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Developing a Public Transportation Application for the Elderly

Interaction Design
Master's Degree Programme in Computer Science
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Master of Science Thesis

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The purpose of this study was to develop a public transportation application, to assess the prevalence of public transportation among older adults in Turku and to describe the conditions and physical functions these older adults.

A prototype application for older adults was developed and tested. Data gathered from Turku healthcare study consisting of 75-year-old participants was used to assess prevalence and conditions of the passengers. This data shows that most older adults in Turku use public transportation and their health status is good. Good health status, female gender, and not using a car turned out to be significant factors increasing the possibility for older adults to use public transportation.

The testing of the prototype seems to indicate that current public transportation application used in Turku does not manage as well as the prototype. Prototype's minimalistic design with vertically structured interface and clear page titles seems to function better compared to the official application's design. Test group brought up that their reasons to not use public transportation applications are caused by the perceived complexity of technology and the lack of perceived usefulness which led to frustration.

Keywords: transportation, public transportation application, older adults, prototype

Table of contents

1 Introduction

Public transportation is essential part of larger cities' traffic infrastructure in Finland. It can consist of many different modes of transportation, for example, trams, trains, metros, buses, funiculars, and ferries. In this study, the focus is on bus systems because they are common and easily deployed public transportation solutions. Besides bus stops, they do not usually require large changes in the traffic infrastructure making them more affordable compared to other modes of public transportation.

Public transportation passengers consist of people of different ages, conditions, and backgrounds. This makes the public transportation system challenging to design as it needs to be viable and easy to use for everyone. This is challenging because there are many actors and factors in the system like route planning, bus stop placements, and applications. Also, different people have cultural, physical, and psychological differences as well as differences in experience and knowledge that can affect how they perceive and tend to use public transportation.

One varying quality within the passengers is age. As observed, older adults face many challenges using public transportation (Ravensbergen et al., 2021). Age-based decline in motor functions and physical activities becoming more difficult to perform are common problems (Pirhonen et al., 2020; Ravensbergen et al., 2021; Wong et al., 2018). Also, modern software systems are being developed to use more digital components which is also something that older adults can find challenging to adapt to as they grew up without digital systems (Pirhonen et al., 2020**).** The transition from non-digital systems into digital systems is called digitalization.

Digitalization is an ongoing phenomenon. In the context of public transportation, it offers means to improve environmental, social, and economical sustainability (Davidsson et al. 2016). COVID-19 pandemic accelerated the digitalization greatly as, by demand, new digital solutions and systems were developed (Amankwah-Amoah et al. 2021). Therefore, people are becoming increasingly dependent on digital systems. This might be a problem for older adults who do not manage as well as younger generations with the rapid development of new technologies (Pirhonen et al. 2020).

Digital components offer many possibilities improving the quality of service and enabling real-time communication between the systems of the public transportation provider and the passenger. If it was truly believed that digitalization of the public transportation is an improvement, it should be made compelling to use for all the passengers. Especially, the needs of older adults might be easily ignored because they are not, on average, as capable with technologies as other population.

Public transportation being as accessible to older population as possible is important because it is beneficial for their health. Macdonald and Hülür (2020) mention that older adults might be at increasing risk of loneliness, and it is a significant health concern. By making it possible for older adults to move more freely enables them to have more social interaction. Older adults might have otherwise limited means of transportation as they might not be able to drive a car or use physical modes of transportation like cycling or walking.

As public transportation systems develop, passengers will become more dependent on the technologies and machines (Davidsson et al. 2016). Therefore, it must be considered what challenges there currently are for older adults and what may arise with modern technologies. There are many factors that might make it unnecessarily difficult for older adults to use these systems. If digitalization and use of modern technologies are priorities in the future of public transportation, these systems should be designed for everyone.

The research questions in this study are:

- RQ1. Is it common for older adults to use public transportation?
- RQ2. What affects the older adult's use of public transportation?
- RQ3. What improvements can be made in the design of the current public transportation applications to make them easier to use for older adults?

To answer these questions a literature review of public transportation, older adults, and design process of a product must be conducted to gain an understanding of the subject and prototype development. For RQ1 and RQ2, a statistical analysis of Turku healthcare data needs to be conducted. For RQ3, a prototype is built based on the findings in the literature review and tested together with the official public transportation application to find whether the design improvements work.

The structure of this theses is as follows. In Chapter 2, the literature and implementations of public transportation and public transportation applications are reviewed. Next, the target demographic of this study, older adults, their behaviour, and conditions are examined. Lastly, the design process and models are considered ending the literature review. In Chapter 3, the aims of this study and subject groups are defined and the prototype design process is presented. This is followed in Chapter 4 by presenting the results of statistical analysis and prototype testing. In Chapter 5, discussion of the results and findings in presented. Lastly, concluding remarks appear in Chapter 6.

2 Background

Public transportation is a system that offers means of group transportation on fixed routes and at set times (OED, s.v. "public transport", n.). It is usually designed for everybody to use it who are traveling within its vicinity. Many different modes of public transportation exist, for example, buses, ferries, trams, and trains. In larger scope, even airplanes and larger ships could be considered a mode of public transportation. In this study, public transportation focuses on local solutions, especially buses.

Public transportation can work both locally and for longer, more complex journeys by combining different modes of transportation. As a broader term, public transportation system includes every actor that somehow interacts with public transportation. This includes, for example, passengers, drivers, other public transportation employees, municipalities, public transportation vehicles, stops, traffic infrastructure, info signs, and public transportation applications. This system is built based on passengers' needs and municipality's objectives and limitations.

Stojanovski (2019) states that larger cities struggle with sustainability when it comes to traffic. Many people tend to prefer cars as they are convenient to use. On the other hand, having too many private cars is bad for both the environment and the traffic. Cars can also be a safety concern, especially for pedestrians and cyclists.

It is not uncommon for people to drive their cars without any other passengers in them, therefore only one person may take a lot of space in traffic which can cumulate into large congestions. In larger cities this might end up being a serious issue as cars end up requiring many lanes and specific infrastructure planning in an environment that is already very limited in space. Cars also require parking space and if the city lacks parking spaces drivers might park illegally instead which can cause many kinds of issues. One solution to decrease the number of private cars on the roads is to get more people to use public transportation by making it efficient, affordable, and effortless to use.

As public transportation is meant to be used by the public, passengers consist of many different groups of people. Older adults are a large group of diverse people. Even though they have different needs, some of these needs are emphasized as they are not as common in other age groups. As Ravensbergen et al. (2021) point out, older adults face all kind of problems while using public transportation, both physical and mental. In addition, as digitalization causes public transportation systems to utilize more digital components, older adults might have significant issues using these new systems (Hunsaker & Hargittai, 2018; Pirhonen et al. 2020).

2.1 Public Transportation and Public Transportation Application

Interest in public transportation has been changing for the past few decades. In the year 2005, the Finnish Ministry of Transport and Communications studied the usage of public transportation in mid-sized cities in Finland. In the study, they compared statistics between different cities and found out that that state of public transportation had degraded in every city from year 1993 to year 2003.

Up to more recent years, the regulations of public transportation have been decreased and markets made freer (Kivineva 2017). This can also be seen in the statistics of public transportation. Between years 1990 and 2000, the number of buses registered in Finland has not increased or decreased but from year 2000 to 2022 the number of registered buses in Finland have almost doubled (Liikenne ja matkailu | Tilastokeskus 2023). More companies have joined the business increasing the competition for the benefit of the passengers. Sustainability might be one of the reasons explaining the increase in public transportation services.

Pei et al. (2010) points out that sustainability can be broken down into three categories: environmental sustainability, economical sustainability, and social sustainability. Environmentally public transportation is very sustainable when compared to regular cars. Especially electric buses, trams, and trains can be used to reduce carbon emissions. It is ideal to get people to use public transportation instead of more polluting options. Economical sustainability requires the system to be cheap or affordable to run. Lastly, social sustainability relates to equity and inclusion. Public transportation enables people to move outside their living environment affordably and accessibly. It enables people with lower incomes to still live and work in a city where living expenses can be higher closer to the workplaces. (Pei et al. 2010).

Finnish Transport and Communications Agency Traficom states, that in densely populated urban environments the conditions for the use of public transportation are ideal (Finns' Travel Habits | Tieto Traficom, 2023). According to Traficom, public transportation is considered, in addition to walking and cycling, a sustainable mode of transportation. In 2021, 36 % of journeys were sustainable. According to The Finnish National Travel Survey, in the year 2021, Finnish people travelled an average of 34 kilometres a day. Domestic traveling consisted of 62 % using cars, 23 % walking, 7 % cycling, and only 6 % using public transportation. (Finns' Travel Habits | Tieto Traficom, 2023).

Even though cars still dominate the modes of traveling, there is a growing interest for more environmentally sustainable solutions like public transportation when it comes to traffic. In 2021, an average length of a bus journey was 12 kilometres. There is a difference between genders when it comes to traveling habits. Over 50 % of the journeys by men over the age of 18 were travelled in a car. Women do not use cars as often as men and, in the cases of using a car, they are usually passengers and not drivers. There is a significant decrease in the use of cars within women over the age of 65. On the other hand, women use public transportation more than men. (Finns' Travel Habits | Tieto Traficom, 2023).

It is beneficial to get more people to use public transportation. To get more people to use public transportation, it is important to have enough loyal customers who use the service regularly to make the system more economically sustainable. The loyalty of the customer depends on the good design and user experience of a system. Users are more likely to use products and systems that feel easy to use and are efficient. Having more passengers in the in public transportation makes it more likely to be economically sustainable as more people pay for the tickets.

Economical sustainability is not the only reason to incentivize as many people to use public transportation as possible. Public transportation might improve health of the passengers because they are more likely to walk compared to those who do not use public transportation (Kwan & Hashim, 2016). Good health of the citizens is important because it improves the productivity and makes it less likely for them to use public healthcare which can save a lot of money overall.

Modes of public transportation should feel intuitive to use. Buses should have their destinations written on them, bus stops should have relevant information about the buses in an easily understandable manner, and the method of paying or the process of buying and using a ticket should be designed to be easy and quick. One challenge of public transportation is delivering information to the passengers and the public. Without digital components, up-to-date information is difficult to deliver reliably and visibly. As buses rely heavily on timetables and predetermined routes and arrangements, any sudden changes might cause the potential passengers to lose their trust in the system.

Digital components are useful as they may provide up-to-date information instantly and make it possible for the passenger to interact with the system. Visible digital components include embedded screens such as those installed on bus stops or buses. There is a limit to how much information can fit in different sized and types of screens and this is why announcements usually instruct people to visit a web page. On the other hand, public transportation applications may provide more information as they have navigable views, for example, an interactable announcement page. This is only one reason for the public transportation provider to provide an application for the users.

2.1.1 Public Transportation Application

Public transportation application is an application that enables the user to buy tickets, plan journeys, contact the customer service, and find general information about the public transportation. These applications can be either web applications or mobile applications. All public transportation providers in Finland do not have a distinct mobile application, but most providers have some sort of route planner solution. For example, mid-sized cities might not have a personal route planner, but they can encourage passengers to use a nationwide route planner web application Matka.fi (*Matka.fi* | *Traficom*, n.d.).

Journey planners are an important part of public transportation applications. They will calculate and present to the user a possible journey from their chose origin point to their chosen destination with detailed instructions and a map view of the required steps (Figure 1). Traditional, physical timetables hold a lot of unnecessary information that the user needs to ignore. Physical timetables might also make it hard to find the right stops. They might list every stop for a certain route. This is not very intuitive for the passenger, especially if the passenger is not very familiar with the route, the city, or the street names. Not every bus stop name might be self-explanatory.

Physical timetables can also focus on one bus or stop at a time, because the space is very limited. It is hard for the passengers to see the bigger picture, for example, which all buses will take them to their destinations unless they read each listed stop of each listed bus line. This is why journey planners were made. Journey planners are designed to offer a lot of information is a compact package. In the application, the user can examine buses, routes, bus stops, and changes in real-time.

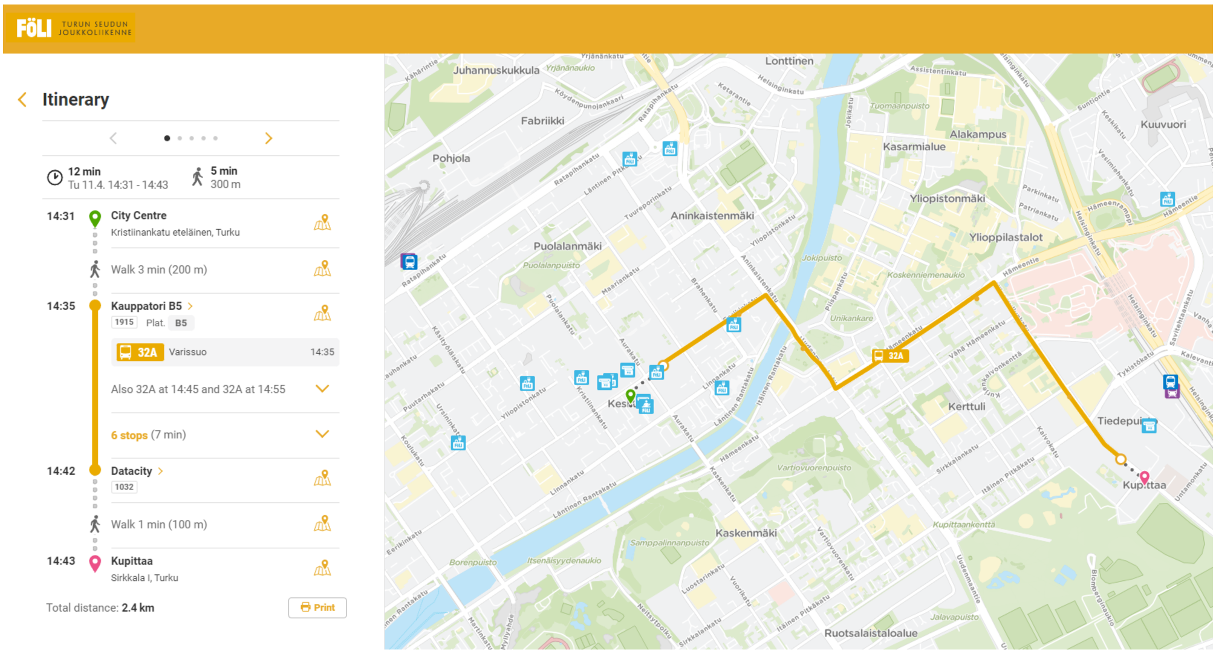

Figure 1. Föli route planner application (Fölin Reittiopas, n.d.).

A well-designed public transportation application is intuitive to use. The user should see the interface and know what the application offers. The application should be designed in a way that it does not drown the user in information and, at the same time, is naturally able to offer all the essential features. The user expects the use of public transportation to be efficient and easy so the application should also follow these two guidelines. If the application is too inefficient or challenging to use, users may choose to decrease the number of times they engage with the application. Some users may also not possess technological know-how which, for this type of poorly designed application, may alienate them completely from using it.

2.1.2 Public Transportation Systems in the Future

As public transportation is an efficient and sustainable mode of transportation, it is highly likely it will still be a common mode of transportation in the future. If cities know that public transportation is a stable, long-term investment, they might end up planning their city infrastructure even more around it. In theory, this means that public transportation will be more efficient and more compelling for the citizens to use. More common public transportation gets, more economically sustainable it gets. Therefore, more money can be used to improve it and new technologies in the system emerge.

Public transportation users might become even more dependent on technologies as the number of digital components in systems grow. This is an ongoing phenomenon called digitalization. Digital solutions get developed as more people are familiar with digital systems and possess digital devices. Also, new technologies emerge which enable new solutions whereas older technologies become cheaper and, therefore, affordable to use in the system. Even more data may be collected and used efficiently to provide up-to-date and reliable information.

It is highly likely that older adults in the future will be more familiar with using technologies. Older adults have been getting better at using technologies, but they are still behind younger generations (Pirhonen et al. 2020). As Finland has an aging population, there will be more older adults in the future but, on the other hand, their technological skills might be significantly better. This makes it hard to predict what effects digitalization has on older adult population in the future. Accessibility will, at least, be an important factor.

There is a possibility that autonomous vehicles will be used in public transportation in the future. Autonomous vehicles are defined as vehicles equipped with automated driving systems (Fleetwood 2017). There have already been few pilots across Finland for robot buses (*Helsinki Pilot - FABULOS*, 2020). Even though robot buses do not require drivers, they usually have a driver whose job it is to make sure the bus does not make any fatal mistakes. The technology is still too new for robot buses to be commonly used, especially in Finland where weather conditions might get tricky during winter.

Robot buses are cost-efficient since they, by definition, eliminate the requirement for human drivers. A human is only required in customer service situations or when inspections on buses' conditions need to be conducted but even these can be automated to some degree. This cost-efficiency can help to bring public transportation to places where it is not currently profitable to operate.

Autonomous vehicles are in theory much safer than vehicles operated by humans. 94 % of fatalities caused by vehicles in the United States were caused by human error (Fleetwood 2017). Significant portion of fatal crashes are caused by alcohol or drug usage, distraction, fatigue, or combination of these. By removing human errors, autonomous cars could prevent

10 million deaths in a decade worldwide, which is a very significant improvement (Fleetwood 2017).

2.2 Elderly Users of Public Transportation

Although few different ways to classify older adults exist, some studies have classified older adults between the ages of 65 and 74 years as youngest-old, those between ages 75 and 84 years as middle-old, and those aged over 85 years as oldest-old (Lee et al., 2018). In this study, an older adult is the age of 65 or over. In this chapter, older adults, their conditions, and behaviour are reviewed. The goal is to understand the target demographic of this study, especially what matters to older adults when it comes to public transportation and technology.

2.2.1 Mobility of Older Adults

Pirhonen et al. (2020) state that the use of technologies was challenged by the age-based decline in functional abilities. Older adults might face decline in motor functions, sight, hearing, and cognition. As bodies get older, they can become more vulnerable to damage, and problems with physical health can become more common. Motor functions can deteriorate causing shakiness or inaccuracy with physical actions. For example, older adults might face problems with smart phones due to their small screen sizes and cramped user interfaces. It might be hard to read from a small screen or press the correct button with worsened motor functions. Especially typing with a smart phone can be demanding as the keys are small and extremely close to each other. This can be considered when designing applications for smart phones by, when possible, avoiding designs that require typing.

Mobility describes the ability to travel safely, reliably, and freely (Satariano et al. 2012, Siegfried et al. 2021). Of course, everyone's mobility is somewhat limited, but the mobility of older adults on average is worse than the mobility of younger adults. This is due to many factors, one of which is the inability to drive a car or use physically demanding modes of transportation like walking for longer distances or cycling. Also, according to Traficom, statistically there are differences between traveling behaviours of men and women (*Finns' Travel Habits | Tieto Traficom*, 2023). Men over the age of 74 travel, on average, 1.5 times a day and women 1.2 times a day. Compared to women, men more often use a car whereas women walk or use public transportation more than men.

Mobility is important since it is an enabling factor. It enables people to have social contacts and attend events, run errands, and take care of themselves. Especially for older adults, the mobility is important for their physical, social, and mental health. It enables them to participate in social events and meet other people. It makes it easier for them to partake in physical activities and move outside their living spaces which benefits both their physical and mental health.

Regarding mobility, walking and standing as well as any other physically demanding activities may become more difficult after aging (Wong et al., 2018). This is the reason why mobility aids such as walkers are used so often by older adults. Some older adults might avoid walking which can reduce their willingness to use public transportation. This might cause them to use taxi services or cars instead. Another possibility is the decrease in the number of times older adults leaves their homes. The decrease in mobility may by itself cause people to be cut out from the society easier.

2.2.2 Older Adults as Passengers

Ravensbergen et al. (2021) describe the problems older adults might face while using public transportation. Weather and seasonal conditions affect the willingness of the user to use public transportation. Heavy rain, ice or snow on the road and sidewalks, and coldness or hotness might make the journey to the bus too hard for some to make. Even if manageable, it might make them consider other modes of transportation over public transportation.

Stojanovski (2019) points out that urban designers usually consider a bus stop reachable when it is in 5 to 10-minute walking distance. This translates roughly from 300-400 meters to 600-800 meters. This might not consider physical disabilities or weakened physical state of the passenger. For these types of people, even 300 meters may be too long of a distance to walk, and they end up using private cars or taxis.

Physical problems and defects might cause a need for mobility aids, which are harder to use in harsh conditions. These aids include any devices or things that enable people to move more freely. For example, blind people might have a cane or a guide dog, older people might use a cane, walker, or a shopping trolley, and people with inability to walk commonly use a wheelchair.

People using mobility aids might find it hard to travel to the closest bus stop because of their physical conditions. They also might avoid bus traveling during busiest hours because less passengers makes it easier to find empty seats on the bus. Narrow corridors on the buses are also easier to navigate with less people and there is more space for aids which can take a lot of space. Some older adults might also avoid large groups to prevent diseases from spreading to them.

Seat availability can be important factor for older adults (Wong et al., 2018). Some older adults might feel it is emotionally too hard to ask for another passenger to give up their seat (Ravensbergen et al. 2021). Also, depending on the passenger and their needs, not all seats are equally as good. Older adults might prefer seats that are closer to the doors and easier to exit from. Some seats might be in the upper parts of the bus which are harder to reach. Space is also important if there are any mobility aids in use.

Priority seats for older adults can be useful when designing the bus to be as accessible for older adults as possible. Usually, these seats are in easily accessible parts of the bus near the exits. For example, according to the Finnish equality law (2015) public transportation must be designed in a way that takes everybody into account. This includes older adults or other people with disabilities.

Boarding and exiting the bus can also be hard people with physical problems (Ravensbergen et al. 2021). Because not all disabilities are as visible as others, the driver might not realize the passenger has one. This may cause the bus driver to not lower the bus or start driving too early when not all older adult passengers have yet seated down. Sometimes exiting the bus might also be troublesome because the bus might be too far from the sidewalk, or the step is too large. This can happen, for example, with temporal stops due to roadworks or snow blocking the stop. Even when lowered, the bus might still be too high for comfort. For some older adults with worsened physical conditions, a long step might also be dangerous as they could fall.

Journey planning, walking, and changing buses are also few things that might cause unwillingness to use public transportation (Ravensbergen et al. 2021). Taxis and private cars have an upside that they will take the passengers from the starting point to the destination easily. Public transportation must rely on people planning their journey based on routes and timetables because the buses have fixed routes and timetables.

Buses require the passengers to be capable to either know or search for the right routes. This information can be gathered from route planning applications, public transportation customer service, bus stops, or physical timetables. The use of public transportation does not require a lot of technological knowledge but due to digitalization, people are incentivized to use digital solutions provided by the public transportation provider. Using applications and websites should make it easier to get relevant information and manage practical tasks like adding credit to travel card.

As bodies grow older, they get more fragile. This means that safety will become a higher priority for older adults as they are more likely to get severely injured by, for example, falling. The Finnish Road Safety Council Liikenneturva points out that feeling of safety comes from good design (*A Safe Road Environment for Older People - Liikenneturva, 2021*). When the person grows old, the mobility becomes more limited, and safety and accessibility become more essential. The safer the environment, the more likely a person is to travel outside their home. Therefore, it is important to consider the aspect of safety when designing public transportation system. This becomes even more essential in the future as older adults are a growing group.

2.2.3 Attitudes and Acceptance of Technologies

Digital solutions are implemented in public transportation systems because they offer an easy, cost-efficient, and highly effective way to interact with the passengers of public transportation. Any changes, like updates to routes or announcements, can be implemented easily and in a synchronized manner. In a non-digital public transportation system, informing about the changes is not as easy, as it requires physical changes, like new printed timetables or signs. This information needs to be then presented in many different, visible places to make sure it reaches as many passengers as possible.

This is why public transportation providers prefer using applications, digital components, and websites to communicate with the users. For example, an application will stay up-to-date automatically and journey planner can search for the right stops, times, and bus routes taking any changes into account. For public transportation provider, having as many people use these solutions as possible is beneficial as it is cost-efficient and makes the communicating with the passengers more efficient. On the other hand, prioritizing digital solutions might not be an improvement for every passenger. Digital solutions might end up alienating older adults who are not as willing to use them or find them too difficult to use.

Older adults are not unequivocally against new technologies. Iwasaki (2013) found out that older adults tend to use technologies they find affordable, accessible, and usable. This means that technology must be cheap to buy and maintain, the information and services related to the use of the technology must be easily and readily available, and the technology must be easy to use. Even though many might find technologies useful to some degree, but it is common for older adults to also feel that the technologies are developing too fast (Pirhonen et al. 2020).

Updates are common in software development which might change how the product is used. Older adults who have learned to use certain technologies to some degree might get frustrated if they are suddenly unable to figure out something on their own which motivates them to give up easier. Because digital systems are rapidly updating, for older adults it is possible to get overwhelmed. Also, digitalized solutions and systems are becoming more common in modern societies. Therefore, it is understandable that some might feel like this quite rapid development is hard to keep up with.

Berner et al. (2011) found out that age and education of the older adult seems to have a significant effect on their acceptance and usage of technologies. This can be seen when studying the usage of Internet within older adults. Even though the rates of older adults' Internet use have been steadily increasing, the rates are significantly behind the general population (Hunsaker & Hargittai, 2018; Pirhonen et al. 2020). The rate of the Internet usage drops linearly as age increases. As digitalization often relies on people's ability to use the Internet, older adults might struggle with new digital systems. For 75–89-year-old older adults in Finland, the rate of daily Internet usage is 23 % and for 60–74-year-old older adults it is 57 % (Pirhonen et al. 2020). It is safe to assume that as the younger generation will eventually grow older, the technological capabilities will increase within older adults. This does not definitely mean that older generations in the future will be able to keep up with the development of new technologies.

One example of the older adults' attitudes and acceptance of technologies is in banking. Pirhonen et al. (2020) point out that even though banks have invested in highly developed digitalized systems, there might still be older adults queuing inside the banks to pay invoices and calling the customer support lines to enquire about their account balance. Both tasks are easily manageable with banking applications. This shows that there are people, who are not willing or capable to use digital systems, even when it could save them a lot of time, effort, and money. There might be underlying attitudes against the digitalization or some personal problems which make it hard or impossible to use digital systems.

Some older adults also view the digitalization as a way to maximize economic efficiency and not a way to make user experience or people's lives better (Pirhonen et al. 2020). It is understandable that these older adults might reject a technology they perceive to cause decline in people's socio-economic statuses. If older adults fear that technologies will eventually replace humans, they might feel it is unjustifiable to support these technologies. Therefore, some might choose to not use technologies to delay or prevent this type of unwanted development. Kristoffersson et al. (2011) and Lundberg (2013) point out that there has been a real fear of humans getting replaced by robots within older adults.

2.3 Design and Development of Applications

When designing public transportation application, a technology acceptance model should be used to better understand what makes the user accept the application. Models like Technology Acceptance Model (Davis 1989) and Unified Theory of Acceptance and Use of Technology (Venkatesh et al. 2003) are usable in this scenario. These models are suitable for predicting whether the user might accept the technology or reject it. They can be used in the context of this thesis to better understand the motives and behaviour of the users of public transportation applications.

Models in user interface and user experience design can be used to guide the design process. This guides the design process to avoid mistakes and implement solutions that have already been proven to work well. Designers may also struggle understanding users, especially those with different backgrounds and experience compared to them. This is important because the designers should not design the project for themselves but, rather, the target demographic they may not even be part of.

In the field of interaction design, also heuristics exist. Heuristics are not formulated models but, rather, general rules of thumb to guide the design process. Whereas acceptance models, like TAM, examine the motivations, expectancies, qualities, and behavioural patterns of the users, heuristics may offer more specific and concrete design points. For example, Jakob Nielsen's ten usability heuristics (Nielsen 2020) offer general guidelines to design a user interface.

2.3.1 Technology Acceptance Model (TAM)

Technology acceptance models (TAM) try to explain why users either accept or reject a technology. Classical TAM model explains the acceptance using only two factors: perceived ease of use and perceived usefulness. Perceived ease of use means that users believe that the technology should not require too much effort or knowledge to use. Perceived usefulness relates to performance: users expect the technology to be useful and efficient. These two factors together affect the users' intention to use the technology and the usage behaviour. (Davis 1989).

Perceived ease of use can be predicted in the design process to some degree by using personas, scenarios, and user stories. The group of interest in this study are older adults. Even though older adults are a not a homogenous group, some generalizations are possible to make based on the literature. Some older adults might face problems with sight, some struggle with acceptance of technologies overall, and some may have physical conditions making the use of public transportation more difficult. Therefore, by taking these into account while designing the application or public transportation services, it is possible to make them less difficult to use, hence making older adults more willing to use them.

Perceived usefulness assumes that users prefer using technologies that benefit. Ease of use and usefulness rely on each other to predict the acceptance of technologies. The product must be easy to use and produce an outcome that justifies the effort put into using it. It might not be enough if it is only easy to use or only efficient. What counts as efficiency is usually defined by the purposes of a product. How well a product does the thing it is designed to do? For buses, efficiency can be, for example, getting from point A to point B in a timely manner. If passengers must wait for a long time, change buses many times, walk for long distances, or plan their days based on bus schedules, they probably prefer other modes of transportation if possible.

There is a problem with TAM that it is too simplistic and universal of a model. It does not directly account factors like age of the users which is important in this study's target demographic. Therefore, for this study's purpose it is on its own too broad and does not point out enough specific areas of interest for the design process. TAM might be efficient but there are more efficient models that take more factors into account. There are models based on TAM that extend the two factors and introduce new ones. For example, one of these models is the Unified theory of acceptance and use of technology that introduces two new factors: social influence and enabling conditions (Venkatesh et al. 2012).

2.3.2 Unified Theory of Acceptance and Use of Technology

The Unified theory of acceptance and use of technology (UTAUT) is a model created to explain the use and acceptance of technologies. It was formulated by integrating eight different models: the theory of reasoned action, the technology acceptance model, the motivational model, the theory of planned behaviour, a model combining the technology acceptance model and the theory of planned behaviour, the model of PC utilization, the innovation diffusion theory, and the social cognitive theory. The result, UTAUT, was then empirically validated. The model ended up using four key factors to explain the acceptance and use of technology: performance expectancy, effort expectancy, social influence, and enabling conditions. (Venkatesh et al. 2003).

Compared to the classical TAM model, there are two new factors: social influence and enabling conditions. Social influence is defined how users' intentions are affected by the people they deem significant, and enabling conditions are defined whether the users believe there to be an infrastructure present enabling their usage of the technology. This includes technology, resources, and support. An example of the effect of enabling conditions would be a senior citizen with an older cell phone. This type of phone might not be compatible with many modern application or website dependent solutions. These four main factors of UTAUT are also generally hypothesized to be affected by the gender, age, and experience of the user. (Venkatesh et al. 2012).

The extended unified theory of acceptance and use of technology (UTAUT2) was created by extending the UTAUT model (Venkatesh et al. 2012). It was created by focusing on consumer use context. Enabling conditions were renamed to facilitating conditions and three new key factors were introduced: hedonic motivation, price value, and habit. This new model was found to have even greater predictive ability compared to UTAUT, explaining around 74 % of the variance in users' behavioural intention and 52 % of the variance in the usage of a technology (Tamilmani et al., 2021). This UTAUT2 model is presented simplified in Figure 2.

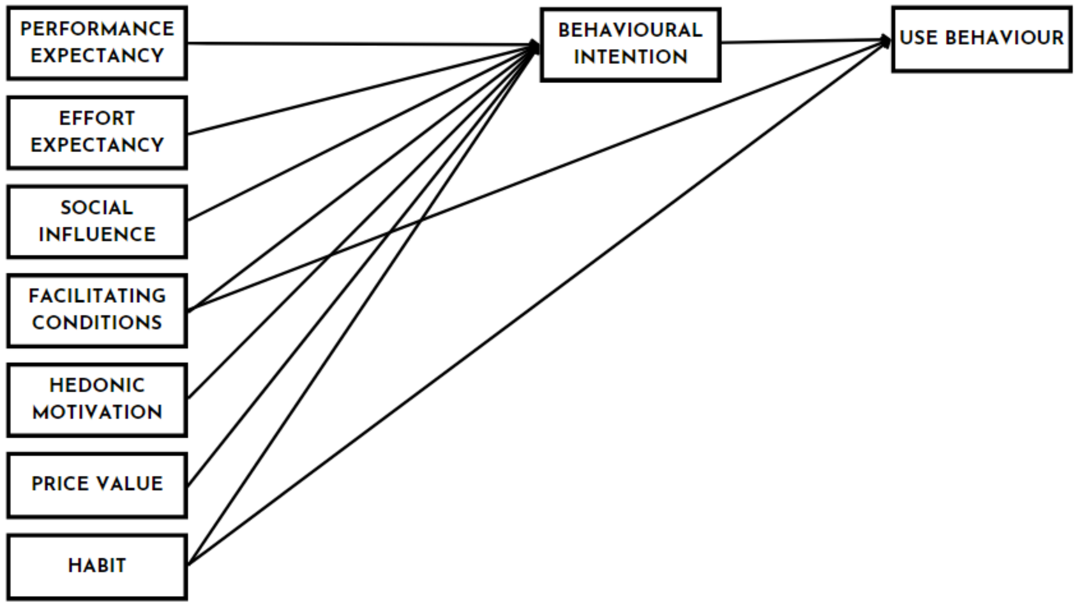

Figure 2. Simplified UTAUT2 model.

Performance expectancy is defined as the users' expectations of how beneficial the technology is to perform certain activities. Public transportation application should offer information in a timely, efficient manner as well as the ability to buy a ticket or add money on the public transportation card. Effort expectancy is defined how easy a technology is perceived to be. This might be one of the most significant reasons for older adults to not use certain technologies. If they do not have experience in using technologies or devices, it will take them a lot of effort to learn. Even one time effort that is perceived to be too high can affect people to not use the technology, even though it may save them a lot of time and effort in the future.

Social influence is defined as the influence that other people have on certain individuals. This might be a friend, a family member, or a public figure whose use of public transportation application motivates the user to use it as well. Some users might be more likely to use a bus if their friends or family use it as well. Some may avoid traveling during busiest hours which is an example of social influence of larger groups. There are too many social reasons to list that affect individual's public transportation behaviour and usage and it is hard to find all the underlying effects that other people may have on certain individual. Facilitating conditions, as explained previously, are related to users' expectations of resources and support to use a technology.

Hedonic motivation is defined as enjoyment or pleasure that using a technology produces. This has been proven to have a very strong effect on the use and acceptance of technologies (Brown & Venkatesh 2005). It is understandable that people avoid using applications that cause them to feel unenjoyment or distress. Of course, not every application can be made to produce maximum amount of entertainment, but it is still important to take it into consideration. For example, having an easy way to keep track of the journey can produce some enjoyment for the passenger.

Lastly, price value is important in consumer products because people do not often enjoy wasting their money and habit is defined as the degree people tend to perform certain activities automatically or without thinking them. The difference between experience and habit is that experience is needed for habit to form and, secondly, very different habits can form out of similar or almost identical experiences. Both habit and experience make the use and learning of technologies faster, for example similar looking user interfaces become easier to get used to. It is important to understand design wise that breaking a habit might cause a lot of confusion and inefficiency.

Because all these factors seem to be relevant when discussing public transportation and public transportation application, this extended model seems to be suitable for this use case. UTAUT2 also was especially for consumer context which is relevant with this study's target demographic. However, price value in the model might not be as relevant as some other factors from the designing standpoint as setting ticket and service prices is not designers' responsibility.

UTAUT2 explains that age, gender, and experience affect many of these factors:

- age affects facilitating conditions, hedonic motivation, price value, and habit.
- gender affects facilitating conditions, hedonic motivation, price value, and habit, and.
- experience affects facilitating conditions, hedonic motivation, and habit in addition to how behavioural intention translates to use behaviour.

Age is a central variable within target demographic of this study, so it is important to understand how it affects the use of technologies. UTAUT2 defines facilitating conditions as a factor affected by age, which means that older adults lack either means, devices, or understanding to use technologies as well as younger generations. They might not also enjoy using technologies as much as younger generations which affects their use intention. Price value is not an important factor in this study but, on the other hand, habit is. Older adults may have certain habits that have formed during their lifetimes which can be difficult to change. Therefore, they prefer using methods they are familiar with. This affects both the intention and the usage.

2.3.3 Jakob Nielsen's Ten Usability Heuristics

Jakob Nielsen's ten usability heuristics describe principles that summarise good practices to be considered when designing a user interface (Nielsen 2020). These then heuristics are presented in Table 1. In Nielsen's (2020) own words, these guidelines are more like rules of thumb and not specific guidelines. Using these heuristics leaves many choices for the designer. For example, minimalism is generally good design choice to some degree but overemphasizing it may cause user interface to be too empty. Hiding some information is necessary but might make finding this information less intuitive. For second example, error prevention is best done by limiting the freedom the user has but, on the other hand, user freedom is also a heuristic. In conclusion, these heuristics need to be taken into consideration but not followed blindly. For designer, this requires understanding how to balance the elements for more optimal user experience.

For older adults, these heuristics are very viable. Older adults might not have much experience with technologies so visibility of system status, error prevention, recognition and recovery, and minimalistic design are important. They need a user interface that tells them what is going on in an understandable way, does not drown them in information, and prevents them from running into errors. Avoiding technical terms is, of course, also important and being able to always go back and undo actions.

Table 1. 10 Usability Heuristics for User Interface Design by Jakob Nielsen.

Heuristic	Description for the designer
1. Visibility of system status	Communicate the system's state to the user. Give continuous, as immediate feedback as possible.
2. Match between system and the real world	Use real world language, not technical terms unless necessary.
3. User control and freedom	Design the ability to undo and redo actions and always offer an exit from an interaction.
4. Consistency and standards	Improve learnability with consistency and standards.
5. Error prevention	Prevent error situations, for example by constraining the user or offering default values.
6. Recognition rather than recall	Avoid design choices that force user to recall information.
7. Flexibility and efficiency of use	Offer different ways to achieve same things. Enable personalization and customization.
8. Aesthetic and minimalist design	Focus on essential elements that prioritize primary goals of the user.
9. Help users recognize, diagnose, and recover from errors	Provide easily noticeable message about the error, explain what went wrong in easily understandable language and offer a solution.
10. Help and documentation	Make help and documentation easily available and offer concrete steps.

2.4 Prototypes, Personas, Scenarios and User Stories

Application design process may include prototype development. Prototype, by definition, is the first or primary type of a thing; an original on which something is modelled or from which it is derived; an exemplar, an archetype (OED, s.v. "prototype", n.1). Simplified, it is a proof of concept or a first, possibly partly functioning, version that is still too underdeveloped for production.

Prototypes may inexpensively help finding plausible design flaws that may occur in any stage of development (Deininger et al., 2017). In user interface design a prototype might be developed by using tools like Figma (*Figma: The Collaborative Interface Design Tool*, n.d.). Figma allows the designer to create interactable designs that can be used for both visual presentation as well as testing.

Gardenghi et al. (2020) explain the prototyping process using six steps. Firstly, the service must be diagnosed by gathering as much information from the service as possible. Second step is to analyze the service by analyzing the findings in the first step. Third step is to identify the requirements. This requires understanding the users and their goals of using the service. Fourth step is to elaborate the prototype by designing it. Last two steps are verifying and validating the prototype.

Prototypes are good for testing. Developing a product with a fundamental flaw in the design might make it harder to correct it the further the development continues. Therefore, a prototype can be developed to verify whether the concept or design works. Testing verifies whether the interpretations and implementations of models and heuristics produce the desired outcome. For example, testing the user interface of digital products may prove whether the user interface is easily comprehensible or not.

To develop a prototype, knowing the target demographic is essential. One method to do this is by using personas (Pruitt & Adlin, 2006; Reeder & Turner, 2011). Personas are fictious, yet specific representations of target users and are used throughout the design process (Fuglerud et al., 2020). Fuglerud et al. (2020) point out that personas lead to successful research projects and product developments by making the designers focus on the personas rather than themselves. It is important to find personas that are common in target demographic or have distinct needs or experiences. One persona for this study could be an older adult who struggles with technology but uses public transportation regularly.

Scenarios are also an important tool (Carroll, 1995; Reeder & Turner, 2011; Rosson & Carroll, 2001). Scenarios focus on the context and actions of the user, presenting the interaction as a story. This helps the designer to understand what happens and matters during the interaction with the product. To create a scenario, a persona must be placed in a story describing the user's actions and events in a certain setting. Scenarios might vary a lot as personas have different motivations and needs. Therefore, scenarios should be constructed for different personas.

Lastly, user stories explain the motives of the user in a format like this:

> as a **<user>,** I want **<a goal>** so that **<a reason>**

User can be replaced with a simplification of a persona, a goal is what the user wants to achieve, and the reason explains the user's motivation. Stories need to be extremely compact to be effective. They do not go much into detail, especially in a technical sense. For example, as an elderly passenger, I want to use the public transportation application to check timetables so that I do not have to carry a physical timetable with me or rely on my memory. This extremely story explains what the user wants and why. It should be used to guide the design process and effectively keep the priorities and users in mind. (Beyer, 2010; Cohn, 2009; Turner et al., 2013).

3 Aims, Subjects and Development of the Prototype

In this chapter, the aims of this study, the subject groups are defined, and the prototype design process is presented. In other words, this chapter explain the goals of this study and the means to reach those goals.

3.1 Aims

This thesis has four aims:

1. to assess the prevalence of public transportation usage among older adults in Turku.
2. to describe the conditions and physical functions of older adults using public transportation in Turku.
3. to develop a public transportation application prototype for older adults.
4. to test the usability of the prototype in comparison to Föli's current application in use.

These aims are based on the three research questions of this study:

- RQ1. Is it common for older adults to use public transportation? This research question is related to aim 1.
- RQ2. What affects the older adult's use of public transportation? This research question is related to aim 2.
- RQ3. What improvements can be made in the design of the current public transportation applications to make them easier to use for older adults? This research question is related to aims 3 and 4.

Firstly, the prevalence of public transportation usage among older adults in Turku will be assessed to gain an understanding of how common the use of public transportation within older adults is and how many people the application potentially affects. Secondly, the physical functions and conditions of these older adults using public transportation will be examined. It is important to find whether there exist common factors that should be considered when designing the public transportation application. This information could also be beneficial to improve public transportation experience and usage among older adults in other ways, for example designing the interiors of the buses.

Thirdly, a prototype will be built that utilizes findings in this study to create an application targeted towards older adults. This prototype should differ from the official Föli's application as it is targeted toward one group instead of the whole target demographic of the public transportation. This prototype will then be tested and compared to Föli's application to understand what functions work better or worse than others. Testing is essential to validate the design and find whether the solutions work as intended.

3.2 Target Population

This study has two groups. Group 1 consists of people partaking in a Turku healthcare study. The data collected from Group 1 is used in this study's statistical analysis. Group 2 are volunteers who partake in the testing of the prototype developed in this study.

3.2.1 Group 1

The subjects were derived from older adults of the public healthcare in Turku, Finland. The subjects were 75 years of age, born in 1945, and they lived at home or in sheltered housing. The study is cross sectional and population based. The questions asked from the participants that are included in this study are presented in Appendix 1.

3.2.2 Group 2

Group 2 consisted of five volunteers who partook in the usability testing of the prototype. Nielsen and Landauer (1993) found, that three to five people are enough to find most of the usability problems which should be enough to assess whether the prototype and Föli's application are viable and find most common usability problems. This is visualized in Figure 3. Five people find approximately 85 % of usability problems in a design.

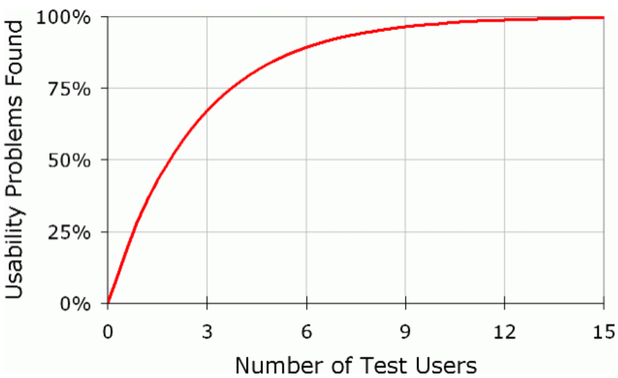

Figure 3. Graph visualizing how many people are required to find certain percentage of usability problems.

There were three prerequisites for the test subjects. They should be at least 70 years of age but preferably close to 75 years of age. They should have some experience in using public transportation within one year period and some experience in using technologies such as computers or smart phones.

Youngest test subject was 73 years of age and oldest was 83 years of age. Four of the test subjects were female and one was a male. Every test subject used public transportation at least once in few months and most of them used it at least weekly. Three of the participants travel usually alone and the rest travel usually with their friends or spouses.

Only one person mentioned using application or website to search for information related to the public transportation. Others mentioned using physical timetable books or just walking to the bus stop and taking the next bus. When asked how they would get information about the changes in routes and new timetables, they answered that they would ask the bus driver. One test subject mentioned that there is usually no need of knowing when the buses depart if the route is frequent enough.

3.3 Development of Research Prototype

Prototype was developed by utilizing Turku healthcare data (Group 1) and Group 2 for testing. Föli (Turku), HSL (Helsinki) and Nysse (Tampere) public transportation applications were evaluated to find standards and features that are usable in the prototype.

3.3.1 Assessing Public Transportation Applications for Mobile Devices

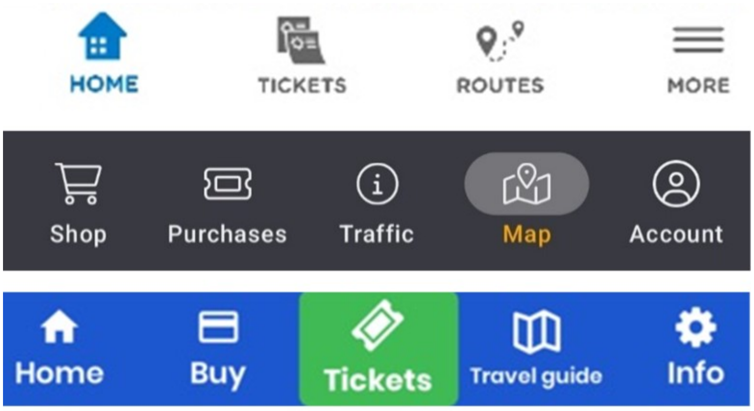

Figure 4. Navigation panels of the route planning applications. From top to bottom: HSL, Föli, Nysse (accessed 30.4.2023).

Föli (Turku public transportation), HSL (Helsinki public transportation) and Nysse (Tampere public transportation) applications all look quite similar. There is a navigation panel located at the bottom of the application and contents of the panel are similar (see Figure 4). This is natural as the applications offer same functionalities in different designs. Most notably, HSL's application does not have a distinct shop and purchases tabs unlike Föli's and Nysse's applications.

HSL application has four main views accessible from the navigation panel: *home, tickets, routes*, and *more*. *Home* page is where announcements, news, and information are being shared. This is also the main view when the user opens the application. Next page is *tickets*, where users may purchase new tickets or view already purchased tickets. Next is the *routes* which includes route planner and lastly *more* options. These options include settings, customer service, feedback, and other information.

Föli application does not have a home view. It opens directly into *shop* showing different tickets for buying. These tickets can be viewed at the *purchases* tab. *Traffic* view consists of three views *my interests*, *announcements,* and *news,* first of which is the main view of these three options. The idea of this structure is that users may choose their topics of interest and have a personalized feed as the main view. Without picking topics of interest this view only shows a prompt that suggests editing topics of interest. *Map* includes a route planner and *account* includes settings as well as both user and application information.

Nysse *home* page includes announcements and information like HSL application. Navigation objects *buy*, *tickets*, *travel guide,* and *info* are comparable to Föli application's *shop, purchases, map,* and *account* objects. When it comes to navigation, all these applications are quite similar to each other. This is good because it helps the recognition of certain elements between the applications. If a person has used one of these applications before, using the other two should be well manageable. There are also icons on top of each navigation button which makes recognizing the buttons faster.

HSL application's navigation is simplest of these three. Minimalism is one of the ten heuristics for user interface design by Jakob Nielsen (2020) which states that navigations should prioritize primary goals of the user. This helps the user to understand the layout of the objects and navigation more easily. For these three applications, navigation panel is always visible and interactable at the bottom of the screen. This makes it faster to navigate the application. Having less navigation objects means that these objects can have more space between them.

In HSL application, the designers assumed that it should be obvious that tickets, both unbought and bought, can be found under the same tab called tickets. Föli, on the other hand, has decided to include bought tickets under different tab: *purchases*. The icon on this tab indicates that the tickets can be found there. Nysse application has the same solution. This most likely to make sure that the store page's interface has enough space.

Digital tickets use usually QR-codes, and these QR-codes must be large enough to be readable by the devices in the bus. Despite this, HSL has managed to fit all the information and functionalities on the same view, which proves that it can be done with less navigational elements. In Nysse's and Föli's applications there is also a chance that the user by mistake navigates to *purchases* or *tickets* to buy tickets. This is not a large or time-consuming mistake but is preventable with HSL's design.

HSL lists three different ticket types: single ticket, day ticket (1-13 days), and season ticket. There is button at the top right corner that shows any valid bought tickets. If the user has a valid ticket, the ticket will be opened instead of the shop. The user can then change back to the shop view to buy additional tickets or click a button under a valid ticket. In the shop view, after clicking on one of these three tickets the user gets to pick travel zone, customer group (adult, child), when the ticket will be valid and how to pay. Nysse application's shop is very similar to HSL's as there are three same tickets to be bought. The user must pick a zone, customer group, and payment method.

Föli shop has more options which makes it more complex. There are seven different tickets separately for sale and the user can also add credit to their travel card, which is one more button. One thing making the shop more complex is that there are three different versions of single tickets: the best price ticket, a ticket for an adult, and a ticket for a child. Then there are two more options for 10-trip series tickets, one for adult and one for child. This adult and child separation can be integrated into one ticket instead like HSL and Nysse have decided to make the user interface less cramped.

Föli's, HSL's, and Nysse's route planners all work similarly but there is a difference how the user can navigate to the route planner. HSL and Nysse have route planners directly accessible from the navigation panel. Föli's application, on the other hand, takes the user to a map view from the navigation panel. To get to the route planner, the user must then press a button in the top left corner to get to the route planner (Figure 5). This seems unnecessarily complex compared to HSL and Nysse route planners. Föli seems to prioritize the importance of a map over the route planner. HSL also has a map view, but it is integrated into route planner so that top half of the screen is a map and bottom half is a route planner.

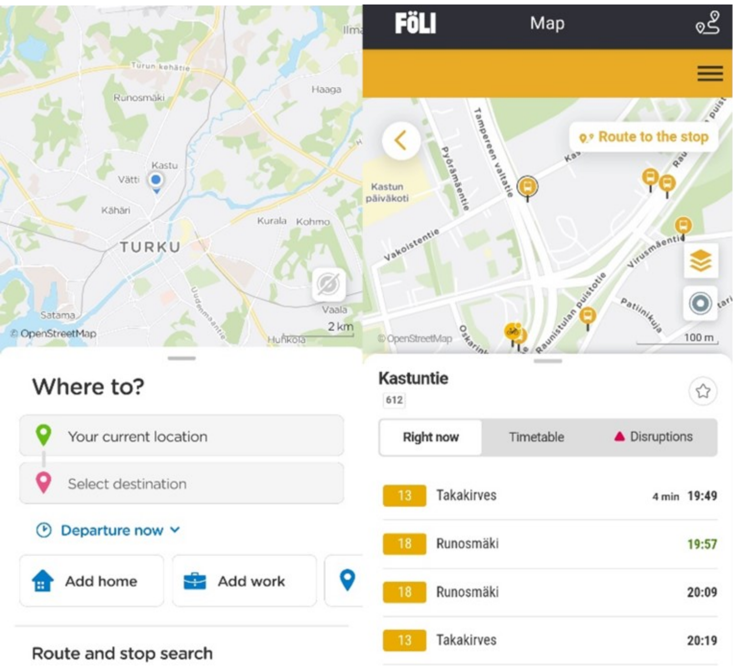

Figure 5. HSL route planner and Föli map view (accessed 30.04.2023).

In the route planner, users may enter their origin and destination points and time. When the planner lists possible journeys, the user may choose to avoid walking or prioritize certain modes of transportation. The user can also set their walking speed from slow to fast. Avoiding walking may be important for some older adults who have problems with their physical health.

List of possible journeys show the user starting and ending times for the journey, the first bus stop, required walking, and bus routes. By clicking on a listed journey, the user is shown a more detailed description of the journey. Upper half of the screen shows a map while the lower part of the screen shows a chronological step by step description of the journey. The textual instructions and instructions on a map together communicate the journey in a very natural way.

3.3.2 Target Demographic for the Prototype

The target demographic consists of older adults. As Pirhonen et al. (2020) point out, some older adults have trouble using modern technologies. This is caused by factors such as lack of motivation to learn, lack of experience, fear of too rapid development, or physical problems. Therefore, one important trait of a persona is the inexperience in using technologies. There are many levels of inexperience because some older adults might have strong attitudes and reject all modern technologies. On the other hand, some might have smart phones or computers and know by memory how to do certain tasks but are unable to easily do any tasks beside those previously learned. For this prototype, it is assumed that the target demographic has at least some experience in using either computers or mobile phones. This should be fine because a person with no smartphone or computer could not access the application in the first place.

As seen in Group 1, one in four 75-year-old adults have problems with their sight. The prototype must be built in a way that is makes it possible for them to use it. Web Content Accessibility Guidelines 2.1 (*Understanding WCAG 2.1 | WAI | W3C*, n.d.) should be utilized to make sure the prototype is accessible.

There are three natural goals for the use of public transportation application. The user should be able to search for information, announcements and changes in routes and timetables. These should easily be available through the home view in the application. Secondly, the user should be able to search for a journey between two points using journey planner. Lastly, the user should be able to buy a ticket.

A journey planning scenario should start by, for example, an older man opening the application. He knows that the application can search for journeys between two points. He should see a journey planner option in the navigation panel. He presses the button and gets sent to a view with two fields named *origin* and *destination*, a clock, and a search button. Typing with mobile phone is hard for him so he is glad the system offers him recommendations based on just few letters he wrote. After choosing his origin and destination, he presses the search button and is shown few different options for journeys. He chooses the one that has fewer bus changes and is shown to be quicker. He then examines all the main stops and times for his journey as well as a map view that shows him how to get to the next stop.

Purchasing a ticket should also be designed to not be unnecessarily complicated process. The man clicks a button that is named *tickets*. He then sees a message stating that he does not have any active tickets now and may buy them below this message. After some comparing of the tickets for sale, he finds the ticket he wants and proceeds to buy it. The application offers him few different options to pay. He chooses to pay the ticket in his next phone bill. The application then tells him that the purchase was successful and offers him a button to get back to view his ticket. Now there is no longer a message stating that he does not have a ticket. Instead, the application shows a QR-code, ticket information, and short text explaining how to use it on a bus.

3.3.3 Prototype of Public Transportation Application for Older Adults

A prototype of a public transportation application was developed using design tool Figma. The platform was chosen to be Android phone. Goal of the prototype was to test and validate certain findings in this study and to find whether older adults find the prototype easier to use than the regular application. This prototype was designed in Finnish but also translated into English.

Accessibility is an important part of the design. As pointed out by the data, 27 % of older adults had some or significant problems with their vision. Older adults might also have difficulties with performing tasks that require accuracy as they might have problems with motor functions. Therefore, every interactable object should be large enough and distinct from every other object around it to prevent accidental presses and make them stand out from each other.

Web Content Accessibility Guidelines 2.1 lists accessibility guidelines for web content but these can also be used to assess mobile applications (*Understanding WCAG 2.1 | WAI | W3C*, n.d.) In this prototype, these guidelines were used to verify some accessibility choices to make the application more accessible to those with worsened eyesight or motor functions. For example, prototype’s contrast is designed to make it easier to distinguish different elements from each other, enabling the users to also use the application in both bright and dim environments.

WCAG 2.1 also states that pages should be titled to help the user identify their current location without need to interpret the page content. This is very important with this prototype’s target demographic as people with less experience in using technologies are more likely to get confused and need guiding. Any designable feature that makes the use of the prototype easier without adding too much complexity should be considered worth adding to the prototype.

It is also important to make the prototype as easily understandable as possible, even though some loss of information will occur. As Nielsen (2020) points out, avoiding technical jargon is important. This is due to the presumption that some older adults might not have experience in using public transportation applications or much experience in technology overall. Therefore, using simple words to describe the functions makes it easier for older adults to understand the application.

Consistency and standards are one of the ten usability heuristics for user interface design (Nielsen 2020). Standards should be used while designing the prototype to the extent it does not make the user interface or user experience more complex. As the target demographic might not have a lot of experience, the design cannot rely too much on standards communicating the information to the user. Every function should be made easily discoverable instead.

On the other hand, standards should still be enforced when they do not make the use of the application too hard. This is because some older adults might have experience in using other public transportation applications. Secondly, if standards are broken, they might not help the learning process when the user switches applications. By enforcing standards on the design, the designer can help the users to get accustomed to other applications as well.

The user interface should be designed to be as minimalistic as possible without losing too much information. Minimalism is important because unnecessary or rarely used elements distract the user (Nielsen 2020). To decide what information is important and should be prioritized, it is crucial to understand the goals of the user and the target audience for the prototype and their needs. Why would an older adult use public transportation and how would an application make it more efficient or easier to use it?

Regular public transportation applications have a lot of functions and information that might not be required in basic use. As the target audience for this application are older adults trying to perform the most basic activities, some functions and information might be less important. By adding more information inside the application, the complexity of the user interface rises. Understandably, some users might find this simplified version too limiting and they should be recommended to use the regular application instead. As stated before, there are few main reasons to use a public transportation application:

- To search for a suitable route between two points.
- To find out information about certain bus stops and routes.
- To find information related to the public transportation system and changes.
- To buy tickets.

The user should have an easy access to these application functions from the main view or the navigation panel.

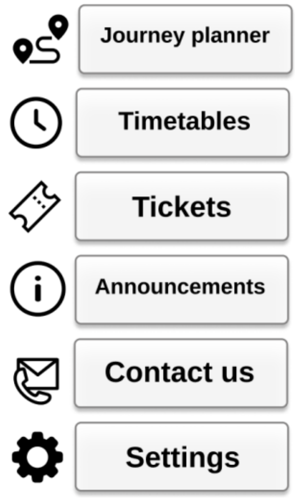

Figure 6. Prototype main navigation view.

The prototype design of the main navigation view is shown in Figure 6. Unlike the regular application, the prototype will not have a navigation panel that stays at the bottom of the user's screen. The navigation should be a distinct view so the information can be displayed in large enough font in an easily understandable manner. If the user does not have a lot of experience in using mobile applications, this type of navigation makes it easier to understand what functions the application offers because every option is easily readable one by one.

Of course, this type of navigation is slower, but understandability is prioritized over efficiency. Also, this type of navigation might prevent accidental presses because the buttons are larger than they could be on navigation panel. Also, the navigation panel at the bottom of the screen might cause accidental presses that takes the user to a completely different view that they intended.

When users open the application, they are greeted with navigation view. There are five possible buttons: journey planner, timetables, tickets, announcements, and contact information. Each of these buttons are assigned with a unique icon which should help the user recognize these options. Each of these buttons try to explain clearly what can be found by pressing them as recommended by the WCAG 2.1 (*Understanding WCAG 2.1 | WAI | W3C*, n.d.). More navigation buttons could also be added without cramping the content too much like account information.

As Nielsen (2020) points out when talking about user control and freedom, it is important to offer the user means to exit an interaction easily. The prototype should always have a button visible that takes the user back to the previous view. Therefore, the user will not feel trapped in an interaction he does not want to have. This button will always be in the bottom left corner of the screen. The user could also use one of the smart phone's system's built-in navigation buttons or gestures to go back.

The prototype design of route planning function is presented in Figure 7. Journey planner is challenging to design because there are many possible navigational paths the user might take. By typing or selecting the starting and ending points of the journey, the system searches for different journey options. Some of these options, depending on the locations and routes, might require multiple bus changes and walking between stops. Therefore, some journeys might be simple whereas others might require more than two different buses to complete. Also, many journeys include some walking between the stops. This information is difficult to present easily and can be confusing for someone with less experience with these types of applications or technologies overall.

A natural way to communicate the journey to the user is to use a map. However, this solution can be demanding for someone who is not familiar with navigating mobile phone maps. Another way is to list the phases of the journey like in Figure 7, but this requires the person to be familiar with the city and the public transportation system. Even then, a person is unlikely familiar with every bus stop name in the city making this method insufficient in most cases.

In this prototype, the journey planner is designed to be as minimalistic as possible. Only origin point, destination and time are required. The user's location is, if made possible by permissions, set as the default origin point and time is automatically set to the present time. Destination field has grey text "*type here*" implicating that the user can input information in that field.

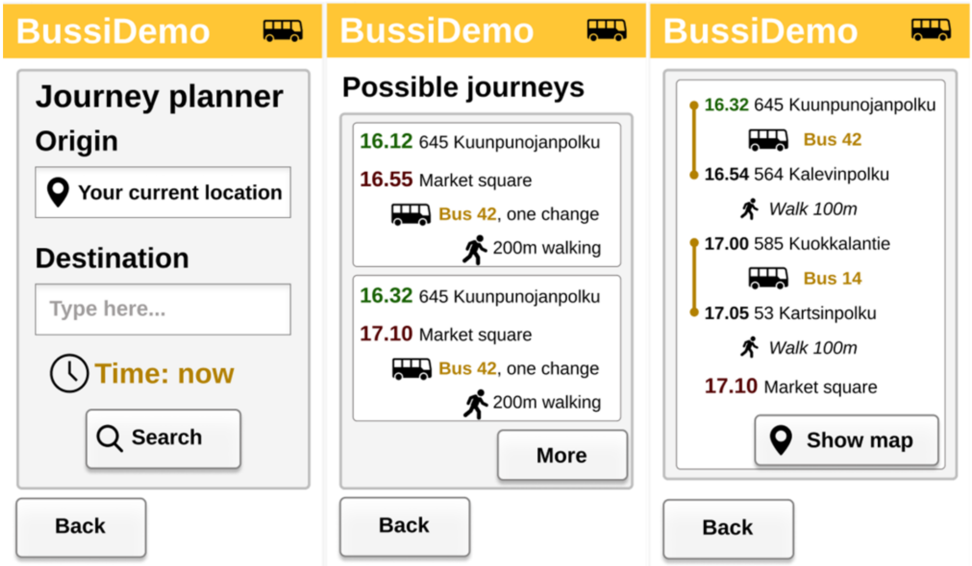

Figure 7. Prototype journey planner, possible journeys, and a journey view.

The system should by default offer few of the user's most picked destinations to prevent them for having to type as well as predict what the user is typing. As smart phone keyboards are very small, typing can be demanding and frustrating especially for older adults. Currently there are no options in the prototype to prioritize certain modes of public transportation or choose routes with less required walking. Only two journeys are presented at a time in the list of possible journeys not to make the user interface too cramped.

Journey planners usually have a map view that the user can use to examine nearby stops, buses, and routes (Föli 2023). This feature can also be used to set starting point and the destination in the mobile application, but it might be too advanced for the target demographic of this prototype. If required, a better place for a map on the prototype might be under timetables rather than journey planner. This map could be used to examine nearby stops. This prototype uses a map only when the user is examining a journey offered by the journey planner.

The prototype design for buying tickets is presented in Figure 8. *Tickets* compresses two different features of the Föli application together: shop and purchases. There is no need to have two different options for these two features that are clearly linked. This view shows any active tickets on the top of the page and purchasable options under it. The layout is chosen to be vertically piled cards which is easily readable. In case users do not have any tickets, the top card guides them to buy them below it. Each ticket card has a small title that explains the content.

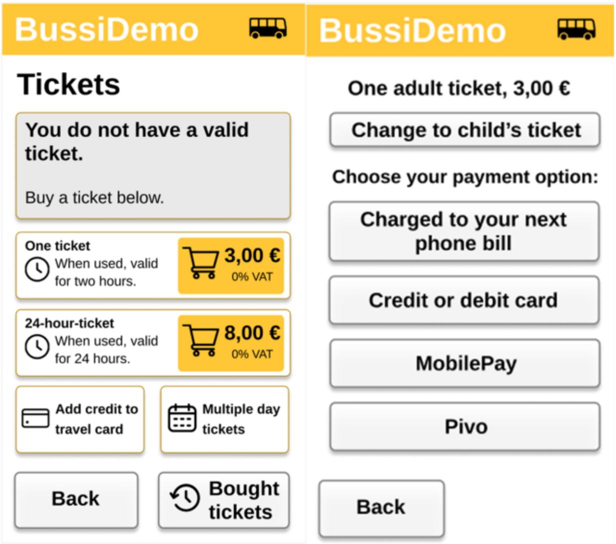

Figure 8. Prototype ticket shop and purchasing a single ticket.

The prototype design for information and announcements is presented in Figure 9. The main navigation view has two buttons: *announcements* and *contact us*. *Announcements* should have information about changes, problems, and important news in chronological order. *Contact us* should have the information about the customer service. Only few announcement cards should be visible at the same time. Instead of scrolling, there is a button that shows older announcements.

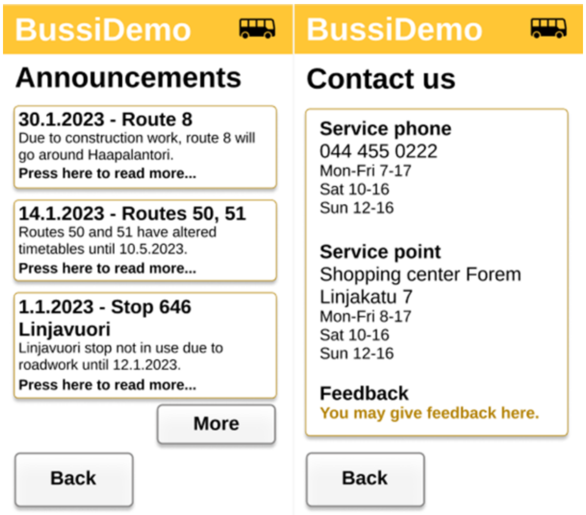

Figure 9. Prototype announcements and contact information.

3.3.4 Testing the Prototype in Comparison to Föli Application

The test commenced with collecting some basic information. The reason for this was to gather information that might give more context to choices the test subjects make. Each participant was then presented with the same scenario. They should find how to get from the place of testing to the city centre by using public transportation and find information how to do this on an application.

The made-up scenario consisted of three different tasks:

1. The test subjects have to find information on how to get to the city centre using the application's route planner. This task is considered complete when they can point out a viable bus stop and a bus.
2. The test subjects have to find information about possible disruptions in bus traffic by locating the announcements page on the application. This task is considered complete when they locate the announcement page and find whether their chosen bus has any disruptions.
3. The test subjects have to locate a single ticket usable in the bus they found on the first task. This task is considered complete when they choose a payment option for a correct ticket type.

Every test subject was given these three same tasks to perform on two different applications, Föli public transportation application and the prototype developed in this study. The subjects were provided an Android smart phone with 6,6" display and already opened public transportation application. The test organizer did not intervene with the actions the user took but only focused on observing and writing the observations down unless the user got stuck. The next task was explained after the previous task was completed or the user was unable to do the task on their own.

Each participant was encouraged to think aloud while performing any actions. Observations were written down as well as any significant spoken-out thoughts. The test organizer did not guide the process unless the person got stuck or gave up. The prototype had some limitations that the regular application did not have. It did not have real data, routes, ability to change the time, or GPS-tracking. These were not required for the test scenario but might confuse the test subjects. These functions would have been too time consuming, complex, or even near impossible to model using Figma and they would not have given any useful information related to the goals of the testing. The participants were told to not focus on the correctness of the information provided by the prototype.

4 Results

In this chapter, the baseline characteristics of Group 1, the results of the statistical analysis of Group 1 and prototype test results of Group 2 are presented.

4.1 Baseline Characteristics of Group 1

The number of persons participating in Turku healthcare study was 1296. The participants included in this study (N=1218, 94 %) were those of whom sufficient data was collected. Baseline characteristics are presented in Table 2. A table of all the collected variables is presented in Appendix 2.

As visible in Table 2, prevalence of public transportation usage among older adults was 73 %. Regarding the health of the participants, most of the participants' self-assessed health status were good or better (92 %). 94 % percent of participants had normal cognition. 6 % of all participants used one mobility aid and 4 % used two or more mobility aids.

4.2 Logistic Regression (Group 1)

P-value of 0.05 was considered significant and SAS Enterprise Guide 8.3 was used to perform the logistic regression. Logistic regression could be used as the dependent variable, use of public transportation, is a binary variable.

Gender, use of car, living conditions, ability to use stairs, use of aids, and ability to walk four hundred meters were found to affect significantly to older adults' use of public transportation by one versus one testing. Odds ratio estimates of gender state that women are 2.5 times more likely to use public transportation.

People living alone are 1.8 times more likely to use public transportation compared to those who live with their spouses or their partners. Those who do not use cars are 2.8 times more likely to use public transportation. Those who do not use aids compared to those who use two or more are 2.2 times more likely to use public transportation. Ability to walk four hundred meters had the largest effect. Those who can walk four hundred meters are 12 times more likely to use public transportation compared to those who are unable to. These findings are summarized in Table 3.

Table 2. Characteristics of the participants (n = 1218) in the study

Variable	Values	n (%)
Gender		
	Male	475 (39)
	Female	743 (61)
Self-assessed health status		
	Excellent or very good	629 (52)
	Good	494 (40)
	Fair or poor	95 (8)
Able to walk 400 m.		
	Easily	1051 (86)
	Without help	130 (11)
	With help	13 (1)
	Unable	24 (2)
Able to use stairs[(a)]		
	Easily	1053 (87)
	Without help	141 (11)
	With help or unable	22 (2)
Public transportation user		
	Yes	881 (73)
	No	332 (27)
Car driver		
	Yes	826 (68)
	No	390 (32)
Cognition		
	Normal	1145 (94)
	Mild decline	28 (2)
	Significant decline	45 (4)
Mobility aids		
	No	1093 (90)
	One	78 (6)
	Two or more	47 (4)

[(a)] Able to use stairs has 2 missing values

Table 3. Odds ratios of significant effects in Group 1.

Effect	Point Estimate	95% Wald Confidence Limits	
Gender, Female vs Male	2.533	1.956	3.280
Marital, Married, or cohabitating vs Widow	0.571	0.430	0.758
Living with whom, Alone vs Spouse or another partner	1.812	1.377	2.385
Able to use stairs, easily vs unable	7.343	2.594	20.786
Able to use stairs, able vs unable	5.864	1.967	17.478
Car user, no vs yes	2.790	2.040	3.814
Aids, No aids vs Two or more aids	2.194	1.206	3.992
Ability to walk 400 meters, easily vs unable	14.622	4.953	43.164
Ability to walk 400 meters, able vs unable	12.431	3.979	38.840

4.3 Prototype Test Results (Group 2)

All test subjects brought up that navigating the prototype was much easier compared to Föli application and the user interface was simple to understand. It was brought up multiple times by the test subjects how important it is that the main view after opening the application is as simplistic as possible. This helps the user understand how to use the application and what features are available. Every interactable navigation option was clearly named and navigating the prototype was easier and faster than Föli application. Also, first impressions are important because they effect expectations of the use. Expectations are important because, for example, UTAUT2 model states that effort and performance expectancies affect the behavioural intentions which affects the use behaviour (Venkatesh et al. 2012).

As all but one test subjects did not have experience in using public transportation applications, they had to spend learning the user interface. In both Föli's application and the prototype, the test subjects seemed to prefer starting to familiarize themselves with the user interface from top to bottom, by going through every object and text one by one. The design of the prototype's navigation was oriented vertically, which seemed to help test subjects to understand and familiarize themselves with it much faster. It took considerably longer for test subjects to familiarize themselves with Föli application and even then, they would not navigate the application easily.

One of the most confusing tasks for the test subjects in Föli's application was finding a bus route from the testing location to the city centre. Föli application does not have a direct way to get to the route planner from the navigation panel. Users must first navigate to map which shows nearby buses and stops. Then they need to press a button to go back to get to the route planner. It is understandable older adults found the route planner hard to find. It took many tries from every test subject to locate the route planner and two out of five test subjects were unable to find it.

After tests had concluded, these test subjects were shown how to open the route planner and they stated that they could not have known this. According to them, it was not clearly presented in the user interface. For older adults, replacing the map with route planner in the navigation panel would make using the application easier.

Another problem with Föli application was locating announcements. Föli application offers personalized feed so that users may add topics of interest to their application. Then the information page shows announcements and news related to those topics. Information page by default opens with this personalized feed. If the user has not chosen any topic of interest, the page tells the user that there are no announcements for their selected topics.

For test subjects, the empty feed was very confusing. There is a navigation on top of the page to view all announcements and news, but this was hard to locate for them. Eventually, all but one test subjects were able to locate announcements, but every test subject struggled. Personalization is a part of *flexibility and efficiency of use* heuristic (Nielsen 2020). It is a good thing to have but the design should not force the users to take extra steps unnecessarily if they have not personalized the application.

Typing was hard for the test subjects. Not a single test subject was able to type without making multiple mistakes. It should be noted that any solutions to make typing less necessary should be considered adding. Föli, Nysse and HSL route planners offer users a feature to save locations and use them in the future without typing them. This solution was overlooked in the prototype as it would not be beneficial for this one-time testing. On the other hand, it should be included in the route planners as it makes the use much easier for older adults if they decide using it.

Föli shop was also more complex for the older adults as they usually spent time reading every option before picking one. As pointed out before, Föli shop, compared to other applications' shops, has more options to choose from. It was a reoccurring theme during testing that test subjects would scan everything on the user interface before deciding what to press. It is important when designing to try minimizing the number of objects on the screen or at least make them easily recognizable. This is why navigating the prototype was easier and faster for the test subjects. They did not have to spend as much time reading information that is less relevant to them and the information was portrayed in an easily understandable and readable vertical layout.

The information portrayed by the prototype had been set in advance and was not changed before testing. The test subjects were told individually that the information portrayed by the prototype will not be dynamic or real. Despite this, two test subjects pointed out that buses and stops portrayed in the application were nowhere near the testing place and the time was incorrect. One test subject had to be reminded that the prototype does not work in real time with real buses and was guided to continue after giving up because he thought that the prototype was broken. It might be relevant to customize the prototype in the future to better fit the time and place of the testing.

Most test subjects also mentioned that frustration is the main reason for the loss of motivation to use a technology. If the application seems too hard to be used or not logical enough, they will just not use it. According to UTAUT2-model, this is effort expectancy (Venkatesh et al. 2012). If users think that the required effort is larger than the benefits to be gained or the system is just unnecessarily difficult to use, they will be less likely to use it.

Those test subjects, who had not used public transportation applications before, mentioned that the reason for it was that they did not think it would benefit them enough. This is performance expectancy described in the UTAUT2-model, which is a significant predicator for the acceptance of technologies (Venkatesh et al. 2012). For these test subjects, they perceive that it takes too much effort to learn and use the application for it to be beneficial and even then, the benefits might not be significant enough to them.

Test subjects mentioned that they use physical timetable books or read the timetables presented at the bus stops to find the correct timetables instead of using digital solutions. Few mentioned that they choose buses by walking to the stop and knowing what buses to take by experience. If there were any changes, they would ask the bus driver whether the bus goes to their destination or not.

5 Discussion

Well-structured public transportation system is something that affects positively on the mobility and based on the literature, the health of older adults. In Turku, 73 % of subjects used public transportation which is quite high, and the overall population is quite healthy. It is difficult to assess how largely the health of the population is affected by the prevalence of public transportation. However, good health status makes the use of public transportation easier as it requires some physical work.

It was an interesting find that self-assessed health status was not a significant factor even though physical health seems to have a large effect on the use of public transportation. This may indicate that the self-assessment of the health status is relatively subjective, or it does not directly correlate with the ability to walk 400 meters or use stairs. It is likely older adults' attitudes or social relationships affect how they assess their own health conditions. If a person is surrounded by people with worse health conditions than he, he might be more likely to think more positively about his health conditions.

People with limiting physical conditions most likely prefer other modes of transportation. Older adults who are unable to walk four hundred meters might choose not to use public transportation because the distance to the nearest bus stop is too long or the distance between the final bus stop and the destination is too long. They might also fear that at least some modes of public transportation do not take their conditions into consideration well enough and therefore choose safer modes of transportation.

A possibility to use taxi services or privately owned vehicles must be more appealing to those who struggle with walking for longer distances. Privately owned vehicles and taxis have the advantage of taking the passenger directly from the origin point to their destinations. Also, the passengers most likely do not need to carry their groceries of luggage for as long distances as with public transportation.

Falling on the bus is also a possible fear to those who have problems with their physical conditions. Buses have usually narrow corridors which makes walking to the seat and exiting the bus more difficult. As pointed out previously, the fear or the possibility of not having an empty seat might limit the use of public transportation (Wong et al., 2018). This must be a concern for those with worse physical conditions. For them, falling is very likely to cause more damage compared to those with better health.

Older adults are a growing group of people with their own needs and challenges. They are also an interesting group because they change with the population as, eventually, younger generation will get old. Besides physical conditions, older adults also struggle with technologies. As Hunsaker and Hargittai (2018) point out, even though older adults' Internet usage is getting more common, it is still significantly behind the general population. It is hard to know whether older adults will get significantly better with technologies or still struggle in the future. On the other hand, the technological solutions need to be implemented based on the settings of current situation.

As Pirhonen et al. (2020) pointed out, the rejection or the inability to use technology might cause older adults to use traditional methods instead. This was brought up in the literature review as well as the prototype testing. Older adults seemed to prefer traditional methods compared to the digital services. UTAUT2-model states that age also affect what a person enjoys (Venkatesh et al. 2012). Lack of enjoyment can demotivate older adults from learning to use technologies.

Prototype testing showed that participants had difficulties using and understanding smart phone applications. Even when older adults might try to learn to use some technologies, these technologies are likely to get updated and changed making relearning necessary. For people with limited understanding of technologies or negative attitude towards them, this can have a significant effect. Therefore, having digital solutions that expect the user to be familiar with even the basics of smart phones might already cause issues.

For this study, it would have been interesting to test the prototype with people more familiar with Föli's application. This would have given feedback on how people with experience with Föli's application find these changes proposed by the prototype. One of the subjects had experience with Föli's application but her experience was limited to adding money to her bus card. In other words, this study proved how people with almost no experience with public transportation applications would act.

Target demographic's likely unfamiliarity with smart phones was kept in mind while designing the prototype. The design was kept simplistic, and navigation was made as clear as possible. Even though using the prototype might feel odd for someone with a lot of experience using smart phone applications, for the test group this prototype was less difficult to use than the regular application. As the prototype made basic functions of the regular application available while removing the less used functions that made the user interface more complex, older adults were able to use the prototype much easier.

The prototype was designed in the way that the users did not get overwhelmed with information as soon as they opened the application. It is difficult to balance minimalism without losing too much information in the process. It seemed that, optimally, information should be presented from left to right and from top to bottom in easily understandable and structured layout. This might be a cultural habit, as Finnish is read from left to right and from top to bottom and might be different for other cultures.

While older generations have difficulties getting used to new technologies (Pirhonen et al. 2020), digitalization is a rapidly developing phenomenon that causes services, systems, and products to become increasingly digital (Amankwah-Amoah et al. 2021). If these systems were beneficial to the mobility and well-being of older adults, it would be justifiable to design them in a way that takes capabilities of users or willingness of the users to use the systems into account.

Most modern, extensive systems, like banking systems or public transportation systems, should not yet rely on everybody in their target demographic being able to use technologies. Some might not be able to use them as well as others while some might be unable to use technologies at all. Not all older adults in Finland even have experience in using the Internet and even though the rates of usage are going up they are still way behind younger people (Hunsaker & Hargittai, 2018; Pirhonen et al. 2020). This poses an interesting question that when it is possible to rely on only digital systems. Based on literature and tests conducted in this study, there is still a long way to go.

It is also important to understand that many older adults are actively using or have used digital systems (Pirhonen et al. 2020). Older adults are not uncapable of learning, but the systems, if possible, should be built in a way that help them get accustomed to using the systems. When designing an application, it might be difficult to point out every feature that may be hard for people with less experience to use. This is why usability testing should be conducted to get a better understanding of any usability problems within the target demographic. It is also complex to design the product is a way that the basic functionalities are less likely to be changed in the future which makes it easier for older adults to get accustomed to the product and use it easier.

Considering Group 1, another factor that significantly predicts the use of public transportation is the use of a car. Older adults who do not use cars are 2.8 times more likely to use public transportation. The question presented to the subjects did not clarify whether the person drives the car or travels as a passenger. This finding indicates that either older adults using cars do not have an easy access to public transportation, or they do not find it convenient to use compared to cars.

Most likely the convenience of a private owned car outweighs the benefits of public transportation. This is a challenge for larger cities, that already struggle with sustainable traffic (Stojanovski 2019). The overall older adult population in Turku seems healthy so it might be that use of a car over public transportation is more likely to be a matter of convenience. It would also be interesting to have data that makes it possible to research on how the distance to the bus stop affects the use of public transportation. It is possible people living in close proximities of bus stops are already using public transportation regularly whereas people living further away prefer other modes of transportation.

As Traficom pointed out, men are more likely to use a car and less likely to use public transportation compared to women (*Finns' Travel Habits | Tieto Traficom*, 2023). This might be a gendered habit. It is possible men prioritize cars for their own errands while women are more likely to use public transportation instead. Traficom (2023) also stated, that women are less likely to be a driver of a car.

Also, wealth was not a factor in the use on public transportation, which is an interesting find. From city's point of view having people of all different socioeconomical statuses use public transportation is desirable. Public transportation should not be only for those who cannot afford driving a car or using a taxi. If people willingly use public transportation, it means that public transportation has succeeded making itself a desirable option compared to other modes of transportation.

Group 1 did not specify how often they use public transportation. The question, on the other hand, implies that the person answering "yes" uses public transportation at least occasionally. This makes it difficult to know whether the financial situation affects how often public transportation is used, for example if a person can pay for taxi services but still occasionally uses public transportation. This type of person would still answer similarly to a person who uses public transportation daily. It would be an interesting statistic to that out of every journey they make, how often older adults in Turku use public transportation and whether this has any correlation with their wealth.

The strength of this study was a high number of participants in Group 1. Another strength of this study was that Group 1 could be used to understand the qualities of the target demographic for the prototype. The comparative testing scenario also brought observations about the limitations of the current public transportation applications in use for the older adults. The limitation of this study was the lack of economic resources that limited the testing and the development of the prototype.

Also, the data of Group 1 was limited to the city of Turku which means that it might not be generalizable to the whole Finnish population. On the other hand, having data on national level would include people who do not live in a proximity of public transportation and, therefore, not be a target demographic for this study. If there was more data available, it should be analysed in a way that takes the difference between municipalities into account. It might be necessary to only compare those municipalities with similar sized public transportation systems.

6 Conclusions

This study had three research questions:

- RQ1.Is it common for older adults to use public transportation?
- RQ2. What affects the older adult's use of public transportation?
- RQ3. What improvements can be made in the design of the current public transportation applications to make them easier to use for older adults?

For RQ1 and RQ2, when examining the prevalence of the use of public transportation within older adults in Turku, it was found that most of the older adults in Turku used public transportation and their health status was good. According to statistical analysis, health status is a factor that affects the use of public transportation. Those older adults with better physical health are much more likely to use public transportation compared to those with weakened physical health.

Those older adults who are unable to walk for longer distances or use stairs are much less likely to use public transportation. There are also significant differences between men and women. Women are significantly more likely to use public transportation compared to men. It was also found that older adults who use cars are less likely to be public transportation users. Wealth, self-assessed health status, hearing, sight, or marital status were not significant factors.

For RQ3, the prototype developed in this study for older adults worked better than Turku public transportation application for the test subjects. Significant design choice was found to be simplistic, minimalistic design with vertically structured interface. The interface should always offer an easy way to navigate back, and each view should be titled as older adults might be less confident navigating in the application. The main view after opening the application should state clearly what are the user's options to navigate to. Every button should be titled as clearly as possible to describe the content behind it.

In prototype testing group, frustration was one of the main reasons brought up to explain the lack of motivation to learn to use a technology. The subjects perceive technology too complex to use. Another reason brought up was the performance expectancy, as some test subjects did not think that the application or technology would be beneficial for them. They seemed to prefer traditional methods, like physical timetables. These two factors, perceived ease of use and perceived usefulness are both part of technology acceptance model, which in this case proved to be an excellent predictor.

For future research there few interesting findings that were not examined further in this study. There is a gendered difference between the use of public transportation between older adults, as women are 2.5 times more likely to use public transportation. Any reasons for this were not examined in the study. Secondly, as this study is also focusing on Turku, it would be valuable to see whether these results vary between different cities and why. Lastly, a study implementing a real application, for example for beta testing, would probably produce more data to be analysed beyond only usability. Prototype developed in this study was proven to have good usability within test group but there are no indicators older adults would choose to use it.

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Appendices

Appendix 1

Question and possible answers presented to the subjects.

Gender	1 male 2 female
Marital status	1 single 2 married, living together 3 married, living separately 4 cohabitating 5 widow 6 divorced
Who do You live with?	1 alone 2 spouse or partner 3 spouse or partner and someone else like child or grandchild 4 child (and his or her family) 5 someone else
How do You feel about your current financial situation?	1 excellent 2 very good 3 good 4 fair 5 poor
How is Your health status currently?	1 excellent 2 very good 3 good 4 fair 5 poor
Are You able to walk 400 meters (around the block)?	1 without trouble 2 with trouble but without help 3 with help 4 no
Are You able to walk one stair flight without resting?	1 without trouble 2 with trouble but without help 3 with help 4 no
Are you able to use public transportation?	1 without trouble 2 with trouble but without help 3 with help 4 no
Do you use public transportation?	1 yes 2 no
Do you drive a car?	1 yes 2 no
Has Your sight deteriorated so that it has a negative effect on your everyday life?	1 no 2 yes, some 3 yes, significantly
Has Your hearing deteriorated so that has a negative effect on your everyday life?	1 no 2 yes, some 3 yes, significantly
Cognition (tested during interview with 6-CIT)	1 normal cognition 2 mild decline 3 significant decline
Aids in use	1 no aids 2 walking cane 3 four-point cane 4 crutch (elbow) 5 crutch (armpit) 6 walking poles 7 four-wheeled walking aid 8 wheelchair 9 someone helps 10 something else
Fallings in the last 12 months	0 none 1 one 2 two 3 three or more

Appendix 2

Characteristics of the participants (n = 1218) in the study

		n (%)
Gender		
	Male	475 (39)
	Female	743 (61)
Marital status		
	Married or cohabitating	735 (60)
	Single	68 (6)
	Widow	415 (34)
Living circumstances		
	Living with a spouse or another person	758 (62)
	Living alone	460 (38)
Financial status		
	Excellent or very good	634 (52)
	Good	527 (43)
	Fair or poor	57 (5)
Health status		
	Excellent or very good	629 (52)
	Good	494 (40)
	Fair or poor	95 (8)
Able to walk 400 m.		
	Easily	1051 (86)
	Without help	130 (11)
	With help	13 (1)
	Unable	24 (2)
Able to use stairs[a]		
	Easily	1053 (87)
	Without help	141 (11)
	With help or unable	22 (2)
Ability to use public transportation[b]		
	Easily and without help	1170 (96)
	With help	18 (2)
	Unable	28 (2)
Public transportation user		
	Yes	881 (73)
	No	332 (27)
Car driver		
	Yes	826 (68)

	No	390 (32)
Problems with vision[c]		
	No	889 (73)
	Yes, some	294 (24)
	Yes, significant	33 (3)
Problems with hearing		
	No	847 (70)
	Yes, some	318 (26)
	Yes, significant	53 (4)
Cognition		
	Normal	1145 (94)
	Mild decline	28 (2)
	Significant decline	45 (4)
Mobility aids		
	No	1093 (90)
	One	78 (6)
	Two or more	47 (4)
Fallings in the last 12 months		
	0	957 (79)
	1	197 (16)
	2 or more	64 (5)

[a] 2 missing values
[b] 2 missing values
[c] 2 missing values