TU WIEN Informatics

Examining the Usability of Self Service Technologies in the Retail sector

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Wien, 29. März 2024

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Examining the Usability of Self Service Technologies in the Retail sector

DIPLOMA THESIS

submitted in partial fulfillment of the requirements for the degree of

Diplom-Ingenieur

in

Media and Human Centered Computing

by

Albrecht Völkl, BSc
Registration Number 00926987

to the Faculty of Informatics

at the TU Wien

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Assistance: DI Janis Lena Meißner, MRes PhD

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Albrecht Völkl, BSc

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Kurzfassung

Self-Service Technologien (SST) haben in den letzten Jahren viel an Bekanntheit gewonnen, insbesondere während der weltweiten COVID Pandemie in den Jahren 2020 und 2021. Allerdings fiel mir, während ich Recherche über diese Technologien und ähnliche Forschungsarbeiten durchführte, auf, dass es einen Mangel an wissenschaftlichen Arbeiten gibt, welche gezielt die Nutzbarkeit (Usability) dieser Technologien untersuchen, insbesondere im Handelssektor. Dies könnte dazu führen, dass solche Technologien öfter zwingend verwendet werden müssen, während deren Nutzbarkeit nicht weiter untersucht wird.
Diese Arbeit konzentriert sich auf die Analyse der Probleme im Bereich Nutzbarkeit. Konkret widmet sie sich Selbstzahlkassen und Supermarkt-Onlineshops, die im österreichischen Handel mittlerweile verstärkt angeboten werden. Nachdem Einkaufen ein Thema ist, das sämtliche Bevölkerungsgruppen betrifft, legt die Studie besonderes Augenmerk auf Personen unterschiedlicher Altersgruppen mit verschiedenen technischen Fähigkeiten, sowie unterschiedlicher Muttersprachen. Im Zuge dieser Arbeit wurden Antworten auf folgende Forschungsfragen formuliert:

1. Welche Denkprozesse haben Personen während der Benutzung von handelsbasierten Self-Service Technologien? Welche Schritte sind bei der Verwendung unklar?
2. Was sind auffällige Unterschiede bei den kritisierten Aspekten basierend auf Altersgruppe, Muttersprache oder technischen Fähigkeiten?
3. Was sind - nach der abgeschlossenen Analyse - die wichtigsten Eigenschaften welche verbessert werden müssen?

Um diese Fragen zu beantworten wurde ein Mixed-Method-Ansatz bestehend aus Auto-Ethnografie (Eigenanalyse der Technologien), Thinking Aloud (während der Nutzung der SSTs) und Fragebögen (nach der Nutzung der SSTs) angewendet. Insgesamt nahmen 23 Personen an der Studie teil. Die Ergebnisse ergaben einen Überblick über unterschiedliche Probleme in verschiedenen Usability Kategorien, sowie Lösungen zu deren Verbesserung. So wurde erkannt, dass häufig einzelne Probleme den Gesamtvorgang unterbrechen, und viele Unklarheiten mithilfe von einfachen technischen Verbesserungen und dem Anbieten einer Anleitung gelöst werden können. Allgemein besitzen SSTs im Handelsbereich in Österreich noch einen negativen Ruf, welcher aufbauend auf den hier gesammelten Erkenntnissen verbessert werden könnte.

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Abstract

Self Service Technologies (SST) have gained a lot of popularity over the recent years, especially during the worldwide COVID pandemic in 2020 and 2021. However, while conducting research about these technologies and similar theses, I noticed a lack of scientific work researching specifically the Usability of these technologies, especially in the retail sector. This could lead to an increased mandatory use of such technologies, while their Usability is not examined any further.
This thesis focuses on the analysis of issues in terms of Usability. Specifically, it examines self checkout terminals and supermarket online shops, which have become more widespread in the Austrian retail sector by now. Since shopping is an activity that concerns all demographic groups of the population, this study includes participants of all age groups with different technical skills as well as multiple mother languages. Over the course of this thesis answers were formulated for the following research questions:

1. What are people's thought processes when using retail-based Self Service Technologies? Which steps during execution are unclear to the user?
2. What are the noticeable differences in the aspects being criticised depending on age group, native language, or technical aptitude?
3. After the completed analysis, which are the main aspects that need to be improved?

To answer these questions, a mixed-method-approach was applied, consisting of Auto-Ethnography (personal analysis of the technologies), Thinking Aloud (during use of the SSTs) and questionnaires (after use of the SSTs). In total, 23 participants completed the study. The results yielded an overview of multiple issues in different Usability categories, as well as solutions for their improvement. It was discovered that single problems often halt the overall process, and that many uncertainties could be solved with simple technical improvements and by offering a manual. In general, SSTs in the Austrian retail sector still have a negative reputation, which could be improved based on the insights that were gathered here.

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CHAPTER 1

Introduction

The history of Self Service Technologies in retail (or SSTs for short) dates back at least until the beginning of the 19th century, when vending machines started becoming more popular in public areas [Ben23] [Ven22] [Gre22]. With the emergence of modern computer technology, the concept of customers becoming more independent from employees when acquiring a product or looking for information was rapidly expanded to multiple areas of daily life. Bank transfers can be conducted without having to leave home, millions of products can be bought without ever going to a single shop, and one can visit thousands of libraries without travelling anywhere. But there are also several instances where self service technologies are embedded in a retail setting, such as ticket machines at railway stations or information terminals at hardware stores. Said hardware stores and the retail sector in general have also started implementing another technology allowing customers to act more independently in the form of self service checkouts. Instead of queuing at a single checkout requiring an employee to operate everything, multiple terminals can now be installed within the same area. This allows customers not only to handle the checkout process at their own pace, but it also enables more people to pay for their products at the same time. Associated with the rising popularity of online shopping services, many supermarkets also started offering different means of buying groceries and other daily products online. This is usually done either by entering a list of items online and picking it up at a specific location afterwards, or having it delivered directly to one's doorstep.

While all these possibilities first appear to make daily shopping a lot easier for everyone, there are multiple other factors that also need to be considered. Self Service Checkouts in general are rather simple systems and do not require special training for correct use. Instead, it is usually enough to operate them two or three times to understand the basics of how they work. Similarly, most online shopping websites follow the same operating principles, and the understanding of one often leads to the understanding of others. Depending on different countries and different cultures, the extent of use of self

service technologies - namely within the aforementioned retail and supermarket sector - varies greatly. This can be attributed to different cultural and technological factors, such as overall acceptance of new technology by the population, but also the quality of the provided services. In Europe, multiple distinctions have been identified between different countries in terms of availability and acceptance of SSTs, showing a wider overall spread in middle and northern European countries [Mö23]. Having many cultural similarities, Germany and Austria show similar levels of adoption of modern technologies, but both countries are usually ranked considerably lower than other so-called "first world countries" in terms of technological infrastructure [Get23]. While availability itself is the most important step to integrate something new into a society, another very important factor is often ignored in the process, which is *Usability*. Considering the wider spread of SSTs in countries with higher technological development, it can be presumed that the overall quality of service is also better than if said services are offered in less developed countries. Austria for instance has only recently begun implementing self service checkouts within supermarkets, and only very few companies offer a working online shopping service. Due to certain observations that were made in preparation and execution of this study, it became evident that very few locations have self service checkout terminals installed, and company websites exhibited multiple severe flaws. Upon first personal use of these services, it quickly became apparent that several usability issues exist that are likely to deter customers from regular use. This thesis attempts to identify any Usability issues within the currently provided systems, and in turn presents possible solutions for general improvement. Participants were invited to either make a purchase at a regular supermarket, which was then concluded by using a self service checkout, or to try out an online shopping service offered by a supermarket company. The research data was collected using a mixed method approach consisting of three different methods: During use, *Thinking Aloud* protocols were generated, which were then complemented with a *questionnaire* including both qualitative and quantitative questions. Additionally, an *auto-ethnographic approach* was conducted, which focused on personal experience by the researcher in terms of design principles and general knowledge about computer technology. The collected data was then analyzed using a combination of mixed method research with both inductive and deductive data analysis to formulate answers to the following research questions:

1. What are people's thought processes when using retail-based Self Service Technologies? Which steps during execution are unclear to the user?
2. What are the noticeable differences in the aspects being criticised depending on age group, native language, or technical aptitude?
3. After the completed analysis, which are the main aspects that need to be improved?

In conclusion, it was discovered that several identified problems would only require minimal modifications of currently implemented systems. Additionally, specific key differences between demographic groups were also discovered, especially in terms of age difference and technological aptitude. The auto-ethnographic document mainly discusses

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technological design principles as well as concepts about human perception, and includes further analysis of different technical components.

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CHAPTER 2

Related Work

Self Service Technologies within the retail sector are becoming more and more popular in recent years, and their number will most likely continue to grow in the future, both in availability as well as in use. To ensure that such - as well as other - systems work as intended and can be used successfully by customers, it is necessary to conduct regular tests and research during development. This process begins with the theoretical system design, following through several iterations of redesigning and adjusting the technical implementation, until the final product can be inspected by actual users as well. To facilitate a more thorough design and development process, knowledge from many different scientific fields should be included and both technical as well as social aspects need to be considered. Research methods have to be planned and executed, and the data gathered then needs to be processed, analyzed and interpreted. The following section describes the main scientific areas coming together during the production of this thesis and will also look into some previous research that has been conducted on SST in terms of usability in the retail sector.

2.1 Self Service Technology

Self Service Technology (SST) encompasses all kinds of technology where a person is utilising a service offered by someone else - mostly a company - without any direct involvement from another person such as a cashier or consultant. Instead, the customer is presented with a physical artifact such as an information guide, or - as it is mostly the case today - needs to use some form of computer system. Some examples are: buying a ticket for public transportation online or at a vending machine, browsing the website of a clothing store and ordering something online, paying at a self service checkout cash register, or reading through a FAQ (Frequently Asked Questions) catalogue of a website, although FAQs may also be presented in paper format. Both the amount and variety of use in terms of SSTs have grown rapidly within the last years, with some of the driving

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Figure 2.1: Ticket vending machine from Wiener Linien GmbH & Co KG[Onl11]

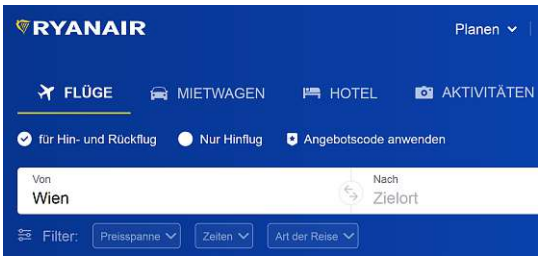

Figure 2.2: Screenshot: Online Booking Service from Ryanair Holdings Plc[plc23]

factors being the worldwide distribution of the internet as well as how easy it became to acquire and set up modern computer technology [CAE10] [CM05].

Due to various technological developments, SSTs are not necessarily bound to a single terminal or machine, and do not need to be accessed from a specific location either. Shopping websites and other web-based services can be accessed from basically any device at any location as long as an internet connection can be established. Also, devices such as smartphones or tablets, which can easily be transported, offer the ability to display documents or images in a detailed manner. That way tickets or vouchers can be stored electronically and shown on the screen, removing the need to print them out before use. Authenticity certificates can be distributed, stored or accessed by different methods as well, such as QR codes (which for instance were often used for self-testing documents during the recent COVID pandemic), fingerprint readers, or by offering services like the Austrian Digital Signature [fF22] which allows users to sign documents electronically in a legally valid fashion. The distribution of SSTs is estimated to grow consistently over the next years, and while such technologies can offer several advantages such as independence (in terms of location or requiring personal assistance) or efficiency, it is also important to keep potential challenges in mind, such as financial requirements or availability of the necessary technology [CP+22]. In the long-term, one also needs to consider the potential benefits and challenges for society as a whole, with negative implications such as certain jobs becoming obsolete on one hand, and positive factors such as making services of all kinds more accessible for everyone.

With the estimated growth of SST distribution, it is likely that many services that currently involve interaction with other human beings will be completely replaced by machines in the future. It is therefor crucial to ensure that future (as well as current) systems are developed with high Usability standards to guarantee a positive user experience for everyone. This thesis offers an inspection of both location-dependent and independent SSTs, with the former being presented by discussing the self service checkouts located at specific supermarkets. Location-independent technologies are covered by the inclusion of online shopping services, which can be accessed from any computer with an internet connection. Both of these technologies are not widely distributed in Austria yet and

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many customers voice their negative experiences while using them [Var23a] [Var23b]. With proper implementation, many positive improvements can be achieved by the use of SSTs in retail (see 5.3). This thesis contributes to this by examining and presenting improvements in terms of Usability.

2.1.1 Previous evaluation of Self-Service in retail

In 2014, Kallweit et al. have studied the willingness to use self-service information technologies in relation to the quality of the systems at hardware stores [KST14]. They used the Technology Acceptance Model (TAM) by Davis [Dav89] as their main research basis, and emphasized the importance of Perceived Service Quality (PSQ). This means that what matters is how the users themselves perceive the quality of the service [GSC93]. In the end, the researchers used a combined approach consisting of four different methods:

- conducting expert interviews
- creating their own application for testing
- a scenario-based laboratory experiment which simulated the information process
- a structured questionnaire

The questionnaire was created by ”borrowing” different items from other literature and measuring them using a five-point Likert scale. In conclusion, one of the main findings of the study was that quality of information is significantly more important than quantity, and that both the Perceived Ease of Use (PEOU) and Usefulness of Content (UC) have a high impact on the overall Attitude Towards Using (ATU).

Turner and Szymkowiak conducted a diary-based approach about the experience with Self Service Checkouts with the focus being on novice users [TS19]. They chose a sample group of inexperienced users and compared their perception towards Self Scan Checkouts prior, during and post use. Before use, one negative aspect that was mentioned was the lack of social contact, or that people would not like to buy many products that way. Positive aspects were mentioned in combination with buying a few, simple products, or that social contact could be avoided when a customer is in a bad mood. During and after use, a variety of negative experiences were recorded, such as feeling stressed or controlled if help from a staff member was required. In the end, the majority of the participants continued to have a negative opinion about the use of Self-Service Checkouts. However, in situations such as being in a hurry or being in a negative emotional state, they were still considered as a viable option.

Hyun-Joo et al. conducted a study about ”The influence of consumer traits and demographics on intention to use retail self-service checkouts” by conducting a web-based survey[LCXF10]. Initial research brought the conclusion that the interaction between consumer traits and demographic factors has an effect on the willingness to use SSTs in retail. The researchers then attempted to analyze the influence of each of the two factors

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on their own, as well as the influence of demographic factors combined with personal traits. They first present previous studies about the effect of different consumer traits and demographics, such as "As age increases, technology anxiety increases." or "As education level increases, technology anxiety decreases." To gather data, 437 invitations to their survey were sent out, which produced a sum of 285 usable results. The conclusion of the study was that demographic factors only influence willingness indirectly by having an effect on consumer's personality traits. Two of the main influential factors that were identified were age and gender, while education neither had any direct or indirect effect.

Previous Usability evaluations on SSTs showed a considerable lack of research covering the retail sector. The three works presented here either inspected only the willingness to use technologies such as self service checkouts, or focused on a very specific user group. Conducting Usability research on broader target groups in retail appears to be a topic that was not often investigated in the past. Having a mixed group of participants attempt to successfully use self checkouts or online supermarket websites allows this thesis to create results which cover a broader spectrum of key factors than previous work by including different demographic groups. Several of the improvements that are presented in section 4.4 can be applied universally and would not only improve Usability for Austrian SSTs in retail, but can be implemented by other countries or companies as well.

2.2 Usability

Several forms of measurement and analysis exist to determine whether a technology is capable of performing the task it was designed for. Industrial devices may require a certain accuracy or physical strength, pumps need to transfer a specific amount of liquid, or computer systems need to be able to process a specific amount of information. One type of measurement to determine how well a user can interact with a - often computer-based - system has been developed in the form of Usability. In general, Usability measures how well a device or software can be used by someone, but the overall topic spans several areas of application with different key properties.

In 1991, Bevan et al. proposed a unified definition for the term "Usability". They concluded that "Usability lies in the interaction of the user with the product or system and can only be accurately measured by assessing user performance, satisfaction and acceptability"[BKM91]. ISO 9241-11:2018 sets an updated definition with the three main usability attributes being *effectiveness, efficiency and satisfaction*[ohsi18]. Usability can also be described by naming five different key factors [Ter18]:

- *Effectiveness*: how well does the product or service support the user in fulfilling a task
- *Efficiency*: how quickly and easily can a task be fulfilled

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- *Engagement*: measures if the overall appearance and experience of use are appealing to a person
- *Error Tolerance*: ensures that errors or unexpected behaviour can easily be understood or handled by the user
- *Ease of Learning*: designing a system in a way that little learning effort is required for successful use

Companies such as the Microsoft Corporation also offer extensive Usability guides for software developers in several fields [Cor18] [KBMJvtQ22]. According to their work, it can be concluded that both adequate presentation and successful interaction are equally important for providing a positive user experience.

Depending on the target group or intended use, priorities and focus on what is important change significantly. I provide three examples to illustrate that, while all consider the same Usability factors, they generate very different results for the question about what is adequate.
Related to these examples, three different technologies need to be developed for different user groups, specifically:

- A learning software for infants (with additional physical components)
- A smart home control interface for people with - potentially age-related - physical impairments
- A visualization software for a car mechanic

Each of these items has a different purpose and target group, but they all share similar key factors. Based on specific Usability aspects which have previously been discussed in related research, the following list compares some of them for each of the different technologies.

- Color scheme: It is known that children enjoy colorful things, which leads to the conclusion that software specifically designed for them should use a lot of different bright colors as well. On the other hand, people with impaired vision might require more focus on good contrast, limiting the use of color to certain, easily distinguishable choices. The software for the mechanic might require a very specific color scheme, highlighting different car parts in different ways to offer an efficient and informative visual overview.

- Operation methods: Since children like to grab and touch things, a device developed specifically for them could be controlled by using a touchscreen or by adding additional mechanical parts such as buttons or dials. People with physical or cognitive impairments might have issues with their motor skills or have difficulties identifying specific control elements. In this case, it is recommended to offer a multimodal way of operation. For example, the system could be operated either by speech input (and

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corresponding output) or by using a large touchscreen. For a mechanic, a ”classic” setup with a mouse and keyboard (and possibly with additional touchscreen functionality) is likely to be the best option to offer precise control over all parts of the software.

- Text and symbols: It might be appealing to children to create text in rainbow colors or have text displayed in different directions or angles. On the other hand, if the software is designed for children below the average age of learning how to read, easily understandable symbols will be required to assist with navigation. Users with poor eyesight however will most likely require a large, clearly readable font with little room for any unconventional design choices. Text can also be supplemented by symbols with the same meaning to allow for easier identification of elements or functionality. Finally, the software for a mechanic requires a mix of different font sizes as well as symbols to properly describe different parts of a vehicle and allow specific options for highlighting and selecting elements.

With these examples in mind, it becomes evident that good Usability cannot be achieved by simply following a strict formula. For each project, a separate evaluation is necessary depending on the intended use, target group, or context. In terms of context, it is important to consider differences between cultures all around the world, especially when designing products that are to be used in multiple areas. Symbols or gestures can have different meanings, color schemes might be interpreted differently, and not all countries read text from left to right either.

The works presented in section 2.2.2 demonstrate that Usability can be measured by a multitude of different variables. The segmentation used in this thesis is based on the previously presented five key factors. While accessibility is a different aspect of technology design and generally focuses more on development regarding people with disabilities, it shares similar goals as Usability and both concepts overlap in certain areas [WAI16]. Due to these similarities, certain Accessibility concepts will also be included in the analysis of the inspected technologies, such as readability and understandable content.

For this thesis, the Austrian culture plays an essential factor for developing solutions which intend to improve the Usability of SSTs which are already in use or will be developed in the future. At the same time, it is crucial to keep customers from other countries in mind as well, such as immigrants, exchange students or workers. To develop concepts which can be more universally implemented, including features such as functioning language selection is required and aspects like specific colour schemes must be chosen with different interpretations in mind.

2.2.1 Usability & User Experience

While Usability and User Experience are both terms which are often used when it comes to assessing the quality of a product or technology, they have a notable difference in meaning. While the definition of usability is well established by international standards, definitions for user experience still appear to be unclear [HGE17] [LRH+09]. Hassan et

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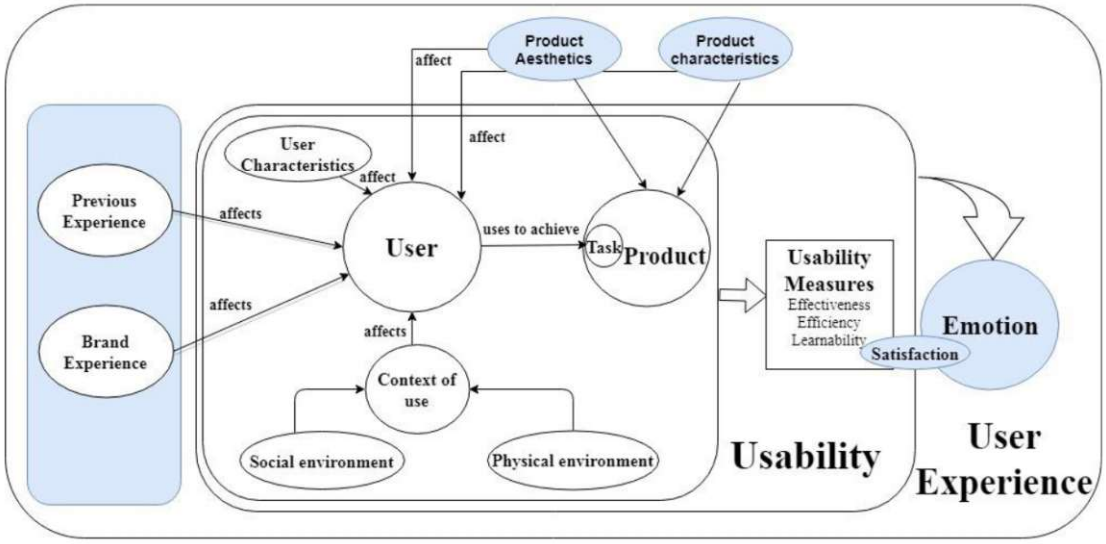

Figure 2.3: Usability-User Experience Relationship Framework by [HGE17]

al. [HGE17] attempt to clarify this issue by first presenting several previous definitions for both usability as well as user experience, and then drawing a new conclusion based on their findings (see Fig. 2.3). They conclude that usability is a part of user experience, stating "we consider it as the heart of user experience" and that both should be used together to generate proper understanding. Vermeeren et al. state that user experience should be measured multiple times as the perception of a user towards a product or system can change before, during, and after use[VLR+10].
Within the scope of this thesis, each participant has used the technologies that were covered only once without any further sessions being conducted afterwards. Since repeated use and previous experience are crucial factors for measuring user experience correctly, it was decided to focus the analysis on the Usability concept only.

2.2.2 Usability Evaluation

Evaluation is an essential part of the successful development of both old and new technology, although the large number of failed product ideas during history shows that it is obviously being neglected at times. This is demonstrated best by coming in contact with (or hearing about) devices, software, or systems that are being offered which - among other things - might show high error rates, do not perform as expected, or simply do not work at all. For technology that needs to be actively operated to perform its designed scope of functions, usability evaluation is one of the most important factors to ensure success in this area. Depending on the technology that is being evaluated, different factors (additionally to the previously mentioned main attributes) or aspects of usability are measured.

Nathan and Yeow conducted a survey about important Web Usability Factors (WUF)[NY11]

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and mentioned variables such as *Use of Colour and Font, Trustworthiness of Website* or *Ease of Web Navigation*. In total, seven variables were tested for their impact on Overall Web Usability (OWU). Their research scope covered websites from different industries with 400 respondents and combined three different research methods: usability questionnaires, laboratory tests (to offer a consistent testing environment), and user-testing methods (let the end-users themselves do the testing). In conclusion to their research, the seven OWU factors were ranked by importance, with use of colour and font being determined to be the most crucial one. It was also noted that the Trustworthiness of Websites was considered to be more important for the testing group than it is for the average internet user.

Sheehan et al. conducted a study about accessing healthcare information on mobile devices, [SLR+12] and based their framework on the FITT model [AIM06]. Their research aimed to gather details about learnability, satisfaction, efficiency and effectiveness. As main research method, they created a laboratory-environment and observed participants - which were students at a public high school - while they were using four different mobile devices. In the end, the goal was to complete five different tasks which all involved accessing (and using) medical information. In conclusion, the researchers found out that based on their implementation of the FITT model, completion time varied strongly depending on the application and device used. However, participants always succeeded in completing their given tasks.

Rose et al. conducted a qualitative study to "improve the Usability of an EMR" (electronic medical record), focusing on the Results Manager of the web application Longitiudinal Medical Record (LMR) [RSP+05]. The target user group of the study were physicians, who described multiple reasons as barriers against using EMR systems. Two main qualitative methods were applied, namely field studies using task analysis and multiple focus groups. Afterwards, the data collected via each method was analysed separately and then combined to find similarities and common themes. Most of the issues that were identified were also found in previous studies and are "associated with various theories of human cognition and visual sensory perception." In conclusion, they recommended a system design that appeals to multiple user groups, keeping both beginners and experts in mind.

To conduct a thorough assessment of the Usability of SSTs in retail, it was deemed necessary to conduced a mixed method approach using three different methods (see section 3.1 for a detailed description). Studying previously conducted evaluations, it became evident that Usability research can only be interpreted meaningfully by dividing the findings into appropriate categories. Although the collected data itself already offers some insight and can be used to make improvements, further categorization makes it clearer which Usability factors were neglected or pose the greatest challenges. To offer the same quality of insight in this thesis, Usability categories were also used to present the findings of research questions one and three.

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All of the studies presented here either make use of qualitative or quantitative methods, but a mixed methods approach is rarely used. While a quantitative study design offers a quick numerical overview of a topic by using mathematical methods, qualitative studies can be used to identify patterns that cannot be calculated, such as certain mannerisms, behavior, or social issues. While quantitative methods generate quick results about variables such as task time or success rate which can then be compared with other variables such as age or experience, information about the "how and why" is often missing. Different countries with various societies show different levels of adaption of technology, and acceptance of new devices may vary significantly. It is therefore necessary to investigate and understand the needs, uncertainties and social traits of the target user group, which in this case is mainly the population of Austria.

2.3 Demographic research on Usability related to age

As people grow older, the human body undergoes a number of changes, both physically and mentally. Strength often declines as well as speed, and reaction time and overall speed of thought decreases [DCG+09] [BBG+12]. Given the demographic trend of the the aging population in Austria, age needs to be considered as an important factor when designing technology that is to be used by everyone. Since SSTs in the retail sector also belong into this category, this study encompasses research on this topic as well.

In 2022, Ali et al. conducted a demographic Usability study (researching the correlation between different Usability attributes and specific demographic factors) about the mobile application "Houzcalls"[ARM+22]. They stated that to successfully create a usable program, it is imperative to understand the needs of the users based on different attributes such as personal objectives, intelligence, or age. It is also emphasised that there is a significant difference between design principles and Usability metrics of mobile applications and "traditional" computer programs. Tests were conducted based on a two-stage plan consisting of the analysis of the application to be investigated - which was in the prototype stage at the time the thesis was conducted - followed by the implementation of the PACMAD Usability Model[HFD13]. Finally, five different tasks were prepared for participants to complete which were conducted within a laboratory testing environment. Several general Usability attributes were analysed in accordance to the PACMAD model, including efficiency, satisfaction, and errors. In conclusion, significant differences have been identified in all attributes, with the higher-aged testing groups scoring lower in every aspect.

A study on Web Usability in relation to age was conducted in 2002 by Chadwick-Dias et al. to find out what sort of impacts on performance specific design changes could make [CDMT02]. In the first stage, the participants (aged between 20 and 82) had to complete a series of 15 tasks on a prototype website. The tests were conducted in a laboratory environment, and different usability factors were measured, including

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other variables such as click behaviour, preference ratings, and overall differences in behaviour. The first testing stage showed a strong negative correlation between age and overall success. After the conclusion of the first test, the prototype website was redesigned based on the previous results, and participants were asked to perform the same tasks again. Changes included improved terminology, reducing unnecessary text and improving instructions, and a simplified navigational menu. The results showed significant improvements for both main age groups (below and above 55), with a strong negative correlation towards increased age still being present.

Wirtz et al. decided to "identify shortcomings of electronic interface designs for older users", focusing on language and visual aspects[WJZ09]. Initially the researches emphasize the significance of different biological changes towards higher age, such as sensorial, physical and cognitive changes. Furthermore, it is important to consider what types of technology a specific generation grew up with, which continuously differed over the last decades. The target of the study was the evaluation of a program called "Touch Speak Designer", which is part of the Touch Speak device, a "computer based portable communication assistant for people who suffer from a speech disorder". After an initial expert evaluation of the software, each participant was asked to complete six different tasks. An initial quantitative analysis showed that older participants required a considerably higher task completion time, with the difference increasing depending on complexity. Further qualitative task analysis was consistent with problems identified during the expert evaluation phase. These problems included inconsistencies in terms of software consistency, layout, feedback or structure.

The work presented in this section suggests a trend of lower success and higher error rates when technology is used by higher aged participants. Apart from different age groups, this thesis also aims to find differences between other demographic groups, namely people with different technological experience. SSTs in retail, especially concerning supermarkets and other areas of daily life, are a form of technology that all sorts of people with different understanding, needs and requirements come into contact with. To offer a better Usability standard, it is necessary to consider as many user groups as possible to create a design that can be successfully operated by as many customers as possible.

2.4 Summary

This chapter identified a blindspot in previous research evaluating the Usability of SSTs and motivated a mixed-method approach to fill this gap tailored to the specific demographic and cultural context of Austria. There are several different possibilities how Usability research can be conducted in multiple areas. Various analytical methods or frameworks can be applied, and in turn, corresponding variables are measured. Depending on the topic that is being investigated, it is necessary to consider the exact goal one wishes to achieve, and choose the corresponding methods accordingly. While it might be

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tempting to try and include as much information as possible in one scientific research project, it is better to focus on a specific direction of analysis. This analysis is normally based on either qualitative or quantitative research methods, and combining those in a mixed methods approach can offer a more thorough overview about a specific topic. But once again, it is necessary to consider what is important for gathering a sufficient amount of data to generate results.

Research about previous studies in terms of Usability about SSTs - both in retail and in general - have shown a lack of available data especially in the retail sector. It was further demonstrated that demographic factors need to be considered as well while designing technology not only for a specific group, but especially when everyone needs to be able to operate a system successfully. Austria has only recently begun to implement self service checkouts and online ordering websites for supermarkets, creating an opportunity to positively support further distribution throughout the country. To better understand both current and potential future difficulties or benefits of this development, it is necessary to consider previously established methods of both Usability measurement and research about technology in general. These are then adapted accordingly depending on the desired research scope, setting, and also ubiquitous factors such as social traits of the local populace. Helping to design better systems for future use will not only reduce the already present issues that were identified in this thesis, but can also be applied for preparation of future challenges. For instance, due to improved medical conditions especially over the last 50 years, the amount of elderly people in Austria continues to grow, further emphasizing the importance of age-related research.

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CHAPTER 3

Methodology

The intention of this study was to gather enough data to provide a general overview of the current state of SSTs used in the retail sector in Austria, specifically in the context of supermarkets. As almost everyone needs to go to a supermarket regularly, it was an important goal to include people of multiple demographic backgrounds, especially different age groups as well as people with varying levels of experience in using computer technology. In the end, this study used three different research methods in a mixed methods approach, which is further demonstrated at the beginning of this chapter. As the first step of the study design process, a number of previous studies about Usability, Acceptability and User Experience were reviewed (see Chapter 2). Afterwards, different findings such as significant Usability attributes and other key aspects were combined to generate first drafts of the study process, which were then further examined and refined.

Study Design Overview

While the study is based in Austria and therefore focuses towards the needs and peculiarities of this society, the results that are gathered attempt to provide insights that can be universally implemented as well. The main research questions that are being asked are:

1. What are people's thought processes when using retail-based Self Service Technologies? Which steps during execution are unclear to the user?
2. What are the noticeable differences in the aspects being criticised depending on age group, native language, or technical aptitude?
3. After the completed analysis, which are the main aspects that need to be improved?

Three research methods were chosen to collect the data which would then be further examined:

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- Thinking Aloud: Record direct thoughts and actions of participants during use of the technologies
- Questionnaire: Gather both qualitative and quantitative information about personal experiences, concerns and recommendations.
- Auto-Ethnography: Incorporate personal experience and expert knowledge as additional source of information

These methods were then applied using a Mixed-Methods approach and are further described in the following section.

3.1 Mixed Methods Research

During early stages of designing the study, it was already highly likely that a mixed method approach will be necessary to successfully gain enough insight to formulate a satisfying study outcome. Migiro and Magangi name three specific "methods for conducting research: quantitative, qualitative, and mixed methods[MM11]." While quantitative methods such as questionnaires or rating scales can offer a quick overview about some basic attributes of a system, it is the qualitative methods that offer a deeper understanding about why people make specific decisions, and what sort of experience they are having. This is especially true for studies focusing on the user experience of a device, system, or other product, which often include some form of quantitative data collection for this purpose [BBBB06] [HIIG14] [CL19].

Based on the work of Creswell and Clarke [CC07], Almeida created a guide for performing a mixed methods study, and named four overall design principles[Alm18]:

- *Triangulation design*, which is used to obtain "different but complementary data on the same topic" by combining both the qualitative and quantitative results.
- *Embedded design*, which claims that one data set is not enough to formulate results, and that it needs to be combined with a secondary data set, with each of them including a different type of data (qual. and quant.).
- *Explanatory design*, where an initial quantitative result is formulated and further expanded upon by combining it with qualitative data to offer a better explanation.
- *Exploratory design* can be described as the opposite version of the explanatory approach, with the roles of qualitative and quantitative data being reversed.

For the study conducted in this thesis, the principle of triangulation design was chosen: The Thinking Aloud method would first be used to gather qualitative information providing insight directly about the experience during use, which will then be complemented by both the qualitative and quantitative data generated by the surveys. Lastly, the findings from the auto-ethnographic approach, which are again both of a qualitative and quantitative nature, are added as well. Those three data sets will then be combined to formulate

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a list of both existing problems as well as potential solutions. While one may argue that the explanatory or exploratory design approach could be used here as well, there is one main reason why this would not be feasible in the context of the chosen methods: First, these two principles place one part of the collected data (quantitative or qualitative) as the primary result, while the other part only offers a supporting role. In case of this study however, all types of data are considered to be equally important for generating results. A graphical representation of the final study concept is presented in Figure 3.1: Based on the identified research gap and foundation, three different methodological approaches were formulated and further expanded upon with specific data collection methods.

3.2 Preparation of the data collection

One of the main requirements while preparing the data collection methods was to create a final draft for the questionnaire. The last version had to be ready before the first shopping sessions could be conducted, as it was not planned to make any further changes afterwards since they would have partially invalidated previously filled out forms. Furthermore, the questionnaires were to be filled out directly after the shopping experience to ensure that most details could still be recalled by the participants. The basic process of the "Thinking Aloud" approach was clear from the start and rather simple: record people during the use of a self service system by using a smartphone as a recording device. For the auto-ethnographic approach, it was deemed to be most effective that an external document would be generated in a fashion that is appropriate for this research method. The information generated from this document would then be analyzed and incorporated into the main thesis.

3.2.1 Deciding upon the final research scope

This study focuses on the Usability analysis of two Self Service Technologies based in the retail sector, namely self checkout terminals and online shopping services provided by supermarket companies. Another form of SST that is also part of the retail sector can be found in the form of information terminals, which are sometimes available at large hardware or furniture stores. It was decided not to cover this type of devices in this thesis for the following reasons:

First, it was very difficult to find locations where such devices were available, limiting the area of possible participation significantly. Secondly, the systems that were discovered often had very limited (but not inadequate!) functionality with only a few options to work with. Finally, two specific realizations have led to the decision to remove information terminals entirely from the study: First, it was considered that most participants would only be interested in buying something they would actually need, which generally are products found in supermarkets. Purchases including furniture or hardware are less frequent and would therefore have hindered the overall progress significantly. The second reason was that while creating and refining the questionnaires, the content started

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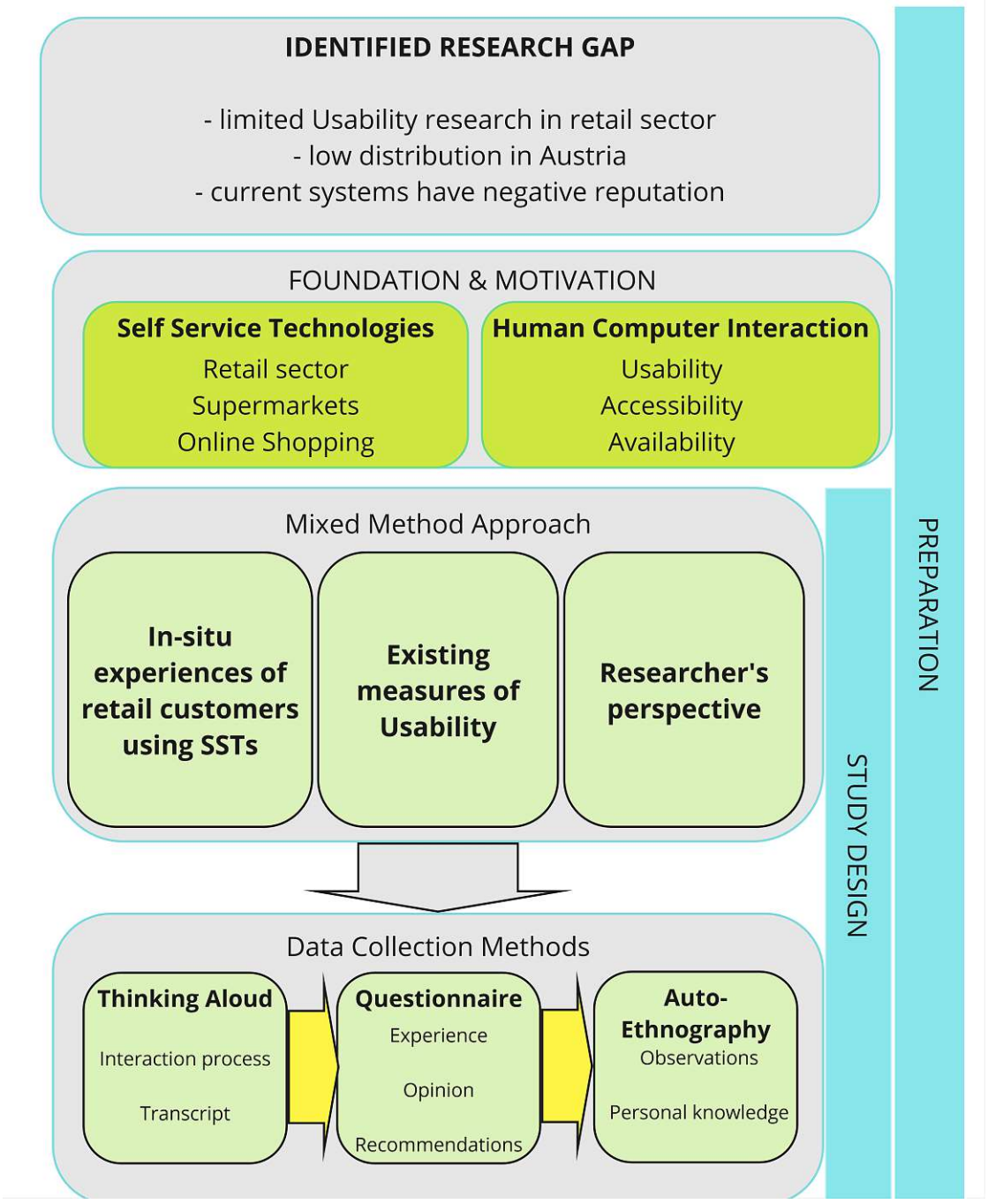

Figure 3.1: Overview of the study method concept

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mainly covering areas that would only be found in systems involving a purchase of some kind, while information terminals were constantly being moved closer to the sidelines. A great advantage that can be achieved by the use of SSTs is location-independence. While self checkouts only provide (partial) autonomy during the shopping experience but are bound to a specific location, online supermarket websites can be accessed anywhere. Two of the largest supermarket companies which are present in Austria provide both of these SSTs, making this a great opportunity to investigate multiple retail-based technologies. After completing the data analysis, many similarities were discovered both in terms of issues as well as potential improvements (see section 4.4).

3.2.2 Basic quantitative questionnaires

Questionnaires are well-established tools for gathering information in any scientific research area and can be considered as a valuable resource. When describing the foundation of their own frameworks, many researchers are mentioning the same or similar basic concepts of general usability research and questionnaire development. To adapt to emerging technologies, new concepts for usability questionnaires are proposed regularly, such as the Purdue Usability Testing Questionnaire (PUTQ)[LCS97] or the Telehealth Usability Questionnaire (TUQ)[PLJGB16]. While a vast number of frameworks for questionnaires about the analysis of different technological (and non-technological) systems and to determine their overall user experience or usability already exist, it is often necessary to generate new customized versions depending on the issue that is being examined. This is regularly the case when attempting to determine the impact of new technology, such as mobile health applications[ZBS+19] or "handheld augmented reality"[SPT+15]. Through the research of previously conducted studies, three key questionnaire frameworks were identified which were then used as basis to create a custom combination paired with personal ideas to gather both qualitative and quantitative data at the same time.

System Usability Scale

The System Usability Scale (SUS) was developed by Brooke in 1995[Bro95] and is a standardized questionnaire that is often used within scientific research about technical systems. It consists of ten different statements which participants need to rate on a Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree) (see Fig. 3.2).

To generate a final rating, a specific calculation is conducted for each statement, with the maximum possible score being 100 points in total. These calculations are required due to the fact that there are only ten questions yielding a maximum of five points each, resulting in a possible final score of 50 points. More importantly, the SUS alternates between positive and negative statements. For instance, question 1 and 3 in the previous illustration are positive statements if a person chooses "strongly agree". The second question on the other hand has a negative impact with a 5 point rating. To calculate the final score, points for positive statements are added, while points for negative statements are deducted, and the result is then given accordingly (with a general score above 70

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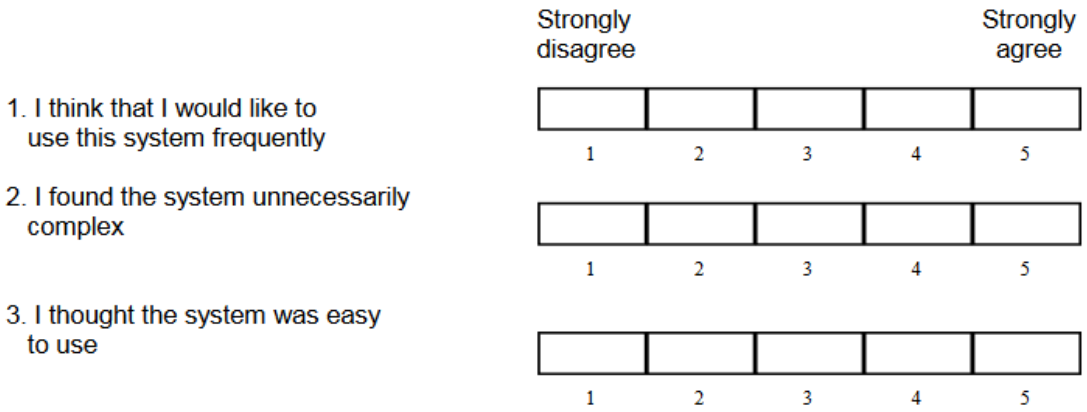

Figure 3.2: Excerpt of the SUS template by Brooke [Bro95]

points being considered as a positive result). Lewis claims the SUS to be "the most widely used measure of perceived usability" and describes several alternative, expanded, or reduced versions in his historical overview[Lew18].

Technology Acceptance Model

The Technology Acceptance Model (TAM) was proposed by Davis in 1985[Dav85] and can be used to measure the willingness - or acceptance - by users to work with a multitude of different technologies. Initially, he described that the motivation of a user to interact with or use a system strongly depends on perception, and he based his first model on three specific key factors:

- perceived usefulness
- perceived ease of use
- attitute toward using

Over the following years, Davis kept refining and altering the model, and also created a number of different measurement scales for both perceived usefulness and perceived ease of use, which were generally using Likert scales as a foundation[Chu09].

Software Usability Measurement Inventory

To quickly explain the basic concept of the Software Usability Measurement Inventory (SUMI), it is best to cite the explanation given on the official homepage:

"The Software Usability Measurement Inventory is a rigorously tested and proven method of measuring software quality from the end user's point of view. This used to be called simply user satisfaction but in fact, since when it first came out in the 1990s, SUMI has

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Statements 11 - 20 of 50.	Agree	Undecided	Disagree
I sometimes wonder if I am using the right function.	○	○	○
Working with this software is satisfying.	○	○	○
The way that system information is presented is clear and understandable.	○	○	○
I feel safer if I use only a few familiar functions.	○	○	○
The software documentation is very informative.	○	○	○
This software seems to disrupt the way I normally like to arrange my work.	○	○	○

Figure 3.3: Excerpt of the SUMI questionnaire by Kirakowski [Kir23a]

always actually been measuring user experience."[Kir23b]

The difference between user satisfaction and user experience might be difficult to understand. While user experience is described as "a person's perceptions and responses resulting from the use and/or anticipated use of a product"[BFB+15], user satisfaction is basically how happy - or satisfied - a user is with a product. In other words, user experience is the entirety of every emotion, every sensory input, every feeling that is experienced during use, while user satisfaction is a final verdict that is given based upon combining all these factors. The SUMI consists of 50 questions in total, which can each be answered with either "agree", "undecided", or "disagree" (see Fig 3.3).

It is strongly emphasised by the creator, Dr. Jurek Kirakowski, that the full SUMI questionnaire as well as any results being gathered through its use are only to be incorporated within academic work and that under no circumstances must they be shared directly for making profit.

Key aspects of each framework

Each of the three presented questionnaire frameworks included certain key aspects that were used to create a new document for this thesis. The SUS was directly incorporated with certain modifications which are explained in section 3.2.4. The overall design of the SUMI framework was used as basis for the second part of the quantitative survey. Lastly, the content of both the TAM and SUMI were used as inspiration to create meaningful statements for the second quantitative and the following qualitative segment of the document. To allow for the collection of qualitative data using quantitative surveys as base models, an open answer concept was implemented to offer participants the opportunity to freely state their thoughts and opinions.

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3.2.3 Overview of the qualitative research methods

There are a vast number of qualitative research methods that can be used to gather insights about user groups, a specific system, environment, or technology [Bow09] [Sof02]. They can also be used to convey thought processes, describe specific actions, or explain the reason behind certain behaviour. Data gathered through qualitative methods usually cannot be processed mathematically, and must instead be analyzed individually depending on the research context. The following section describes two different qualitative research methods which were used as core components in this study.

Auto-Ethnography

Ellis et al. describe Auto-Ethnography as "an approach to research and writing that seeks to describe and systematically analyze (graphy) personal experience (auto) in order to understand cultural experience (ethno)"[EAB11]. In other words, it is a method where personal experience or insight is freely recorded and used to generate data for a study without using a specific previously set concept such as a questionnaire or interview. Conducting Auto-Ethnography is not limited to only participants of a study, but can be conducted by the researchers as well, effectively putting them into both roles for a specific project. Traditionally, experiences were often written down using a diary-based approach or recorded via audio. With more and more people using the internet and coming together within newly formed digital spaces, such as social media websites, blogs, or large chat communities, researchers see the need for a new kind of Auto-Ethnography that focuses on the analysis and exploration of how different people behave within this new environment[DM20].

Auto-Ethnography still remains a great topic of debate within the scientific community[Poe21] [PS16], including Human Computer Interaction[Rap18]. In general, an auto-ethnographic document is written (or otherwise recorded) in a story or diary-like approach, meaning that the wording and style may not be consistent with what one would read in other scientific work. However, it is still important to not just tell a story, but to include scientific topics, discussions or explanations etc as well.

Thinking Aloud

The Thinking Aloud method stems from the scientific field of psychological research and is based on the introspection method[VSBS94]. It follows research or study participants who are asked to state their thought processes while completing a specific task, which are immediately recorded via audio or in written form. During inspection of the method, it was proven that people sometimes fail to recall their thought processes or reasons for a certain decision after an experiment, which can be prevented by using this approach instead[EA17]. One other advantage of the Thinking Aloud method is that the data gathered is often very direct and unfiltered, offering an honest overview of the participant's actual opinion about the subject matter that is being discussed.

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3.2.4 Designing the study questionnaire

After choosing the main quantitative aspects of the questionnaire based upon the frameworks described in section 3.2.2, they were combined with a number of qualitative questions and ideas to create the final document. The overall design of the questionnaire was already set with the first version: a short introduction and gathering some information about the participants, followed by a number of quantitative and qualitative questions about the experience and tested system itself.

Introduction

At the start of the document, a small overall explanation of the purpose and content was given so that participants would know what to expect and how to handle the questionnaire in general, with further explanations being added on top of every following section. Afterwards, participants were asked to give a bit of personal information, specifically:

- age
- mother language
- personal assessment of technological aptitude (concerning devices such as computers or smartphones)
- whether they regularly use a computer, tablet or smartphone.

In later versions of the document, the order of the last two items was reversed and the question about technological aptitude changed from "How would you assess your general technological aptitude?" to "How would you assess your skill in using the aforementioned devices?" It was imperative to ensure anonymity of all participants by not including any information which could be used to identify them directly, which is explained further in section 3.3.1.

Overall rating

The second section of the questionnaire is a direct implementation of the System Usability Scale, although two alterations were deemed necessary: First, a translation of the questions was made from english to german since the study was conducted in Austria. Second, after showing the first draft to potential participants, the wording of some questions was slightly altered to reduce the possibility for misunderstandings. In essence however, the meaning and focus of each question remained the same. The reason why it was deemed useful to incorporate a SUS into the custom questionnaire was due to the fact that it can easily be used to create a quick overview over the acceptance and partial usability of a system. Furthermore, the rating system remained unchanged, despite conflicting with the Austrian general rating standard: In Austria, 1 is seen as the best possible rating, while 5 is considered to be a failure, with the SUS implementing an opposite rating system.

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The reason why no changes were made to the rating system was because it was deemed that it would make the score calculation unnecessarily complicated.

Operation

Following the SUS was a combination of three statements strongly influenced by the Software Usability Management Inventory (SUMI) (specifically questions number 2, 3, 6) and four other, self generated statements. These other statements were partially inspired by different reports and documents on the TAM, which include a number of items Davis used in one of his initial evaluations[Dav89]. The SUMI rating scheme consisting of the three options agree - disagree - undecided was adopted for this section as well since it was also fitting for the other statements being presented. At first it was considered to transform the SUMI rating system into a 5 or 7 point Likert Scale similar to the SUS used before, but it was ultimately decided to keep the 3 options for the following reasons: First, it was deemed to be potentially confusing to use a 7-point Likert scale after confronting participants with a 5-point scale just before that. Second, it was mentioned in a number of discussions with future participants that people do not wish to fill out too long or too complex surveys, so the 3 option scheme was deemed to be simple enough while also allowing the collection of sufficient data.

Personal remarks

This section of the questionnaire covers the qualitative part of the survey. Participants are presented with four open questions in total, asking them about things that they liked and disliked about the system, whether they would use it again, and if they have any suggestions for improvement. It is noteworthy that it was emphasized at the beginning of the section that filling out any of these questions was optional, and that there would be no penalty should anything remain unanswered. This was especially important about the last question concerning ideas for improvement, since it is often easier to point out problems than finding a solution for them.

Comparison

Finally, the document closes with an optional section which was only to be filled out by participants who participated in the survey multiple times while trying out different systems. Specifically, this section was about comparing the same type of system from different companies. This means for example: testing out a self service register from both supermarket A and supermarket B, or trying out the online-shop from both supermarket A and supermarket B. In the end, this part of the questionnaire was only filled out by two participants in total.
An overview of the questionnaire in german can be found in section 6.

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3.2.5 Designing the Auto-Ethnographic approach

The main reason for involving an auto-ethnographic approach as a research method was due to personal experience within the field of information technology, as well as combined knowledge gathered during different master courses that were previously concluded. Another reason became evident when discussing the first draft of a checklist which was used for data gathering: Upon presenting the list to others, one question was asked stating "Why not summarize all this so that you don't need to go into detail?" However, one purpose of this approach is to do exactly that: to offer an opportunity for a more detailed (as well as more technologically focused) analysis of the technology that is being examined.

The information gathered would then be used to name further issues more precisely apart from those that were already identified through the other research methods, and should also yield more possibilities for improvement from a technical point of view. Following the basic auto-ethnographic guidelines, a combination of two documents was designed: First, a general checklist was created to ensure that each technology and topic will be covered thoroughly and inspected from different perspectives. The other document includes the actual auto-ethnographic story that is incorporated into this thesis (see section 6.

Structure of the auto-ethnographic checklist

The checklist is divided into two main categories: the analysis of the Self Service checkouts, and the supermarket online shopping websites. The first part is the personal analysis of the self-service terminals, which is divided into six main categories. Out of those, four are further divided into a number of sub-categories, which will be used as guidelines to inspect several technical aspects in detail. Furthermore, each section also contains additional comments and remarks about any other findings that were noticed during inspection. The first category is about the hardware design of the SST systems deployed within the supermarkets. It consists of three different main categories: The labeling of different components, the space that is available for the user to handle their shopping items, and the visibility of different components such as the cash intake or card readers.

The second category deals with the main aspects and elements of the user interface. This includes the overall layout of the system elements on the screen, other visual features such as font size or coloring, and basic accessibility elements (languages, audio prompts, etc). Next is the assessment of the overall software functionality. All possible features, especially those that were rarely or never used during the Thinking Aloud sessions, will be tested for proper functionality and behaviour. Also, overall operation of the interface is examined, along with error management (for instance when attempting to scan an unknown article) and overall system assistance.

Autonomy will also cover further questions about error management: is it possible for a user to conduct a product reversal or handle other errors without assistance? This section also covers the ability to enter discounts, conduct an age verification, or to manage

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special products (without bar code, varying size or weight, etc). The last two sections will offer free space for the researcher about any possible improvements that might come to mind during or after inspection, as well as free space for additional notes that can not be directly categorized.

For the inspection of the shopping websites, a combination of three main topics was designed:

- investigating the website using the Web Accessibility Evaluation Tool (WAVE) browser plugin
- an open test where a purchase was conducted (but cancelled before payment had to be transferred)
- creating two reports using the Web Content Accessibility Guidelines (WCAG) report tool

WAVE is a browser extension tool that can be used to analyze a website (mainly) in terms of accessibility and was first launched in 2001 at the Utah State University by the WebAIM group[Web23]. It can be installed for every popular web browser for free and gives an overview about website errors, warnings, and structure and offers corresponding recommendations or solutions.

The WCAG are an official web standard created by the Web Accessibility Initiative (WAI), which is part of the World Wide Web Consortium (W3C)[WAI23a][WAI23b]. The main goal of WCAG is defined as ”providing a single shared standard for web content accessibility that meets the needs of individuals, organizations, and governments internationally.”[WAI18] The report tool was incorporated into the auto-ethnography to provide a partial overview about the technical state and implementation quality of the website.

3.3 Data Collection

This section describes different parts of the data collection phase in detail such as a number of issues, experiences, and insights which were all gathered while both searching for participants as well as working with them. It also covers the process of the auto-ethnographic approach and how all of the data was processed to make it available for further analysis.

3.3.1 Choosing and recruiting participants

Overall, a total of 23 people agreed to test out different systems, with five participants joining more than once. However, one participant was unable to fill out the questionnaire afterwards, leaving one data set incomplete.

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While this study attempted to include participants of different age groups between 18 and above, as well as covering different technical skill levels and mother languages, a number of challenges quickly became evident. First, most participants were chosen from a direct personal environment, which in turn limited the age group to ages mostly between 30 and 80 years, with only three participants being younger than 30. The second challenge emerged later on when attempting to find out where supermarkets with a self-service checkout were actually present. It was first assumed that most cities above a certain size (about 10.000 inhabitants including the surrounding area) would offer such a service at least in one place, but it was quickly discovered that this was not the case, and that self-service checkouts are instead distributed randomly over different areas. This in turn limited the possibility for recruitment even further, as it was deemed non-feasible for participants to travel several kilometers just to participate.

Consent and Anonymization

Before participating in the study, every person was presented with a consent formular including an overview of:

- the aim of the study
- overall process
- data security
- right of withdrawal

The consent form also offered the possibility for collected audio recordings to be replaced either by a re-recording using a different person or by running them through a voice editing software. Participants were then asked to confirm that they have been informed sufficiently about participation in the study. They also had to confirm their given consent for further use of the collected data, namely the filled out questionnaires as well as audio recordings.

Furthermore, each person was given a previously random generated ID number for the purpose of anonymization. To ensure that participants would have the ability to fully withdraw from the study and have all their collected data deleted, contact cards were handed out including the participant's ID number, a regular address, an email address and a phone number. The reason why a regular address was included was to offer participants who do not have an email address or barely use a telephone the ability to contact the researcher as well. In case of participants losing or forgetting their given ID number, a backup for this was also implemented: On a local computer, a list including the participant's names as well as their ID numbers was created, which was then secured using an AES-256 Bit encryption [LP15] algorithm with an above-average safety-level password[AAQIJ16].

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3.3.2 Thinking Aloud sessions at the Self Service Systems

Participants were given the opportunity to try out four possible kinds of technologies: The self service checkout devices from one or both of the two largest Austrian supermarket companies, as well as their corresponding online ordering services. As mentioned earlier, most participants only decided to try out a single system, which led to a lack of data being gathered about the comparison of the same kind of system being offered by different companies. A microphone which could be used in combination with the audio recorder on a smartphone was used in all cases to make an audio recording.

Self Service Checkouts

Each meeting at a supermarket was combined with a regular shopping trip of each participant. Before arriving at the checkout, they gathered whatever products they wanted to buy, and recording began shortly before arriving at a self checkout terminal. At first, recording was conducted by attaching the microphone below the neck, while the cable was connected to the researcher's phone, who held said phone in hand during recording. This was quickly discovered to be rather impractical, since the cable would often get in the way, and the researcher had to stay close at all times. Instead, it was considered that it would be easier for the participants to put the phone as well as the cable into their own pocket or bag. This allowed for further improvement of testing conditions by giving the researcher the possibility to wait at a spot away from the participants, reducing the feeling of being watched, which might make them feel uncomfortable at times.

Once the recording was started, participants would continue their shopping routine as normal while voicing their thoughts and concerns. In two extreme cases, the researcher had to step in to offer a little bit of assistance with correctly using the self checkout system so that participants would not completely get stuck facing an unexpected issue. After the checkout processes were finished and participants gave their final comments, the audio recording was immediately stopped and stored for further analysis.

Online Services for Supermarkets

Examining the online services had the great advantage of being location-independent since the websites could be accessed from any computer (including tablets or smartphones) with an internet connection.

Before conducting the first testing sessions, a personal analysis of two online supermarket systems was conducted. This revealed one crucial detail which was essential for further planning: Each online supermarket website required a minimal order value of 40,00 €, which is far above the average amount participants were spending for the study so far (it can also be established that this value is above what most people spend during a regular purchase in general). At first, simple general navigation of the provided systems was deemed most important for generating valid study data, while the actual conclusion of the purchase was considered to be only secondary. In turn, the first participant only

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tried some basic system functionality, which generated only a limited amount of results for further analysis. However, the second participant then suggested to fully cover an online shopping experience, including the entire process from choosing products to setting a date for delivery or pickup, which would then simply be cancelled in the end before payment is conducted. This more thorough process was then repeated for each of the following attendants. It should be mentioned that due to a number of bad design choices in the online shopping systems, the researcher often had to offer assistance in case of unexpected technical difficulties emerging during use. This will further be explained in detail in the findings section.

3.3.3 Conducting the questionnaires

Participants were offered the options to either fill out the questionnaire online or to use a printed version. In the end, everyone preferred to fill out the document using pen and paper. This in turn had two further positive side effects:

First, when using a public online service for conducting the questionnaires, it is not certain that anonymity can still be guaranteed. Especially some of the largest IT companies worldwide are notorious for collecting and selling user data - at times without their knowledge - which could then be cross-referenced to precisely identify a person. The second advantage was given by the fact that all participants decided to fill out the questionnaire right after the Thinking Aloud session. Due to this circumstance they could easily recall most of the details from the experience they previously had, which allowed them to more truthfully and elaborately answer the questions which were presented before them.

Since the completion of the questionnaire was always conducted in proximity of the researcher, uncertainties could easily be clarified, although only one notable issue occurred multiple times: As it was previously mentioned in section 3.2.4, the rating system of the System Usability Scale is contradictory to the Austrian standard, which has caused some confusion among a number of participants, who at first rated the statements in exactly the opposite way of what they originally intended.

3.3.4 Creating the auto-ethnographic document

The auto-ethnographic document is divided into four main sections: two introductory vignettes, observation of others, personal analysis, and key findings. The first step was to conduct some purchases at different self service checkouts and to take notes on the previously designed checklist afterwards. The same procedure was repeated when two supermarket online shopping services were inspected. Afterwards, the collected information was incorporated into the first part of the narrative.

After the introduction, the document opens with two story vignettes, both detailing personal experiences during the use of different SSTs. Following this, a self reflection was conducted about the observations and insights which were made directly while attending

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the Thinking Aloud sessions and observing the participants. Section three includes the personal observations which were made while testing all previously covered technologies, and also describes the outcome of both the WCAG reports as well as WAVE tool tests. Finally, the closing section of the document offers an overview about several key findings, and ends with a few personal remarks of the author.

3.4 Data processing

During the data gathering part of this study involving other participants, two different types were collected: audio recordings and analogue written questionnaires. To make further electronic analysis of this data easier or even possible, a few pre-processing steps were necessary before the results could be properly examined. For the auto-ethnographic part, most data was already made directly available, with only few processing steps being necessary for further analysis.

Thinking Aloud audio recordings

For each of the recorded sessions, an electronic transcript was manually created so that the results could be presented in written form, which was done for two reasons: First, it helped to provide further anonymity for the participants by completely removing any remaining personal connection between them and the recording. Second, while it would be possible to listen to an audio recording multiple times to extract any significant data for an analysis, it is much easier to investigate a written document, which can also be used in combination with different software to generate graphics such as wordclouds. In the end, a combination of the free audio/video player "VLC Player" and office software "LibreOffice" was used to create transcripts of the conversations. When participants were speaking to a staff member or in case of the cash register giving audio cues, the corresponding passages in the text were marked accordingly to easily distinguish between outside interference and personal thoughts.

Terminal: Please move the article into the packing station.
- well i am still standing at the register no help is coming, no help is coming
Terminal: Please move the article into the packing station.
- i am still standing at the register nobody is coming, nobody is coming...
- ah so this is how it works, okay. (*Note: towards employee*) This means you need to go there separately or can only you do it?
Employee: no we have to do it
- right.
Employee: you need to go back

(Translated) excerpt of the transcript by user ID 718 at a self-checkout

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Questionnaires

As it was previously mentioned, all questionnaires were submitted as written documents on paper. A sample version of the document can be found in section 6. To secure the collected data, each questionnaire was first scanned and then stored electronically. Afterwards, all submissions were transferred into a document including different tables for each of the five categories. First, the personal data was collected, with numerical codes respresenting the answers given about which electronic devices are used regularly (yes = 1, no = 0,). Furthermore, a simple code system was introduced to distinguish between the different systems that were being tested. For the System Usability Scale, the given scores were entered, and the results were already calculated using the official rating system. The third part about usage with the three possible answers was also encoded numerically: -1 for ”no’, 0 for ”no answer”, and 1 for ”yes”. Lastly, both final parts including open questions were combined into a single table, with the answers being added as plain text.

3.5 Data Analysis

After concluding the data gathering and preparation phase, the following amount of material has been collected for analysis:

- 8 audio recordings by the researcher combining the Thinking Aloud and Auto-Ethnographic method
- 30 filled out questionnaires with 180 pages in total
- 30 transcribed Thinking Aloud protocols comprised of 55 pages
- auto-ethnographic document spanning 16 pages (not counting bibliography)

The final dataset consists of material which was collected from the analysis of the self service checkouts and the supermarket online shopping services. In most cases, these two technologies were split up and analysed separately, but also combined for certain statistical overviews, such as the results gathered using the SUS from the questionnaires (see 4.1).

3.5.1 Mixed User Research

As it was described in section 3.1, a mixed method approach was chosen for the study, creating three different data sources. Initially, it was assumed that research question number one and three would mainly use qualitative data, while the result of question two would be based mostly on quantitative results. Due to a lack of options for specific statistical data analysis caused by the relatively limited amount of participants, it was decided to follow a dynamic mixed method research design instead. Both the qualitative and quantitative data sources that have been generated were analyzed together, and specific key findings and aspects were first collected to formulate a result for the first

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research question. This was followed by the attempt to find specific distinctions between different demographics based on the previously collected insights. The process was heavily influenced by both an inductive as well as a deductive research process [Str23], which was comprised of two previously formulated theories: On one hand, the observations that were made previously were used as an inductive data source suggesting that each demographic group showed the same tendencies. On the other hand, previous studies as demonstrated in section 2.3 suggested a strong negative correlation between age and technical problem solving abilities. Conclusively, both methods combined together were successfully used to both create new results by disproving specific initial assumptions as well as confirming already existing hypotheses. For the final research question about potential usability improvements the datasets which were formed during the previous analysis process were again inductively combined. One part of the results offered a more general overview of different issues, while the other highlighted specific demographic distinctions. Both sets in combination were then used to generate a number of potential improvements while keeping in mind the specific needs of different user groups.

3.5.2 Data Preparation

To find answers for the proposed research questions, each type of research document was inspected in a different manner:

- *Thinking Aloud protocols*: All protocols were read manually without using any software for quantitative analysis. Specific situations of interest and key moments were identified and then annotated in separate lists for each of the two SSTs.
- *Questionnaires*: These have been inspected using two different methods: The two quantitative surveys at the beginning were examined using the software "IBM SPSS Statistics". During this process, summarizing results spanning ratings for both technologies were created, as well as separate statistical overviews. These were then used to see if either system was received more positively than the other and to gather an overall opinion about the use of SSTs in retail. The qualitative section of the questionnaires was again inspected manually and important comments and suggestions were noted.
- *Auto-ethnographic document*: This document was inspected last for two main reasons: After summarizing all of the previously collected findings, it was determined which of the statements found here can be used as a meaningful addition to the other data. It was also important to ensure the prevention of repetitions from previous statements.

The collected data was then inspected separately for each research question:

- *Research Question 1*: First, a list of all issues that were mentioned was created for both technologies. Afterwards, the lists were sorted using the five key factors

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mentioned in 2.2 as categories. In some cases, direct quotes from the protocols have been added to emphasize the significance of specific discussion elements.

- *Research Question 2*: For each participant, the age and technical knowledge were noted along with the type of issues they experienced. The results were then manually compared to find any similarities and trends both within and between different demographic groups.
- *Research Question 3*: Formulating an answer for this question was strongly dependent on the results previously gathered by research questions 1 and 2. While some recommendations for improvements could already be extrapolated from the collected datasets, it was also important to consider the reported issues. Similar to question 1, the results gathered here were also divided into different Usability categories. Additionally, personal knowledge and experience was used to add further potential recommendations for improvements.

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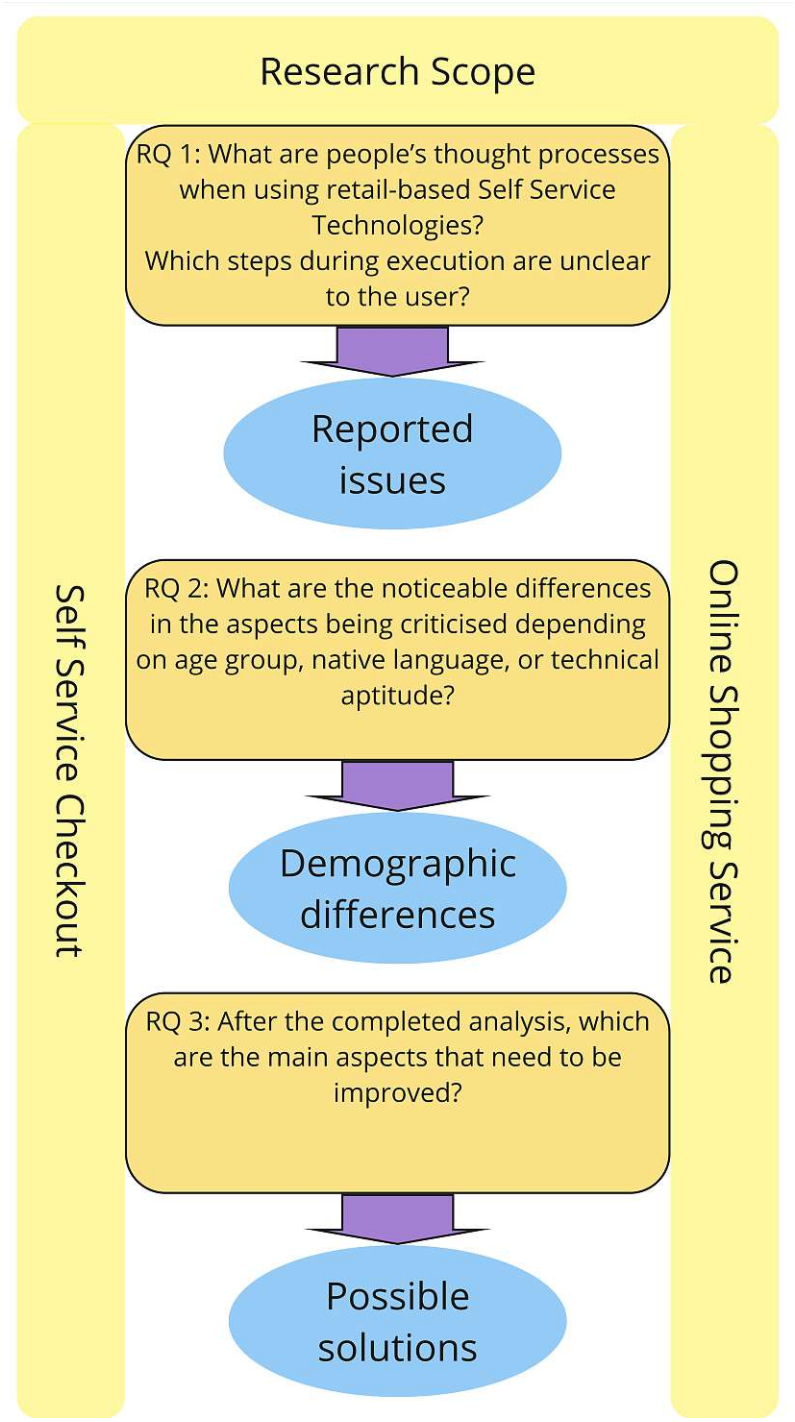

Figure 3.4: Overview of the research scope

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CHAPTER 4

Findings

During the course of this thesis, 23 people decided to participate, with five participants attending multiple times. This yielded a final result of 30 different datasets, consisting of:

- 12 participants testing the self service checkout of supermarket A
- 8 participants testing the self service checkout of supermarket B
- 2 participants testing the self service checkout of a hardware store
- 3 participants testing the online ordering service of supermarket A
- 5 participants testing the online ordering service of supermarket B

Each of these datasets consists of an audio recording & transcript of the Thinking Aloud session and a filled out survey. Those were used to already collect a large amount of research data and to identify different key factors and issues, which were then supplemented by the auto-ethnographic reports.
In the following section a demonstration of the key attributes from the quantitative survey segment is given. Afterwards, the focus will shift onto the presentation of the three main research questions this thesis is based upon.

4.1 Overview of the quantitative survey results

The quantitative section of the survey consists of two parts: the SUS table and an additional part with some further statements about operating the system.

System Usability Scale Results

When first inspecting the SUS results, three datasets have been identified as potential aberrations: One participant showed a strong negative overall opinion about self service

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	Frequency	Percent	Cumulative Percent
poor	15	50,0	50,0
acceptable	6	20,0	70,0
good	5	16,7	86,7
outstanding	4	13,3	100,0
Total	30	100,0	100,0

Table 4.1: System Usability Scale rating overview

technologies, which was made evident by intentionally choosing the worst possible ratings. This resulted in a final score of 2,5 points, which is by far the lowest score given by any participant. Two other participants have marked the option ”1 - do not agree” on most questions in an indiscriminate fashion, leading to the assumption that the statements were not properly looked over. In total, the rating for all tested self service systems resulted in an average score of 52,25 points, implying an overall low acceptance and high need for improvement. The second lowest rating - excluding the aforementioned 2,5 points - was 15,0, and the highest rating a score of 90, which was given by a participant examining the self service checkout at a hardware store.

It is important to mention one likely reason for the high score that this specific checkout has received, with that reason being simplicity: Unlike regular supermarkets, all products that can be purchased at hardware stores receive a barcode beforehand, therefor eliminating any requirement for manual product search or inspection by an employee. This results in a very simple system where one product is scanned after another, leaving very little room for any potentially confusing software components. Regardless, the basic principles of operation remain the same as other self service checkouts that have been investigated.
The highest rating achieved for testing a system at a supermarket was 85. The overview in table 4.1 shows a four-point rating scale which is generated when translating the given score values to different categories (based upon the general guidelines provided by [Ala23]). Half of the given ratings were considered as ”poor”, further confirming the assumption of required improvement given by the average rating score. On the other hand, only four participants gave out a rating that is considered to be ”outstanding”.

Operation Questionnaire results

First analysis of the system operation survey results (as seen in figure 4.1) suggests that most participants were able to understand the content that was presented to them. However, several problems with the successful operation have also been identified. While the system elements were mostly regarded as readable and understandable, the content itself was often not considered to be helpful in regards of assisting with fulfilling the desired task. Even though after 20 out of 30 tests people claimed that the system was easy to use, it was also stated 15 times that its behaviour or responses were unexpected at times. In conclusion, only in 14 cases users stated that they were easily able to reach

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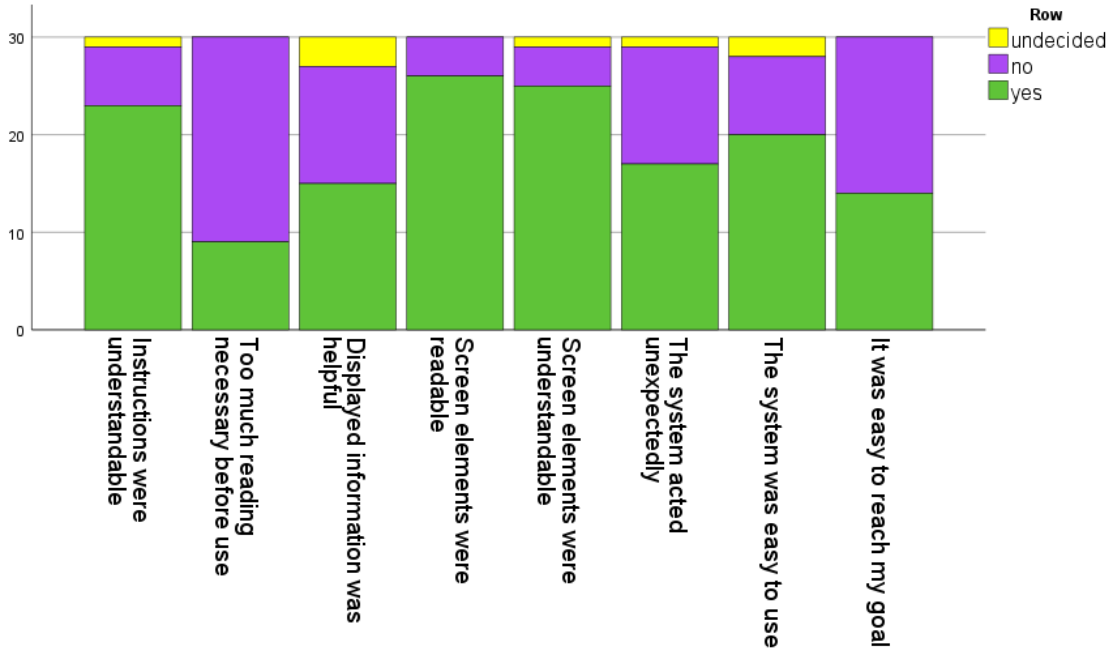

Figure 4.1: Summary of the given answers of the Operation survey

their desired goal.
Examining only the results given for self service checkouts shows that the same assumptions can be applied here, while the experiences with the online shopping websites - being 8 in total - appear to have been received more positively. Additionally to the already identified understandable elements and instructions, most of the users claimed that the displayed information also helped them with successfully interacting with and using the system. Furthermore, only three surveys mentioned considerable difficulties while reaching the desired goal, and seven stated that the system was easy to use.

In conclusion, it can be assumed that the overall user interfaces of the examined self service technologies offered mostly useful information, but it is not always clear how to navigate through the different steps required during operation.

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Type of Usability issue	Amount
Effectiveness	5
Efficiency	5
Engagement	5
Error Tolerance	5
Ease of Learning	3
Total	23

Table 4.2: Usability Issues identified for Self Service Checkouts

4.2 Examining Research Question 1

"What are people's thought processes when using retail-based Self Service Technologies? Which steps during execution are unclear to the user?"

The previous section offered an overview of the quantitative survey methods used within this thesis. Overall, a mixed opinion about SSTs was identified, and most participants strongly disagreed with the statement "I think that I would like to use this system frequently." If that opinion were to change both for current and future systems, further analysis is necessary about the reasons behind these results.

To offer a better understanding on the reported problems and their impact on Usability, the following section uses the five categories presented in section 2.2 to arrange the gathered results. These are further divided into the analysis of self service checkouts and online services. Both sections include results gathered from the analysis of all three research methods: First, key points gathered from the transcribed Thinking Aloud protocols were noted, which were then supplemented by additional insights from the questionnaires. Lastly the auto-ethnographic document was inspected to find any additional points of concern.

4.2.1 Research Question 1 on Self Service Checkouts

Table 4.2 presents an overview of a total amount of 23 Usability issues for self service checkouts that were identified within five categories. While three problems were reported in the category "Ease of Learning", the other four principles all include five problems each. This does not only show a distinct need for improvement, but also that Usability issues are present within all attributes. The following five sections include a thorough description of each reported main issue as well as quotes from the Thinking Aloud protocols when they can be used as supplementary information.

Effectiveness

Effectiveness describes how well the product or service supports the user in fulfilling a task. This can be achieved by presenting meaningful and understandable instructions, or

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by incorporating a good overall design. This section includes all statements that have been identified to be in conflict with this Usability principle.

Age restricted items are often considered to be a nuisance when attempting to buy them at a self service checkout. Most users who used such a system before are aware that additional assistance is required in such a case, prompting them to choose a regular checkout instead. For inexperienced users, the ”examination required” issue (see category about error tolerance) applies again which can bring the entire checkout process to a halt. One person that was not directly involved during the recorded sessions also described a personal experience where non-alcoholic beverages were wrongly categorized, such as malt beer or sparkling wine for children.

Certain issues were also caused by different cases of ill-considered hardware design. One study participant who tested out the checkout system of a hardware store reported an issue when attempting to pay using a bank card: A card reading device that was attached to the screen of the terminal was believed to be used for the payment process. Instead, it was a device for employees to log into the system using their ID cards, with the actual card payment terminal being placed nearby.
In another case, users had trouble with both finding the receipt output as well as identifying the receipt of the current purchase. This was caused by the printer either being concealed by other items or the printing output being positioned in a hardly noticeable position. In turn, customers would often not take their receipt with them, causing a large pile-up of paper at the checkout, which makes it difficult for others to find their own receipt afterwards.

The most important principle in all self service technology is that a customer does not require additional assistance from other people. Several instances were observed when that principle could not be upheld during use of the provided checkout systems. Most of these situations are being described in the following sections, such as having to deal with age restrictions or most errors in general. This removes the advantage of customer independence completely, which would also help with reducing time constraints both in terms of duration for the checkout process as well as opening hours. From the perspective of the companies, it also makes it difficult for employees to find time for other tasks that might emerge unexpectedly, such as cleaning up broken glass or arranging deliveries off schedule.

Many electronic devices have certain symbols connected to specific actions or hardware, such as the on-off symbol that can be found everywhere today. On self service checkouts, symbols are also used to label specific parts of the hardware, such as cash intake and output, and sometimes parts of the software like the different payment methods. Two main problems were identified when symbols were used without any accompanying text.
If a self service system is to be used either in different countries or by people from different countries, it must be ensured that everyone can understand the meaning of all forms of

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instruction, such as different labels. However, it is known that several symbols or colors have different meaning in various cultures and countries, such as the thumbs up hand gesture that is seen as a positive sign in large parts of the world, while being an insult in a few regions. In case of self service checkouts it can be assumed that mostly people who are familiar with a countries' culture would use the device, but it would still be helpful for foreigners to have verbal context as well. People with bad eyesight might also have difficulties to correctly identify a symbol on the machine and would eventually be more reliant on visual signals or large text. Lastly, it is also a distinct possibility that a label has been chosen that does not make sense in a specific context, or is merely not understood by some customers.

For every device that includes any sort of visual interface, it is imperative to ensure that all elements on screen can be identified and that all available space is used in an appropriate fashion. The size of every component needs to be large enough to keep them both identifiable and readable, and no overlapping of different elements should occur unless it is a specifically intended feature. This was not always the case with the checkout systems that have been inspected, and the issue became most obvious when using the manual product selection menu. Overall fonts naming the different product choices were very small and difficult to read, and oftentimes too many images were put together on one page, making it very hard to identify similar looking products. Lastly, it is imperative to ensure that an image always fits the framed area it is given on screen, as incorrect scaling would otherwise cut off parts of the element.

Efficiency

Efficiency measures how quickly and easily a task can be fulfilled. reported issues fitting this category would include anything that hindered overall progress of caused any form of confusion.

Among the issues mentioned by Zarinfard [Zar20] another problem some supermarkets might face is being understaffed. In combination with other issue such as unexpected errors, it can take several minutes for an employee to arrive and resolve the situation. While the obvious issue here is losing time - which is especially important in situations such as being on lunch break - it can also lead to additional stress by having others wait in line behind the current customer. Employees might also face emotional pressure in such a situation when having to deal with both their own station as well as the issues at the self checkouts, causing additional waiting times for everyone involved.

Discounts are often a topic of concern when it comes to self service checkouts. In several transcripts, comments were found about whether a price reduction was registered properly or not.

> - i wonder if it has the discount now ah what's that there called ah once... twice... yes it has reduced it, i must check it there, and i have so, such little

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trust (...)

(Translated) excerpt of the transcript by user ID 484 at a self-checkout

In general, participants were very distrustful when they decided to use a self checkout to purchase discounted products. It is important to mention that every time a regular discount was involved in a purchase, such as a quantity discount, the systems reacted normally and adjusted the product cost accordingly. However, products that are close to the ”best before” date or do not sell well are often marked with a -25% or -50% discount sticker manually by the staff. These stickers neither include any sort of code or other identification that would allow self checkout systems to recognize them. Also, since these discounts are only applied to very specific items and not the entire stock, it is not feasible to edit the registered database entry. Another issue arises when a supermarket gives out their own discount coupons. These stickers can be applied to any product a customer wishes to purchase, and just as with items which are already marked by the store, the system has no way of knowing about it automatically. While one company inspected in this thesis has implemented a solution for this problem a few weeks after the data collection was concluded (see section 4.4.1), it still remains an issue for others. Although some items do receive an adjusted bar code after being offered for a lower price, it is still often necessary to ask for additional help.

A unique issue was identified when one participant wanted to include different gift cards in his purchase. While the first gift card was registered normally, the others were rejected by the checkout with an ”unknown product” error message. Even after an employee was called for assistance, the issue could not be resolved at first, even after trying the same with several different discount cards of the same kind. It was later discovered that when attempting to scan said items at a regular checkout, the system was able to recognize them without any problems. This leads to the conclusion that traditional and self service checkouts do not always share the same product database, which might cause different issues. For one, if an inventory change is made because a product is not sold anymore or a new one gets added to the available stock, discrepancies between the two systems could emerge. Furthermore, it is possible that a discount for a specific product is registered in only one database, while the other one is not receiving the correct update.

Overall, many users claimed that the main advantage they see in using a self-service checkout is to quickly buy a small amount of groceries to save time. However, several previous statements show that in many cases assistance becomes necessary which severely increases the required time. In fact, multiple situations have occurred which have led to a total required checkout time that was significantly higher than the average needed on regular checkouts[Dep08]. One user specifically stated that he considers self checkouts to be useless since ”you need assistance every time anyway”.

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In one case, it was possible to identify an unexpected deadlock state within the software that was used. In general, deadlocks in technology describe a specific system state that is reached and cannot be escaped by any regular means of operation. In such a case, it is often necessary to restart the entire system, which can lead to services becoming unavailable or loss of data. For self service checkouts, a deadlock describes an unexpected situation that a customer cannot escape without the help of an employee. It is important to mention the difference toward a situation where assistance is necessary, such as those described in section 4.2.1. For instance, if a person buys alcoholic beverages, it is reasonable that an employee needs to confirm that the customer is old enough to do so. In case of the situation experienced here, a deadlock was discovered while choosing one option of the available payment methods. Upon selecting the option ”other”, the system was immediately locked up completely and the user was informed that ”an employee will be with you shortly”. No option was offered to cancel or go back, meaning that if a customer accidentally makes the wrong choice, it is not possible to simply choose another payment method. Instead, it is always necessary to wait for external assistance, all because of selecting one of the many available choices.

Engagement

Positive engagement ensures that the overall appearance and experience of use is appealing to a person. Any statement defining a strong aversion against the use of SSTs in general or their design falls into this problem area.

All tested supermarkets offered a large amount of products which do not receive a specific bar code or other means of automated identification. On a regular checkout, cashiers have a small (mostly printed) catalogue covering these items and are able to type in a specific product ID. On self-checkouts, these products are included in a list that can be accessed by choosing the option ”enter product” on screen. A system menu is then displayed which is divided into three main parts: different product categories such as fruit or vegetables, a list of the products available in said categories, and an option for manual product search.
The first issue that was identified here was that normally, each entry in the list has an accompanying image showing the actual product. This is not the case for all products however, which can cause customers to unintentionally make the wrong choice. In one test case, a user deliberately selected a random product out of frustration about the missing visual information. Accidental errors can also be caused by having to choose between very similar items, such as lemons offered both by company A or company B.

> - Lemons, the lemons... ah the lemons do not have a *(bar)*code, search article...
> **Device: Please select from the list.**
> - Pineapple avocado sen fig banana kiwi lime mango... pomelo lemons organic demeter... doesn’t matter if they are those i’ll just click it.

(Translated) excerpt of the transcript by user ID 707 at a self-checkout

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Furthermore, when customers decide to use the manual search option, the displayed on-screen keyboard does not always include special characters, making it very difficult to enter item labels including such letters. Lastly, in some cases, unlabeled products forced the previously described ”examination required” state.

Some systems that were tested use an audio prompt to remind customers not to forget any of their items in the packaging area. While this is generally regarded as a helpful feature, the issue here is the timing of the message. In multiple test cases, participants were barely finished with the payment process before said information was first related to them via audio message. This caused a lot of irritation for several participants, who unambiguously voiced their dissatisfaction in the Thinking Aloud recordings.

> - **Device: Please choose payment method**
> - pay with card... that’s part of it too...
> - **Device: Please take your items with you**
> - yeah stop stressing i’m taking it with me already!
>
> (Translated) excerpt of the transcript by user ID 385 at a self-checkout

> - **Device: There is an unexpected item in the packing station. Please remove the item before continuing**
> - Right this is a no-go. Ah because uhm because that way it tells me that I am not wanted. Now how is this called in a... it is, it is that it tells me now in a way now like f*** off now(...)
>
> (Translated) excerpt of the transcript by user ID 484 at a self-checkout

This suggests that not only timing but also the wording of the message is important for the customer since this was criticised as well for generating a negative overall shopping experience.

Most people who go to a shop or a store in Austria pay either using cash, a bank card, or some sort of gift card. There are also some additional payment options available which are used very rarely. To accommodate as many different payment methods as possible, self checkouts give the user several options before concluding the last step of the process. Some participants reported to have been overwhelmed by the large amount of different choices they were presented with when choosing to use a different payment method than cash, and criticised the overall layout of this system menu.

Apart from identifying a lot of technical and other usability related issues, there have also been some debates about the social implications of replacing human personnel with automated machines for the checkout process. One participant claimed that he specifically missed the conversation with employees, but others also began questioning issues about

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society itself in the process. The product scanning process felt like being a worker on an assembly line in a factory (as researcher it is important to mention here that some employees might have a similar feeling being stationed at the checkout most of the day), and that any social interaction is completely taken away. This leaves a very stiff, dull system in which everyone is treated like a robot, with no room for individual needs or wishes. In general, it became evident that for some customers the social component is also a very important part of the shopping experience. Taking that part away, the whole process felt very unsatisfying and incomplete.

If an information system or self service technology that is required to be used in a certain place is publicly available, one will often find an option to select a different displayed language. In many cases, this is being adapted to the people frequenting a specific area, but the language selection usually always includes english. On one of the tested systems, the only languages that could be selected were german or - as it was just mentioned - english. One might argue that the vocabulary of a self service checkout is rather limited, and that adding the option to choose more languages does not require much effort or electronic storage space. However, it is imperative that any language that is being added to the system is thoroughly audited and checked for errors. During one inspection of a checkout system, it was quickly made clear that this step is sometimes neglected before implementation, as a missing string error was instantly identified on the main page after choosing a different language.

Error Tolerance

Error tolerance ensures that errors or unexpected behaviour can easily be understood or handled by the user. If error messages are unclear, not recognized or cannot be corrected, this section presents the related issues.

In many cases after scanning a product, checkouts would respond with a message stating ”Examination required” without any further explanation. This means that a product was scanned which needs to be checked additionally by an employee. There are various types of products where this can be the case, including:

- age restricted items such as alcohol
- non pre-packed items such as fruit, vegetables or bakery
- items with random weight such as pieces of cheese or meat

Since no further reason for the required examination is given, the meaning of the message is often unclear to customers. In this state, the checkout allows users to continue scanning the products they have collected, causing some to forget about the issue entirely. When attempting to begin the payment process, the system would then ignore the user input due to the unresolved issue, leaving several participants confused and at times frustrated. In one case, cash payment was even received by the machine, but no according change in

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the current system state has occurred.

Large models of self-service checkouts usually include a specific area where customers are expected to put every product after being scanned. These include a weight sensor which compares the placed product with its registered weight. This type of construction had led to specific issues which came up during observed shopping sessions:
One error that was recorded can occur when purchasing an item with very little weight. These include gift cards, different paper based items such as decorated envelopes, or - which was especially important during the COVID pandemic - face masks. Such items often fail to trigger the sensor embedded into the product storage area, causing the system to prompt the user to "please put the item into the storage area". With no way to resolve these issues on their own, customers again need to wait for employee assistance to step in.

There are several reasons why customers would make a mistake while checking out their products. In a stressful situation, one might act too hasty during the scanning process or become otherwise unnerved, which could lead to a product being scanned more than once. This is also a considerable issue for people with any sort of illness that causes uncontrollable trembling of the limbs. Another possibility for a mistake is that when buying a product more than once to scan it one time too many or to register the strawberry yoghurt twice instead of the peach flavoured one. Also, if a specific product is on discount and the user accidentally bought the wrong brand or variety, a correction is again required.
One situation that occurred during testing was when one of the participants attempted to buy a case of six water bottles. Upon scanning the first bottle, the checkout system offered an option to choose the form of packaging that was taken. However, upon choosing the case option, 20 bottles were booked instead of just six.

> - well all right... why is... half a case... no not a whole case that is wrong now. Noo what do I do now? That's wrong now since it registered the entire case not the six. Now we need help... Heelp! Hm... i can't revert it...
> - *(Talking to staff)* I only have 6 instead of a whole case. I pressed case. And it registered a whole case meaning 20 bottles instead of...
>
> (Translated) excerpt of the transcript by user ID 596 at a self-checkout

In all of the aforementioned situations, it is necessary to adjust the list of already scanned items to correct the mistake. However, as seen in the previous quote not all systems include such an option, which again causes situations where additional staff support is required.

While waiting for assistance after an error status has occurred, several participants became unnerved, stressful, or started feeling insecure. While error messages usually

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claim that ”an employee will be with you shortly”, it often takes a long time for someone to arrive, which might be perceived as far longer than it actually is[RSX19]. During this waiting period, some users began making irrational choices such as clicking random options in the system, resulting at times in additional disorientation. In conclusion, self checkout systems lack an option to inform the user that a request for assistance has actually been received by an employee instead of just presenting a static message on screen.

Some supermarkets with little space available offer smaller versions of checkout terminals, which differ from other models in two aspects: they do not have a specific item storage area and also accept only payment via bank card. However, all card payment systems require some form of network connection, and if this connection gets interrupted, payment becomes impossible. This in turn also renders all self-checkout systems unusable until the error has been fixed. When this was the case during one test, the terminals would function normally while scanning products, but were unable to execute the final step of the payment progress. Even though the issue was already known for about an hour, no information whatsoever was made available about it to he customers, and the self checkouts were not temporarily deactivated either.

Ease of Learning

To ensure ease of learning, it is necessary to design a system in a way that little learning effort is required for successful use. If a participant appears to have had problems with understanding the inspected device, it will be noted here.

Another issue connected to models using a weighted checkout area has been identified in this Usability category: After stepping towards the self checkout system, some participants with no prior experience decided to put their shopping bags into the conveniently placed large, empty, elevated area which was actually designed for already scanned items. In this case, the checkout instantly displayed an error message stating ”Unexpected item in packing station. Please remove the item.”, with an additional audio prompt. Unaware of the issue that was caused by this condition, they attempted to start scanning items either way without paying any attention to the instructions given to them. When the system showed no reaction to their actions, participants were left clueless about how to proceed. In each case, the situation was only resolved after someone else explained what the problem was.

Before conducting the first testing sessions, several of the participants had not used a self-service checkout before. It was therefor criticised that for first time users, it can be very difficult to figure out specific aspects of operation, such as having to enter unlabelled products manually. Another issue that often occurred which was already mentioned before was that the item storage space was often confused for a regular deposit area. Additionally, should an error occur during use where the cause is unknown to the user, no explanation of any kind is given. Instead, an employee arrives sooner or later, takes care of the issue - at times even without saying a word - and leaves again without describing

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Type of Usability issue	Amount
Effectiveness	8
Efficiency	4
Engagement	2
Error Tolerance	2
Ease of Learning	2
Total	18

Table 4.3: Usability Issues identified for Online Supermarkets

what went wrong.

Several important differences were noticed in behaviour depending on the experience of the participants with the use of self checkouts specifically. The first one was the overall confidence and its relation to the time required during the checkout process. Novice users often required some extra time examining the overall layout of the machine and what could be interacted with, while experienced participants quickly stepped up and started scanning their products. Secondly, how customers deal with errors or unexpected situations also depends strongly on previous experience. Inexperienced users were usually stumped and confused whenever a message unexpectedly appeared on the screen. Even basic instructions such as choosing the amount of a product were first met with uncertainty, and only handled after carefully reading all available options. Error messages were often ignored at first, and at other times received with anger about the machine not fulfilling its purpose. On the other hand, recurring users showed confidence during each step, only requiring extra time when searching for a specific unlabeled product. In case of an error occurring, they were usually able to identify the cause themselves and already instruct the employee about the situation on arrival.

4.2.2 Research Question 1 on Online Supermarkets

While only few participants showed interest in testing out online supermarket services, it was still possible to gather a large amount of valuable insights about their experiences. First, it is important to mention that the indicated overall technological skills of the six participants differ noticeably: three rated themselves as having ”good” technical skills, two claimed to be ”very good”, and one stated to have ”exceptional” skills. During the auto-ethnographic analysis, the technological aspect of the websites was mostly evaluated, yielding very different results for the two companies that were reviewed. In Austria, these companies are Spar and Billa (which - as previously mentioned - is part of the REWE company), who offer online shopping and delivery services all over the country. In connection to this thesis, it is necessary to mention that after data gathering sessions have been concluded, some of the issues that were identified have independently been fixed or improved by the corresponding companies. In one case, it has been decided to give a description of one feature that is not available anymore due to a lack of functionality.

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Same as the previous section about self service checkouts, this part is divided into five different Usability categories. A short description of the categories can be found at the top of each subsection in 4.2.
Online supermarket websites show a great necessity for improvement in the two Usability categories *effectiveness* and *efficiency*. They contain the majority of reported issues with 12 out of 18 in total, while the other three principles only include two entries each (see table 4.3).

Effectiveness

Many customers visiting shops of all kinds like to see what sorts of products are currently on discount. Just as in physical places, those who wish to do their shopping online often want to do the same digitally. However, in some cases participants had difficulties with identifying discounted products, which led to some irritation during the experience.

> - And this chocolate is supposed to be on discount, hmm i don't know if it really is on discount? Since it doesn't say anywhere what the discount actually is but you always have the price next to it and it seems to me that it isn't significantly cheap, so this sorting by discount or not seems a bit suspect to me i believe i'd have to search for longer if i had to see whether anything is really on discount or not.
>
> (Translated) excerpt of the transcript by user ID 001 using an online shop

Furthermore, not all online supermarket systems offer the possibility to sort the product list by showing discounted items first. This forces customers to very carefully scroll through the list of items, always looking out for things with a reduced price tag mixed in between the others. An option to show only discounted products was missing entirely. Lastly, if products are discounted, the reduced cost is usually presented using red text or a red background. This can be very difficult to identify for people with colorblindness or someone using some form of alternative display with a low color range.

In most cases, every item that is available for purchase online features a detailed products description, including both text and images. Most products, especially cleaning, cosmetic, or other household items also offer detailed information about potential hazards, recommended usage, ingredients etc. However, a lack of images showing the actual products from different angles has been mentioned as a negative remark by a participant for different reasons. Single images taken from a front view can make it difficult to estimate the actual product size and amount of content. This is also an issue in case of so-called deceptive packaging, where the boxing of a product is significantly larger than the actual content. Furthermore, customers are unable to look at the expiration date of a product, which can strongly impact the decision whether to buy something or not. Especially for items that would be stored for a long time, being unable to inspect this crucial bit of information might deter some from buying them online.

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One online supermarket offered a feature that was originally supposed to help customers to quickly and effectively conduct their purchases. The idea was to add a feature where one could enter different keywords, such as ”bread”, ”milk”, ”orange juice” etc at the same time. The website would then present a selection of products corresponding to each of the entered keywords, but upon testing, the feature turned out to be severely defective. Once all queries were listed, some would not show any products underneath, or queries would get mixed up, showing milk products below the fruit query, and completely leaving out others. Also, the amount of presented products corresponding to a query was severely limited, and most products could only be found after searching for them using the regular function. Lastly, when a user decided to remove one query from the list, the remaining ones would get mixed up, show completely different products, or present results that were previously not visible. The feature has been removed from the website by now, but it remains as a reminder that proper quality control is crucial for every software function.

If a customer wishes to search for a specific product brand or type, it is possible to manually enter a query into a product search function. This query is then processed using a database search function, and the results are then presented to the user. In some cases, those results included items that had little or nothing to do with the actual query. For instance, typing in the search query ”paprika” showed several types of paprika, paprika based or flavoured products, with the third search result being different types of carrots.

> - uuhh frozen vegetables tomatoes on the vine but no paprika. Right... paprika powder. Poooowwdeerr maybe it works then. Enter. Soo paprika fresh paprika fresh frozen vegetables doritos with paprika... right doesn't exist ah there, i got it i got it!
>
> (Translated) excerpt of the transcript by user ID 707 searching for ”paprika” using an online shop

In another case, a search for ”batteries” also returned three types of hair trimmers and shavers.
When using a product search function or overview online, different filter options are usually available to specify the search criteria even further. Examples include showing different types of products such as ”lemon” as fruit, flavoured beverages or even detergents. In one case, such a filter option was not available, which might force users to search several pages of different products until they find what they were actually looking for.

When working with people who do not regularly use computers, it was observed that the mouse wheel scrolling feature is often ignored due to the users being unaware of it. Instead, the scroll bar on the side of a document or program is often dragged using the

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Figure 4.2: Different styles of scroll bars on different computer operating systems[Vil22]

left mouse key, and in some cases the keyboard arrow keys are used. During inspection of the different product catalogues, a detail was identified with the presented filter options that could cause problems in relation to the aforementioned circumstance. While some websites show their filter options as a list on the side of the screen, which allows for navigation using either of the previously mentioned options, others use expandable or shrinked down menus that include an additional scroll bar. Depending on the browser that is being used to access a website, scroll bars are sometimes designed to be very slim with a light grey colouring, which can make them very difficult to be identified (see Figure 4.2). Especially in such a case, an inexperienced user might ignore this additional navigational element and fail to properly move through the list of options. While scrolling through a submenu using the arrow keys is also possible after clicking on it with the left mouse key (thus changing element focus), it is unlikely that inexperienced users are aware of this feature.

Most websites include an additional content section on the bottom of each web page with details about the company and service, including legal information, contact data or FAQ catalogues. In some cases, an additional quick navigation menu is included on top of a page, giving the possibility to jump to that section with only two clicks. Each of the inspected online supermarkets lacked such a feature, therefor making it necessary to first scroll through the entire website to be able to access said information. Since the rest of the webpages are filled with advertisements and images of different products specifically designed to focus attention, it is unlikely that most users would notice a small collection of text on the bottom. Additionally, the only indication that the different text elements are links that can be selected is a minimal change in color or the addition of a thin line below when hovering over them with the cursor.

An overall issue for people with bad eyesight is the use of small text in any form of media, both physical or digital. Concerning online supermarkets, this was often the case for additional information describing specific product details such as price per liter or kilogram. If a product is currently on a general or quantity discount, the regular single product price tag is shrunk down and sometimes crossed out to focus the attention on the lowered value instead. This makes it difficult to identify the regular cost, which is

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especially important if a customer wishes to purchase only one piece of a product. Small text was also identified in other sections of the websites, especially in the list of the FAQ Catalogue. Most modern websites - including those covered in this thesis - react accordingly when using a browser's resizing feature, and change the size of the displayed content accordingly, including the magnification of small text. However, many users on PC are unaware of how to use this function properly, with some sources claiming that only 2-3% overall are using website resize features[Sam17].

Efficiency

Both online supermarket services that were involved in the data gathering process of this thesis require a minimal total purchase value of 40 €. Numerous issues that are connected to this condition can be described, with the first one being visibility. In several instances, the information prompt that is displayed before the required amount has been reached was either not noticed or outright ignored by participants. This was mainly caused by the displayed information being too inconspicuous, either by only getting displayed on the side of the screen, or in a later stage of the overall shopping process as plain text. For neither of the inspected systems was it ever necessary to unambiguously confirm that the required minimal fee has been acknowledged.
Issues concering visibility or interrupting navigation are not the only problems that are caused by the minimal value requirement. If a customer is forced to reach a specific limit to even be able to purchase anything, it compels people to buy additional items they do not actually need. This proves that online shopping in supermarkets is not a viable option when someone only requires a small amount of groceries, and even larger purchase with a total value just slightly below the minimal amount cannot be concluded.

When someone goes shopping to a supermarket, it can be assumed that all or at least most items are for sale unless they are currently sold out. For online supermarkets, the provided inventory is severely limited in some aspects, and items that normally are readily available cannot be purchased. There are two main product categories where this been observed the most. Many types of fresh food such as raw meat and fish show a very limited availability for online purchases, with the reason for this being unknown. It may also occur that while a certain item is available for delivery in a specific area or city, it cannot be ordered online everywhere else, which is often the case when regional producers offer their products to local supermarkets. However, it is possible to already gather all items one wishes to purchase before entering a delivery or pickup address, and some of them might become unexpectedly unavailable afterwards. Lastly, a very important issue that was criticised by many participants was the complete absence of beverages in deposit bottles.

> - It cannot be that there are only... these 4. 0,33 "helles" that can't be it that can't be it i want a case of beer and nothing else. So they don't have Gösser either i'll type in again Zwettler 0,5 litres maybe it understands this... no. Don't have it. Right then i have to pass then we'll let it be.

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(Translated) excerpt of the transcript by user ID 707 searching for beer using an online shop

While it is often custom to buy larger quantities at once to have a certain storage amount at home, doing so using online services is exceedingly more difficult or not possible at all.

The following two deficiencies have only been discovered at one of the inspected supermarket websites, and the first one can be classified as a very severe functionality issue. As previously mentioned, it is always necessary to enter a delivery or pickup address when conducting an online purchase. In case of this company, a customer needs to enter a postal code so the system can display only products which are available in this area. The FAQ contains an unsorted block of several numbers which serves as a list of valid delivery areas. If one were to enter a code that is not included in the list and wishes to continue with the purchase, the only products that are being offered are different kinds of fruit and vegetable baskets. Furthermore, if a user now attempts to view product listings of different brands that are being advertised, the screen only displays a message reading "Your search for * has returned 0 results.", which indicates a very serious software issue. A Thinking Aloud testing session where one participant attempted to use the website actually had to be cancelled due to this situation occurring. Going back to the delivery address menu, a small inconspicuous text can be found that further explains this issue. If the provided postal code is not included in the list written into the FAQ, a small red text appears in the delivery selection, informing the user that miscellaneous areas can only order said baskets.
This is not the only issue that was discovered within the delivery menu however, as the pickup point list also shows a severe lack of quality control. If a person wishes to make an online purchase and pick it up at a store or - in this case - a supermarket, it is often possible to view stores in a specific area, or those that are nearby. In case of this company, with hundreds of stores all over the country, a total of nine pickup stations are offered, regardless of the postal code that is entered first. Lastly, every time the delivery address selection is opened again, the user is required to enter the same number again, as the system fails to automatically fill out the form after a previous entry.

The second issue that was identified concerns the amount of a product that can be selected for purchase. Many products such as meat include the term "1 kg", or one kilogram, in their name. Below that text an image of the product is shown, and further below a customer can click the "add to cart" button to put the product into the virtual cart. What one might not realize is that there is a small light grey text on white background to the left of that button where the amount of weight for the product can be selected. In many cases, this is set to far less than the 1kg mentioned in the product title. If a user does not notice this detail, it is very easy to accidentally purchase the incorrect amount of a product, unless they carefully inspect the shopping list in the "my cart" view again. The selected amount of each item is presented a lot clearer with a large black font, which raises the question why the same design is not used in the product

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catalogue as well.

Engagement

When opening an overview of available products within the online shop, the website displays them in several rows on different pages. One participant claimed that it was annoying having to click onto the next page after scrolling through the previous one. It was said that having everything on one page which would allow to scroll through everything at once would be a far more comfortable mode of operation. However, there are also those who prefer the regular, magazine-like style of checking the catalogue. Conclusively, this is mainly an issue when it comes to personal preference.

If a customer enters a supermarket online shopping website, the first thing that is being presented is a large array of different advertisements for several brands and products. These include images, large text and symbols as well as automatically switching images. All of these techniques are used to change the focus of attention to what is being presented to get someone to buy something they eventually do not need. The actual product search function and catalogue overview are located on top of each web page within a narrow space lacking visual highlights of any kind. This often led to this part of the screen being ignored at first, and during testing sessions most participants expected to find some form of product overview or catalogue below the advertisements and started scrolling through the website. In this case, the top section of the screen is reduced even further, making it even harder to notice until the view is moved to the top again. In the end, this has often caused a lot of disorientation among participants, who struggled at first to find what they were actually looking for.

Error Tolerance

If a person wishes to conduct a purchase online, it is normally a strict requirement to offer an email address to allow for the electronic transfer of any necessary documents. Even when a customer does not wish to create a new user account for a single transaction, it is still required to confirm a purchase by receiving a specific message. If that message cannot be sent or does not arrive - which is exactly what happened during one thinking aloud session - the entire process cannot be concluded. Especially in times of immediate need, for instance people who are incapable of receiving groceries otherwise, a system failure such as this can potentially lead to dire consequences.

Before the ordering process can be concluded, customers are asked to enter the postal code of the area where they wish to either pick up the products or where they want to have them delivered. Online supermarkets also tend to use this information to display only items which are available in the corresponding area, or might not be available anywhere else. During the checkout progress, a user might make a typing mistake when entering the address and choose to continue without double-checking. In one checkout system, the participant was then presented with a form where it was necessary to enter

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all the other required data, such as name, email etc. The address that was previously entered was also displayed, but upon noticing a mistake and attempting to fix it, it was discovered that this part of the document was locked and could not be edited, causing severe frustration for the user. Even with additional assistance from the researcher, it took more than one attempt to move back in the checkout progress and enter the correct address. Another cause for astonishment was that after confirming the correctness of the now edited delivery form, the software then offered the option to change the delivery address afterwards.

Ease of Learning

Some participants reported having difficulties with navigating the software especially when attempting to finish their purchases. When searching for a ”conclude purchase” option, it was not always clear that this was only possible by opening the cart overview first, and then clicking the corresponding button there. One checkout system then redirects the user to a completely differently designed part of the website, where most interface elements that were present before are suddenly gone. This may lead to additional confusion for customers, who could become disoriented or otherwise unsettled by the sudden change of appearance.

As with most activities in life, things become easier after gathering experience. Most technological devices and also some software include some sort of manual, tutorial, or other document to offer first time users additional assistance. Such a feature is missing when it comes to most online shops, and new customers often require a significant amount of additional time and effort to understand and correctly use the system. While a general terms of use or FAQ document normally exists, those are often hidden in some corner on the bottom of the interface and may not be noticed. Furthermore, having to read through the entire document to get a basic idea on what to do is very time consuming as well and might not even include the desired information.

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	Frequency	Percent	Cumulative Percent
20-30	3	13,0	13,0
31-45	7	30,4	43,5
46-60	5	21,7	65,2
61-80	8	34,8	100,0
Total	23	100,0	100,0

Table 4.4: Age of participants

4.3 Examining Research Question 2

"What are the noticeable differences in the aspects being criticised depending on age group, native language, or technical aptitude?"

The second research question of this thesis attempts to find evidence for the question whether significant differences can be identified between the user experience of each participant depending on different demographic factors. The factors that were originally considered for this analysis were age, overall technical aptitude, and having german as a mother language. As described in section 3.5.2, the results generated here are based on the findings generated by research question 1. Out of all 23 participants, 10 were aged 45 years or younger, and the other 13 were older, with the most prominent age group being those between 61-80 years, closely followed by 31-45 (see Table 4.4).

4.3.1 Dismissal of mother language as a factor for success

Regardless of having german as a mother language or not, no participant showed any difficulties with any lingual aspects of the tested systems. This can be attributed to the additional fact that all non-native speaking participants have been living in Austria for several years already, and therefor either had an excellent or very good understanding of the german language. In each instance where the question about understanding the instructions given to the user by the system was answered with "no", the participant stated to have german as mother language. In one instance, a non-native speaker answered the question with "undecided". It needs to be mentioned that the participant giving this answer also submitted the lowest overall rating of the SUS scores. During the observation covering the Thinking Aloud session, no significant issues when operating the system were perceived, but a lot of concern about a potentially negative social impact was voiced instead. This leads to the assumption that in this case a negative rating was not given since the instructions were in fact understood, but due to the overall negative attitude a positive rating was dismissed as well, leaving a neutral answer in the end.

4.3.2 Regularly used devices and perceived technological aptitude

All 23 participants were asked whether they use a computer, smartphone or tablet regularly. 19 answered that they use a computer, 20 a smartphone and only 9 a tablet.

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	Frequency	Percent	Cumulative Percent
fair	2	8,7	8,7
good	6	26,1	34,8
very good	9	39,1	73,9
excellent	2	8,7	82,6
exceptional	4	17,4	100,0
Total	23	100,0	100,0

Table 4.5: Perceived technical skills of participants

There was no indication that the amount of different technologies being used would be linked to age, as out of the six participants who claimed to use all of the three aforementioned devices regularly, half are above the age of 50. Furthermore, there are multiple factors indicating that many participants either overestimate their own technological skills or simply did not take this part of the questionnaire seriously. For instance, one participant who has already asked for technological assistance in a private relation outside of this thesis multiple times marked his technical skills to be exceptional. In total on a scale ranging from 1 (very poor) to 7 (exceptional), nobody stated their technical skills to be very poor or poor, while 73,9% claimed to have experience ranging between fair (3) and very good (5). Since experience in the past has shown some of the participants asking questions about different topics that would be considered to be basic computer usage[GCFnd], it is debatable that a rating of 1 or 2 would be more fitting to describe their knowledge. At the same time, the testing group included people of all age groups with high or low technical skills. This would indicate that, while several studies prove that elderly people often struggle more with using technology (see section 2.3), the main demographic factor for successful task completion appears to be direct experience with using the technology.

4.3.3 Ratings of the quantitative questionnaires

The overall quantitative results of the questionnaire as presented in section 4.1 indicate a rather negative opinion about Self Service Systems in retail. 50 % of the participants rated the usability as poor according to the results of the System Usability Scale (see table 4.1), while the other ratings cover a range from acceptable to outstanding. Results of the operation survey (see fig 4.1) demonstrate that the basic components and use of the system were clear and understandable, but successful task completion was often hindered by different issues.

Inspecting the SUS ratings further in correlation to age implies that these two factors are independnt from each other, as all groups include varied ratings. For instance, a 34 year old participant submitted a rating of 30 points for a self service checkout, and a 71 year old a rating of 32,5 points. Corresponding more positive ratings can also be found in all age groups. Using a simplified version of the score calculation of the SUS

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scale on the Operation Survey (positive answers add 1 point, negative answers reduce one), a correlation between the ratings of the SUS scale and the operational survey was identified: In almost any case where a negative rating was given on either scale, the rating on the other scale valued correspondingly, with the result being the same for positive ratings.

4.3.4 Impact of age and technological aptitude on experienced issues

It has been noticed that different issues can occur in all age groups, which naturally has a significant impact on user satisfaction. While the amount of hindrances is independent of both age or knowledge about technology, it turned out that these factors still play an important role for successful task completion. This section first presents differences between demographics that were recognized during the use of checkout terminals, followed by an analysis of the online websites.

Differences with Self Checkout Terminals

All participants who had used self service checkouts for the first time showed significant problems with the first steps of the operating sequence: Items were sometimes initially stored in the wrong area, and instructions are often slowly and carefully read. This first implication indicates that when it comes to SCTs, experience with using the system itself is most important. Unlike a personal computer, Self Service Terminals of any kind offer a limited set of possible tasks, and it is normally impossible to accidentally exit the program or having to deal with issues coming from the underlying operating system. Thus it is not necessary to possess a lot of general knowledge about computers to successfully operate these specific systems. Instead, the correct use of a single terminal can easily be learned after a while if either another person demonstrates the features or they are understood using trial and error. If a participant was either younger or had a better overall understanding about technology in general (or both features applied), the greatest difference towards inexperienced or older users was the overall speed that has been observed. Tasks were often fulfilled faster, instructions were read and understood quicker, and errors or unexpected situations were also noticed more often.

To present a comparison of identified differences in terms of age: Participant ID 861, aged 65 with a personally rated technical skill of 4 (actual rating based on personal experience by the researcher would be closer to 3), was experiencing insecurities during use of a self service checkout, and decided to use the ”call for help” function. While waiting for an employee, the checkout process was continued, and the call for assistance was dismissed shortly after. During the payment process, the machine refused to conclude the procedure due to the still unresolved call for help, which was already completely forgotten about. In a different case, participant ID 464, aged 40 with a personally rated technical skill of 4, eagerly started using the checkout system, quickly beginning the process and scanning the first article. Since the item was not placed in the checkout area, the machine quickly displayed a message ordering the participant to do so. The error message was immediately

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recognized, however, its meaning was not understood, and only after receiving further assistance the situation has been resolved.

The next comparison demonstrates the differences between participants belonging to different technological skill groups: Participant ID 718, aged 62 with a personally rated technical skill of 5 (actual rating based on personal experience by the researcher would be closer to 4) attempted to buy an article with an applied discount which could not be registered by the self checkout system. While waiting for assistance, prompts by the machine to put the article into the packing area were continuously ignored. After a while, the participant attempted to solve the issue by attempting to log into the employee system on the machine, which required an unknown password. Some time later, help arrived and the situation was resolved.

Participant ID 385, aged 38 and having exceptional technical skills (rating of 7), attempted to buy different gift cards during the Thinking Aloud shopping session. However, these were not recognized by the checkout system, and every time an attempt to scan them was made, the machine refused, displaying an error message saying "unknown article". The meaning and reason of the error message was perfectly understood from the beginning, and once an employee was called for assistance, the issue was immediately explained in detail. After some further attempts using different gift cards, it has been decided to try using a regular checkout instead (this specific occurrence has also been described in section 4.2.1).

In conclusion, it has been observed that in general, younger participants are more aware of the current system status as well as errors occurring, but may lack the understanding about resolving the situation. On the other hand, elderly people sometimes outright ignore such details as they are often not properly perceived by them. Regardless of age, technical skills mostly make a difference in understanding the reason behind unexpected situations during the checkout process. These situations include error messages or exceptional products which require additional input or assistance to be registered properly.

Differences with Online Shopping Websites

Unlike self checkout terminals, online shopping websites can be accessed from different electronic devices, such as PCs, smartphones, or tablets. This adds the additional challenge of having to be able to successfully use and partially understand the underlying system as well, and not just the provided service. As it can be derived from the literature presented in section 2.3, the technological environment that a person grows up in can have a significant effect on successful use of a - mainly newly developed - device. However, personal interest is also a deciding factor in this regard, seeing how anyone - including elderly people - who puts a lot of effort into learning about a specific technology will most likely gain a better understanding about such devices. At the same time, it can be assumed that users of lower age who only focus on a fraction of the potential function-

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ality of their devices would struggle just as much with tasks going beyond that knowledge.

One of the most significant differences that has been observed both between different age groups as well as people with varying technical skills was the overall navigational speed. Both elderly people and those with less experience required much more time to read instructions on screen, identify all present elements, and figure out what is necessary to achieve their goal. If the overall operational process is unexpectedly complicated or unclear in an intuitive sense (for instance having a continue button placed on the bottom left side of the screen and the return button on the bottom right), overall experience plays a greater role than differences in age. This is also the case when discussing the use of online shopping services in general, which share most basic principles and functionality:

- a product catalogue exists which can be browsed using search terms, categories and filters
- the delivery must either be picked up or gets delivered
- a certain amount of personal data needs to be provided in an online form
- the payment process needs to be conducted online most of the time as well

It stands to reason that people who have gathered previous experience within this service environment are much more likely able to easily adapt to new providers as well.

A specific issue that was identified in relation to personal experience when assisting others with conducting online purchases, is that some users are unable to complete the payment process due to modern security measures that are involved. Almost all modern banks and credit card companies require additional confirmation of a payment in a secure, electronic fashion, and one method is using a so-called Push-TAN function [Ösnd][Obend][Gmbnd][Bannd]. Some users have not set up such an authentication system, which makes it impossible for them to successfully conduct any kind of online payment process directly using their bank account. According to the Austrian National Bank (OeNB) in 2018, about 60 % of all citizens older than 14 made use of online banking services [Thi19], and while it can be assumed that this number has grown since then, an alternative payment method such as cash on pickup or delivery is sometimes missing.

As previously mentioned, users of online services need to be able to operate the computer system used to gain access. These systems can also be cause for unexpected problems that occur during the shopping process. To present an example, assume that a person uses the arrow keys to scroll through a website and the mouse to click on different screen elements. The person enters a product catalogue view, and clicks on a filtering option located in a small sub-menu with its own scrollbar. The person then tries to continue scrolling through the website, but since the focus has now changed to the previously clicked sub-menu, the website does not respond to the input anymore. If a user does not understand why this issue occurs, it will most likely negatively affect the overall experience.

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In conclusion, it is not only important to understand how to use an online shopping website, but also to be able to work with the device used for gaining access. Additional required technologies, such as online banking services have to be acquired as well. Since people from earlier generations often have difficulties adapting to new technologies, both age and technological experience play an important role for success.

4.4 Examining Research Question 3

"After the completed analysis, which are the main aspects that need to be improved?"

This section is comprised of a comprehensive collection of potential solutions for most problems that have been identified in course of answering the previous research questions. Specific problems will be reviewed, followed by suggestions that would likely improve the current condition. The first section demonstrates solutions for issues that were reported about using the self service checkouts, followed by the online shopping services. As several previous studies have proven that focusing on Usability issues can greatly improve product acceptance and overall user experience of a product or system, the following suggestions are likely to also have a positive effect on these factors.

This section implements a similar structure to research question 1: recommendations for both the self service checkouts and online shopping websites are presented separately, and will also be divided into the Usability categories shown in section 2.2. At first glance, it can be noticed that the amount of presented solutions in this section is considerably lower than the reported Usability issues. Additionally, the distribution across the different categories differs significantly as well. This can be attributed to the circumstance that several of the proposed solutions would help to counter multiple problems in some cases, and are also considered to be part of different Usability principles.

4.4.1 Improvements of Self Service Checkouts

Several of the issues that were identified during the inspection of Self-Service Checkout could be corrected with relatively little effort. It is generally not necessary to completely redesign the entire machine or software system, but instead, small modifications are all that is required to positively influence the overall Usability. In most cases, a tangible solution will be presented after first discussing basic methods for potential improvement. As shown in 4.6, most adjustments would have to be made to improve the system's efficiency, while a lack of positive engagement has also been identified as source for potential improvement. The other three Usability categories would require only a small amount of changes.

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Type of Usability issue	Amount
Effectiveness	7
Efficiency	2
Engagement	3
Error Tolerance	2
Ease of Learning	1
Total	15

Table 4.6: Usability improvement options for Self Service Checkouts

Effectiveness

Three issues have been identified in the program function for manually entering unlabeled products. First, it has been observed that too many items were displayed on the pages of the catalogue overview, which causes the text showing the product names to be very small as well as images being either difficult to see or being partially cut off. Enhancing the visibility of these elements would be rather simple: Two possible solutions would be to either split up the shown products over more pages or by implementing a scrolling feature, either by adding two directional buttons or by allowing free finger movement to change the current overview.
Second, not every product is accompanied by a visual representation, instead the user only gets to see a white square above the product name. Since most products in the overview include an accompanying picture, ensuring that this is the case everywhere would require little effort. Lastly, several instances have been recorded where an unlabeled product was missing from the selection catalogue. In this case, a regular review of the store's inventory in combination with the current database is necessary. For this purpose, an automated computer algorithm could be implemented that regularly compares the amount of available unlabeled items with those present in the selection list.
Continuing with the issue of too many elements being displayed at once, this problem has also been reported in combination with the payment options, which could be split in two sections instead. One section would cover three regular payment options such as cash, bank card, or gift cards from the store. A section with miscellaneous payment methods would then display all other possible means of conducting a transaction.

During the worldwide COVID-pandemic, people could purchase regular face masks at a multitude of different places. Self-service checkouts were already implemented in some markets back then, and models with a storage area including a scale were often unable to recognize the masks being put there due to their low weight. Two possible solutions can be applied to solve this issue: One would be to label specific items as "non-weighable" so that the sensor would ignore them. Another way would be to entirely remove the requirement of putting scanned items into the packaging area, as people likely want to take the items they paid for with them either way.
One more issue that was part of the packing process were the overly pressing prompts to remove every item from the packing station. While one solution would be to remove

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these messages from the system entirely, it would be more efficient to simply increase the timing delay after which they are triggered. If someone were to forget an item in the packaging area, the system could refuse to allow the start of a new checkout process completely until the weight reduction has been registered.

Labeling of different hardware components could be improved both in regards of availability and design. While only some systems included labels on specific parts of the machine to offer a quick functional overview, adding such symbols or text everywhere would require little effort. For already implemented systems, a combination of permanent marker color with stencils could be used to add new, identical symbols or text wherever necessary. Easily removable marks such as stickers could be replaced in the same fashion to offer a more permanent solution. Additionally, all symbols should be connected with accompanying text to counter possible issues with recognition or understanding.
If different hardware elements are connected to specific actions that need to be carried out at a certain moment, these hardware elements could be equipped with a visual indicator. New models could be outfitted with see-through symbols with a back light attached to them, and these would then light up accordingly. For instance, should a company implement the previously discussed age verification module, these could be highlighted if one wishes to purchase a restricted item.
Apart from labeling, it is also important to keep all input and output devices clearly visible for the customer. Other objects such as shelves must only be positioned in a way that does not block the view to components such as the receipt printer, and an appropriate distance between components needs to be upheld to prevent potential confusion as to what appendage has which purpose.

Efficiency

In Austria, cigarette vending machines are equipped with an age verification module to ensure that no underaged customers are able to buy any of the products on offer. Regular vending machines selling alcoholic beverages implement the same system for specific items as well. This technology could be adapted for self service checkouts, removing the requirement for additional employee assistance if a customer wishes to purchase an age-restricted item. Additionally, it would further benefit the overall payment process by improving the autonomy of the user, as well as shortening the duration of the procedure.

If a customer makes a mistake during the payment process, it is necessary to have the option to make a correction or to cancel it entirely. While such an option was already present in one of the systems covered in this thesis, it was not available everywhere else. In this case, an employee needs to be notified for assistance, which could severely lengthen the payment process. There are several instances where having a reversal option would benefit the user: In a stressful situation or if someone suffers from involuntary, irregular tremors, it may occur that an item is scanned more often than it is purchased. Such mistakes can then be corrected with little extra effort. In another case, someone might choose the wrong amount of a product (as demonstrated in a quote in section 4.2.1), or

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make an incorrect choice in the product selection menu. Lastly, customers sometimes misinterpret discounts, either by choosing the wrong product or by overlooking details such as the required amount for it to apply. A cancel option would help to quickly solve such a situation without additional assistance.

Engagement

Many participants reported having doubts about whether a self service checkout is able to correctly identify and apply any discounts currently available for a specific product. Two cases have also been recognized where a price reduction can only be conducted with the assistance of an employee: Either if a product has not received an adjusted barcode, or if no function to apply personal discount tickets is available. While one of the inspected systems did in fact offer the possibility to apply a 25 % discount on a limited number of products during a specific time, employee assistance was still required for confirmation. To improve the situation concerning the use of stickers to mark a product for a discount, a QR code could be added which could then be scanned to apply the cost correction. QR codes can store relatively large amounts of information compared to traditional bar codes, adding the possibility to outfit every sticker with a unique identifier. This would reduce the potential for abuse since after a sticker has been used, it can be marked as expired within the system. To prevent the database to get overfilled with discount-sticker identifications over time, a reset could be conducted regularly after a sufficient time period.
To solve the problem concerning the customer's trust in the system automatically recognizing regular discounts, additional prompts could be implemented. Currently, additional text messages are displayed next to a product where a discount has been applied. These messages do not differ in style or colour compared to the other text displayed in the list of already scanned products, prompting users to double-check that everything is working as expected. Instead, the confirmation of a discount could be displayed using different colouring or additional symbols which are placed next to the affected items. That way, it would be much easier recognizable as the difference in text layout would already convey enough information without requiring additional reading. Alternatively, a short audio prompt, such as a small jingle or beeping sound could be played to add a non-visual method of confirmation.

If a customer calls for help or employee assistance is required, there is no way of knowing that the message has actually been received or how long it will take for someone to arrive. To optimize the process, a confirmation system can be implemented where someone has the option to acknowledge that the notice has been received. One possible realization would be a signaling system that would send a message to all regular checkouts or the information office, where it would either be acknowledged and or redirected towards any available personnel. Another option would be to connect these calls with any mobile computer device used within the supermarket system environment using specific hardware or mobile applications. Employees could then also use this service to send a message back to the terminal of the customer including an approximate time of arrival.

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Error Tolerance

One of the mostly occurring problems that was observed during testing was the incomprehension or dismissal of error messages. This mainly concerned error messages stating "inspection by an employee required." without further explanation. A considerable improvement here would be the addition of further explanatory text or to change the displayed message depending on the context. For instance, age-restricted items could inform the user specifically that an age restricted item has been detected and that an age verification by an employee is necessary. Furthermore, items with varying weight or unlabeled products can be provided with a simple message that such products need to be additionally verified.
Some of the study participants initially put their groceries onto the deposit area which is supposed to be used only for items which have already been scanned. Instead of merely stating that "An unexpected item has been detected in the deposit area. Please remove the item." the message could be refined, informing the user that this specific area is only to be used after scanning a product.

Ease of Learning

Whenever a self service checkout area was approached, it was noticed that customers were never presented with any form of manual or guide about correct use. Such a guide could either be presented as a large picture inside the store or offered as a small booklet which customers can take with them. The same guide could also be offered online as an electronic document, along with an instructional video offering a detailed representation about the correct operation of the system. When designing such a document or video, it is important to keep accessibility and general design principles in mind. All elements must be easily readable and understandable with little effort, and a video representation should include additional subtitles to enable deaf viewers to grasp all conveyed information.

4.4.2 Improvement of Online Shopping Websites

Every online shopping website has its own design scheme, overall layout style, and is generally easily recognizable. The underlying systems of those services often share similarities, either by using similar algorithms or by requiring a similar task completion process. Enough similarities have been identified between the two tested systems that most of the suggestions presented in this section could be applied to either of them.

Effectiveness

Multiple options can be implemented to improve upon the negative aspects that have been mentioned about how online websites present discounted items. While both tested websites already include sections specifically offering an overview about current discounts, such a filtering option could be added within the regular product catalogue as well, either as an additional search filter or as a link leading to one of the other discount overviews. Furthermore, only one company has included a "sort by discount" option, which combines

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Type of Usability issue	Amount
Effectiveness	3
Efficiency	2
Engagement	2
Error Tolerance	1
Ease of Learning	2
Total	10

Table 4.7: Usability improvement options for Online Shopping Websites

both an overview over all products as well as a grouping of special offers. To make it easier to recognize the border between the two items groups, extra space or another form of visual indicator can be placed between them.
If a quantity discount has been applied to an item, the regular price is barely visible anymore. Alternatively, the system could initially display the regular price of the item, with a clear indicator in form of distinctive colouring and an additional symbol (thus making it easier to recognize for colourblind people) informing the user that a discount is available. The temporarily reduced value could then be displayed either if the user is hovering over the price tag with a pointer, or after the corresponding amount has been chosen.

All informational content within the product catalogue needs to be clearly visible for every user. Low text contrast issues such as using light grey text on a white background need to be replaced by more easily distinguishable colour schemes, and overall text size must be large enough to be readable by people with impaired eyesight as well. Other information, such as price per kilogram or litre are hidden in smaller, far more inconspicuous text below the regular product price, although these are important values to enable customers to compare actual product cost between different brands or package sizes. Lastly, products such as fresh meat where a customer needs to choose an amount by weight instead of number of items must clearly define the pre-selected amount. Inconsistencies in this regard such as those described in section 4.2.2 can be prevented by adding a minimum amount such as a message stating ”starting at ...g”.

Efficiency

A major issue of supermarket online shopping services is the minimal value requirement and how it was always visualized in an inconspicuous fashion. Before a customer begins the ordering process, a clear message requiring confirmation from the user needs to be displayed. This should already occur before choosing a product, as otherwise time might already be spent browsing through different categories and looking for discounts, and the entire process is eventually cancelled after receiving the information. During the item selection process, a conspicuous message showing the current difference between the current value and the required amount could be displayed on top of the screen for a few seconds. The message would be displayed and removed automatically, thus not hindering the overall control procedure. When attempting to confirm the selected amount

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of products for purchasing, one participant failed to notice the small message appearing on top of the list stating that the required value has not been reached yet. Instead, a similar message such as the one suggested for display when entering the website could be implemented to ensure that the information is not overlooked.
Another part of a potential solution is to reduce the minimal fee for online purchases, which is far beyond what customers normally spend, as is demonstrated in the auto-ethnographic document (see section 6). With the current required limit being 40 €, it can be assumed that a reduction by 50% to 20 would encourage more people to regularly use the provided service.

Engagement

If a website is displaying large amounts of content at the same time, said content is usually divided into a page style view. Users can scroll through each page after another, and click a ”next page” option at the bottom of the list. During a Thinking Aloud session, one participant criticised this form of navigation, stating that he would prefer a scrolling feature through all content instead.

> - That can’t be it... there are four pages of chocolate too why can’t i just keep scrolling down and see everything... now i need to click on number 2.
>
> (Translated) excerpt of the transcript by user ID 001 while using an online shopping service

Both options have advantages and disadvantages: The page view limits the displayed content to prevent users from missing an item and makes it easier to keep track of everything, but at the same time this limitation can be considered as a nuisance. Furthermore, constant extra clicks are necessary. On the other hand, using a feature to freely scroll through everything allows the user to have access to all products at once, but at the same time it is easier to lose focus if a list is too long or an input error is made. A compromise would be to allow the user to switch between either a page view or a scrolling view, depending on personal preference. Some page view layouts also offer the option to decide how many items should be displayed per page, making pages showing many entries at once a viable third option.

Seeing only one image of a product can take away valuable information that might influence the decision to make a purchase (see section 4.2.2 for details). To offer a better comparison to a direct inspection, the first option is to include different viewing angles as well as images from all sides of the item. These images should be provided in a resolution high enough to enable a customer to perceive and read all information that is present on the physical packaging. Additionally, a visual size scale could be included instead of merely adding the measurements to the product information text. It has been established that multiple factors influence how size is perceived in pictorial representations[Kos75]. It is therefor reasonable to assume that presenting a visual scale next to the product

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would increase the comprehension of its actual dimensions. One option to convey weight and density is to choose one standardized type of product (for instance a 1 kg pack of flour or sugar) with known dimensions, and use it as comparison towards the current selection. A technological advantage of having such a comparison image available is that it needs to be stored in the database only once, and other products would merely require a link to establish a connection to the resource.

Error Tolerance

One online supermarket website asked the user to choose an address for either pickup or delivery before beginning the checkout process, and it was not possible to change said address in the personal data form that had to be filled out later. To prevent inconsistencies by changing the address later to an unavailable location, but still allowing the option to make adjustments, a link leading back to the location selection menu could be added. This menu already includes an automatic address verifying algorithm, so no further changes in this regard would be necessary. It is recommended that this link would be provided in form of a labeled button or some other form of element that does not only consist of a text string. After entering a new address, the system would then inspect all previously selected products again to see if an item would be unavailable at the new selected location. In case of an item having to be edited or removed, a list view including all affected entries would be presented, as well as information whether the required total value could still be reached afterwards. If no changes are necessary, the system would automatically redirect the user back to the personal information document.

Ease of Learning

If a customer enters a supermarket online shopping website, the attention is focused mainly on advertisements and nothing is explained. Multiple adjustments can be made to improve overall design, orientation, and navigation. First, if an unregistered user enters the website for the first time, a message or other form of information can be displayed offering to show a demonstration of basic website functionality. This manual can be stored in form of images with accompanying text, or as a video including both audio and subtitles. Alternatively, it would also be possible to program some form of assistance software that would accompany a user during the entire experience, although such a solution would require considerably more effort.
The different sections of the website should be clearly visible and distinguishable from the start. Based on the principle that in several countries including all of Europe information such as text is acquired from left to right, a menu section going from the top of the screen to the bottom on the left side might be easier noticeable than the small top bar that is currently used. Furthermore, the currently implemented overview section could be improved by adding more visual elements or enhancing already existing ones. A navigational menu for the website needs to be implemented and should feature a strong distinction from the surrounding elements, including different colouring, an easily visible outline, and significantly large text. This menu would then offer easier access to different

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documents such as all the information being stored at the bottom of the website and include some of the options currently positioned in the top banner.

4.5 Summary of Usability issues and presented improvements

In this section, all previously shown statements for research questions one and three will be summarized in tables and presented in an overview. While the lists are again divided into Usability categories, some solutions can be found in a different category than the problems they address. As research question two has demonstrated, the main difference between age groups is the time required for task completion as well as general awareness of the system status. In terms of technical skills, understanding and handling unexpected situation are mostly related to a user's general knowledge. In case of online shopping websites, experience with the device and operating system being used might also influence the user experience.

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USABILITY OF SELF SERVICE CHECKOUTS	
Identified issues	Proposed Solutions
Effectiveness	
- Age restricted items cannot be purchased without assistance - Hardware elements might be misunderstood or obstructed - Too much overall dependency on employees - Hardware labelling might be unclear - Cultural barriers (use of colour & symbols) - Screen elements are not clearly visible or distinguishable	- Improve layout options of product catalogue - Ensure availability and images for all products - Split payment options into multiple pages - Remove light products from weighting requirement - Adapt timer for prompts to a sensible number - Add meaningful markings \& text to hardware components - Ensure visibility of all components
Efficiency	
- Understaffed shop causing long waiting times - Discounts cannot be applied - Customers do not trust automatic discounts - Product database between checkouts is not synchronized - Requiring employee assistance takes much time - Software deadlocks may occur	- Implement age verification devices - Offer product amount correction / cancelling options
Engagement	
- Manual product search incomplete or missing elements - Information prompts sometimes negatively received - Too many payment options in one list - Scanning process feels robotic, social interaction missing - Multiple languages not available or incorrectly implemented	- Improve visibility or recognition of discounts - Redesign discount stickers with QR codes - Confirm that employees were notified about assistance
Error Tolerance	
- Error messages often unclear - Weighing area causes confusion or errors - Cancel / correction option often not available - Unclear if employees received call for help	- Rework error message to be clearer - Add instructions on how to correct certain errors
Ease of Learning	
- New users don't understand deposit areas - Nothing is explained for first time users - Inexperienced users require much more time	- Offer any kind of instructions or manual about use

Figure 4.3: Overview of Self Service Checkout issues and solutions

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USABILITY OF ONLINE SHOPPING SERVICES	
Identified issues	Proposed Solutions
Effectiveness	
- Discounted products not clearly visible - Cannot display discounted items only - Discounts often marked only with colour - Product description may lack information - Product demonstration lacking images - Implemented features are not properly tested - Search queries return erroneous results - Lack of filtering options for product search - Current element focus not clear / visible - Additional information section difficult to access - Additional information not clearly presented - Element and text size often too small	- Enable filtering or sorting by product discounts - Ensure availability of regular cost and discount - Improve visibility of elements, especially text
Efficiency	
- Minimal purchase value is too high - Information about minimal value often missed - Minimal value causes unnecessary spending - Inventory partially very limited - Difficult to buy beverages in deposit bottles - System not informing user about unavailable delivery - Not all stores listed for pickup - Product amount labelled in confusing fashion	- Clearly inform user about minimum value - Reduce minimal value significantly
Engagement	
- Product catalogue only available in pageview -Users overwhelmed by advertisements - Navigational elements are not promoted	- Offer different types of navigation through catalogue - Add more pictures and details for products
Error Tolerance	
- Purchase without email confirmation impossible - Delivery address errors difficult to correct	- Ensure that contact form can easily be modified - Confirm availability of product choices if address is edited
Ease of Learning	
- Navigating through system elements often unclear - No tutorial / information about use available	- Offer option to give instructions - Label navigational components more clearly

Figure 4.4: Overview of Online Shop issues and solutions

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CHAPTER 5

Discussion

Self Service Technologies have managed to significantly improve many aspects of our daily lives. Tasks that required travelling to a specific location or sending a letter which took several days can now be done in a few minutes at home. At the same time, shopping is now maybe more comfortable than ever before, with the ability to browse through millions of products online and choosing anything to be delivered to one's own doorstep. In the supermarket and grocery sector, SSTs aim to bring the same benefits that were already spread over multiple other areas of daily life, but in some countries, this proves to be a more difficult task than anticipated. Furthermore, a lot of hidden potential risks need to be kept in mind which might get overlooked in first implementations.

This section goes into detail about different aspects that were discovered in the course of the data collection and also discusses possible consequences. First, each research question is reviewed, and the most significant key points that were extracted from the results will be presented. Additional focus is directed towards question three, where an additional discussion about potential feasibility is presented. Following this is the consideration of potential current and future implications of the results, including both positive and negative aspects. Lastly, the most impactful issues that were faced while conducting this thesis is discussed, as well as potential plans for future research.

5.1 Key findings of the research questions

For each research question certain factors were noticed that occurred multiple times or had a significant impact on the the task execution. Some crucial concepts for usability improvement have also been identified and will be presented at the end of this section.

5.1.1 Research Question 1

Analysis of the Thinking Aloud protocols of the self service checkout tests in combination with the questionnaires revealed two main issues. First, most issues that customers were facing are not severely impactful and could be corrected by themselves or fixed with relatively little effort. When a problem occurred during the overall shopping process, such as requiring additional product inspection or not finding a product in the list, no additional issues were experienced afterwards. Furthermore, only two cases have been recorded where the checkout process could not be completed and had to be cancelled entirely.

Secondly, the occurrence of errors or other unexpected situations often caused a disturbance in the autonomy of the customers, which is actually one of the main principles of using SSTs. Every time an error occurred, the participants were unable to make any corrections themselves and always had to wait for an employee to offer assistance. This has also led to severe disturbances in the duration of the overall process: While correcting an error took only a few seconds once an employee arrived having to wait for one due to severe understaffing often took several minutes. In turn, this also proved to be a major problem for the employees themselves, as they often were required to operate two stations at the same time, causing additional waiting times for everyone.

Similarly to the aforementioned Self Service Checkouts, users of the Online shopping websites also experienced a number of specific overarching problem occurrences. While working with online-shopping websites, all participants required a certain amount of additional cognitive effort to understand the basic navigation of the website and to gain an understanding of the different menus and categories that could be accessed. It always took a while to recognize all main navigational elements, how they work together and what their purpose is. One of the main impediments before beginning with the actual shopping process was caused by the focus on advertisements on the main page. Customers get caught up in a mixture of colourful images, large presentations of specific product groups and lifestyle trends, and the main components required to conduct the actual ordering process are pushed into the background.

Overall, participants were experiencing a widespread variety of different issues, but only in rare cases more than one in a single session. Most of these issues can be resolved in the future with feasible solutions, which will be further discussed in section 5.2. This leads to the conclusion that the overall Usability of the tested SSTs is generally acceptable, but there are certain key factors which can cause a severely negative impact on the overall experience. Correcting these key factors would in turn most likely greatly improve the user experience with relatively little required effort.

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5.1.2 Research Question 2

While it was initially assumed that participants of all age groups and technological prowess had the same issues during the testing sessions, specific key differences were later discovered upon further inspection of the Thinking Aloud protocols and questionnaires. Starting with the successful utilization of Self Service Checkouts in terms of age, the recorded experiences coincide with the findings of other literature examining relationships between age and successful use of technology (see section 2.3). Older people often showed issues with understanding the system overall, and were often completely clueless on how to proceed in case of an error occurring. Younger participants with no extended technological knowledge noticed when something went wrong, but were unable to identify the cause. Lastly, technologically skilled people were quickly able to identify and understand any error situation, but were also unable to handle most of them without employee assistance. In terms of task completion time, only differences between different age groups have been identified, with older people taking longer due to a combination of different factors such as insecurity during use or physical difficulties.

When it comes to online supermarkets, a positive user experience while using a website appears to be mostly dependent on previous experience with general online shopping services. Regardless of age or technological experience, users who have conducted multiple online purchases before quickly find their way around the provided framework despite the problems that were identified. Participants with lesser knowledge sometimes missed crucial information or got caught up in unwanted features by being strongly influenced by advertisements or suggestions to buy discounted products. However, it is safe to assume that a significant factor for overlooking certain information was that it is often not displayed in a distinct and clear fashion.

Conclusively, it would appear that the successful use of both SSTs is mainly dependant on having previous experience with the corresponding computer system. While age differences have also been identified as a significant influence on overall success and required time, it does not hinder anyone to learn about new technologies. Therefor, it is likely that the overall use of SSTs, both on site and at home, would increase if customers would have access to some form of manual beforehand.

5.1.3 Reasearch Question 3

Although multiple Usability aspects that need to be improved have been identified, those can be divided into a handful of categories which will be presented to cover the main components that need to be examined. Some of the proposed concepts can be applied to both the Self Service Checkouts as well as the online shopping services.

Possibly the most effective way to improve the user experience with Self Service Checkouts is to provide a proper user manual that can be inspected prior to first use. Many customers with no previous experience using these machines show difficulties with specific

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aspects of operation that are in no way explained beforehand, such as proper use of the item deposit area. After reading a basic manual, most of these issues could easily be avoided, and understanding of errors or other unexpected cases could be significantly improved.

The other main issue that would have to be fixed is to ensure that the product database is complete. Missing products were one of the main causes for delays and required assistance during testing, and in one case an item could not be registered at all despite an employee attempting to resolve the situation. Lastly, error management and understanding would be greatly improved by modifying the displayed messages to better inform the user about the cause of the problem or current system state.

The analysis of online shopping services revealed three key factors that had a severely negative impact on user experience. The inclusion of some form of a user manual would again help new customers significantly during first use. Basic navigation would be explained, and how to progress after product selection could be demonstrated in more detail, such as the differences between pick-up and delivery options. Second, overall product availability needs to be improved if online shopping should become a viable alternative to going to a store. This mainly considers fresh products such as raw meat, and beverages that can normally be purchased in returnable bottles. Various problems were also identified concerning overall visibility of displayed elements. Warning messages were overlooked multiple times due to them being shown using small inconspicuous text instead of dedicating an unmissable popup window to them. Navigational elements were also often discovered only after spending several minutes browsing through all the displayed information, emphasizing the meaningfulness of designing a better overall layout.

5.2 Feasibility of proposed improvements

Formulating a theoretical solution for a problem can be a simple task, but successfully implementing it in a system, device, or anywhere else can prove to be trickier than anticipated. Several factors such as time constraints, resources, and required skill need to be considered, as well as how much of an improvement could be achieved. In terms of the investigated Self Service Technologies, the two main categories to which improvements can be applied are hardware and software. While software improvements are conducted on a digital level by editing existing or writing new code, hardware improvements also need to consider material cost, required space, and production times for parts. The following section offers a discussion about multiple key factors that need to be considered before attempting to realize the recommendations listed in section 4.4. These will be divided into suggestions for Self Service Checkouts and online shopping systems.

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5.2.1 Self Service Checkout improvements

Software changes vary greatly in terms of required effort and complexity. If new features are added to a system, everything needs to be thoroughly tested and compatibility with the already existing parts of the software must be ensured. Smaller improvements, such as adjusting already existing features or correcting small errors are usually connected with less effort. Hardware improvements are generally connected to various requirements that can severely impact the possibility of implementing a suggestion.

Software improvements

Database consistency: The database that is used in Self Service Checkouts often proved to be incomplete and requires additional content to be added. This task could be executed with relatively low effort due to the following reasons: First, the overall system structure managing the database is already implemented, and several entries have been added or edited before. In the product selection overview, some items were missing an accompanying picture, which can have two likely causes: The first one is that obviously no image file exists for the product, and the second one is that a typo mistake has been made when setting a reference to the file. In either case, to identify and correct the issue, the catalogue could be inspected directly on the Self Service Checkouts to be able to cover both of the aforementioned error cases. The reason for suggesting this specific method of error tracking is as follows: If a search query is formulated to select all items from the database with no image attached to them, it would only display those with no set value. However, images with typo mistakes are also error cases, but would not be displayed after the search, as they technically do include a value linking to a file, even if that link leads to nowhere. While it is also possible to program an algorithm identifying each database entry not including a valid image path, this may not have been implemented yet, leaving the suggested procedure as a potential solution.

Adding missing products to the database would also be an easy task on a simplified technical level. Assuming that an interface exists for editing, removing, and creating entries, this can be used to efficiently make any necessary adjustments. While other factors of networking such as data synchronisation, security or redundancy must be considered as well, these are not essential to the research questions proposed by this thesis and will therefor not be further discussed.

Visibility of elements: When presenting a list of products or payment options, the display was often overfilled with different choices, even though the catalogue is divided into multiple pages. Existing systems already use such page overviews in the manual product selection function, but the required effort for editing them may vary depending on the underlying technology. The following is a theoretical example of a system that can be easily edited for varying display sizes:

Most product catalogues consist of three main components: a category selection on

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the left side or top, the product overview grid in the center of the screen, and an option to navigate through the different page views. The product overview grid consists of a specific number of displayed rows per page, and each row includes a specific number of items. An additional algorithm automatically calculates the total space available on the display and adjusts the size of each item accordingly. The program further sets the number of pages required to display all products depending on the number of items that can be shown on each page with the currently set variables. If said variables result in the overview being too compressed or the images getting truncated, multiple values can be tested until a satisfying outcome is achieved.

Improving Understandability: Adjusting displayed error messages or other text to offer more information follows similar principles. The already implemented system can be adjusted depending on the new requirements by editing existing text strings. The suggestion about employees being able to inform customers about receiving a call for help can be solved in multiple ways, with each posing different challenges. Due to mobile computing having advanced to a point where devices such as smartphones can partially replace ”traditional” personal computers, already existing technology can be used to implement a potential solution. Therefor, designing and building any new hardware for this solution would not be necessary. Since employees already receive a notification if a customer specifically asks for assistance in a self service checkout system, it can be established that an information transfer channel already exists. Using the same channel, a response system could be implemented which allows an employee to specifically acknowledge the request or requirement for assistance, possibly including an estimated time of arrival.

Hardware improvements

Hardware alterations may vary significantly in terms of required effort, resources and feasibility. Anything that would include significant design changes for the machines that are being used can most likely be implemented only in newer models. One needs to consider the cost of acquiring such machines - which can be as high as 25.000 € [Jah17] - and that companies will likely wish to use them for as long as possible. However, design changes that would be beneficial for the user experience can be applied to newer models which could then be used in other locations. Considering that during this thesis it was discovered that several supermarkets in Austria still have not implemented a Self Service Checkout system, it would be an opportunity to offer a better service in the future from the start.

Hardware labeling: Improving the current state of hardware labeling could be achieved by different methods which would not require a replacement of currently used hardware. One simple solution is to apply stickers with meaningful symbols, instructions, or other text as needed, or to use a form of permanent colouring. Laser-technology based engraving tools have also become widely available in recent years, making this another possibility to add additional markings on already existing machines in combination with other

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materials such as attachable plastic tags.

Age verification: Implementing the possibility for customers to conduct an age verification by themselves can be achieved by using technology that already exists in nearly every Self Service Checkout. To make cashless payment possible, each system uses a bank card scanner, which can nowadays also be used in combination with cellphones or smartwatches because of NFC technology [SABS16]. As previously mentioned, such scanners can also be used to conduct age verification, meaning that the existing technology only needs to be adapted to offer this functionality as well.

5.2.2 Online Shopping Service improvements

Since the type of server and hardware architecture used by different supermarket companies for their online services is unknown related to this thesis, this section will focus only on feasibility concerning the software aspects of the presented suggestions. Similar to Self Service Checkouts, multiple improvements that were suggested in section 4.4.2 could likely be implemented without the need to make significant modifications to the underlying system.

Categories and sorting: The overview of different categories as well as results of the search function are most likely based on common database queries: A search criterion, such as ”category = fresh meat” or ”on_discount = true” is forwarded to the database and the corresponding results are returned and presented to the user. To implement new category overviews or add new filter options, new queries need to be formulated and added to the already existing ones. Presenting items in a specific order could be achieved in the same fashion by using a sorting algorithm based on the desired display mode.

User manual: There are multiple methods available to offer users a manual about correct use of the provided online service. The first would be to directly embed an explanatory document into the website itself that could be accessed by using a specific link. Such a document could also be presented as a downloadable PDF file, which could be easily printed out or stored locally on any electronic device. Alternatively, the instructions could be presented in form of an educational video. Regardless of the chosen method, it would be important that the resource used is directly stored on the server of the website. Resources that are hosted by other companies (such as news websites displaying embedded videos hosted on a different platform) might become unexpectedly unavailable, either due to getting deleted or the hosting server being unreachable.

Element visibility: It has been criticised that, upon visiting an online supermarket service, users are presented with a magnitude of advertisements for different products, brands and discounts. While the obvious solution is to simply remove most of this unwanted content, one needs to consider the economic side of things as well. Advertisements are important to make customers aware of available items, and it is only understandable that a company wishes to motivate people to buy different things. Instead, a balance needs to be found between presentation and functionality. While no company would likely

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agree to remove all advertising, they could instead enhance the visibility of navigational elements. For instance, an overlay could be displayed over the website pointing out specific functional elements at first, which is then removed afterwards to give way to other content. Varying colour schemes for different parts of the system, font sizes, styles or other visual techniques to improve differentiation offer another solution that can be considered.

5.3 Advantages & Disadvantages of Self Service in Retail

Each of the previously presented and discussed technologies - Self Service Checkouts and online supermarkets - can bring benefits to society but also have the potential for negative impacts. These influences can affect people in different parts of daily life, and the following sections cover some crucial points in this regard.

5.3.1 Self Service Checkouts

Advantages

A broader offer of Self Service Checkouts in supermarkets provides customers with more autonomy, especially with simple or small purchases. For instance, if a worker wishes to quickly grab something for lunch, it is often not necessary to wait in line at a regular checkout for several minutes. Instead, for example, a simple purchase consisting of about 3 items can be purchased in no more than one minute. These circumstances apply to every customer who only wants to get a few products quickly, and can make short shopping trips a lot more comfortable. These same positive aspects of self service can also be expanded upon by implementing fully autonomous stores where customers can go shopping at any day at any time. Lastly, Self Service Checkouts usually require less space than regular models where people stand in line. Because of this, more checkouts can be put in the same space that would otherwise be required for just one, and more customers can be processed at the same time.

Disadvantages

Perhaps the most obvious disadvantage that would be caused by increasing the availability of Self Service Checkouts is the higher probability of workplaces being cut. Those same employees also often offer help to those in need of assistance if someone is looking for a specific product or requires additional information about an item. Overall, a lot of the tasks that would normally be carried out by others would then fall to the customers, who would then have to solve everything on their own. As previously mentioned, many people also enjoy the social aspects of shopping and having a conversation with employees. These opportunities would also be reduced greatly in case of job cuts being conducted. While a company might see this as an opportunity to further increase their profits, it is the customers themselves in the end who need to cope with the negative consequences of such decisions.

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In case of an employee falling ill, they can temporarily be replaced by a colleague for the required time. If the entire Self Service Checkout infrastructure fails to function, for instance due to the electronic payment system not working anymore, a technician is required to fix the issue. If there is no alternative method of checkout available at the time, customers cannot pay for their items. Should a fully automated supermarket suffer a critical system failure, the whole store becomes unusable until repairs have been made if no form of a backup system exists.

Customers who use the Self Service Checkouts might mistakenly choose the wrong products during the scanning process, forget about an item - be it intentionally or unintentionally - or attempt to leave without paying at all. In any case, at least one employee needs to be present at all times to prevent such instances, and also to assist in case of any problems occurring. To deter people with potential criminal intent, it is also advisable to hire an additional security guard, which in turn would cause additional cost for the owner of the store.

5.3.2 Online supermarkets

Advantages

The most significant advantage of using an online supermarket is that there are no travel times involved for the customer and the wares do not need to be carried over long distances. This circumstance also leads to numerous additional benefits for the user. A significant quality of life improvement can be described for elderly people who are not physically fit anymore or those with injuries - both temporary or permanent. Removing most of the physical requirements of the shopping process greatly enhances their ability to handle their everyday needs without additional assistance.

During the COVID-pandemic, the demand for online shopping has increased significantly, both due to the recommendation to only go outside when necessary and also because of the fear of infection from many citizens. Delivery services therefor offer a helpful alternative way of covering daily needs in such times, and can also be used by people who generally prefer to avoid crowded places due to personal reasons.

It might occur that a specific product is sold out at a supermarket, be it due to a discount, delivery issues, or other reasons. Should a customer spend a significant amount of time heading to a specific destination for such a product which is then unavailable, it would understandably cause a lot of frustration. With the option to order the desired items online, it is possible to either be informed about a shortage beforehand or for the delivery service to collect the desired items from a different location. Furthermore, with the ability to gain a fast overview about available items, customers can also compare prices of different providers and search for specific brands or discounts.

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Disadvantages

One important issue that has been identified in section 4.2.2 is that products presented on a website can only be perceived visually, and multiple details such as the best-before date or amount of content cannot be properly inspected. Especially if a customer wishes to try out a new item, they might prefer being able to physically interact with it beforehand. Furthermore, it is not possible online to consult an employee to get additional information about a product. Although the desired information might be presented in text form, some people still prefer having a personal conversation about such topics. Additionally, as it was discovered during the Thinking Aloud tests, multiple products that are purchased by customers on a regular basis are often not available online.

As it has already been discussed in relation to Self Service Checkouts, online shopping websites also consist of a computer infrastructure that might become unavailable due to different reasons. Should a specific area have no regular supermarkets located nearby, this would cause severe problems for residents, especially if no (public) form of transport is available.

Many regular supermarkets include an area where items that are either to be removed from shelves or close to their best-before date are offered for a discount. Using the online service instead, such products cannot be browsed and one possibility to save money while shopping becomes unavailable. Continuing with the topic of cost, it needs to be mentioned again that a major disadvantage is the requirement for a minimal item value as well as a delivery fee, making small or spontaneous purchases impossible.

5.4 Potential impacts on society

While this thesis deals mostly with Usability aspects of self service systems, it is also important to consider how an increased use and availability might affect different aspects of society. The reviewed topics include social, economical, and partially moral themes which might be influenced by improved self services for supermarkets. Most of the information presented in this section is based on common knowledge and is partially typical for Austrian culture. Specific topics will not be elaborated in excessive detail to stay relevant to the main questions of this thesis.

The first subject is whether SSTs - mainly self checkouts - should be used as an addition to traditional checkouts or as a replacement. While fully automated supermarkets with no requirement for direct interaction with any employees already exist in other (european) countries [Sen23] [Gro22], Austria has not yet begun implementing this concept. Since both checkout methods have a series of advantages and disadvantages (which are further described in section 5.3), it is likely that the best method would be to use both options in parallel. Multiple participants of this thesis have also mentioned that they enjoy having a conversation with employees at times, further emphasizing this assumption.

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Currently, some online shopping services exist in Austria such as "Gurkerl", which offer the opportunity to order products from multiple other markets on one platform to have them delivered home. The company itself however does not own any regular supermarkets. If larger chains were to improve their own services and also increase the variety of items that can be ordered online, it is unclear how this would affect overall competition. The situation might lead to a race between different companies trying to offer better services than the other, or newcomers such as "Gurkerl" could get pushed out of the market again. Since this is mainly an economical question, it might be more meaningful to have experts in this field discuss the circumstances in this regard.

Austria offers many forms of financial aids for people in need, such as citizens currently searching for a job, and can be considered as one of the more generous systems in the European Union [KS21]. If supermarket companies were to reduce the number of employees by fully changing their checkout systems to SSTs, it might have two different negative impacts. First, said social aids are only made possible by working citizens paying a tax which is then redistributed to those in need. If less people find work, less money might be available to be used in those systems. At the same time, more citizens would require these aids due to now being left without a job, causing a stronger demand while in parallel the financial resources are decreasing.

Many european countries have most shops closed on Sundays, be it due to religious reasons or to ensure that people have at least one day off during the week. Should fully autonomous self-service supermarkets become more prominent, this would enhance the opportunity to be able to go shopping at any day and eventually at any given time. In turn, people will most likely begin assuming that anytime they need to acquire an item of daily life, it could simply be picked up nearby. Related to this, they might store less supplies at their homes and would rely more on constant availability. Should a crisis of any form occur, such as the recent COVID pandemic where people were urged to stay home and many shops were closed, the results of this circumstance would show very quickly. Stores would be likely overrun, products quickly sold out, and an increased potential for violence might be recorded as well.

Some models of self service checkout machines only accept electronic payment methods, often because machines with a cash management system are more expensive and require more space. A constant topic of concern for many people is the fear of cash being completely removed from society. Note that this statement will not be accompanied by a specific citation as a massive amount of different articles and discussions has been conducted about this topic in the past. Should cashless payment in turn of an enhanced SST availability become more prominent, different conflicts in terms of privacy and personal freedom might arise. Countries such as China prove that it is possible that bank accounts of citizens can be blocked, basically threatening a person's entire existence [He22] [Ni22]. Such blockades can also potentially be conducted for political reasons,

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such as citizens revolting against the state or to put pressure on others. Without a form of anonymous currency that is not tied to any central service, such systems can easily be exploited for personal power and oppression of others.

5.5 Limitations

The greatest limitation that was faced in relation to this thesis was the relatively low number of participants compared to other works in the area of Usability research, especially in regards of online-shop analysis, where only six participants were available. Since Self Service Checkouts are not yet widely available in Austria, the required travel times proved to be an additional obstacle in gathering additional people to contribute. Another severe limitation that was faced when conducting the tests of the online shopping services was the required payment. Since it could not be expected from participants to spend 40 € or more on random items they eventually do not even need, every Thinking Aloud session was cancelled before completing the payment process.

Due to the overall low amount of participants, limitations in the demographic variety were also noticed, especially in regards of age. While it was attempted to cover a relatively balanced spectrum of different age groups, most participants were 30 years old or older. Similarly, only a few people did not have german as mother language, which caused the analysis of this demographic factor to be omitted later on. In conclusion, while the collected data was sufficient to successfully formulate a result for each research question, more variety would have been beneficial for additional statistical observations.

5.6 Future Work

To have society profit from the insights that were formulated in this thesis, it is necessary to approach the corresponding companies with the collected information. This could happen in form of publishing a paper presenting this thesis and its results, or by directly getting in contact with producers of SSTs. To formulate an international standard for specific technologies, it is necessary for different countries to work out a set of rules and guidelines for technological design and functionality. Such guidelines could also be created for SSTs of different kinds, which in turn would likely improve the Usability across several countries due to certain standards being implemented. Lastly, further investigation into the Usability of SSTs in retail could be conducted by preparing a series of multiple tasks. Examples would include:

- checkout of a small amount of simple, pre-packaged items
- checkout of items including discounts
- checkout of items without a barcode

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or a combination of those tasks. Once more companies in Austria will start implementing Self Service Checkouts and online shopping services, they could also be compared in terms of Usability, User Experience, and other factors.

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CHAPTER 6

Conclusion

Like most inventions, Self Service Technologies add both new possibilities as well as potential dangers to society. In the retail sector, numerous positive developments can be attributed to their use, especially in terms of independence and availability. However, all tested systems also showed a number of flaws and many participants did not consider them a viable alternative to ”conventional” shopping and checkouts.

By implementing a mostly qualitative mixed methods approach, numerous findings have been collected after a thorough analysis of the available material despite being able to recruit a limited number of participants. During the course of this thesis, it was possible to identify and precisely describe several reasons and factors causing people's aversion towards SSTs in Austria. In turn, this work can also help companies with improving both the functionality and appeal of their systems using the presented means for improvement. While many of the Usability issues and other problems that have been identified could be improved upon with rather little effort, the next step would be to encourage people to use them more frequently. Some countries, such as the USA or UK, already provide a multitude of automated shopping services, while the results collected here show that Austria still requires a lot of improvements in terms of availability and Usability. But this development might in turn also have a negative impact on social aspects which many consider an important part of their shopping experience, and in the end leads to the customer having to do all the work as well. Computer technology can be used to automatically manage a vast amount of different systems, a circumstance that has been viewed as a danger for employment by many critics over the last decades. The same concerns have been voiced in regards of SSTs in the retail sector, where several self checkouts could be managed by a single employee instead of several. And even if a well designed system is implemented, developers have no control over specific additional risk factors, such as customers deliberately leaving without paying, not registering all products or breaking the machines.

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Design, implementation and acceptance of technology are all equally important, and many ideas fail because one of those details is overlooked or does not receive enough attention. If Self Service in the retail sector is going to be spread further in the future, it is imperative to keep all these things in mind both when improving currently used systems as well as implementing new ones. While Austria is a country with a society that can be slow in terms of embracing new technology, the results gathered here suggest a general openness towards further developments. The most important part will be to create systems that are simple and can be presented and explained before use, preferably with a demonstration involving another human being.

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Appendix

Final version of the questionnaire

ID _____ Kassa / Webseite / Info Spar / Billa / andere

Fragebogen: Verwendung von „Self Service“ Technologien beim Einkaufen

Vielen Dank für Ihre Teilnahme! Dieser Fragebogen ist in insgesamt vier Abschnitte unterteilt.
Zuerst bitten wir Sie um einige Angaben zu Ihrer Person. Im Anschluss bewerten Sie unterschiedliche Eigenschaften der Technologie. Sie können dabei ohne Bedenken auch sehr schlechte oder sehr gute Bewertungen angeben!
Der dritte Abschnitt beinhaltet einige Fragen, zu denen Sie freie Antworten angeben können.
Optional gibt es noch einen weiteren Abschnitt, den Sie ausfüllen, falls Sie Systeme von unterschiedlichen Märkten getestet haben.
Anmerkung: Das Wort „System“ bezeichnet das Computersystem, welches Sie vorhergehend bedient haben.

- Alter: _____ Jahre

- Ist Ihre Muttersprache deutsch?

JA **O** NEIN **O**

- Verwenden Sie regelmäßig einen Computer (PC, Laptop, Mac, …), ein Tablet oder ein Smartphone?

Computer **O** Tablet **O** Smartphone **O** Nein **O**

- Wie schätzen Sie Ihre allgemeinen Kenntnisse bei der Verwendung der drei erwähnten oder ähnlichen Geräte ein?

Sehr schlecht						Sehr gut
1	2	3	4	5	6	7

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1) Allgemeine Bewertung

Bitte füllen Sie die nachfolgende Tabelle aus, indem Sie die Bewertung ankreuzen, die laut Ihrer Meinung zu der Aussage passt.

	STIMME GARNICHT ZU 1	**2**	**3**	**4**	**STIMME GANZ ZU 5**
Ich möchte das System häufig verwenden.					
Ich fand das System unnötig komplex.					
Ich fand das System einfach verwendbar.					
Ich benötigte die Hilfe einer Fachkraft, um das System verwenden zu können.					
Ich finde, dass die unterschiedlichen Funktionen in das System gut eingebaut sind.					
Ich fand, dass es zu viele Widersprüchlichkeiten in dem System gegeben hat.					
Die meisten Leute würden schnell lernen das System zu verwenden.					
Ich empfand die Verwendung des Systems als anstrengend.					
Ich fühlte mich bei der Verwendung des Systems sehr sicher.					
Ich musste viele Dinge lernen, bevor ich das System nutzen konnte.					

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ID _____ Kassa / Webseite / Info Spar / Billa / andere

2) Bedienung

Bitte wählen Sie bei jeder Frage eine der drei Antwortmöglichkeiten aus.

- **Die Anweisungen von dem System waren verständlich**

JA	NEIN	KEINE ANGABE
O	O	O

- **Ich musste zu viel lesen, bevor ich das System benutzen konnte**

JA	NEIN	KEINE ANGABE
O	O	O

- **Die zu jeder Zeit angezeigten Informationen waren hilfreich**

JA	NEIN	KEINE ANGABE
O	O	O

- **Die Elemente auf dem Bildschirm (Text, Symbole, etc.) waren gut lesbar**

JA	NEIN	KEINE ANGABE
O	O	O

- **Die Elemente auf dem Bildschirm (Text, Symbole, etc.) waren gut verständlich**

JA	NEIN	KEINE ANGABE
O	O	O

- **Das System reagierte manchmal auf unerwartete Weise**

JA	NEIN	KEINE ANGABE
O	O	O

- **Das System ließ sich gut bedienen**

JA	NEIN	KEINE ANGABE
O	O	O

- **Es fiel mir leicht, durch die Verwendung des Systems mein Ziel zu erreichen.**

JA	NEIN	KEINE ANGABE
O	O	O

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ID _____ Kassa / Webseite / Info Spar / Billa / andere

3) Persönliche Anmerkungen

Bitte beantworten Sie die folgenden Fragen mit einem oder mehreren Sätzen. Sie können auch Fragen unbeantwortet lassen. Sollte der Platz zum Schreiben nicht ausreichen, verwenden Sie bitte die Rückseite.

- **Was hat Ihnen am System gut gefallen?**

- **Was hat Sie bei der Verwendung des Systems gestört?**

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ID _____ Kassa / Webseite / Info Spar / Billa / andere

- **Würden Sie das System erneut verwenden? Begründen Sie bitte Ihre Antwort.**

- **Haben Sie Verbesserungsvorschläge für das System?**

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ID _____ Kassa / Webseite / Info Spar / Billa / andere

4) Vergleich unterschiedlicher Anbieter

Füllen Sie diesen Teil des Fragebogens nur dann aus, falls Sie im Zuge dieser Studie dieselbe Art von System von unterschiedlichen Anbietern getestet haben.

- **Hat Ihnen ein System besser gefallen als das andere? Begründen Sie bitte Ihre Antwort.**

_____
_____
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- **Welche Probleme sind bei der Bedienung aufgetreten?**

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Auto Ethnographic Document

Examining the Usability of Self-Service Technologies in the Retail sector

Auto-Ethnographic Analysis

Introduction

Why did I choose this topic for my master thesis? I believe it was out of my own frustration that I experienced at a "Merkur"-Supermarket, back when I first decided to try out one of those new checkouts where you do everything by yourself. While Self Service checkouts in supermarkets are not often found in Austria (while I was unable to find any official numbers about this matter, research for my master thesis has shown this to be the case), it is most likely a trend that will increase in the following years. One does not need to be a social or economic expert to realize the main reason for this: money. Having the customers deal with the checkout themselves saves cost for personnel that one would meet at a regular checkout otherwise.
Then there was the recent COVID pandemic, where everyone was urged to stay at home as much as possible to avoid contact with others (Kleine Zeitung, 2021). But how do you do your grocery shopping in such a situation? In this case, the only option for some is to order the things you need online. If these online services are not functioning properly or cannot be comprehended by a regular person either, it is going to cause severe problems.
While the general concept of self-service is not a bad thing by itself and can support many positive factors such as both location and personal independency or reducing time constraints, it is important that the technology is implemented in an understandable and – even more importantly – working fashion. Although a lot of research has been conducted about how self-service technologies need to be designed to improve general acceptance and of course, how to make them profitable for the companies that implement them (Hsieh, 2005), research shows that these requirements are not always considered (Editorial, 2021) (Lawton, 2022), leading to bad service , failed products, or other issues.
Since I have spent a lot of my free time during the last 15 years of my life trying to understand, set up, and use all kinds of technology (although I mainly had to deal with different types of personal computers), I have learned that not everyone has the same understanding of technology that I do. While this might seem obvious to some, all the stories about mainly younger people helping their elders with setting up their devices because they do not know how to do it themselves show that this remains an important and often underestimated issue. This prompted me to help others with setting up, using, and most importantly *understanding* their own technical devices as well. I find it important to specifically emphasize the point of understanding technology, as this can help with adapting to new or similar devices, or fixing errors by yourself without the need for any outside help. In turn, I also began to understand how to better see things from the perspective of people who are not very knowledgeable in the field of technology, which also plays an important role in this auto-ethnographic analysis.

In order to fix a problem, you normally need to understand why it occurs in the first place. After receiving my bachelor's degree in informatics and spending over a decade setting up and fixing different kinds of technology, I consider myself knowledgeable enough to be able to offer some solutions as well. If self-service checkouts and online shopping websites are to be

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improved in the future, it is not enough to conduct an analysis about what's wrong (which was the main point of my work with other participants), but also to offer ideas and solutions on how to make improvements. This is the main reason why I have decided to incorporate an auto-ethnographic approach into my master thesis – to combine the ability of others to identify issues that I might not be aware of with my knowledge of technology and thus how to potentially fix them.

In Austria, the two largest supermarket companies are Spar and Billa (which is part of the REWE group) (RegioData Research, 2023), which offer both the use of self-service checkouts at some locations as well as online ordering services. For this reason, these two companies have also been the main subjects of my research.

The remainder of this work consists of six sections which will be split into two different main topics: the analysis of self-service checkouts in supermarkets and online shopping services for said supermarkets. The story begins with two situations describing my first experience with the related technologies. The next step is the discussion of some experiences I have had while conduction experiments with other research participants, which in part also served as a base for planning this part of my work. Afterwards, I will continue with the explanation and results of my personal analysis. Lastly, I will list and discuss different key factors and experiences, which will then be summarized in a final conclusion.

My first experiences with self service technologies

Story 1: Using a self service checkout for the first time

I have been asking around if any of my colleagues know where to find a supermarket with a self-service checkout in my area, and after a lot of discussion, I finally managed to gather a list of some potential locations, which is about ten out of several hundred that can be found in Vienna. A bit irritating that these things are so rarely available, but oh well, one of them is only 15 minutes away. Off to an exciting adventure of scientific shopping! After picking up everything I want to buy, I am now going to try out one of those strange self-service checkouts. Doing everything by yourself sounds kind of fun, let's see if this thing works. I approach the machine with great curiosity, and I see two large storage areas on the left and right, with a computer screen and some input and output devices. I immediately assume that the screen is where you handle the checkout process, and that the devices are for inserting cash and receiving change. After all, there is no keyboard, microphone, or any buttons present, therefor it only makes sense that this is the right place to start. I look at the screen, see a large welcome message on a background image, and two buttons labelled "Start" and "I am using my own shopping bag". And so, the troubles already started before I even began using the thing. Now "Start" is obvious enough, but what does the other one mean? Great, now I am confused, I mean of course I am using my own shopping bag I'm not planning on carrying everything home by hand! Already irritated, I choose this option anyway. The display shows me a list of articles that I have scanned (or rather that I'm about to scan) and both a voice and text prompt tell me to scan my first article. I search for the barcode on my bag of chips and hold it in front of the area which looks just like the scanner that is used on regular checkouts as well. The machine beeps loudly, and I put the article on one of the storage areas in front of me. "Unexpected item in packing station. Please remove the item." Oh great what now? I just want to scan my stuff, pay, and be done with it. Now being confused, irritated *and* annoyed, I stand in front of the

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machine, contemplating what could have gone wrong. “Unexpected item in packing station. Please remove the item.” How is this unexpected? I just scanned my first article and put it in the area next to you stupid machine! As I am starting to lose my patience, an employee walks up to me and asks “What did you choose at the start?” I calmly, but still firmly respond with “use own shopping bag.” Let’s hope that at least you can help me with that thing… “Oh in that case you cannot put your stuff here, you have to pack it right after scanning.” Ah so *that’s* what that message means. Either I put all my things on the area there or pack up immediately. They certainly could have made the instructions clearer about that. Using my newfound knowledge, I now quickly and determined continue scanning item after item and choose the “pay” option afterwards. “Insert cash or choose payment method”. Finally, some clear instructions, at least this sounds simple enough… I notice a blinking light on the machine at a spot which looks like something where you could put money bills inside. I slide in a 20, the machine quickly sucks it up, whirs around for a bit, and throws out my change. A message on the screen thanks me for my purchase, and I leave with mixed feelings. Seems to work well enough once you figured it out, but without any outside help, it’s hopeless. I mean, it is a good concept, and I can see this being helpful if you are on a quick lunch break and want to buy a packed meal and a drink, but I’m not so sure if it works for larger purchases as well.

Story 2: Attempting to do my shopping online

Well now that I have decided what my master thesis is going to be about, I will also need to find some time to try out one of those online shops as well. Can’t be too hard right? I mean, I’ve heard about so many colleagues doing their shopping online during the lockdown, I think I shouldn’t have any issues either. Who knows, I might even be able to use it more efficiently than them, I mean I’m studying this kind of stuff, so I’ll give it a good thorough test run! If everything works as intended, I might actually confirm my product selection and go to pick it up somewhere nearby. After all, I live in the largest city in the country so I’m sure that delivery won’t be an issue. I open the “Billa Online Shopping” website and immediately get bombarded by advertisements moving around all over the place. Well looks like we’re off to a great, annoying start. I’m here to do some shopping, not read the newest discount catalogue or anything. Do I start my actual shopping process below that? I scroll down and – lo and behold – more advertisements. I don’t want to see advertisements I want you to tell me how to do my shopping! Then I notice a small banner on top of the webpage with different buttons “Catalogue” “Product search” “my shopping cart” and “ZIP code”. Okay this looks like what I need, why don’t they put this on the front page in giant letters instead? I guess I shouldn’t bother too much about such details already, anyway what do I want first? How about some bell peppers? I type “paprika” (that’s what we call them here in Austria) into the search bar, press “enter” and… whoa what is that? Here’s some paprika but… carrots? Chips? Mixed frozen vegetables? Looks like someone at database management needs to get a slap on the wrist. Oh well this one looks nice, amount one… oh let’s take two instead. And add to cart… perfect. At least that appears to work as intended, I wonder what kind of major problems I will run into. After all, there are always major problems with technology, especially when using it for the first time. Let’s see what they have in the overall stock view… meat… vegetables, bread… hey this is really well ordered! I continue picking up some more different items that I need while going through a few more categories. After a while, I decide to check on “my shopping cart” and notice a total cost of 21,47. Alright… let’s continue to the checkout. Huh what now nothing happened… that’s weird. Oh, hang on, some small red message has just appeared on top of the screen. What?? Minimum required amount is 40?? Well, isn’t that just great! Why doesn’t

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this stupid system tell me this in the beginning in massive red flashing letters, I mean come on seriously this is probably the most important bit of information! If I really would have needed to make that purchase now, I would be forced to add a bunch of nonsense that I don't want at all. Oh well guess I'm cancelling all this and just take the five-minute walk to the next nearby market instead. Minimum amount 40 bucks this is ridiculous I barely even go shopping for that much. Experiment over, you people have now successfully made me angry at your so-called "service", goodbye!

Summary

Both technologies that I have interacted with during these stories have one thing in common: they both work by using a visual program displayed on a screen, making sight a very important factor for successful interaction. It is therefore very important to be aware of certain rules and instincts about human behaviour in terms of appealing to our visual sense: how to catch one's focus, making certain that the presented information can be easily perceived, and let us not forget about colour blind people or those with any other visual deficiencies! Granted, the focus of this master thesis is not on Self Service Technologies design for people with certain types of impairment (as this would already require a full thesis on its own), but it is not too difficult to pay attention to some basic rules and paradigms a person would require with, say, generally bad eyesight (Julie Fraser, 2000) or a red-green colour deficiency (Alex Chaparro, 2017). Furthermore, all instructions need to be clear and easy to understand. I will continue the discussion about other key factors later in the corresponding section of this document, so let us move on now to my other observations.

Observations during the Thinking Aloud Sessions

During the first phase of collecting data for my master thesis, I have conducted several Thinking Aloud sessions with different participants. In short, the Thinking Aloud method means that during an activity a person constantly speaks what they have on their mind or what is currently going through their head. These activities are usually part of a scientific survey or experiment. One reason why this can be very beneficial for research is the fact that people often fail to recall specific situational experiences or feelings afterwards (David W. Eccles, 2017).
While I have initially attempted to recruit people of as many different age groups as possible, in the end I mostly ended up working with people aged 30 or older. But it quickly became apparent to me that age was not an important factor concerning the successful use of Self-Service Technologies (I will call them SSTs during the rest of the document).

Observations from Thinking Aloud Session at Supermarkets

After deciding a time and place, I've followed the same procedure with every participant: Let them gather all the things they want to buy, attach a microphone to them and hand them my phone to make a recording, and then have them interact with the checkout.
The first thing that caught my eye was the different levels of confidence people displayed: Unrelated of age, those who have used a checkout before were much more focused and progressed quickly. On the other hand, inexperienced users took their time, carefully read every instruction, and struggled a lot more with unexpected situations. Naturally one would consider this to be obvious, but it is important to mention because of another observation I have made in combination with the latter: People with more general technological experience

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than others struggled just the same as everybody else. This leads me to conclude that the overall design of self-service checkouts is not exactly something that many researchers would consider to be intuitive (Denis Cavallucci, 2000) (Mortensen, 2019).
I also noticed a general struggle of comprehension in the event of unexpected error messages appearing on screen. This happened mostly when either a product was not properly recognized after being placed in the checkout area (accompanied by an error message stating "unknown product in packaging area") or when a product was not recognized in the packaging area at all (accompanied with an error message saying "product has not been put down yet").
Finally, I recognized how important it is not only to add proper labels to every element of the software, but for the hardware as well. To give an example, I will explain the labelling on a checkout at a "Eurospar" Supermarket: a medium-large, white sticker about 7-8 cm in diameter is placed directly below the area with the product scanner. The number 1 is clearly visible on the sticker, along with the word "SCAN". Another sticker is present on the product storage area, this time showing the number 2 with the word "DEPOSIT". Lastly, a sticker is placed near the cash and coin slot showing – you guessed it – the number 3 and the word "PAY".
Considering the simplistic design of these visual cues, is it important to mention a few rules of basic (human) visual cognition. First, the colouring and form of the stickers makes them easily distinguishable from the machine itself, which corresponds with the basic laws of the Gestalt principles (Cherry, 2023). By law of similarity, one can quickly surmise that the three stickers somehow belong together due to having the same colour and form. Then there is the principle about the distinction between figure and ground (Interaction Design Foundation, n.d.). Were the stickers coloured similarly to the surrounding area (in this case some sort of silver-grey), it would be difficult to distinguish them, but thanks to the large difference in contrast, one can easily tell everything apart.
When these labels were present, the participants quickly managed to get the overall gist on how to work with the system. In case of missing labels, several related issues were recorded: Some participants initially put their entire shopping bag into the deposit area, others mixed up the cash input and outputs, and the entire process took much longer overall.
Finally, I would like to talk about one of the main principles of self-service in general, and how it often did not work out: independence. Independence is perhaps the most important advantage people have thanks to self-service technologies, after all it is basically in the name: self-service. However, there were many situations during our shopping sessions where it was still necessary for an employee to come over and help us out, which often took several minutes due to staff shortage. These included cases such as buying age-restricted products such as alcohol, unsolvable errors, or the machine simply forcing the participants to wait for an employee ("Examination by an employee required").
I must admit that I was quite surprised by some of the experienced I've had during this part of my observations, mostly by errors occurring which I did not consider to be possible. However, it also gave me a lot of new insight about details to look for myself during my following personal analysis.

Observations from Thinking Aloud Sessions at Onlineshops

Despite only having a total of five different participants to analyse the shopping experience of the online shopping services from supermarkets, the results have been no less educational. The procedure was similar to the one used during my analysis of the checkout systems: Set up a microphone, and let the participants do their thing. This time however, I was able to take full

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advantage of two of the achievements of SSTs: location and time independence. To conduct the sessions, all I had to do was find any place where a computer could be set up (thank you notebooks and phone-based internet hotspots!) and we were good to go.
As the first observation, I would like to talk about a severe issue that emerged during the second session with the website from the "Interspar" company: Early in the ordering process, the user is prompted to enter their ZIP code to show which products are available. However, the number of addresses where deliveries are made is surprisingly limited, and if you enter one that is not included in the list, you suddenly find only fruit and vegetable boxes for sale. Naturally, this has led to a lot of confusion even for me as the observer: whatever you do, whatever you try, nothing but fruit and vegetable boxes. As it turns out, a small error message is displayed when you type in an "unregistered" postal code, informing you that on such locations only the delivery of said boxes is available. How the programmers did not make certain that this message is impossible to be dismissed without proper acknowledgement is well beyond my limits of comprehension.
The second detail concerns the general minimum value that is required on both the "Spar" and "Billa" websites. According to the german magazine "Spiegel" from the year 2007, citizens were spending a little more than 15 Euros per purchase in a supermarket (Spiegel, 2007). Adding some inflation to this, especially from the last 5 years, let us raise that number to 25 Euros. That amount is still far below the required 40 when attempting to order a purchase from either of the two websites. Unless you wish to buy things for a longer time period or get something expensive, online shopping is clearly not an option. What's even more important however is how easily this information can be missed. During the process of choosing different products, the amount you have collected versus the required minimal amount is sometimes shown on the side of the screen, which was not noticed by nearly all participants. Like the previously mentioned observation about the vegetable boxes, it becomes apparent that vital information is not always presented in a way that is guaranteed to catch the user's attention.
Finally, I want to talk about the general design of the main pages. In accordance with research about the basics of how human vision works and how we perceive the reality around us – including information presented to us on a screen – (Rensink, 2011) it is obvious that flashy, bright, moving, colourful imagery quickly catches our attention, as well as elements directly in front of us, or at the centre of the screen. Most participants started their shopping sessions the same way: trying to navigate through the wall of advertisements they were presented with, desperately trying to find the actual product catalogue, which was hidden in an unseeming corner on top of the screen. Had the designers of the websites shifted their priorities away from what marketing believes is important towards what is important for the user, navigation would most certainly be a lot easier for everyone.

Personal analysis

As preparation of my personal analysis, I have prepared a checklist for both self service checkouts as well as shopping websites. Although this is more akin to a quantitative research approach (meaning that data is generated that can be counted and therefor mathematically processed), auto-ethnographic research results are normally of a qualitative nature (meaning that collected data often cannot be simply counted and needs to be interpreted more openly). The reason I have created such a list was to ensure that I would address all important aspects of the inspected technologies, and to create a small base analysis that I could further expand upon here. In this section, I will talk about the checkouts first, and will then continue to showcase the online services from "Spar" and "Billa" separately. The websites have also been

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inspected using the Web Content Accessibility Guidelines (or WCAG) report tool, but more on that later.

"Eurospar" Self Service Checkout

Hardware Design

In terms of hardware design, the Spar checkout designers generally did a good job. All elements are well visible, and unlike with other methods I have encountered, especially the output for the receipt cannot be missed. Furthermore, the labelling – which I have also mentioned previously – helps to quickly understand the basic process of operation. However, I have also noticed some downsides that I need to criticise as well. For starters, said labels are just stickers which have been attached to the machine. Those can be scratched off or otherwise become unreadable over time (by dirt or some funny person deciding to vandalise them out of sheer malice) and could also be slightly larger to better catch the attention of customers.
Furthermore, all inputs and outputs on the machine are labelled only with symbols without accompanying text. This can potentially cause many different issues. First, I would like to talk about differences in culture. It is well known among scientists that different cultures have different meanings for different symbols (yes that triple wording was intentional), prompting many to try and find solutions to create some sort of international standard that can be universally understood (Jari Korpi, 2010). A prime example for different cultural meanings of symbols can be given by mentioning the swastika, a symbol that is associated with fascism and racism in western cultures because of the events of World War 2, while in eastern and Asian cultures it is a very old symbol often used in religious or cultural context with overall positive meaning. Another potential issue is that people with impaired vision might have difficulties identifying symbols correctly, or people simply don't understand what the symbols mean at all! In this case, the addition of accompanying text to the pictures can easily improve the correct perception of the labelled devices, while the symbols still provide information to people who do not know the German language. Lastly, I have noticed that the cash intake and output was extremely close together on some models, which caused a lot of confusion about where the paper bills are supposed to go.

Software Design and functionality

Like all devices based on computer technology, the whole thing becomes useless if it doesn't work properly or is too difficult to understand by the intended user. As I stand in front of the Eurospar machine, I quickly noticed two things: The meaningful use of colour, and the different element sizes depending on their importance. Overall, the interface makes it easy to identify different elements on screen and the corresponding text and symbols are direct and offer a good overview. But as it is with most computer systems, this one is not without fault either. As I've decided to switch the displayed language from German to English, an error string immediately popped up on one of the buttons. Looks like quality testing failed to be thorough in this regard. The manual product search option, which often needs to be used when purchasing unpacked fruit, vegetables, or other unlabelled products, also showed two significant flaws: First, the system attempts to show too many products on one page, which leads to very small text that is even hard to read for people with regular eyesight, along with several small pictures of the products themselves. Speaking of pictures, some products do not have any visual representation at all, which can make choosing the correct item rather difficult.

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Let us now continue with my experiences in terms of the software functionality itself, and oh dear do I have a story to tell. The entire thing generally works flawlessly if you just wish to scan a few simple, pre-packaged products. Press Start, move everything over the scanner, put it into the deposit area, and pay afterwards. Efficient, quickly, and effective. But as soon as you come along with an unlabelled article or want to buy something with an age restriction, things can quickly get out of hand. The issue with age-restricted articles is that you cannot simply – as is custom with cigarette machines – put your bank card on a scanner to conduct an automatic age verification. On self-service checkouts at Spar, you always need to wait for an employee to come to you and manually confirm that you are allowed to buy this product. And seeing how understaffed some locations are, this can easily take several minutes. So much for "quick, easy, and satisfying" I suppose… Anyway another, even more severe issue I have encountered was when I simply wanted to register something from the bakery section. I open up the manual product search, type in the corresponding name, enter said product, put it into the deposit area, and what happens? The screen suddenly shows me a big error message stating "unknown article, inspection required." If a supermarket checkout system is incapable to handle its own products, something is seriously wrong. Finally, the last issue that I encountered was caused by choosing a different payment method. If you want to pay, you can enter cash, use your bank card, or choose the option "diverse". However, when choosing the latter, the system locks down completely asking for employee assistance, even denying you the option to choose something like "go back". Such deadlocks are a serious issue in all forms of computer software (and hardware as well) and one should always make certain that they cannot occur in any possible situation.
Finally, I would like to talk about discounted products. At a supermarket, there are multiple ways a product can be labelled as having a reduced price. Some discounts, such as "2 for 1" or "4 + 2", are normally handled automatically by the system itself once the required amount has been reached. Then there are products which are either close to their "Best before" date or simply do not sell, which usually receive a new price tag and barcode, which can also be scanned automatically. The third case is when you want to redeem one of the "25%" discount stickers the company hands out regularly for free. These stickers do not provide any method of being scanned by the customer (such as an extra barcode or QR code), but instead need to be manually managed by an employee, which again disturbs the concept of autonomy for self-services. However, Spar recently reacted to this issue and added an option called "25% joker", which is only activated during times where such stickers have been handed out. The first issue I immediately noticed here was the awkward naming of the option, it's not a Joker I'm not playing the lottery here, it's a normal discount! Also, in case of stickers being available but the option having been deactivated, it is still necessary to call someone over to help you out.

Billa Self-Service Checkout

I have decided to make this section significantly shorter than the previous one since most things in terms of functionality, design, and scientific principles remain the same between both manufacturers and only a few details are worth mentioning.

Hardware Design

In general, the checkout terminals at "Billa Plus" are very similar to those found at Spar, with two notable differences: First, there are no labels anywhere telling you what to do or where to put your stuff. In that case, understanding the basic operation cycle becomes a lot more

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difficult, which has also caused issues for several of my other participants. Second, the output for the receipt was sometimes hidden behind a sign or was difficult to spot in general for other reasons, leading to many people not finding it after they finished paying (and causing huge lines of printed receipts in the process). Also, everything that has labels is only labelled with symbols, which can cause the same issues about understanding as previously mentioned. Overall, there are few differences between the systems, and most of what has been mentioned before applies here again.

Software Design and functionality

In terms of Software Design, there are also some differences between the systems which caught my eye. First, as I looked at the available language options, “Billa Plus” only offers text in English and German, while Spar offers many more. Although I have been unable to test them all for correctness, I would assume that quality control has put enough effort into their job to ensure that everything works well enough. However, I also noticed some other issues, specifically at the product selection screen at the manual product search. As is the problem with Spar systems, too many different products are cramped onto a single page. This leads to another issue where product images are sometimes cut off and not fully visible. Personally, I do not understand how something as obviously erroneous as this passes through any quality inspection, but fortunately for them, I do not work at their IT management section. One final detail I want to address is that the Billa system has a lot more voice prompts than the one used by Spar, which has both advantages and disadvantages: The obvious advantage is that if you are uncertain what to do, vocal instructions can help you with understanding the situation better than written text. Apart from being a great help for people with visual issues, I have also learned during my studies that certain other impairments, such as deficiencies in intelligence, can profit from getting vocal instructions instead of just visual signals. However, one disadvantage becomes apparent after finishing the payment process: While you put your wallet back into your pocket, the machine starts ordering you to “Please take your products with you”, which is repeated every 15-20 seconds. This can become extremely annoying since packing everything up can take a lot longer than that, and nobody needs a constant reminder to take everything with you while doing so.

Online Shopping Service Analysis

To inspect both the Spar and Billa Online services myself, I have conducted a three-stage testing process. The first part was obviously to try out the shopping experience from both platforms with what can be described as a simulated purchase, with quite interesting results. Afterwards, I conducted a thorough check using the WAVE tool browser plugin, and finally, I wrote a WCAG report for both websites.
The WAVE Web Accessibility Evaluation Tool is “is developed and made available as a free community service by WebAIM at Utah State University.” (al., 2023) As browser plugin, it can be added to pretty much every commercially available Browser, such as Chromium-based software (Chrome or Edge) or Firefox. It automatically scans the structure of a website and can identify errors, give recommendations, and offer technical information about different elements which are being used.
WCAG is short for Web Content Accessibility Guidelines, developed by the World Wide Web Consortium (W3C), who have developed a vast number of global standards over the years “to help everyone build a web based on the principles of accessibility, internationalization, privacy

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and security." (World Wide Web Consortium, 2023). Since I have previously created a WCAG report during my studies, I deemed it to be a good tool to be used in my master thesis as well.

Billa Online Service

User Experience

First, I want to talk about the online service where I noticed far better functionality and less issues, which does not mean that there was nothing to complain about. In the beginning I want to mention the things that caught my eye during the test run I have conducted. Please note that this might begin to sound like me writing down a list at times, because that is actually what I am doing here. Starting on the main page, everything is filled with company ads. Discount this, our own brand that, and click here to discover our newest products. And once you decide to start climbing down that rabbit hole, you might waste more time clicking on random products than you would spend if you were just trying to get what you need. Then – if you're lucky – you might one time notice that small section on top of the screen where you can actually find the important things such as product catalogue, search bar, checkout options etc. This is what they should put first on the main page, not the advertisements. What good are advertisements if your customers are unable to properly use the system designed to purchase those advertised products?
Anyway, the product catalogue itself is something that deserves a big "thumbs up". The categories are well thought out, the listings allow for an easy overview by combining both text and images of the products, and clicking on something immediately shows you a detailed overview along with a lot of additional information. This is exactly what an item overview should look like. The only complain that I have is that the text in the category list is a bit small and will be difficult to read with poor eyesight. But at the same time, I also noticed a large downside when using the product search function, as it was also the case in my previous story experience: searching for a product gives you a lot more results than what you actually asked for. For instance, when typing in "banana", the first result I get is a fruit yoghurt, with only the second result being an actual banana. However, I can easily understand from a technical point of view where this factor comes from: When entering a search query, the entire database of product titles (and probably categories) is scanned, trying to find a match for the query you have entered. In this case, this could be anything: Banana-coloured paint, banana boat swimming pool toy, banana ice cream, etc etc. To compensate for this, many websites incorporating such a search function also include additional search filters. This is also the case here with the Billa-Website, but then the issue of visual focus comes into play again: First, your senses are overwhelmed by all the images popping up at the centre of the screen, completely shifting your focus away from the left side, where filter options can then be applied to dismiss most unwanted products. But even the filters are not without error, specifically in terms of space: All filters are divided into different subcategories, and some of those categories include so many options, that not all of them are displayed and only become visible when using a scrolling function. During my years of helping others to use technology, I have noticed that several people with little technical experience often click the scroll bars in a program with the left mouse button and move around this way, instead of using the far more comfortable scroll wheel instead. In the filter categories where scrolling becomes necessary, a small light grey bar only becomes visible when hovering the cursor over the options, which is a visual effect that I can see as being easily misunderstood or disregarded by many users, thinking that it is just some sort of indicator about your current point of focus.

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Moving back to general website overview and layout, the presentation of important information could use some reworking as well. If you want to know more about Frequently Asked Questions, legal notes or require support, you must scroll through aaalll the advertisements and aaalll other things as well before you finally get presented with what you are looking for. It would only require adding some sort of button on top of the website or a list which allows you to jump to those categories instantly. Once again I can understand that the company wants you to see everything they offer, but functionality still should remain the higher priority.
Finally, I want to close this section by talking about two problems which are exclusive to the Billa Online Service: The first one can be found when attempting to set your delivery address. Should you make a mistake during the typing process and then continue with your purchase, you are presented with a form where you need to enter your name, an email address etc etc. However, since you already entered a delivery address, this field is already filled out, and the huge problem here is that you cannot edit it again to correct any errors which might have occurred. What's worse is that the "return" button on the bottom left of the screen is barely noticeable, only becomes visible when scrolling down, and is labelled as "edit cart" instead. I would highly recommend solving this issue since two of my five online participants almost threw their computer out of the window after being confronted with this situation (they would never have figured it out without my assistance either).
The second exclusive problem comes with a feature that Billa has implemented specifically for their own online service, and how this managed to pass quality control is beyond me. If you scroll down the main page, you find a feature titled "comfortable shopping". The idea is that you create a list of search queries for products you wish to purchase, press "display products" once, and then be presented with multiple search results at once. A useful feature in theory, except that it is completely broken and in fact does not work at all. Half of the actual product catalogue is ignored when displaying the search results, IF anything is displayed at all, after adding or removing one of the list items everything gets scrambled up with products being all over the place except where they are supposed to be. I was actually so baffled by how bad this feature is implemented that I feel like it is my duty to let others know about it to make certain that they won't make the same mistake ever again.

WAVE Tool Test

There is not much to say about the WAVE Tool test. It was conducted to see whether there are any serious technical issues present – especially in terms of accessibility! - and for the Billa Website, this was not the case. The result of a WAVE Tool scan is divided into six main categories:

- Errors, which are things such as an image without alternative text description, a field you can fill out without any description about its purpose, links without any text explaining the purpose etc.
- Alerts, which are often recommendations, such as a link being displayed multiple times, very small text, suspicious (as in: most likely difficult to understand) alternative text for elements etc.
- Structural elements, which, well, shows possible issues with the elemental structure of the current webpage. These issues, however, usually are noticed only when using special technology for people with disabilities, such as screen readers, or when attempting to navigate through a website with a keyboard only.
- Contrast errors, and I believe that the name speaks for itself here.

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- Features, which offers several recommendations about using implemented features correctly. For instance: if an image is used as a link to a different part of the webpage, the feature list reminds you to ensure that any alternative text for the image can still explain to the user what the object does.
- ARIA, which just lists any ARIA elements present on the webpage. In short: "Accessible Rich Internet Applications (ARIA) is a set of roles and attributes that define ways to make web content and web applications (especially those developed with JavaScript) more accessible to people with disabilities." (MDN Web Contributors, 2023)

Overall, the BILLA website only includes a small number of errors, and most of them are not really THAT severe, such as colouring errors in terms of contrast which mostly occur when small elements are present, such as a grey exclamation mark on a white background. Or an empty form label error, which is not really an error in terms of functionality since the error points to one of the filter elements which are supposed to be empty anyway until they are selected.
The tool has also reported some redundant links being present, but I fail to see how that is an issue. For instance, consider that you are reading a large article about a company on their own website, and inside that article, you have the sentence "Get more information by reading our FAQ", with the word FAQ functioning as a link. At the same time, you also have a link to the FAQ at the bottom of the page in the footer area. This would be identified as a redundant link, while it actually makes sense to do this in that specific context.
I want to talk about small text errors specifically because it reminded me of technically unskilled users. If you are a user that is aware of the option to enlarge a website dynamically, you can simply use this feature to compensate. For someone who doesn't know how to do this on the other hand, this can cause severe problems when they are unable to read the text on the screen. That is something that should always be kept in mind when it comes to designing a website. In conclusion, the BILLA website is in a good state, with its main issues being small text and contrast errors.

WCAG Report

I have decided to conduct my report for the currently available version 2.1 of the accessibility guidelines. Furthermore, I have chosen the second conformity level AA (among A or AAA). It basically means that moderate accessibility checks are conducted, but if you wish to know the difference between these three levels, you can read about it in the WCAG information catalogue. (Web Content Accessibility Guidelines Working Group, 2008). Overall, you are invited to look around in their catalogues and documents if you wish to learn more about accessibility on the internet.
In total, I have investigated four different webpages of the Billa Online shop, which were all tested using the AA level success criteria. There are 50 criteria in total, which are divided into 4 main categories with several sub-categories. In conclusion, I have identified 34 criteria that the website has passed, three that it failed, four where I was unable to tell whether the requirement was fulfilled (for example when you need to test the compatibility towards a screen reader, which I do not have direct access to), and nine where the corresponding technology or features were not present (such as queries about audio or video elements). Personally, I'd say that passing 68% of the requirements – or 86 % if we include the "non present" score, is a good result for a regular website.

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Spar Online Website

Since I have already explained many expressions, methods, and technologies in the previous section, this one will contain a lot less text in the latter segments. But beware, what follows is a tale of great surprise, shock, and confusion that shall serve as a warning for all others to come.

User Experience

At the starting page, the Spar Shopping Website looks quite similar to the one from Billa: moving advertisements all the way, small category list on top, and FAQ etc at the bottom in small print. Something that I would consider a downgrade here is that, unlike the way it is on the Billa website, there is no pause button which allows you to stop these annoying ads moving around all the time. Also, speaking of FAQ and small print, while investigating the website's functionality, I clicked on the question "Delivery Area" and could not believe my eyes. The section consists of a row of questions asking "Where do we deliver at…", which is then followed by an unordered, small printed messy heap of unsorted postal codes! It is way beyond my personal comprehensive abilities to understand how something this amateurish was ever approved in the first place. The other FAQ entries – apart from being written in extremely small print – offer good information, but seeing how this is the first category in the list, it makes for a rather questionable first impression.
Let's continue with the second entry in a long line of severe issues: The delivery menu. As soon as you wish to pick your first product, you are prompted by the website to enter your ZIP code first. If you do that, confirm your choice, and open said menu again, you are forced to do it all over again from the start, as the information you gave already is being ignored. This is the first problem. The second problem is the pickup options menu. No matter which address you enter, you are always presented with the same pickup choices, which is only about ten options for all of Austria. The fact that a) the system does not filter out the results to show only locations nearby and b) there are only so little pickup stations available while there are much more Spar supermarkets in Austria makes you wonder again how something as dysfunctional as that ever got approved. But wait, there's more! If you decided to live in a place not included in the list available in the FAQ and then choose "package delivery", you will quickly notice that the entire product catalogue has been transformed into a handful vegetable and fruit boxes. And in case you did not read the very subtle, small red text that appeared just before you hit "confirm", you didn't realize that this is all they are "currently" offering for everybody in those areas, with "currently" being the status quo for months, if not years.
It gets even better if you got caught in their box trap and then click on one of their own advertisements for the official "Spar" home brands. "Your search for ''*'' yielded no results". That's it. That is what you are presented with as a person who just wanted to do some quick online shopping.
Anyway, assuming that you entered one of the locations they decided to include in their messy list of delivery areas, things are very similar to Billa. Product search, filters, text and images, it's all there. But only if you type in specific search queries (or use the catalogue). For instance, entering the search query "beer crate" resulted in a presentation of water colours for children, children's games, and a bunch of other things, but nothing even remotely similar to a "beer crate". Apparently whatever search query they are using to check their database needs some serious improvement. I also noticed that Spar offers about 20% of the product information

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Billa does: Barely any detailed description, no special recommendations, and nutritional facts only for a few select products. Improvement in this regard is strongly recommended.
Continuing the list of issues, if one scrolls through some of the catalogue entries, especially things that go bad easily such as fresh meat, a lot of 🚫 symbols can be seen next to several products. If you try to click on it, nothing happens, if you want to know what it means, you receive no information at all, just a static 🚫 preventing you to click on the product. Only if you select the product name or image to open the detailed description, you will notice a message stating "not available". But that is not the only problem I noticed in the product list. Let's say for example that you have the product labelled "organic chicken breast 1kg". You click on "add to cart", finish your purchase, and once the delivery arrives, you receive 400g of chicken. So what happened? The answer is in the small light grey text field left of the "add to cart" symbol, which in this case is normally set to 400g, allowing you to choose other options depending on the product. This demonstrates once again the importance of proper visual design and focus: If a user were to click on a product and would then be presented with a large pop-up window, or at least an arrow or some other form of highlight pointing out the possible selection of the desired amount, accidents like this would most likely not happen.
After fighting myself through all these issues that I've mentioned previously, I finally arrive at the checkout menu. Here I notice one advantage Spar has over Billa: You are not forced to create a user account to place an order. But the delivery form itself also shows a lot of visual issues that we've already experienced: Light grey text on a white background, small font, and buttons or other elements that are not highlighted in any noticeable way. In conclusion, all I can say about the SPAR Website is that it is a giant mess that requires a lot of improvement and reworking if they expect people to use it on a regular basis.

WAVE Tool Test

I also used the WAVE tool on the Spar website searching for any issues worth mentioning, and I would dare to say that I received far more than I bargained for. The main page alone already contained more errors and alerts than the entirety of all pages I tested at Billa combined. The issues ranged over everything from empty buttons and missing form labels, missing alternative text, literally a hundred redundant links, and many more. The list of errors even included 29 broken ARIA references, meaning that someone at the IT department should definitely get fired for allowing broken code to be published. What surprised me however was that the WAVE tool appears to have problems with identifying low contrast when it comes to text. After all, the FAQ includes a lot of tiny letters on a white background, which can become very difficult to identify if one has poor eyesight. I believe that something like this should also be pointed out as a low contrast error, just like the many instances of light grey symbols on a white background that were identified.
In conclusion, the Spar Online Website can be considered a completely broken technological mess that should be completely reworked from scratch to improve both the usability as well as to reduce the amount of technical issues.

WCAG Report

If you read through the rest of the report so far, you would probably assume that the WCAG result for Spar is also going to be worse than the score that Billa has received. And of course, you are correct. I have conducted the same test for guidelines 2.1 with conformity level AA, and out of the 50 requirements I inspected, 13 have outright failed, compared to Billa which

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only received three failures in total. Only 24 criteria received a “passed”, along with – same as before – four instances of “cannot” tell and nine instances of “not present”. This results in only 48 % of passed requirements, or 66 % when including the non-present elements, which is still less than Billa scored initially. This result demonstrates once again the issues that the Spar website has and validates the assumption that the entire service is currently in a very bad state.

Key findings of the Auto-Ethnographic Approach

If someone wants to know more about human behaviour in general, it is not enough to just follow numbers, you also need to find out about the little details to understand the reasoning behind it. In this case, qualitative research methods such as my auto-ethnographic approach here are a useful technique to gather results. I will now list every section of this document again and demonstrate which specific key points were discovered during each part of the analysis.

Personal experiences

There are three key factors that I wish to review from the personal experiences that I had during my test of both self-service systems. First, let’s talk about how I struggled with understanding the basic functionality of the self-checkout, which can also be applied to the online services. The situation could be greatly improved if a company implementing such a service would also add some sort of manual that customers can read to better understand how to operate the thing. I could imagine a lot more people trying out self-service technologies if someone (or something) would explain to them how they work in advance.
The second aspect is how you often require assistance from an employee to handle specific situation. As I’ve mentioned earlier, one of the core values of self-service technologies is independence. But if you need the assistance of another person to complete a task, that independence is taken away from you, and customers still have to depend on others. Situations such as this clearly show that self-service in the retail sector still requires a lot of optimizations to become a technology that can truly be used by yourself autonomously.
Finally, I want to emphasize the importance of visual perception again. Self-service technologies are a combination of a big machine and a computer screen. If a person takes a quick look at it, it should be possible to already notice all the most important parts in a few seconds. In addition, the focus should always be kept on important elements by a corresponding use of colour or object positioning to guide the customer through the process.

Observations of others

The Thinking Aloud approach has brought up further key points that need to be considered during the design process of SSTs. Let us look at experience first. While it is often proven that demographic factors such as age can have a significant effect on the successful use and adoption of technologies (Zoe Roupa, 2010) (Chiara Leonardi, 2008), I was unable to identify any significance of such variables during the sessions I have conducted. Both younger and older participants struggled the same, regardless of their overall technological aptitude. Instead, those who have already used SSTs before had a much easier time working with them and successfully reaching their goal.

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Second, it quickly became clear that providing clear, helpful instructions strongly influences the required time and success rate significantly. Many participants got stuck and confused when they were presented with information missing clear context or when additional information was absent. A good example for this is the "employee assistance required" message that is often displayed on self service checkouts. It can appear when someone is purchasing age-restricted products, or something without a barcode (in which case someone needs to check if you have actually entered the correct product). It would greatly improve the understanding of customers if an explanation about why assistance is required would be added to the message itself.
Finally, many participants mentioned that they feel rushed during the overall experience, especially when using Billa checkouts, where the machine constantly reminds the customer to pack up all products after paying. Another situation where this occurs unfolds during times where many customers are waiting in line behind you. Since you are the person who needs to take care of the entire checkout process (compared to an employee sitting there), you have a feeling of responsibility to not hinder other customers. This can greatly increase your emotional stress level, which may lead to mistakes while scanning your products, or breaking something when packing everything up because you want to hurry for the sake of others.

Conclusion

Auto-Ethnography as a valid research method often struggles with questions concerning validity, the author's identity, and overall scepticism (Forber-Pratt, 2015) (Jacquelyn Allen-Collinson, 2008). However, after finishing this document I feel confident enough to argue that this method has most definitely earned its rightful place within the scientific community and can be used to generate valid and meaningful results. As this has also been my first use of this method for research purposes, it was an interesting overall experience not only for my master thesis, but for any future endeavours I might undertake as well. Examining something from your own point of view can help you notice small, yet meaningful details that would otherwise stay in the dark and might cause problems later.
If my report has managed to keep you interested enough to continue reading until the end, I am happy to have achieved both my goals of telling an interesting story on one side and sharing useful information with others on the other. As you can probably tell by now, self service in retail for everyday life products are still struggling a lot to gain acceptance here in Austria, but I guess we are that kind of people who are slow to embrace new ideas in some cases. But clearly it is not just the target group who are to blame: some cases that I've previously mentioned about features that are simply broken show that the companies themselves and especially their quality control and testing departments are to blame as well. Here's to hoping that someone working there is going to read this after publication!
In conclusion, I think that self-service technologies for the retail sector are generally a good idea, but a little bit of a human element will always be necessary until every single aspect has been taken over by computers, and personally I do not wish for that day to arrive any time soon. Social interaction has been part of the human shopping experience for thousands of years after all. Marketplaces where people from different villages get together, vendors using creative ideas to get you to go shopping specifically at their place, and regular customers that over time might even become friends. I do not believe that it will do humanity any good if all this were ever replaced by a cold, sterile, robotic environment, but it would definitely be helpful as a substitute option. All it takes is a few improvements in the most problematic areas

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mentioned here, and I am certain that SSTs will not only become more accepted and used but will also be seen as a helpful addition to our overall shopping experience.

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