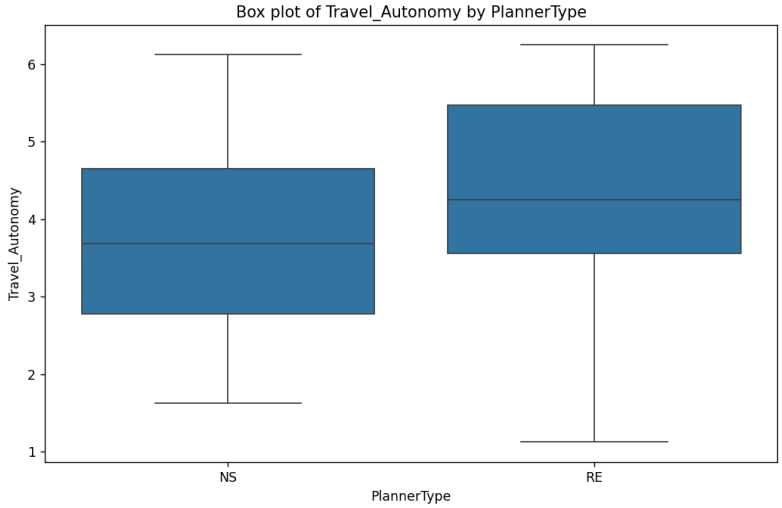


Figure 5.6: Median Scores for Travel Autonomy

the two planners are significant, we can examine *Cohen's d* values (See Table 5.5). The *Cohen's d* values (See Table 5.6) suggest effect sizes ranging from small to medium, highlighting the differences in means between the NS and RE groups.

The Mann-Whitney U test indicated that the travel autonomy levels of the participants differed significantly between the groups, *U = 501.5, p = 0.022, two-tailed*. This can be observed from their overall median scores as well (See Figure 5.6).

5.1.3 Travel Satisfaction

As can be seen in Table 5.7, both groups report high satisfaction levels on average, but the RE group consistently shows higher averages and medians, as well as a higher 75th percentile score. This suggests that the RE group generally finds their travel experiences more satisfying than the NS group.

PlannerType	mean	std	min	25%	50%	75%	max
NS	5.004386	1.202571	2.777778	4.138889	5.055556	5.611111	7.833333
RE	5.29398	1.192625	2.95	4.5375	5.55	6.325	6.888889

Table 5.7: Travel Satisfaction Descriptive Statistics

The participants' responses to the travel satisfaction statements indi-

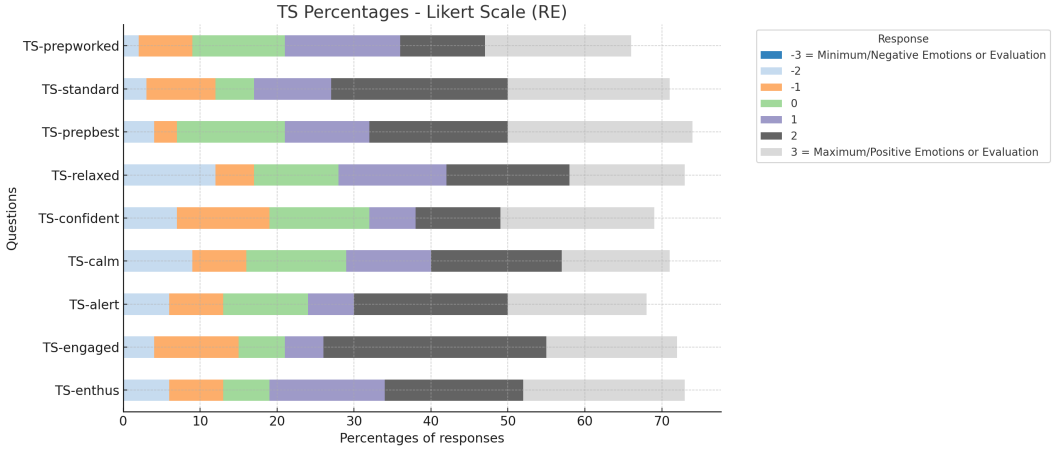


Figure 5.7: TS - Responses for the Re Planner

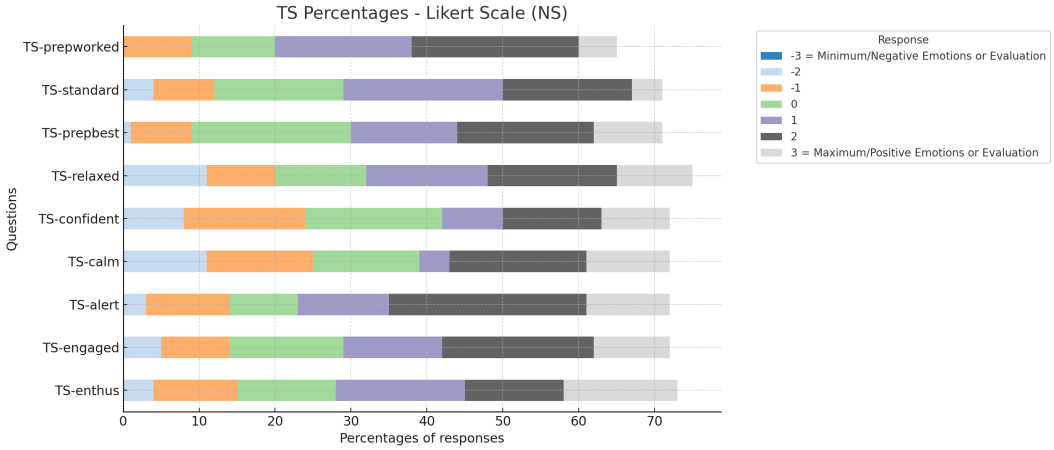


Figure 5.8: TS - Responses for the NS Planner

cate that the RE planner is perceived more positively across various metrics compared to the NS planner [65]. The RE planner tends to have slightly more positive responses, while the NS planner shows a more even distribution, with a marginally higher presence of moderate responses. Negative responses are minimal in both cases, but the NS planner [65] has a slight edge in that category. Users of the RE planner report feeling more enthusiastic, engaged, alert, calm, confident, and relaxed. Additionally, they rate their travel experience higher in terms of standard and preparation. More specifically, questions related to preparation have a higher concentration of positive responses compared to negative ones. Similarly, questions related to feelings of calm and enthusiasm show a higher concentration of positive responses. In contrast, for the NS planner [65], the preparation question predominantly received moderate ratings ("0"). While many responses for the NS planner [65] cluster around the positive end of the scale ("6"), the RE planner sees more responses around the maximum rating of 7, indicating a stronger positive perception.

TS_Scale_Questions	Mean_NS	Std_NS	Mean_RE	Std_RE	Difference
tired/alert	5.261	1.071	5.499	1.232	0.238
stressed/calm	4.697	1.642	5.086	1.771	0.389
worried/confident	4.596	1.669	5.198	1.773	0.603
fed-up/engaged	5.052	1.418	5.473	1.499	0.421
bored/enthusiastic	5.065	1.418	5.418	1.499	0.353
worst/best preparation	5.135	1.641	5.537	1.802	0.401
not well/worked well preparation	5.585	1.268	5.806	1.302	0.221
hurried/relaxed	4.698	1.503	4.983	1.629	0.286
low standard/high standard	4.929	1.538	5.646	1.574	0.717

Table 5.8: TS Scale Questions, Means, Standard Deviations, and Differences

To determine if the differences in responses to each question between the two planners are significant, we can examine *Cohen's d* values (See Table 5.8). The *Cohen's d* values (See Table 5.9) suggest effect sizes ranging from negligible to small, highlighting the differences in means between the NS and RE groups.

The Mann-Whitney U test indicated that the travel satisfaction levels of the participants did not differ significantly between the groups, $U = 587.5$, $p = 0.164$, *two-tailed*. However, the median scores indicate the

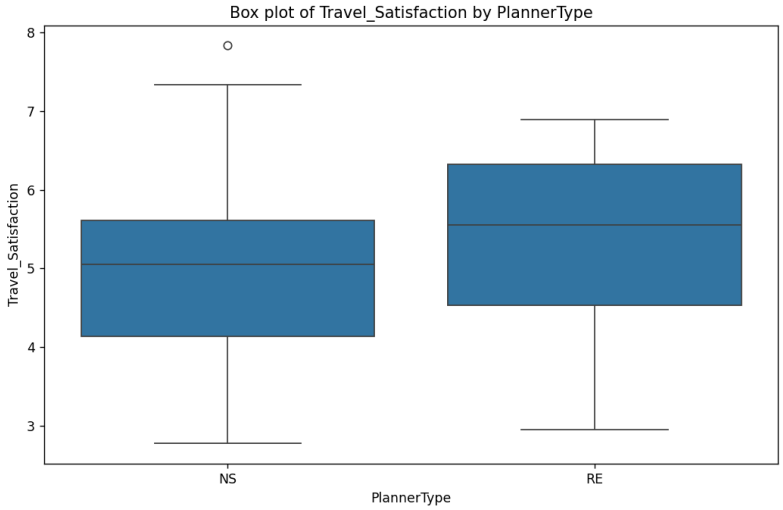


Figure 5.9: Median Scores for Travel Satisfaction

RE Planner still performed better than the NS (See Figure 5.9).

Cohen's d	Effect Size
0.207	Small
0.226	Small
0.344	Small
0.288	Small
0.239	Small
0.225	Small
0.170	Negligible
0.177	Negligible
0.457	Small

Table 5.9: Cohen's d and Effect Size for TS Scale Questions

5.1.4 Information Overload:

Both planners have very similar mean and median values, suggesting that the average user experience regarding information overload is nearly identical for both planners. The 25th, 50th, and 75th percentile values are very close for both planners, reinforcing the similarity in user experiences. Moreover, both planners have similar minimum and maximum scores, indicating a comparable range of experiences. The RE planner shows a slightly higher variation in responses, as indicated by the higher standard deviation.

Overall, users perceive the RE planner more positively in handling the

PlannerType	mean	std	min	25%	50%	75%	max
NS	3.095865	0.321279	2.571429	2.928571	3.071429	3.214286	4
RE	3.053571	0.341885	2.5	2.833333	3	3.214286	4

Table 5.10: Information Overload Descriptive Statistics

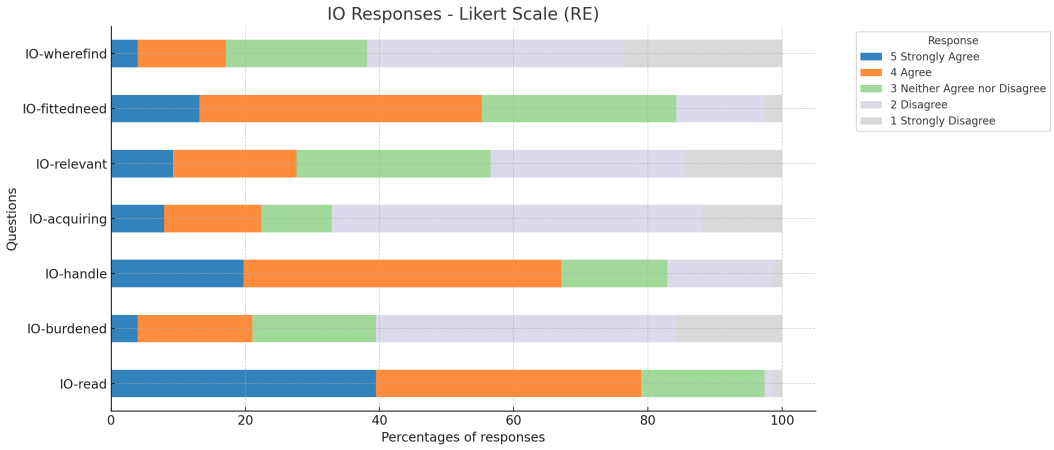


Figure 5.10: IO - Responses for the Re Planner

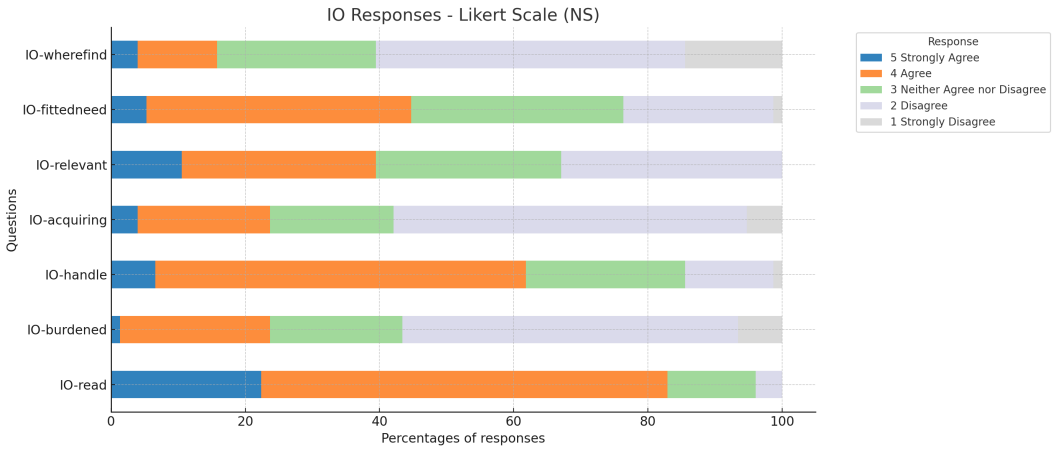


Figure 5.11: IO - Responses for the NS Planner

information overload associated with travel preparation (See Figures 5.11, 5.10). They feel more confident in managing the information provided and find it slightly more fitting to their needs compared to the NS planner [65]. The NS planner [65] users report a higher sense of burden and difficulty in acquiring the necessary information, though they still generally read the provided information carefully. The NS planner [65] has a higher proportion of users who agree that a small part of the information is relevant compared to the RE planner. The RE planner shows a more neutral to slightly negative perception, with many users neither agreeing nor disagreeing, and a significant portion disagreeing with the statement that only a small part of the information was relevant.

To determine if the differences in responses to each question between the two planners are significant (See Table 5.11), we can examine *Cohen's d* values. The *Cohen's d* values (See Table 5.12) suggest effect sizes ranging from negligible to large, highlighting the differences in means between the NS and RE groups. The difference in information relevance is notable (large effect size) indicating users perceive the information in the RE planner as less relevant compared to the NS planner [65].

IO_Scale_Questions	**Mean_NS**	**Mean_RE**	**Difference**
I felt difficulty in acquiring all of this information	2.638	2.519	0.118
burdened in handling it	2.614	2.529	0.085
info fitted to my need	3.253	3.515	0.262
effectively handle all of the information	3.527	3.682	0.154
read every piece of information	4.016	4.242	0.226
info relevant to my need	3.169	2.795	0.374
where to find the information	2.439	2.389	0.050

Table 5.11: IO Scale Questions, Means, and Differences

The Mann-Whitney U test indicated that the information overload levels of the participants did not differ significantly between the planners, U = *795, p =0.450, two-tailed*.

Cohen's d	Effect Size
0.357	Small
0.261	Small
0.774	Medium
0.462	Small
0.671	Medium
1.111	Large
0.148	Negligible

Table 5.12: Cohen's d and Effect Size for IO Scale Questions

5.1.5 Correlation between the Dependent Variables

There is a strong positive correlation between Travel Autonomy and Perceived Accessibility ($r = 0.84$). Similarly, Travel Autonomy and Travel Satisfaction also show a strong positive correlation ($r = 0.76$). These correlations suggest that as perceived accessibility improves, users' sense of travel autonomy increases, and higher travel autonomy is associated with greater travel satisfaction.

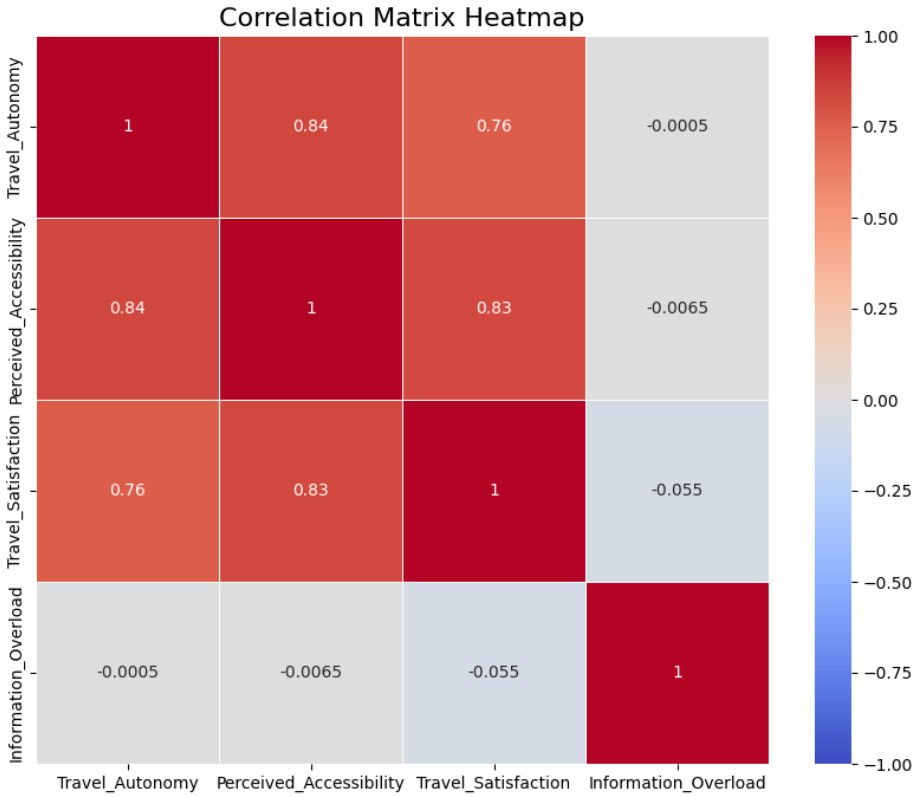


Figure 5.12: Correlations between the dependent variables

Perceived Accessibility and Travel Satisfaction are also strongly positively correlated (*r = 0.83*), indicating that improvements in accessibility directly enhance user satisfaction.

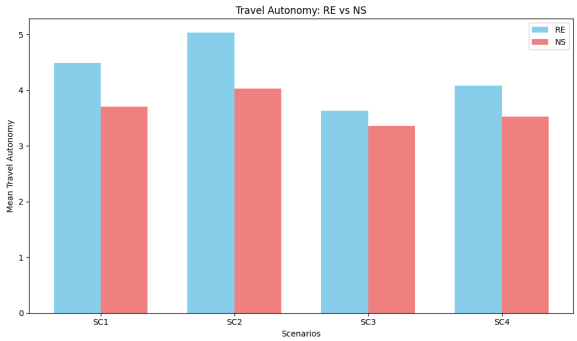
The correlation between Travel Autonomy and Information Overload is negligible (*r = -0.0005*), as is the correlation between Perceived Accessibility and Information Overload (*r = -0.0065*). This implies that changes in travel autonomy and accessibility do not significantly impact the level of information overload experienced by users.

5.1.6 Effect of the Scenarios

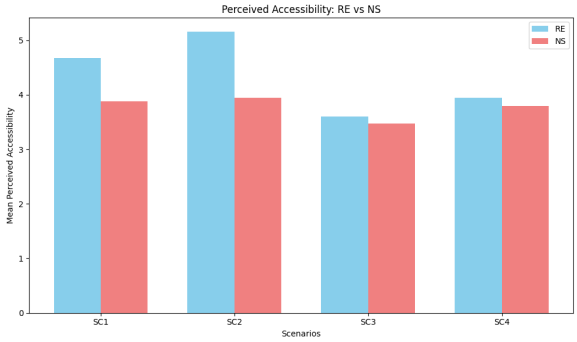
The scenarios (See Appendix A.6) showed similar results for perceived accessibility and travel autonomy between the two planners, with the most notable differences occurring in the scenario where the train was not busy and there was no delay (SC2). In contrast, the scenario (SC3) where the train was busy and there was a disruption showed very close results between the two planners for both perceived accessibility and travel autonomy, with the RE slightly outperforming the NS. For travel satisfaction, the results did not show significant differences between the two planners, with the largest difference again observed in SC2 and the RE, overall, outperforming the NS in every scenario. (See Figure 5.13)

A Friedman two-way ANOVA was conducted to compare the results of Travel Autonomy, Perceived Accessibility, and Travel Satisfaction across different pairs of scenarios. The results indicated that there were no significant differences across the pairs of scenarios for Travel Autonomy ($\chi^2 = 6.19$, $df = 3$, $p = 0.29$), Perceived Accessibility ($\chi^2 = 3.80$, $df = 3$, $p = 0.58$), and Travel Satisfaction ($\chi^2 = 5.72$, $df = 3$, $p = 0.33$).

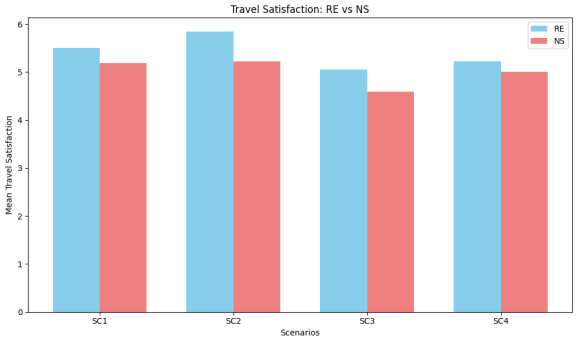
Conclusions: The vignette study revealed that the redesigned planner (RE) generally outperformed the NS Planner [65], especially in perceived accessibility and travel autonomy, with higher mean and median values. This led to higher satisfaction levels and more posi-



(a) Mean Travel Autonomy by Scenario and Planner Type



(b) Mean Perceived Accessibility by Scenario and Planner Type



(c) Mean Travel Satisfaction by Scenario and Planner Type

Figure 5.13: Mean values of various factors by Scenario and Planner Type

tive responses for the RE planner across various scenarios. Statistical tests confirmed significant differences in travel autonomy and near-significance in perceived accessibility.

Although travel satisfaction did not show statistically significant differences, the RE planner had higher mean and median values and more positive individual responses. Information overload levels were similar for both planners. Strong positive correlations were found between perceived accessibility, travel autonomy, and travel satisfaction.

Scenario analyses indicated the RE planner's better performance in convenient conditions, with minimal differences in more challenging scenarios.

6. Discussion

In this section, we discuss the main findings of this research, interpret them, and evaluate their significance. We start by addressing the results in relation to each subquestion, providing a comprehensive analysis of the outcomes. Next, we explore the effects of the scenarios studied and propose design recommendations based on our insights. We then outline the limitations of this research and describe how we addressed these challenges. Finally, we suggest directions for future research based on our findings and the limitations encountered.

6.1 SQ1: Identified Travel Needs and Barriers/ Challenges

The participants' interview responses revealed consistent patterns, highlighting shared experiences, challenges, emotions, and needs. The main barriers identified were extensive planning and sudden disruptions, such as non-functional services and overcrowded stations/trains, aligning with those reported in the literature (See Tables 2.1, 2.4). This consistency underscores the importance of targeted solutions to address these common concerns. Consequently, there is a fundamental nature of the barriers and accessibility issues within public transportation systems. Therefore these findings have a promising broader applicability not only for those with temporary but also for those with permanent mobility impairments. The emotional impact of these barriers leads to significant emotional distress, as already discussed by Penfold [74], and Mackett & Thoreau [50]. These issues have been supported in other studies as well [12, 24, 32, 50, 52, 73, 79, 84]. Based on their experiences with those barriers and those emotions, the need for independent traveling was expressed, which was also consistently

argued in the literature [8, 32, 71]. However, they also emphasized the importance of choosing between independence and immediate assistance. Literature indeed indicates that true independence is about having the choice between those two [59, 68, 83]. To feel more independent now they had to preplan exhaustively, explaining their request for more efficient journey-planning tools that do not require extensive time and effort.

6.2 SQ2: Desired Technological Accessibility Features

Similar to Müller [61], our participants underscored the importance of real-time information and immediate assistance in reducing their travel-related anxiety and increasing independence. More specifically, they requested the provision of real-time information about station crowdedness and elevator functionality that directly addresses the unpredictability and the physical barriers reported in this study and the literature [74, 102]. Such a technological need was expected, as real-time information has also been a highly utilized feature in previous technological solutions that focused on fostering independence and accessibility (See Table 2.5).

The inclusion of a location-based immediate assistance button was particularly requested, reflecting a desire for independence together with the need for occasional support. This feature helps bridge the gap between needing assistance and maintaining autonomy, a significant concern for mobility-impaired travelers [8, 72]. Additionally, this desire stems from their expressed need to avoid seeking in-person assistance from strangers, which they articulated as overwhelming.

6.3 SQ3: Impact of the Additional Features on Perceived Accessibility, Travel Autonomy, Travel Satisfaction and Information Overload

Overall, the findings indicate a positive response to the additional technological accessibility features. These enhancements positively influenced perceived accessibility, travel autonomy, and overall travel satisfaction.

More specifically, the results highlight a significant improvement in travel autonomy with the addition of technological features. This aligns with previous research findings that highlight the effectiveness of technological interventions in enhancing travel autonomy [8, 53]. Specifically, individuals reported enhanced capability, freedom, and the possibility to travel as they wished. Values that can lead to overall well-being and a better quality of life [24, 32]. This means that the additional features can be helpful in the preparation of their journeys, in a way that makes them feel more confident about their independence. Notably, the highest ratings were given to the question regarding the prerequisites for independent travel without requiring assistance from others. This suggests that the new technological features effectively provide the necessary prerequisites for individuals to feel more independent. This finding is significant because reducing the need to ask for help was a critical need identified by participants and independence is a primary objective of this research.

Previous research has highlighted the positive relationship between travel autonomy and perceived accessibility [46], a relationship that our study also confirmed. Although the results did not show a significant statistical improvement in perceived accessibility, there was still a notable enhancement. The lack of statistical significance can be attributed to the fact that participants may need more time to fully adapt to and trust the new technological features. Initial usage might

not be sufficient to significantly alter their perceptions of accessibility [15]. Additionally, if participants had strong pre-existing perceptions of poor accessibility due to previous negative experiences, a short-term intervention might not be enough to change these deeply ingrained views [74, 75]. Therefore, this is promising for significant results in the future as users become more familiar with the additional features.

Questions related to their ability to do all the activities they want, having good access to these activities, and being able to live their lives as they wish were highly rated with the additional features and only moderately rated with the existing NS Planner [65]. This can be explained by the reduced dependence on others facilitated by the new technological features, which likely led to the perception of better access to all desired activities, as supported in the literature [54]. Achieving the ability to live life as desired is closely tied to implementing the main needs articulated by participants. The new features allow individuals to feel more in control of their lives and activities, contributing to higher ratings in this area [32]. Participants felt more capable of engaging in all their preferred activities, likely due to the more reliable information provided by the technological features [74].

Both travel autonomy and perceived accessibility are positively related to life satisfaction [46]. In our study, there was a positive correlation between them and particularly travel satisfaction. While travel satisfaction did not show a statistically significant improvement, there was still a notable enhancement. Achieving a significant result in travel satisfaction is challenging due to the multifaceted factors that influence it. Travel satisfaction is deeply tied to emotions and feelings, which are difficult to fully capture in a vignette study where participants simulate scenarios rather than experiencing real-world settings.

However, our results still show better ratings in terms of emotions and feelings, indicating that the additional features could enhance travel satisfaction even in a simulated environment. This suggests that these

features have the potential to yield even better results in real-world settings.

The travel satisfaction scale showed the highest ratings with the additional features in questions about the quality of preparation ("the best/worst you can think of") and the effectiveness of the preparation ("worked out well/not well"). This can be explained by the fact that having extra information from the additional features leads to better preparation for their travel journey, which is a crucial aspect for mobility-impaired individuals based on both their saying and the literature [61]. Preparation is vital for these travelers, and the new features likely provided the confidence and assurance needed for better planning.

Moreover, as these features were specifically designed to address the needs of mobility-impaired individuals, it was expected that travel satisfaction would be enhanced. Research supports the positive relationship between meeting the specific needs of mobility-impaired travelers and improved travel satisfaction [96]. This alignment between the additional features and the users' needs likely contributed to the observed enhancements in travel satisfaction, even if not statistically significant.

The lack of significant results for Information Overload was expected since most participants were already familiar with the NS Planner [65], which served as the baseline. The additional features in the redesign were not drastically different. The redesign's better results can be attributed to the added information being more useful for individuals with mobility impairments. This is reflected in the high ratings for the relevance of the provided information. In contrast, the NS Planner [65], despite having less information, received higher ratings for causing burdens and difficulty in acquiring information, possibly due to participants finding it less helpful.

6.4 Effect of Scenarios on Perceived Accessibility, Travel Autonomy, Travel Satisfaction

The scenarios examined were not specifically linked to the additional technological features added in the redesign but addressed general issues that all individuals might encounter while traveling. Therefore, significant differences between the two planners were not initially anticipated and that was confirmed by the results. However, it was expected that providing extra and real-time information during busy or disrupted travel conditions would enhance travelers' perceptions of autonomy and accessibility and lead to better travel satisfaction by reducing overall stress and boosting confidence as supported by the literature [75].

The most notable differences observed in Perceived Accessibility and Travel Autonomy were in the scenario where the train was not busy and there was no delay (SC2). This suggests that even in scenarios without disruptions, the RE planner's ability to provide real-time information about elevator functionality, station crowd levels, and immediate assistance options significantly enhances users' perceptions of accessibility and travel autonomy. These features allow travelers to proactively plan for their accessibility needs, leading to a more confident and stress-free travel experience.

On the other hand, the very similar results for perceived accessibility and travel autonomy in SC3 (train busy/delay) can be attributed to the fact that such situations are generally challenging for all travelers, including those with mobility impairments. The additional features provided by the RE planner are not directly related to managing delays or busy trains, which explains the lack of significant difference between the two planners in this scenario.

6.5 Design Recommendations

Based on the findings of our research we propose design recommendations for technological accessibility features for mobility-impaired individuals. In this section, those recommendations will be discussed to inspire and aid in future design.

RECOMMENDATION 1 - Pre-Trip Journey Simulation Feature: Planning journeys is emphasized in the literature and confirmed by interviews (Table 2.4), which is significant. Future accessibility features should include an interactive navigation system that dynamically updates and guides users along accessible routes, avoiding barriers in real time. Research shows that such features enhance users' independence, confidence, and participation in activities. [1].

Inspired by a feature introduced by Google Maps in 2018, which offered wheelchair-accessible routes [51], this advancement aims to make navigation more inclusive and accessible for everyone. When a barrier is detected, the system could recalculate the route to provide an alternative accessible path, avoiding stairs, non-functional elevators, or other obstacles. This feature addresses the need for alternate routes and within-station navigation, reducing anxiety and increasing independence. Accessible features like elevators, ramps, and restrooms could be displayed on the map, with unavailable features grayed out and alternatives shown. Step-by-step instructions, such as "Go straight, turn left in 20 meters, use the elevator on your right," could guide users through accessible routes.

Research on similar systems highlights the feasibility and benefits of such technology. For instance, a study on mobile augmented reality for indoor navigation demonstrated significant improvements for wheelchair users, incorporating features such as the ability to register CAD drawings, find optimal routes, avoid obstacles, and use visual and voice commands for interaction [67].

RECOMMENDATION 2 - Real-Time Barrier Reporting: During interviews with individuals with temporary mobility issues, it was highlighted that both passenger and staff awareness of their needs is crucial. Our design currently provides an immediate assistance feature to inform operator staff but lacks on enhancing their awareness beyond that. One potential solution, suggested by a participant, is to enable users to record and report any barriers they encounter during their journey. This can be implemented through a simple form where users can select the type of barrier (e.g., malfunctioning elevator, blocked ramp), specify its location, and provide additional comments. This feature would help ensure that operator staff are promptly made aware of and can address these issues.

Crowdsourcing applications [9, 55, 70] leverage community input to solve problems and improve services efficiently. By implementing real-time barrier reporting for temporary mobility issues, we can enhance public transport accessibility through user-driven reports of barriers like malfunctioning elevators or blocked ramps. By applying these principles to public transport, we can ensure that temporary mobility issues are addressed promptly and efficiently, enhancing overall accessibility and user satisfaction.

RECOMMENDATION 3 - Comprehensive Information Provision for Available Accessibility Services: During interviews, individuals emphasized the importance of having comprehensive information about the available accessibility services. They often spent considerable time searching for these services or mistakenly believed they were only for those with severe disabilities. A future system could address this by allowing users to customize their travel preferences, such as indicating they are a wheelchair user. Based on their specific journey, the system would then provide tailored recommendations for the accessible services they could book or request if needed. This approach ensures that information is directly relevant to their route, saving them time and effort. Additionally, it may encourage users to seek assistance when necessary while also boosting their confidence to travel

independently, knowing that support options are readily available if needed.

RECOMMENDATION 4 - Adjust Journey Time Based on Condition: Three participants highlighted the need for the travel planner to adjust the estimated journey time based on their condition. For example, wheelchair users often need extra time to reach the elevator, wait for it, and navigate through crowded stations. If users could customize their travel preferences as mentioned in the third recommendation before 6.5, the system could also recommend arriving at the station earlier or provide adjusted time estimates that reflect these additional requirements. This feature would ensure that users can plan their journeys more accurately and reduce the stress associated with potential delays. By accounting for the extra time needed, the system would enhance the overall travel experience, making it more predictable and manageable for those with temporary mobility impairments. This need aligns with the literature, which highlights that individuals often need additional time travel costs to manage and overcome barriers during their journeys.[12, 52, 73, 84]

6.6 Limitations

Several limitations impact this study. The fact that we observed consistent patterns and similar responses among the 7 participants suggests that the sample for the interviews provides an accurate representation for the purposes of this research. However, it may not fully capture the diversity of experiences among temporarily mobility-impaired travelers, limiting the generalizability of the findings. This could be attributed to the sample size; despite identifying patterns and consistent responses, there remains the possibility of missing certain aspects of the broader experience. Still, as they had all experienced traveling with a temporary mobility-disability, they were good representatives of the study.

When considering the results of this study, it is important to recognize

that the evaluation of the redesigned NS Planner [65] app through a vignette study may not fully capture the complexity of real-world usage. Participants were shown screenshots of the app rather than interacting with it directly, meaning the study assessed hypothetical use based on static images rather than the full user experience. Additionally, participants immersed themselves in hypothetical scenarios, and not all had experience with temporary mobility impairments, which could impact their ability to accurately assess the difficulties and benefits of the redesigned planner. However, they were instructed to adopt the perspective of a person with a mobility impairment while responding to the vignette study, simulating real-world settings. Moreover, the screens provided were identical to those users would encounter when planning their journey from start to finish, ensuring the data's relevance for the scope of this research.

The majority of participants had experience with the NS Planner [65] and therefore familiarity bias could be a limitation of this study. Participants who regularly used the NS Planner [65] might have developed habits and expectations based on their previous experiences. Consequently, they might have subconsciously compared the RE Planner to the familiar NS Planner [65], potentially overlooking the additional features and benefits introduced by the redesign. Nonetheless, there was still a sufficient number of representatives without prior experience, ensuring a balanced participant pool.

Another potential limitation could be related to the scales used for the Vignette Study. While the Travel Autonomy Scale is valuable for understanding travel-specific independence, incorporating additional scales might have provided a more broad view of the participants' overall functional independence and ability to adapt to the new planner. Similarly, while Travel Satisfaction Scale provides valuable insights into specific aspects of the travel journey, it may not capture the full multidimensional nature of the overall travel experience. However, the Travel Autonomy and Travel Satisfaction scales were accurately and appropriately chosen for the purposes of this research, to

measure participants' independence and travel experience, based on related literature.

Due to time constraints, not all proposed design requirements were implemented in the final version of the redesigned NS Planner [65] app, meaning some potentially valuable features were not evaluated. However, the most crucial features, based on interview data and related literature, were included, providing a sufficient basis for evaluation in this study.

6.7 Future Work

To address the limitations identified in this study, future research should consider several key areas for improvement. First, increasing the sample size for interviews would help capture a more diverse range of experiences among temporarily mobility-impaired travelers, thereby enhancing the generalizability of the findings. Employing methods to mitigate self-reported data biases, such as using travel diaries or observational studies, could also improve the accuracy and reliability of the data collected.

Those methods could be useful for future evaluation of the redesigned planner as well, as they should move beyond vignette studies to incorporate real-world usage assessments. Conducting longitudinal or even observational studies with participants using the actual app in their daily travels would provide a more comprehensive understanding of its effectiveness and usability. Moreover, future implementations should attempt to incorporate all proposed design requirements. This would allow for a thorough evaluation of the app's full potential and identify which features are most beneficial to users. Assessing the long-term impact of the proposed solutions on users' travel behavior and independence is also crucial. Longitudinal studies that track changes in travel patterns and independence over time would provide valuable insights into the effectiveness of the app.

To address familiarity bias, future studies could ensure an equal number of experienced and inexperienced users. Additionally, designing a new prototype without using an existing one as a baseline could help evaluate potential accessibility features more objectively.

The focus of this research is retained on the planning process of the journey because it is crucial, as indicated by interview data and existing literature. However, in future research, it would be beneficial to investigate the entire travel journey or other parts of the journey as well to gain a comprehensive understanding of the travel experience.

Moreover, when evaluating the technological accessibility features, eye-tracking technology could be used in future research to understand if participants notice them, how they interact with them, and to identify any overlooked features. This approach can provide a comprehensive understanding of the effectiveness of the current accessibility features and guide improvements to ensure a more accessible and inclusive travel experience for individuals with mobility impairments. For this comprehensive understanding, incorporating qualitative questions following the Vignette Study would be also beneficial. These questions can help explain the reasons behind participants' responses and provide deeper insights into the significance of the results.

7. Conclusions

In this study, we investigated the challenges and solutions for empowering travelers with temporary mobility impairments within the Dutch railway systems. The research was driven by the question: "*How can technological accessibility features be designed based on the user needs of individuals with temporary mobility impairments to enhance both perceived accessibility and independence within the Dutch railway systems, thereby improving their overall travel experience?*". This primary question was addressed through three subquestions:

(SQ1): What are the specific travel needs and barriers/challenges of individuals with temporary mobility impairments when traveling with the Dutch railway systems?

(SQ2): What are the main technological accessibility features temporary mobility impaired people desire?

(SQ3): How do the additional technological accessibility features impact perceived accessibility, independence, and overall travel experience among users with temporary-mobility impairments?

To answer these questions, we conducted semi-structured interviews, a vignette study, and a user-centered design approach. As a result, we identified key accessibility features such as real-time updates on station conditions and a location-based immediate assistance button, which can significantly improve the perceived accessibility and independence of temporarily mobility-impaired travelers. This research contributes to the field of Human-Computer Interaction by providing practical insights and solutions for developing more inclusive public transportation systems globally.

Overall, the results from this study are promising and lay the groundwork for future research into technology-based interventions aimed at enhancing perceived accessibility and independence for temporary mobility-impaired individuals. Our findings provide valuable insights into designing effective accessibility features that can significantly improve perceived accessibility and independence. We hope our work will contribute to more inclusive public transportation systems and inspire further research and development in this critical area. From overall findings of this study, the following conclusions can be drawn:

- **Identification of Barriers and Needs**:
  - Interviews revealed significant barriers faced by individuals with temporary mobility impairments that include non-functional elevators, crowded stations, and the need for extensive pre-planning.
  - Emotional impacts such as stress and anxiety were highlighted due to these barriers.
  - Those are strongly correlated with the main needs identified: (a) efficient journey planning, (b) immediate assistance, (c) independent traveling
- **Preference for Independent Travel**:
  - A strong preference for independent travel was expressed by participants in combination with the need for systems that allow for independent travel while assisting when needed.
- **User-Centered Design Approach**:
  - The study employed a user-centered design approach, incorporating feedback from individuals with temporary mobility impairments through interviews, to develop the proposed solutions.
  - This approach ensures that the solutions are tailored to the specific needs and challenges of the target users.

- **Key Technological Solutions**:
  - Real-time updates on station crowding and elevator functionality.
  - A location-based immediate assistance button.
  - These features were designed to fulfill users' needs by reducing the time spent on planning ahead and providing an easy option for requesting immediate assistance.
  - The overall goal was to enhance perceived accessibility and independence, reducing the reliance on human assistance.
- **Evaluation**:
  - The evaluation through vignette studies showed significant enhancements in travel autonomy and promising improvements in perceived accessibility and travel satisfaction.
  - Participants seem to appreciate the ability to receive real-time updates and the option to request immediate assistance.
- **Broader Applicability**:
  - While focusing on the Dutch railway system, the findings can have broader applicability for public transportation systems globally.
  - The research contributes practical insights for promoting accessibility in transportation systems, ensuring inclusivity for all individuals with mobility impairments.

A. Appendix Materials

A.1 Information Sheet - Interviews

(a) **Introduction**

You are invited to participate in a scientific research study designed to improve our understanding and empower individuals traveling by train in the Netherlands, particularly those with temporary mobility impairments. This study seeks to gather insights into the challenges, barriers, and emotional experiences encountered during travel. Please note that the interviews for this study will be conducted online, utilizing Microsoft Teams meetings. This approach allows for a flexible and accessible participation process from any location, ensuring your comfort and convenience throughout the research engagement.

(b) **What is the background and purpose of this study?**

This research is about making railway travel in the Netherlands easier and more accessible for people who have temporary difficulties moving around, like those recovering from surgery or injuries. The idea is to create a digital travel assistant that can guide these individuals through the railway system, making their journeys smoother and less stressful. This way, they can travel more independently, without needing to rely heavily on others for assistance.

(c) **Who will carry out the study?**

This study is carried out by Ioanna Vounzoulaki, `i.vounzoulaki@students.uu.nl`, as part of my master thesis under supervision of Marloes Vredenborg, `m.t.r.vredenborg@uu.nl`.

(d) **How will the study be carried out?**

In this study, you will have the opportunity to share your experiences through an interview, specifically focusing on times you have travelled with the train while dealing with an injury. The focus is on hearing about any obstacles you encountered, challenges you faced, and the emotions you experienced during these journeys. Additionally, your perceptions of accessibility and the sense of independence will be explored. The interview is expected to last approximately 30 to 40 minutes.

(e) **What will we do with your data?**

If you consent to this, an audio recording will be made. This recording will be stored in the researcher's personal secure University drive. The recording will be transcribed so that participants' input is captured into text. The recording will be securely deleted after transcription (within 5 months of the study). The transcribed text will not contain any personal data so that you will not be identifiable. My thesis and any possible publications based on this research, will not include your name or any other individual information by which you could be identified.

Other data you provide will be securely stored, namely (such as name, email, etc.), and your experiences and emotions while travelling by train. As you might be identified from your name, e-mail, etc. all this data constitutes personal data. We will delete those data shortly after the interview sessions are done and they will be replaced with an ID to link them with the rest of your data.

(f) **What are your rights?**

Participation is voluntary. We are only allowed to collect your data for our study if you consent to this. If you decide not to participate, you do not have to take any further action. You do not need to sign anything. Nor are you required to explain why you do not want to participate. If you decide to participate, you can always change your mind and stop participating at any time, including during the study. You will even be able to withdraw

your consent after you have participated. However, if you choose to do so, we will not be required to undo the processing of your data that has taken place up until that time. The personal data we have obtained from you up until the time when you withdraw your consent will be erased (where personal data is any data that can be linked to you, so this excludes any already anonymized data).

(g) **Approval of this study**
This study has been allowed to proceed by the Research Institute of Information and Computing Sciences on the basis of an Ethics and Privacy Quick Scan. If you have a complaint about the way this study is carried out, please send an email to: `ics-ethics@uu.nl`. If you have any complaints or questions about the processing of personal data, please send an email to the Faculty of Sciences Privacy Officer: `privacy-beta@uu.nl`. The Privacy Officer will also be able to assist you in exercising the rights you have under the GDPR. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information at `www.uu.nl/en/organisation/privacy`.

(h) **More information about this study?**
If you have any questions or concerns about this research, please contact Ioanna Vounzoulaki at `i.vounzoulaki@students.uu.nl`.

A.2 Consent Form - Interviews

(a) I confirm that I am 18 years of age or over.

(b) I confirm that the research project "I Want To Break Free: Empowering Temporary Mobility-Impaired Travelers with a Digital Travel Assistant for Accessible Dutch Railways" has been explained to me. I have had the opportunity to ask questions about the project and have had these answered satisfactorily. I had enough time to consider whether to participate.

(c) I consent to the material I contribute being used to generate insights for the research project "I Want To Break Free: Empowering Temporary Mobility-Impaired Travelers with a Digital Travel Assistant for Accessible Dutch Railways".

(d) I consent to audio recordings being used in this study as explained in the information sheet. I understand that I can request to stop recordings at any time.

(e) I understand that if I give permission, the audio recordings will be held confidentially so that only Ioanna Vounzoulaki has access to the recording. The recordings will be secured for up to 5 months after which period they will be destroyed. In accordance with the General Data Protection Regulation (GDPR) I can have access to my recordings and can request them to be deleted at any time during this period.

(f) I understand that in addition to the recordings, other personal data will be collected from me and that this information will be held confidentially so that only Ioanna Vounzoulaki has access to this data and is able to trace the information back to me personally. The information will be secured in the researcher's secure personal University drive for up to 5 months after which period it will be deleted. In accordance with the General Data Protection Regulation (GDPR) I can have access to my information and can request my data to be deleted at any time during this period.

(g) I understand that my participation in this research is voluntary and that I may withdraw from the study at any time without providing a reason, and that if I withdraw any personal data already collected from me will be erased.

(h) I consent to allow the fully anonymized data to be used in future publications and other scholarly means of disseminating the findings from the research project.

(i) I understand that the data acquired will be securely stored by re-

searchers, but that appropriately anonymized data may in future be made available to others for research purposes. I understand that the University may publish appropriately anonymized data in appropriate data repositories for verification purposes and to make it accessible to researchers and other research users.

(j) I understand that I can request any personal data collected from me to be deleted.

A.3 Interview Questions

- **General Questions:**
  - What is your age?
  - How often do you travel by train here in the Netherlands?
  - What is your overall experience with train traveling in the Netherlands?
- **Context about the Injury & Train Traveling:**
  - What kind of injury did you have?
  - How long were you affected by it?
  - During your injury, how frequently did you find yourself traveling by train?
  - Why were you mostly traveling?
  - How much did the injury affect your experience with train travel?
- **Barriers, Challenges Faced:**
  - What were the most frequent challenges/barriers you were facing while traveling?
  - Why were those challenging for you?
  - Do you remember a specific time you traveled and faced specific obstacles? Can you share a story you remember?

  - How do you think these barriers could be mitigated?

- **Feeling of Independence & Travel Experience:**
  - Were you able to navigate these situations independently, or did you seek assistance?
  - Did you think of asking for assistance? If yes, why didn't you ask for it? (if answer in question - was independently)
  - What strategies did you employ to overcome the challenges? (if answer in question - was independently)
  - What kind of assistance? Did it help you cope with the issue you had? (if answer in question - was with assistance)
  - Were there specific moments that made you feel more confident or supported while traveling? Please describe them.
  - In what ways did the accessibility (or lack of accessibility) impact your feeling of independence during your travels?
  - Were there any specific services or accommodations that improved your travel experience? How could these be enhanced?
  - Do you think train traveling is accessible enough for mobility impaired people? Why?
- **Future Planning, Feedback and Suggestions:**
  - Imagine you are planning another journey with the train under similar circumstances. What would be your main concerns, and how would you prepare?
  - Is there anything else about your experiences or feelings while traveling with the train that you would like to share?
  - I am planning to come up with a digital travel assistant that will help people with temporary mobility impairments to navigate and travel by train in the Netherlands. What kind of features can you think that would be helpful or you wish it would have?

- Do you have any final thoughts or suggestions on how the travel experience for individuals with temporary mobility impairments could be enhanced?

A.4 Vignette Study - Information Sheet

You are invited to participate in a scientific research study designed to improve our understanding and empower individuals travelling by train in the Netherlands, particularly those with temporary mobility impairments. This research is about making Railway travel in the Netherlands easier and more accessible for people who have temporary difficulties moving around, like those recovering from surgery or injuries.

In this study, you will be presented with two scenarios depicting situations faced by a person with a mobility impairment while preparing himself to use public transportation for his journey. You will be presented with screens from a travel application planner, and we ask you to imagine using this app for your journey. We ask you to immerse yourself in the scenario and respond as if you are the person experiencing it.

The study should take you approximately 15 minutes to complete.

Participation in this study is entirely voluntary. We can only collect your data for our study if you consent to this. If you decide to participate, you may withdraw anytime, including during the study. However, if you decide to withdraw, we will not be required to undo the processing of your data that has taken place up until that time. The personal data we have obtained from you up until the time when you withdraw your consent will be erased (where personal data is any data that can be linked to you, so this excludes any already anonymized data). Your aggregated anonymized data will be used in future publications and other scholarly means of disseminating the findings from the research project, including data repositories to make it accessi-

ble to researchers. Any publications based on this research, and the data repository will not include your name or any other individual information by which you could be identified. In accordance with the Utrecht University policy, anonymized research data are to be retained for a minimum of ten years.

This study has been allowed to proceed by the Research Institute of Information and Computing Sciences on the basis of an Ethics and Privacy Quick Scan. If you have a complaint about the way this study is carried out, please send an email to: ics-ethics@uu.nl. If you have any complaints or questions about the processing of personal data, please send an email to the Faculty of Sciences Privacy Officer: privacy-beta@uu.nl. The Privacy Officer will also be able to assist you in exercising the rights you have under the GDPR. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information at www.uu.nl/en/organisation/privacy.

This study is conducted by Ioanna Vounzoulaki as part of her master's thesis in Human Computer Interaction under the supervision of J.F.M. Masthoff and M.T.R. Vredenborg. If you have any questions or concerns about this research, please contact Ioanna Vounzoulaki at i.vounzoulaki@students.uu.nl

A.5 Vignette Study - Consent Form

(a) I confirm that I am 18 years of age or over.

(b) I confirm that the research project "I Want To Break Free: Empowering Temporary Mobility-Impaired Travelers with a Digital Travel Assistant for Accessible Dutch Railways" has been explained to me.

(c) I had enough time to consider whether to participate.

(d) I consent to the material I contribute being used to generate insights for the research project "I Want To Break Free: Empower-

ing Temporary Mobility-Impaired Travelers with a Digital Travel Assistant for Accessible Dutch Railways".

A.6 Vignette Study - Scenario

Alex, recently broke his leg and has to move on a wheelchair. He is planning a trip from Utrecht Centraal to Breda for a meeting. To make sure the journey goes smoothly, Alex uses the app on his phone to prepare in advance. Opening the app, Alex goes to the 'Plan Journey' section and enters Utrecht Centraal as the start station, Breda as the destination and 19:00 as departure time. Based on the information provided on the app, his train is going to be *quiet/busy*, however there is a *delay/no delay* on his journey.

(a) SC1: Train is busy / No delay

(b) SC2: Train not busy / No delay

(c) SC3: Train is busy / Delay

(d) SC4: Train not busy / Delay

Please check the following screens as you would normally do if you were actually preparing for this journey as a wheelchair user. For now, we would like you to imagine that you are Alex. Please respond to the statements below from Alex's perspective.

(a) I confirm that I am 18 years of age or over.

(b) I confirm that the research project "I Want To Break Free: Empowering Temporary Mobility-Impaired Travelers with a Digital Travel Assistant for Accessible Dutch Railways" has been explained to me.

(c) I had enough time to consider whether to participate.

(d) I consent to the material I contribute being used to generate insights for the research project "I Want To Break Free: Empowering Temporary Mobility-Impaired Travelers with a Digital Travel Assistant for Accessible Dutch Railways".

A.7 Vignette Study - Questions

A.7.1 Perceived Accessibility Scale - Questions

- *Considering how I travel today, it's easy to do (daily) activities.*
- *Considering how I travel today, I'm able to live my life as I want to.*
- *Considering how I travel today, I'm able to do all the activities I like to do.*
- *Considering how I travel today, access to all the things I want to do is very good.*

A.7.2 Travel Autonomy Scale - Questions

- *To what degree do you have the capability to travel as you wish?*
- *To what degree do you have the prerequisite to travel independently without help from others?*
- *To what degree do you have the freedom to travel as you wish?*
- *To what degree do you have the possibility to travel as you wish?*

A.7.3 Travel Satisfaction Scale - Questions

- *To what extent did you feel enthusiastic/bored, using the planner?*
- *To what extent did you feel engaged/fed up, using the planner?*
- *To what extent did you feel alert/tired, using the planner?*
- *To what extent did you feel calm/stressed, using the planner?*
- *To what extent did you feel confident/worried, using the planner?*
- *To what extent did you feel relaxed/hurried, using the planner?*
- *To what extent was the preparation of your journey the best/worst you can think of?*
- *To what extent was the preparation of your journey of high/low standard?*

- *To what extent did the preparation of your journey work out well/not well?*

A.7.4 Information Overload Scale - Questions

- *I carefully read every piece of information about the preparation of my journey provided on the screens of the planner.*
- *There was too much information about the preparation of my journey on the screens of the planner so that I was burdened in handling it.*
- *I could effectively handle all of the information on the screens of the planner.*
- *Because of the plenty information for the preparation of my journey on the screens of the planner, I felt difficult in acquiring all of this information.*
- *I found that only a small part of information for the preparation of my journey on the screens of the planner was relevant to my need.*
- *I was certain that the journey information on the screens of the planner, fitted to my need for planning it.*
- *I had no idea about where to find the information I needed on the screens of the planner.*

B. Appendix Screens of the Design Process

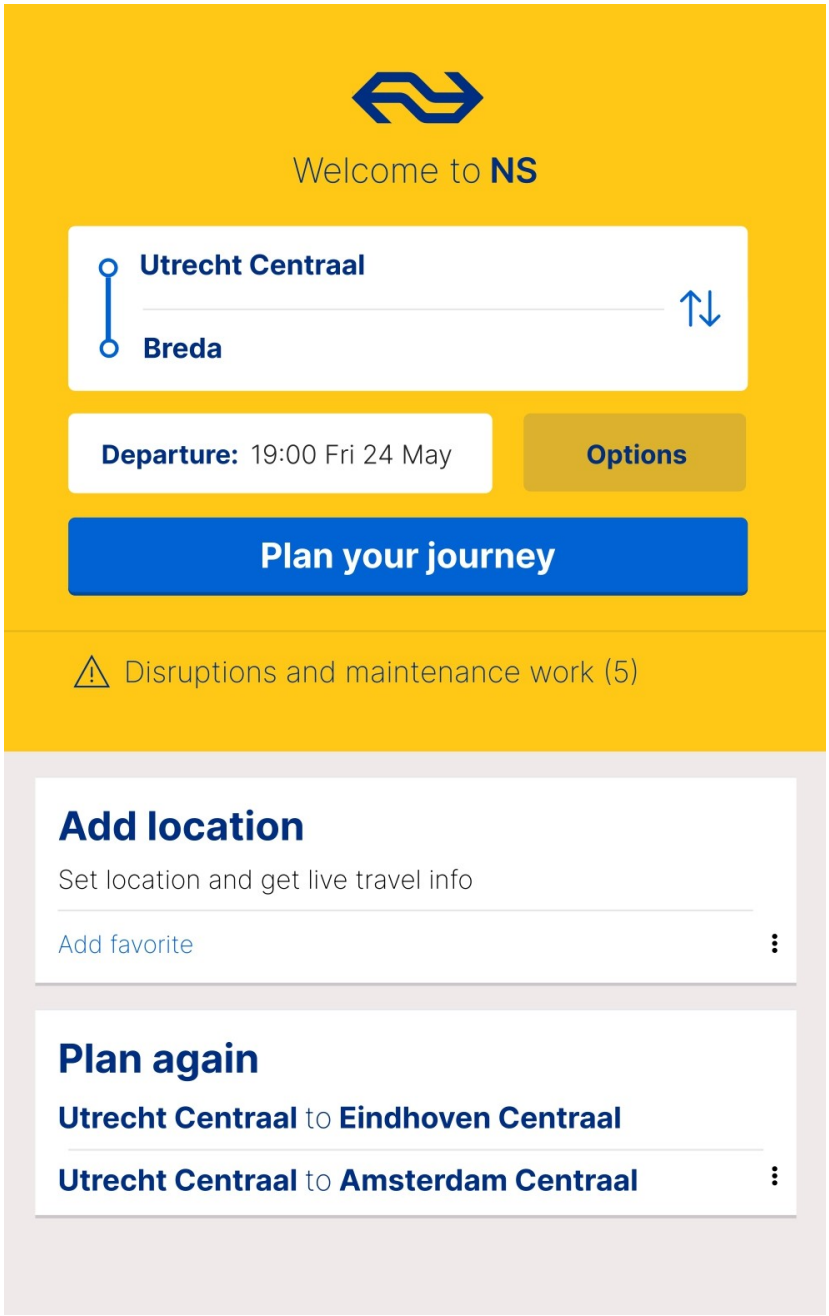


Figure B.1: Main Screen

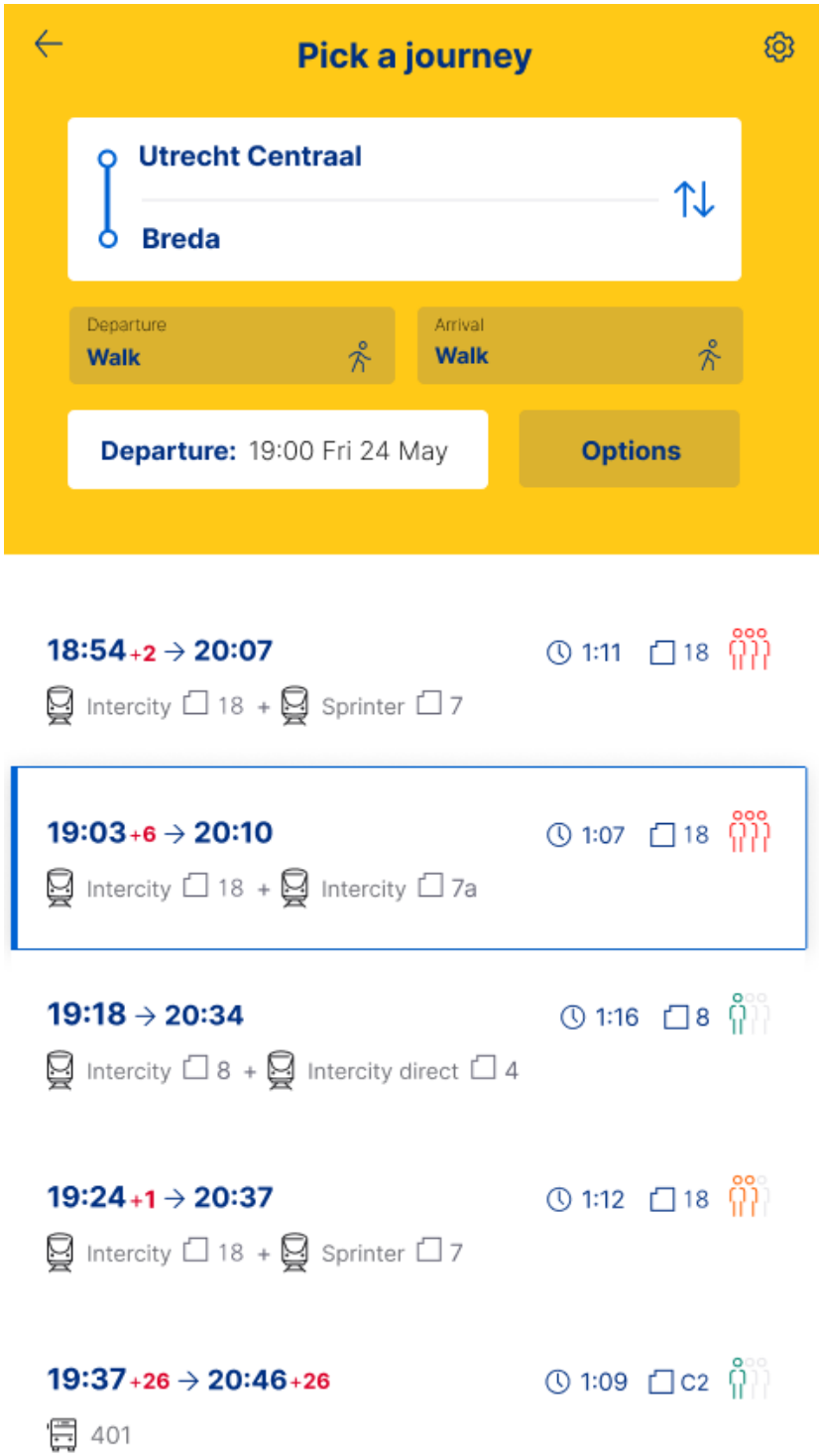


Figure B.2: Possible journeys

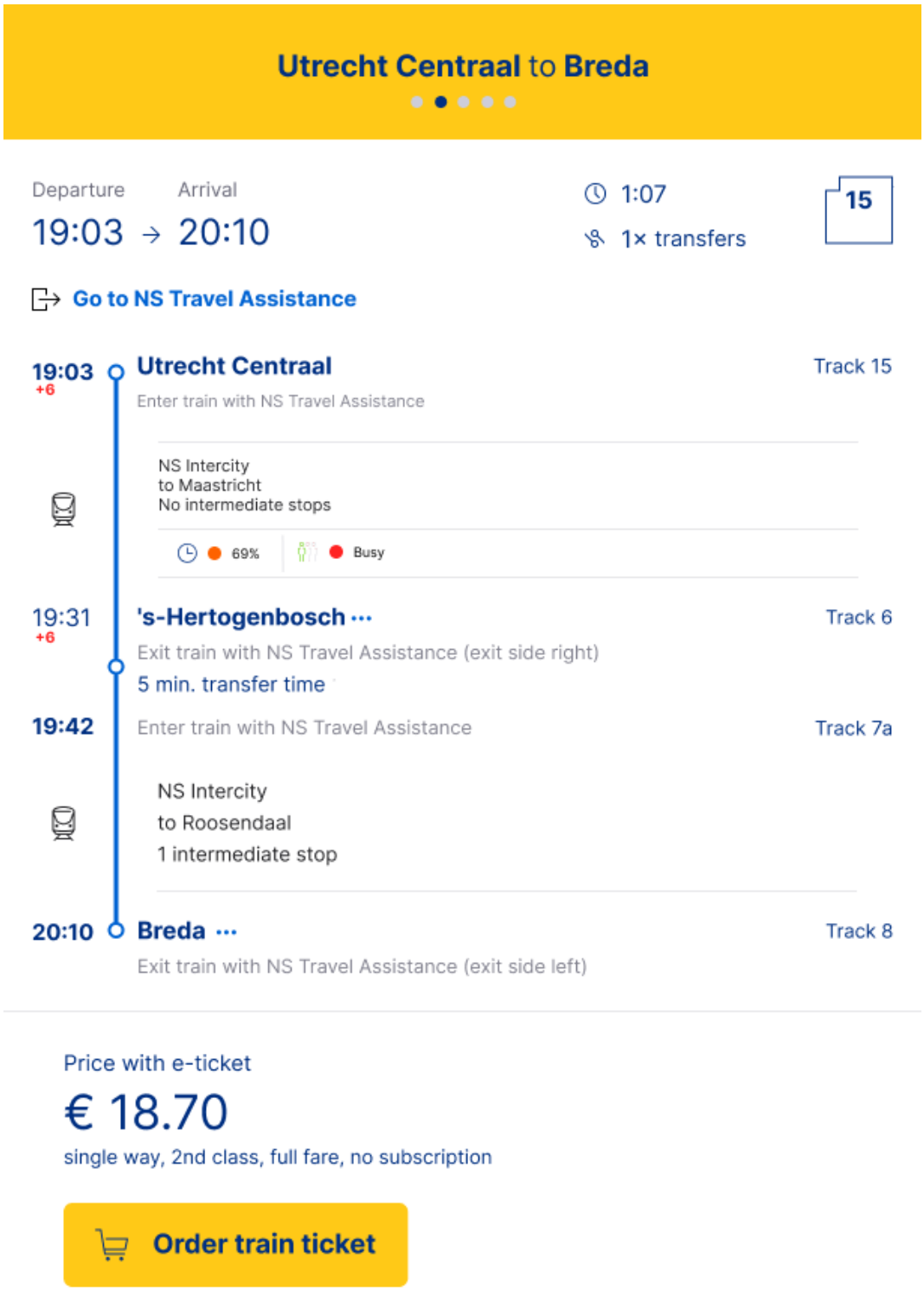


Figure B.3: Journey with the NS

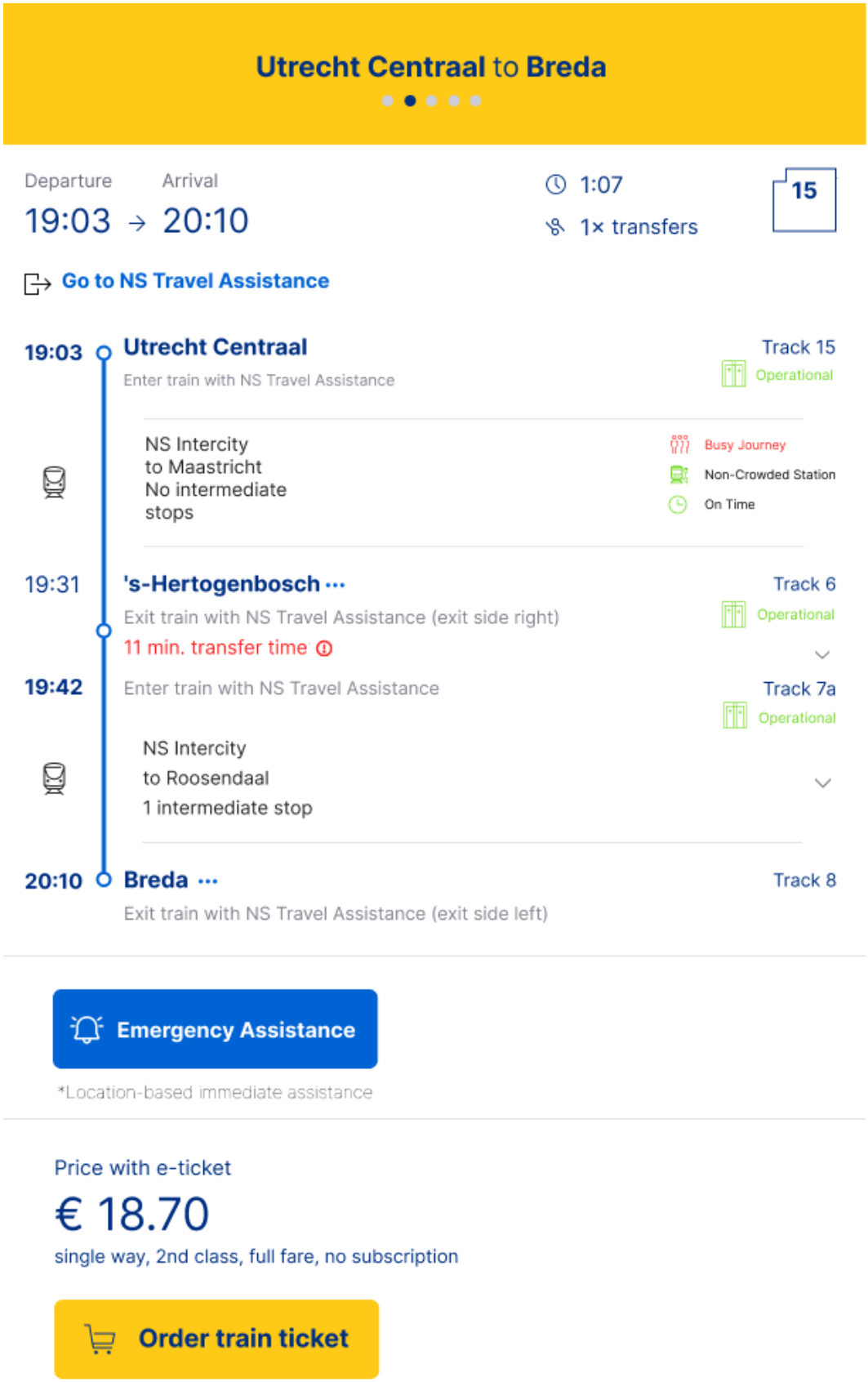


Figure B.4: Font colour choice 1

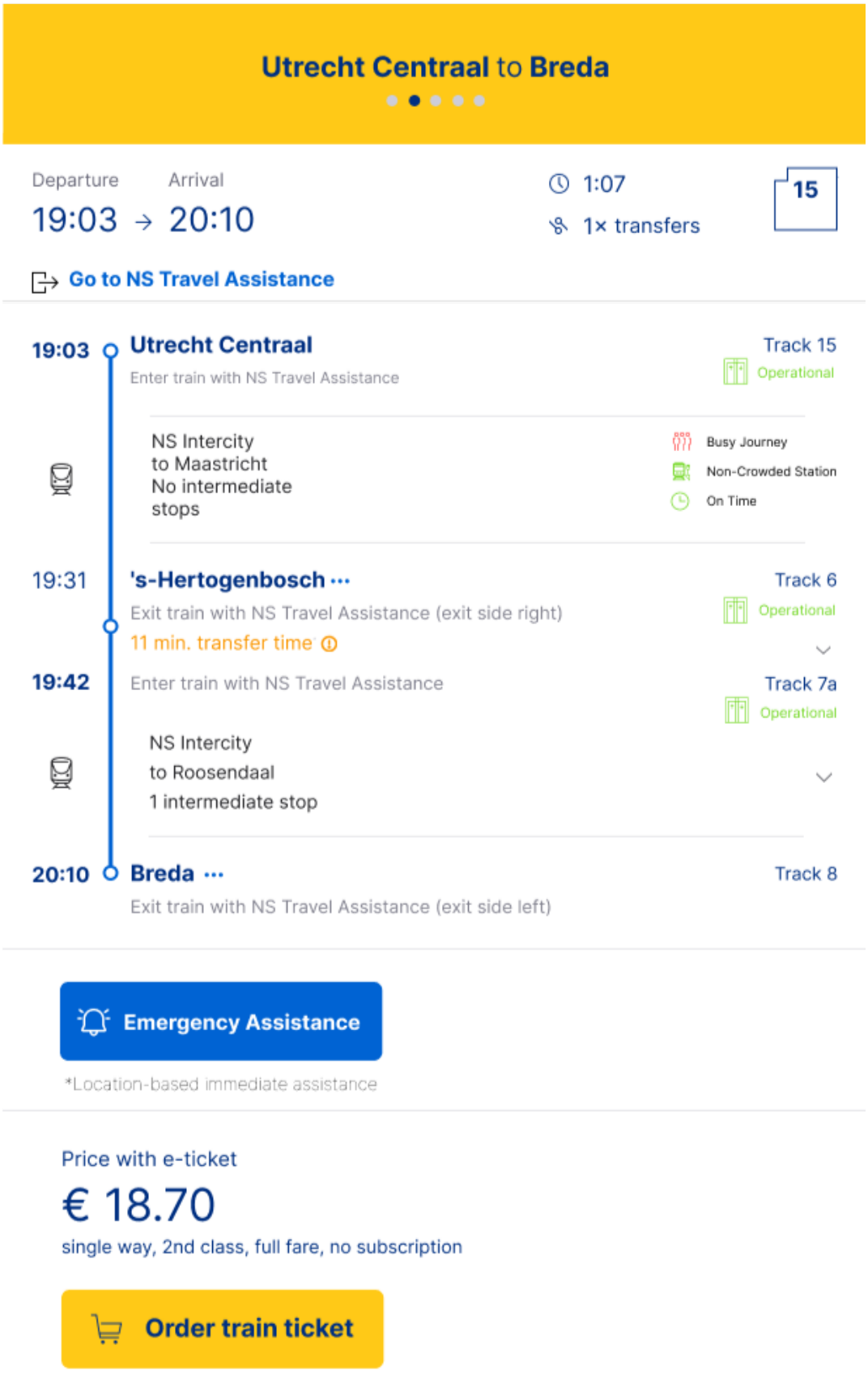


Figure B.5: Font colour choice 2

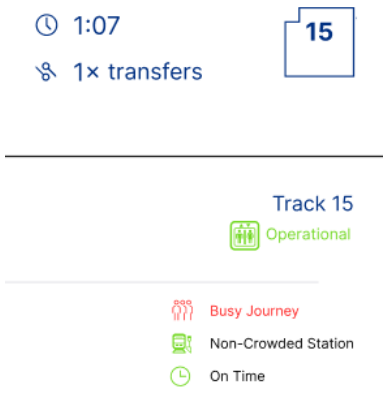


Figure B.6: Option 1 for the elevator icon

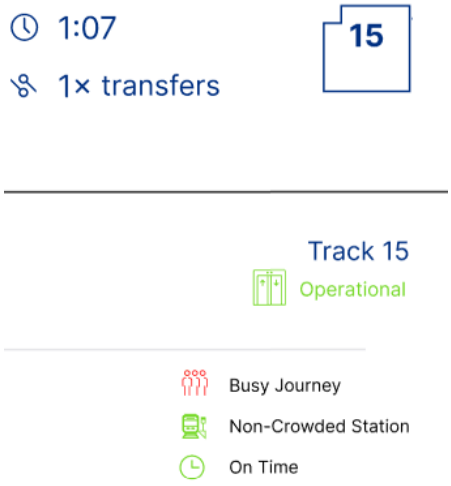


Figure B.7: Option 2 for the elevator icon

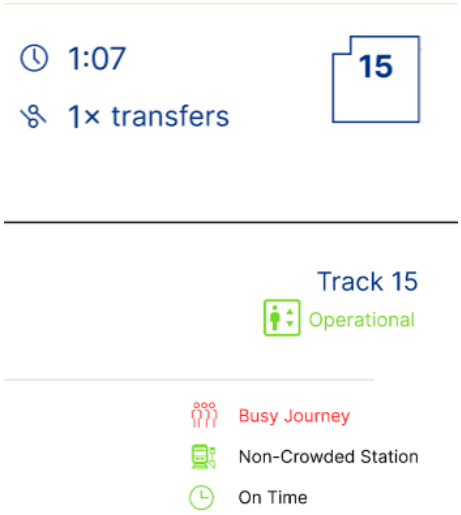


Figure B.8: Option 3 for the elevator icon

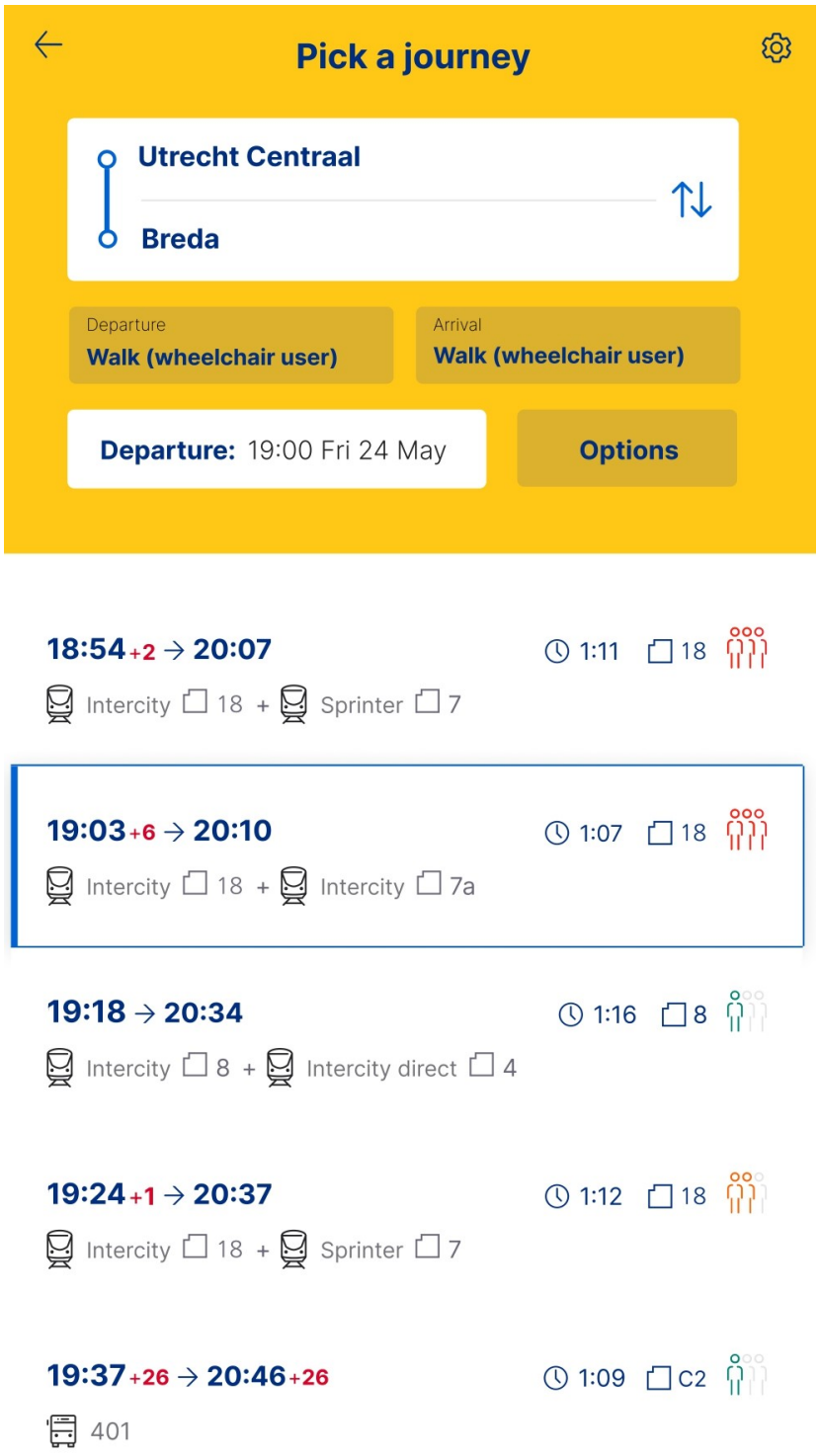


Figure B.9: Screen of the possible journeys

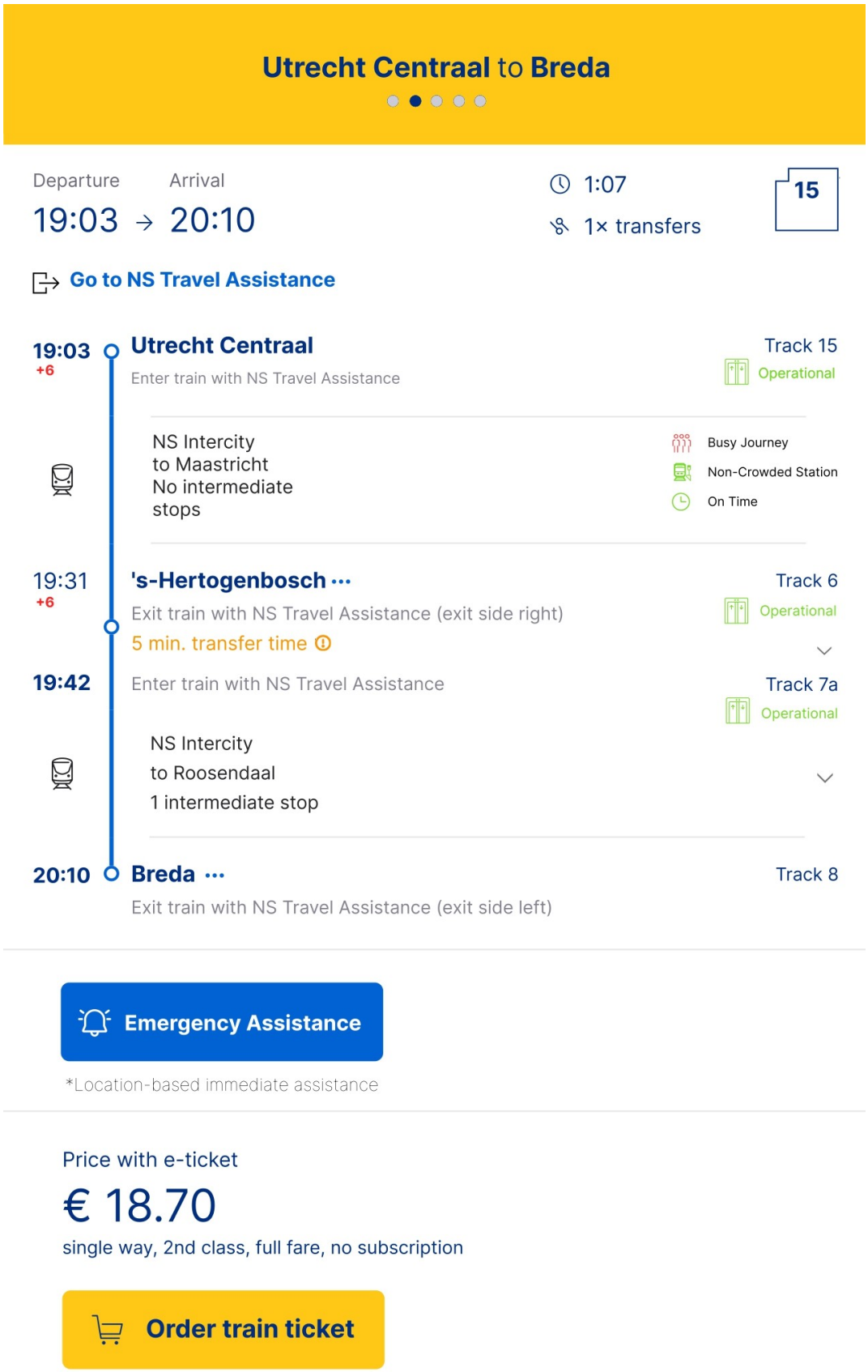


Figure B.10: Screen of the journey with the RE Planner

C. Appendix Ethics Scan

Response Summary:

Section 1. Research projects involving human participants

P1. Does your project involve human participants? This includes for example use of observation, (online) surveys, interviews, tests, focus groups, and workshops where human participants provide information or data to inform the research. If you are only using existing data sets or publicly available data (e.g. from Twitter, Reddit) without directly recruiting participants, please answer no.

- Yes

Recruitment

P2. Does your project involve participants younger than 18 years of age?

- No

P3. Does your project involve participants with learning or communication difficulties of a severity that may impact their ability to provide informed consent?

- No

P4. Is your project likely to involve participants engaging in illegal activities?

- No

P5. Does your project involve patients?

- No

P6. Does your project involve participants belonging to a vulnerable group, other than those listed above?

- No

P8. Does your project involve participants with whom you have, or are likely to have, a working or professional relationship: for instance, staff or students of the university, professional colleagues, or clients?

- No

Informed consent

PC1. Do you have set procedures that you will use for obtaining informed consent from all participants, including (where appropriate) parental consent for children or consent from legally authorized representatives? (See suggestions for information sheets and consent forms on the website.)

- Yes

PC2. Will you tell participants that their participation is voluntary?

- Yes

PC3. Will you obtain explicit consent for participation?

- Yes

PC4. Will you obtain explicit consent for any sensor readings, eye tracking, photos, audio, and/or video recordings?

- Yes

PC5. Will you tell participants that they may withdraw from the research at any time and for any reason?

- Yes

PC6. Will you give potential participants time to consider participation?
- Yes

PC7. Will you provide participants with an opportunity to ask questions about the research before consenting to take part (e.g. by providing your contact details)?
- Yes

PC8. Does your project involve concealment or deliberate misleading of participants?
- No

Section 2. Data protection, handling, and storage

The General Data Protection Regulation imposes several obligations for the use of **personal data** (defined as any information relating to an identified or identifiable living person) or including the use of personal data in research.

D1. Are you gathering or using personal data (defined as any information relating to an identified or identifiable living person)?
- Yes

High-risk data

DR1. Will you process personal data that would jeopardize the physical health or safety of individuals in the event of a personal data breach?
- No

DR2. Will you combine, compare, or match personal data obtained from multiple sources, in a way that exceeds the reasonable expectations of the people whose data it is?
- No

DR3. Will you use any personal data of children or vulnerable individuals for marketing, profiling, automated decision-making, or to offer online services to them?
- No

DR4. Will you profile individuals on a large scale?
- No

DR5. Will you systematically monitor individuals in a publicly accessible area on a large scale (or use the data of such monitoring)?
- No

DR6. Will you use special category personal data, criminal offense personal data, or other sensitive personal data on a large scale?
- No

DR7. Will you determine an individual's access to a product, service, opportunity, or benefit based on an automated decision or special category personal data?
- No

DR8. Will you systematically and extensively monitor or profile individuals, with significant effects on them?
- No

DR9. Will you use innovative technology to process sensitive personal data?
- No

Data minimization

DM1. Will you collect only personal data that is strictly necessary for the research?
- Yes

DM4. Will you anonymize the data wherever possible?
- Yes

DM5. Will you pseudonymize the data if you are not able to anonymize it, replacing personal details with an identifier, and keeping the key separate from the data set?
- Yes

Using collaborators or contractors that process personal data securely

DC1. Will any organization external to Utrecht University be involved in processing personal data (e.g. for transcription, data analysis, data storage)?
- No

International personal data transfers

DI1. Will any personal data be transferred to another country (including to research collaborators in a joint project)?
- No

Fair use of personal data to recruit participants

DF1. Is personal data used to recruit participants?
- No

Participants' data rights and privacy information

DP1. Will participants be provided with privacy information? (Recommended is to use as part of the information sheet: For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information at www.uu.nl/en/organisation/privacy.)
- Yes

DP2. Will participants be aware of what their data is used for?
- Yes

DP3. Can participants request that their personal data be deleted?
- Yes

DP4. Can participants request that their personal data be rectified (in case it is incorrect)?
- Yes

DP5. Can participants request access to their personal data?
- Yes

DP6. Can participants request that personal data processing is restricted?
- Yes

DP7. Will participants be subjected to automated decision-making based on their personal data with an impact on them beyond the research study to which they consented?

- No

DP8. Will participants be aware of how long their data is being kept for, who it is being shared with, and any safeguards that apply in case of international sharing?

- Yes

DP9. If data is provided by a third party, are people whose data is in the data set provided with (1) the privacy information and (2) what categories of data you will use?

- Yes

Using data that you have not gathered directly from participants

DE1. Will you use any personal data that you have not gathered directly from participants (such as data from an existing data set, data gathered for you by a third party, data scraped from the internet)?

- No

Secure data storage

DS1. Will any data be stored (temporarily or permanently) anywhere other than on password-protected University authorized computers or servers?

- No

DS4. Excluding (1) any international data transfers mentioned above and (2) any sharing of data with collaborators and contractors, will any personal data be stored, collected, or accessed from outside the EU?

- No

Section 3. Research that may cause harm

Research may cause harm to participants, researchers, the university, or society. This includes when technology has dual-use, and you investigate an innocent use, but your results could be used by others in a harmful way. If you are unsure regarding possible harm to the university or society, please discuss your concerns with the Research Support Office.

H1. Does your project give rise to a realistic risk to the national security of any country?

- No

H2. Does your project give rise to a realistic risk of aiding human rights abuses in any country?

- No

H3. Does your project (and its data) give rise to a realistic risk of damaging the University's reputation? (E.g., bad press coverage, public protest.)

- No

H4. Does your project (and in particular its data) give rise to an increased risk of attack (cyber- or otherwise) against the University? (E.g., from pressure groups.)

- No

H5. Is the data likely to contain material that is indecent, offensive, defamatory, threatening, discriminatory, or extremist?

- No

H6. Does your project give rise to a realistic risk of harm to the researchers?
- No

H7. Is there a realistic risk of any participant experiencing physical or psychological harm or discomfort?
- No

H8. Is there a realistic risk of any participant experiencing a detriment to their interests as a result of participation?
- No

H9. Is there a realistic risk of other types of negative externalities?
- No

Section 4. Conflicts of interest

C1. Is there any potential conflict of interest (e.g. between research funder and researchers or participants and researchers) that may potentially affect the research outcome or the dissemination of research findings?
- No

C2. Is there a direct hierarchical relationship between researchers and participants?
- No

Section 5. Your information.

This last section collects data about you and your project so that we can register that you completed the Ethics and Privacy Quick Scan, sent you (and your supervisor/course coordinator) a summary of what you filled out, and follow up where a fuller ethics review and/or privacy assessment is needed. For details of our legal basis for using personal data and the rights you have over your data please see the University's privacy information. Please see the guidance on the ICS Ethics and Privacy website on what happens on submission.

Z0. Which is your main department?
- Information and Computing Science

Z1. Your full name:
Ioanna Vounzoulaki

Z2. Your email address:
i.vounzoulaki@students.uu.nl

Z3. In what context will you conduct this research?
- As a student for my master thesis, supervised by::
  (Judith) Masthoff, (Marloes) Vredenborg

Z5. Master programme for which you are doing the thesis
- Human-Computer Interaction

Z6. Email of the course coordinator or supervisor (so that we can inform them that you filled this out and provide them with a summary):
m.t.r.vredenborg@uu.nl

Z7. Email of the moderator (as provided by the coordinator of your thesis project):
graduation.hci@uu.nl

Z8. Title of the research project/study for which you filled out this Quick Scan:
I Want To Break Free: Empowering Temporary Mobility-Impaired Travelers with a Digital Travel Assistant for Accessible Dutch Railways

Z9. Summary of what you intend to investigate and how you will investigate this (200 words max):
This study aims to enhance accessibility and independence within the Dutch railway system for individuals with temporary mobility impairments by designing a digital travel assistant tailored to their unique needs. Recognizing that existing facilities don't fully support independent travel or adapt to sudden challenges, this research focuses on understanding the specific barriers, challenges, and needs of this demographic. Through qualitative methods such as interviews and focus groups, and with the development and testing of a digital assistant, this project seeks to offer real-time information, guidance, and support, thereby significantly improving the travel experience for temporarily mobility-impaired passengers.

Z10. In case you encountered warnings in the survey, does supervisor already have ethical approval for a research line that fully covers your project?
- Not applicable

Scoring

- Privacy: 0
- Ethics: 0

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