Exploring technology acceptance aspects of an NFC enabled mobile shopping system: Perceptions of German grocery consumers

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Contents

List of Figures

List of Tables

List of Abbreviations

AUT	Auckland University of Technology
AUTEC	Auckland University of Technology Ethics Committee
CEO	chief executive officer
EPC	electronic product code
GPS	Global positioning system
I1	Interview or interviewee one
I2	Interview or interviewee two
I3	Interview or interviewee three
I4	Interview or interviewee four
I5	Interview or interviewee five
NFC	Near field communication
OS	operating system
RFID	Radio frequency identification
RIM	Research in Motion
SKU	stock-keeping unit

Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning."

Erik Bast

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AUTEC ethics application

Auckland University of Technology Ethics Committee (AUTEC) approved the interview design under code **10/119 NFC mobile value added services on grocery environments** on 05/07/2010. A copy of the approval is available in the appendix section F.2 starting on page 176.

The participant information sheet, which informs the interviewees about the research is attached in the appendix section F.2 starting on page 176.

A template of the consent form, which all interviewees have to sign prior to the interview is attached in the appendix section F.2 starting on page 176.

An interview protocol is described in section F.1 on page 169.

A copy of the full ethics application can be obtained from the researcher. Complete consent forms signed by the interviewees are stored in a secure cabin in AUT building WT310. Interview data is stored in AUT building WT101A. Both are stored for a minimum time of six years.

Abstract

It is envisaged that with the increasing radio frequency identification (RFID) penetration along the grocery supply chain, a Near Field Communication (NFC) mobile shopping assistant is highly likely to be developed. Such a device would provide the customer with product specific information at the point of shopping. In order to investigate different aspects of this possibility, several potential users were interviewed after they had some familiarisation with a prototype smartphone-based application. Benefits, issues and challenges were identified.

The benefits were: customers can read information of products they are already familiar with; certain information types were easier to read compared to traditional labels; and, additional information supported product selection.

The issues were: security vulnerabilities because the technologies (smartphone, RFID, background systems and databases) exposed the customer to threats to their personal data; the increased public use of expensive smartphones could attract thieves; and, the short life of a smartphone battery and interference of phonecalls.

The challenges were: balancing desired variety and amount of grocery product information in contrast to easy to use software; and, balancing the costs for the service, device, information and support without charging the customer too high usage fees. Personalized advertisements were suggested to subsidise the cost but the customer behaviour profiling would be an additional threat to privacy.

Development of some types of NFC mobile shopping assistant would seem inevitable. This research has revealed that developers and owners of such a technology will need to be alert to the issues and challenges identified in this research. Future research of user behaviour and preferences across different cultures, age groups and user types would assist further progress.

1 Introduction

1.1. Introduction and background information

Smartphones are cell phones with more storage capacity, faster processors and additional features, which effectively transform a cell phone into a portable mini computer that can also be used for making phone calls. Smartphone sales have been growing, whereas sell figures for conventional cell phones are decreasing. The latest statistics indicates that 19% of global mobile phone sales belong to smartphones and 81% belong to cell phones[1]. For 2014 Gartner[2] forcasts a total of 875.573m smartphone sales[2]. Compared to 2009 this means a five year growth of approximitly 500%[2]. In addition, smartphones become more powerfull and are equiped with more features in every new generation.

Smartphone users can install and use additional software, which is not necessarily provided by the smartphone manufacturer or network provider anymore. Independent third parties can develop software for smartphones and distribute them via different channels. The increase of user demand and the freedom and flexibility of software developers creates a high number and variety of available applications for smartphones[3, 4, 5].

There are various types of smartphone software applications available: games, entertainment software, dictionaries, map applications, communication software and so forth. Depending on the actual software, various smartphone features[3] are used. For example, the smartphone's current position is required for navigation applications. The position information comes from the GPS sensor as well as the 3G network. Network connection is one of the most used smartphone features, as it enables com-

[1] See section B.1 on page 148 and B.2 on page 151 for detailed information.
[2] "Gartner, Inc is the world's leading information technology research and advisort company."[1]
[3] camera, location sensor (GPS), network connection (3G, WiFi, Bluetooth), microphone, keyboard or touch screen

munication from and to the smartphone over the internet. Sending and receiving emails and browsing the web were among the first applications for smartphones. Web browsing allows access to any information on the internet that is available. A recent trend in the field of smartphone applications is to have smaller and more specific applications. Instead of using the smartphone's web browser to retrieve weather forecast or to read the news, highly customised applications designed for a single purpose are emerging. That means weather and news information are provided by different applications. That brings the advantage of optimising applications for a specific single purpose, instead of general all-in-one solutions.

Specific purpose optimised applications can also make better use of the smartphone's features. Every new smartphone feature creates new application areas for software. For example, locations sensors, such as the GPS sensor, are used to determine the current position on the globe. The location information is used for navigation purposes. Gravity sensors that have emerged recently allow to determine the device's acceleration in a 3D space. This information allows to determine the device angle and position in the user's hand as well as speed and direction of movement. The information can be used for controlling games or for user interaction with the smartphone.

A smartphone feature that has been trialed over the last few years and is about to penetrate on the market in the very near future is near field communication (NFC). NFC is based on radio frequency identification (RFID) technology. RFID is based on electromagnetic wireless communication, usually with an active battery-operated reader and passive tags. The tags themselves do not have an independent power supply and usually receive power through the electromagnetic field of the reader[6]. A solution that has an RFID reader built into a mobile phone is refered to as NFC mobile phone (or NFC smartphone, depending on the type of mobile phone). In the case of the NFC mobile phone, the built in RFID reader powers and reads the RFID tags (also referred to as NFC tags). The RFID reader also passes the obtained information directly on to the mobile phone. NFC also allows multiple operation modes[4]. NFC smartphones can be used for many different purposes and application areas. Most common and popular are mobile ticketing and mobile payment solutions. The RFID reader built into a mobile phone can be regarded as another feature, similar to GPS or gravity sensors. Consequently, different independent software applications can access the built-in RFID reader and use the obtained information[7, 8, 9, 10, 11]. The various software applications would be specially tailored for a particular purpose and application area. The infrastructure of an NFC mobile phone solution and the environment (RFID tag standard, RFID reader in smartphone) is the same across various applications areas. Hence, every user's NFC smartphone

[4]See section 2.2.3 for further details.

can be used for various independent NFC applications. Being able to use a single NFC smartphone for multiple application areas is one of NFC key advantages. In addition, both mobile phones and, increasingly, smartphones become more present in the daily life.

The first NFC applications and projects were prototypes, research studies or feasibility studies. The studies and projects had to use very basic prototype smartphones, because a mass market did not exist. At the beginning of the Deutsche Bahn's Touch & Travel project, a Motorola L7 was used[12]. Touch & Access[7], Touch & Interact[8], Touch & Share[9], NFC office workflow[10] and the mobile sales assistant[11] used the Nokia 6131 NFC. Other mobile phone manufacturer such as Samsung, Benq or Sagem offer NFC enabled phones as well. All of the NFC enabled phones mentioned above were mainly used for prototype projects, research projects or trials. The mobile phones were not easily available to the mass customers through the usual channels. By the time of conducting and writing this study, the Nokia NFC software development kit was the only available and fully functional development platform for a comprehensive prototype solution. Furthermore, three different Nokia NFC enabled mobile phones are available. Nokia's second NFC mobile phone, the Nokia 6131 NFC has been widely used in the research community for the purpose of developing prototype solutions[7, 8, 9, 10, 11]. One of Nokia's current consumer market smartphones, the Nokia C7, has NFC capabilities built-in. The NFC capabilities will be activated with an operating system update in early 2011[13]. Google's former CEO Eric Schmidt announced that the next Google Nexus S smartphone will have NFC capabilities[14]. Google Android (Google's smartphone operating system) in its latest public release version already contains NFC features that can be used by developers in future project and with suitable future NFC smartphones[15].

The two NFC smartphone examples (Nokia C7 and Google Nexus S) are not predominantly intended for a small developer, researcher and prototype community, as the first existing NFC devices were. They are intended for the wider and growing market of normal smartphone user. Nokia and Google will be a strong NFC smartphone force. In particular Nokia's NFC experience and the already existing developer tools to implement NFC software for Nokia, which the research community and professionals have been testing and actively using for the past two to three years. Also, Google Android's strong market growth[5], high market shares and the growing developer community create a powerful force of users and developers to push technology further into the mass market.

An increasing number of available NFC smartphones make the technology more attractive for other businesses and third party software developers. A growing num-

[5] (See appendix section B.2 on page 151)

ber of users and customers are going to be able to use NFC applications in stores or other environments. The store owners would only need to set up RFID/NFC tags and provide the software. In contrast, the first major NFC project in Germany, which was initiated by Deutsch Bahn, had to provide the full infrastructure to their users. Besides RFID tags and software, the smartphones also had to be given to the users. Deutsche Bahn was also among the first in the German market that utilised the NFC ticketing infrastructure for an NFC side project, which showed that a single NFC smartphone and infrastructure could successfully be used for various NFC applications.

An environment where part of the NFC/RFID infrastructure already exists or where the infrastructure is about to be implemented provides other parties the opportunity to join in and decrease the initial infrastructure costs. Environments that already use RFID technology are logistics, transportation and retail[16, 6]. RFID is used to support tracking and tracing of movable goods. Also, in retail stores RFID supports theft prevention, customer loyalty cards, shopping cart tracking, special customer information shelves, customer recommendation and payment[16, 6].

Even without existing NFC applications, retail stores already provide a great share of the required RFID infrastructure. In addition, there is an increasing number of emerging powerful NFC smartphones (e.g. Google Android Nexus S, Nokia C7), which are independent and can be used for any NFC project. Hence, major parts of the RFID and NFC infrastructure already exist or, in the case of new NFC smartphones is about to be available. As a result, the only major work that is required in order to use NFC in the retail environment is the NFC software application for the particular applications area.

An NFC software application for the retail environment has been developed by Resatsch et al.[11]. Their mobile sales assistant is used by the employees of clothing retail stores to check stock availability and to provide alternative sizes and product combinations. A similar application was developed by Kowatsch and Maass[17]. Their applications provide the customer of electronic retail with additional information and recommendations about products. In both cases the product identification was achieved with high frequency RFID tags. They operate on 13.56MHz, comply with ISO14443A and ISO14443B standards and can be read with NFC smartphones. Resatsch et al.'s application is only intended for store employees and not for customers. However, the latest development in equipping smartphones with NFC capability targets a wide range of users and not only a small group of specialised sales personnel. Hence, looking at application areas where the customer of a retail environment can actively use the NFC smartphone is more suitable for future realistic applications of NFC.

Within the retail environment and with the aim of focusing on the customer side of using NFC, the grocery store environment is particularly interesting for a number of reasons. First, the majority of products offered in grocery stores (supermarkets) are the same across all stores. Second, same products in different stores have the same barcode, which is used for identification at the checkout. Store independent products and product identification make it easier to develop a store independent software solution, because particular support from the stores[6] is not required. Third, the number of different products is high, therefore the software solution can be used for many products and consequently reach a wider user group. Fourth, currently barcodes are the main source of computer aided product identification in grocery environments (e.g during check out). However, RFID is already widely used along the product supply chain for tracking and tracing of products[16, 6]. Large, global retailers such as US Wal-Mart[18, 19] and German Metro[20, 21, 22] are using RFID extensively. Metro even set up two stores where different application areas of RFID inside the store (on the sales floor) are explored and tested[23]. RFID application areas on the sales floor include RFID equipped shopping carts, interactive terminals, automatic check out systems or automatic stock control[23, 24].

It appears that grocery stores (including supermarkets) are promising NFC application areas. One of NFC's key application area, mobile payment, has already been implemented, tested and trialed[25]. Mobile payment can be adopted in grocery stores very well, as it enhances the idea of self-checkout. Other NFC application areas that make use of the RFID infrastructure are likely to follow. Future NFC in store application areas can be driven by the grocery stores to make more use of RFID infrastructure and promote their store. Future NFC in store application can also be driven by the customer demand to utilize the existing technology (NFC smartphones) or to obtain better services.

The next section outlines an NFC smartphone solution for the retail grocery environment and how this solution provides benefits for the customers.

1.2. Motivation

An NFC smartphone solution for customers in the grocery environment can be a NFC mobile shopping assistant. An NFC mobile shopping assistant is a smartphone solution, which provides the user (customer) with additional food product information, makes existing food product information more readable and understandable and includes additional sources to ensure a higher information correctness. An NFC mobile shopping assistant uses the smartphone's NFC technology and RFID tags on

[6] Particular support from the store could be access to store specific product databases.

products for product identification.

Within this study, the NFC mobile shopping assistant is seen as a representative of future NFC smartphone applications in other areas. The grocery retail environment has been chosen because RFID has already a relatively high penetration in this environment. One of NFC's key application areas, mobile payment, is also feasible in the grocery retail environment[25, 26]. The grocery retail environment is very customer centered and affects a large number of people. Therefore, the grocery retail environment is likely to host one of the next NFC application areas.

In addition, food product information written on the product labels was found to be very difficult to read[27], difficult to understand[28] and in some cases even wrong[29] and misleading[29]. An NFC mobile shopping assistant can improve those issues, as outlined in section 2.2 commencing on page 11. Furthermore, to improve food labeling issues, an NFC mobile shopping assistant could assist customers with choosing healthier food products, getting recipes and ingredient lists, the history of certain products (meat, fish vegetables) or an extended ingredients list for prepared food all during the actual shopping and just on time.

Providing additional information at the time of shopping adds benefits to customers, because alternatives would be preliminary research in online databases, on the internet, in literature, in recipe books etc. This would mean that the customer needs to make a list with products and types of information prior to the actual shopping session. Once the customer is in the store, changes or additions to the initial research would be difficult to realize, although not impossible since regular smartphones (non NFC smartphones) with internet access could be used to do this research for particular products and information types during the shopping session. In this case the smartphone's browser or a special application could be utilised. Nevertheless, the particular product identification is difficult, as the total number of available products is very large and variations among similar products are wide. Consequently, choosing the right product from a long list is a difficult task, especially with limited time during shopping and the limited smartphone capabilities (screen size, input options etc.) compared to a stationary computer. A solution to make the product identification easier, quicker and more reliable could be the utilisation of the smartphone's features, such as the microphone for voice recognition or the camera for barcode scanning.

Voice recognition faces a number of challenges, such as background noise, unclear pronunciation of product name, type, brand, size etc. In contrast, barcode scanning has fewer challenges. Barcode scanning utilized the smartphone's camera to take a picture of the products barcode. The barcode identifies every product on a stock-keeping unit (SKU) base, which enables a high level of product iden-

tification. A smartphone software solution that identifies food products based on the SKU level barcode already exists. The "das ist drin Scanner"[30] is a German smartphone software application that has been developed for Google Android and Apple iPhone operating systems and provides the user (customer) with basic food product information, an indication of healthiness and the ingredients. The "das ist drin Scanner" provides a subset of information that the NFC mobile shopping assistant could also provide. The "das ist drin Scanner" can only provide more general information about products, as the identification is based on SKU. That means different production batches, production places, production time frames of the same product cannot be distinguished, because commonly used barcodes do not allow a more granular product identification.

O'Neil et al.[31] compared the user's performance with barcode identification and with NFC identification. They found that untrained participants were quicker with barcodes, but trained participants "significantly improved [the] users' performance with NFC"[31, p. 19]. The NFC mobile shopping assistant is seen as an addition to existing NFC applications to make use of the NFC capability of future smartphones. Therefore, it can be assumed that the owners of NFC smartphones are more familiar (trained) with NFC identification and can achieve better performance. In addition to improved performance, the NFC identification also enables product identification beyond the SKU base, as the combination of RFID tags and the electronic product code (EPC) is emerging. Subsection 2.2.2 commencing on page 14 provides further explanation of item-level tagging, RFID and EPC.

It can be summarized that a NFC mobile shopping assistant can provide various food product information during the shopping session and, in addition, speeds up the product identification. The NFC mobile shopping assistant represents an example of extended usage of NFC and RFID infrastructure by providing useful application areas to users via their personal smartphones.

Besides customers who will benefit from easier access to more useful food product information, there are also other groups that would benefit from this research. Practitioners, may it be grocery corporations, RFID/NFC experts or mobile software developer can gain insights for future NFC projects. The researcher community has benefits as well. As outlined in section 3.3 on page 38, the research method used for this research follows Sun and Zhang's[32] recommendation to apply the technology acceptance model (TAM) in a qualitative direction. Hence, the wider research community is provided with a research output that directly relates to Sun and Zhang by exploring an emerging and exciting technology.

From the researcher's personal perspective, the motivation to plan and conduct this research is based on a three and a half year experience in developing smartphone

software applications in various contexts. The researcher is increasingly interested what users (customers) think about emerging technologies in order to advance the researcher's understanding and to improve design specifications and software implementations of future professional mobile software projects. Further details about the researcher's perspective are provided in section 4.2 on page 61.

1.3. Research Problem

The research problem is that a solution such as a NFC mobile shopping assistant has not been investigated yet. A number of the NFC mobile shopping assistant's benefits, such as quicker product identification, information access during the shopping session, better readability of product label information, more accurate information or provision of additional information have been introduced and outlined in the previous two sections. Those may not be the only benefits of an NFC mobile shopping assistant. Hence, it is desired to identify possible additional benefits but more importantly to identify issues and challenges that could influence negatively the user acceptance of a NFC mobile shopping assistant.

1.4. Scope

The scope of this study covers the user's (customer, consumer, shopper) perception only. Perceptions of grocery store employees, grocery store owners, software developer or similar groups are out of scope. Consumer behaviour aspects are excluded too.

Only benefits, challenges and issues that influence the technology acceptance from a user perspective are under investigation. Acceptance is in focus because the investigated technology solution (NFC mobile shopping assistant) is not in use yet in the grocery store environment. Furthermore, there is not much research in this specific field. From a technology perspective, an NFC mobile shopping assistant can be developed and implemented, but it is unknow whether users would accept it and to what extend certain issues and challenges would influence that. Hence, the level of the user's acceptance and in particular focusing on issues, challenges as well as benefits would contribute to the progress and development of real grocery store environment solutions.

The researcher's understanding of benefits, issues and challenges is outlined below.

Benefit refers to everything that provides the user with an additional advantage

or improves an existing circumstance.

Issue refers to everything that has a negative influence or is regarded as negative. The influence can be direct or indirect. Benefit is the opposite to issue.

Challenge refers to a complex set of mostly issues but also benefits, which are related and influence each other. For example, the effect of a very stable, good, feature-rich software that has no bugs is positive and hence a benefit. In reality, such software is very costly to produce and development takes more time. Price and time are issues. The challenge lies in balancing limited resources (time and money) and the desire to produce the best software. The result of a challenge can be regarded as a trade-off.

In the field of the investigated technology (NFC mobile shopping assistant), all aspects related to how the actual food product information is created, updated, verified, stored and provided are out of scope. The researcher assumes that there are databases which the customer can access. The databases can be directly filled with information form the food product producers, by other members of the food supply chain or by independent authorities and organizations. Out of scope is also how the food product information provider and grocery store owner, manager and employees work and influence the technology.

This study focuses only on grocery stores and supermarkets which predominantly sell grocery articles. Appendix section C.1 on page 154 contains a brief overview of certain grocery and supermarket categories specific to the German market.

1.5. Thesis structure

This theis is structured as follows. An introduction is given in chapter 1 by providing the reader with background information, the researcher's motivation, the research problem and the consequent scope that frames the research.

Chapter 2 provides the reader with an extensive discussion of relevant literature. Section 2.2 focuses on RFID and RFID enabled smartphones. Section 2.3 discusses literature and research in the field of TAM. At the end the research questions is stated in section 2.4 on page 36.

The methodology chapter 3 describes the selected research methodology and justifies its suitability. The research approach is explained in section 3.2, while the research method, the research design, the data analysis method are outlined in sections 3.3, 3.4, 3.5 respectively. Finally, the trustworthiness criteria (reliability and

validity) are discussed in section 3.6.

Chapter 4 covers the researcher's personal perspective in section 4.2 and describes the interview data collection in section 4.3. Finally, the data analysis is conducted and documented in section 4.4.

Chapter 5 presents the analysed data in two ways. First, section 5.2 describes how a concept is created from the data. The concept is then used in section 5.3 to guide the full data report.

Chapter 6 discusses the findings of the research and links them back to the literature review and existing research.

Chapter 7 answers the research question in section 7.2, presents implications for various groups and fields in section 7.3, discusses this research's limitations in section 7.4. Section 7.5 outlines desired and possible future work while section 7.6 finishes with a personal statement from the researcher.

Referencing of this research follows the official IEEE style. A list of all references is available in the reference section commencing on page 133.

This document also contains an extensive appendix, which provides further background information, the transcribed raw interview data, AUTEC ethics documents and outsourced tables.

2 Literature review

2.1. Introduction

The literature review chapter reviews existing research that is related and relevant to the topic of this research. Section 2.2 covers personalization enabled through smartphones (subsection 2.2.1), the potential of RFID technology for product identification (subsection 2.2.2) and the benefits of NFC smartphones for product identification and usability (subsection 2.2.3).

An NFC mobile shopping assistant for grocery environments, as proposed in chapter 1, has not been under investigation yet and its user acceptance is unknown. Section 2.3 discusses technology acceptance research in general and provides further details on related technologies. That discussion provides an understanding of relevant technology acceptance areas in the fields of RFID, smartphones, mobile services and mobile internet, as all of them are involved in a NFC mobile shopping assistant.

At the end of this chapter, relevant technology acceptance areas for a NFC mobile shopping assistant are presented and the research question is formulated (section 2.4).

2.2. RFID and RFID enabled smartphones

Smartphones with RFID capability (NFC smartphones) have the potential to provide the user with better and more personalised food product information. This section outlines how smartphones, RFID technology and NFC smartphone provide this potential. Therefore, the section is structured into three subsections.

2.2.1. Personalisation through smartphone software

The number of smartphones has been growing over the past five years and future high growth rates are forecast[2]. Smartphones are technically more advanced than cell phones. In addition to better hardware, their operating system design allows third parties to install additional software. Before smartphones emerged, the available software and application range on mobile phones was limited to what the manufacturer and vendors offered. The smartphone manufacturers and operating system vendors still provide only a small range of very basic software applications. However, third party software developers are able to create additional software for each of the major smartphone operating systems. Over the past four years that has led to an increasing popularity of smartphone applications and the number of available software applications has increased.

The increasing popularity and growing number of smartphones also means that centralized software application stores have emerged, where the user can browse and select software applications for installation on their smartphones. The centralised stores also provide software developers with a platform to reach customers and users of their products (applications). As of 6th of October 2010, the two biggest smartphone applications stores have about 250,000 applications in the case of Apple App Store[4, 5] and 140,000 applications in the case of Google Android Marketplace[3] available.

The possibility for third parties to develop individual software for smartphones and the available application stores to reach potential users, make the smartphone a powerful device. The smartphone's advanced technological capabilities can be individually utilised for many different purposes by a wide range of parties. Every software developer, researcher, company or private person can customise the smartphone.

Smartphone software applications can access the internet and also other features such as the camera or the location sensor (GPS). This allows smartphone software application developers to create a wide range of application features. Access to databases (e.g. product catalogs, search engines, weather stations) can be established through 3G or WiFi internet connections. The permanent availability of a mobile internet connection allows to store up-to date information on the internet and simply access it with the smartphone.

Typically, every smartphone user has his/her private smartphone, which allows to store personal preferences with the smartphone. Personal settings are then used to filter the information according to the user's settings. Blanco-Fernandez et al.[33] found personalisation to be very important in selecting mobile TV stations, as the

available total number of TV stations is too high and users do not want to browse hundreds of stations. User settings were found to be a good solution to solve the problem of too many TV stations[33]. In the case of news, the personal preferences have been successfully applied to personalize the selection of news information in order to cope with information overload[34]. Lavie et al.[34] found that the filtering criteria is vital for the results, because filtering too strictly results in certain news not presented to the user. Also the opposite, not filtering strict enough, results in too much unwanted results. Furthermore, the user perception and understanding of the filter criteria as well as information criteria were found to be important[34]. In the context of a personalised presentation of food product information, the smartphone software can be specifically programmed to provide the user with a set of food product information types and a threshold level for information depth. Personal settings will fulfill the desire to have only the personally preferred types of information available, as not every grocery customer is interested in the full range of information. Also, the software can incorporate multiple food product information sources by retrieving information from the individual food product manufacturer or from independent food consumer databases. Multiple food product information sources and also customer reviews can create an information overload, which can be handled by applying personalised filter criteria.

One source of food product information is what is already written on the label and provided by the producer. Food product labels were found to be difficult to read because of low colour contrast between font and background, selected font size and font type, typographical factors (line spacing, hyphenation, surface characteristics, print margins, text centering, printing on watermarks) and the grouping of different information types on the label[27]. It was also found that large print size, space between lines, good colour contrast, position and organisation of text, left justification and mat surface make food product information easier to find and easier to read[27]. A smartphone software application can be implemented so that criteria for better readability are considered. First, the typographical suggestions for better food label readability[27] can be considered. Second, personalisation features for the information type and source filtering can be extended to user preferences for font size and other key typographical criteria. Personal settings would allow every user to define personal typographical preferences.

Besides the main source of food product information (label), there is a need for additional food product information sources, because the manufacturer's statements were found to be not always accurate and in some cases even misleading[29]. Although discussion of the sources providing additional information is out of the scope of this study, consumer affair groups, federal ministries or food watch organizations could be seen as additional sources. It is furthermore out of scope how additional

sources technically provide the information, but the use of webservices and open standardised data formats such as XML, enable the smartphone to access additional information.

Apart from additional and independent food product information sources, there is also the area of additional information that is gathered during production and transport of goods, and it is discussed in the following subsection.

2.2.2. RFID implementations providing additional food product information

RFID has become an important technology in the supply chain. Tracking and tracing of goods are key application areas for RFID, since it enables fast, reliable and automatic identification[6, 16]. RFID technology can be used in many ways and in different environments. Tracking and tracing of animals, fruits, pallets, boxes, containers requires customised equipment. For instance, tracking and tracing of animals requires very robust tags and outdoor readers. Also, the tag size and characteristics for fruits or containers are different. That results in at least different tag types and possibly even in different radio frequencies. Different RFID standards at the farm, during the processing and as part of the logistics are also a likely result in different data warehouse systems and IT solutions, because different IT vendors are involved and standardised systems are not widely spread yet. Consequently Martinez-Sala et al.[35] introduced a solution to standardise the RFID frequencies, readers, tags and back-end data warehouse systems in order to unify technology and make more use of aggregated data. Martinez-Sala et al.'s solution consists of two parts, a mobile storage unit and a centralized data warehouse system. The storage unit can be flexibly adjusted to hold different types of products and is intended to be used in various conditions and locations. The storage units are also equipped with RFID tags, RFID readers and communication devices. The RFID tag allows the tracking of the units via other RFID readers, positioned at gates or doors of loading facilities. The container's reader can read RFID tags from products inside the unit. The unit is designed to be used at the food producer's facilities, during transportation, in wholesaler facilities and even on the sales floor. The unit enables tracking and tracing of goods from the producer to the sales floor. In order to do so, the second aspect of Martinez-Sala et al's solution, which is the centralized data warehouse, becomes important. Standardised webservices such as SOAP/HTTP allow all participants of the food supply chain to contribute RFID tracking information to a centralised system.

The result of a centralised and standardised data exchange creates a valuable infor-

mation source for supply chain members. If additional sensors such as temperature or humidity sensors are incorporated, then a wholesaler can check transportation and storage conditions of sensitive products. Furthermore, processed products consist of food from many different sources. If products were found to be contaminated, then fast and accurate back tracking of the source becomes vital to prevent any further damage. Overall the product history and production conditions are accessible much more easily. Product history can be of interest to some grocery shoppers.

Tracking and tracing of goods along the supply chain is highly supported by the electronic product code (EPC). The EPC is a general scheme that allows the unique identification of products around the world, based on a very unique ID for every item. EPC can be used with multiple and different identification systems such as barcodes, QR-codes or RFID individually or all together. EPC provides the technical framework to allow members of the supply chain as well as customers to get access to product information.

There are various scenarios where and how EPC can be used. Both EPC and RFID have their key advantage in unique identification. EPC and RFID can be combined so, that the unique EPC is stored on the data field of advanced RFID tags[36]. The data field from advanced RFID tags can be read by any RFID reader operating on the same frequency. Therefore everybody can access that EPC, but the related information (tracking and tracing data, EPC issue date etc.) need to come from a back-end database. That database however, is not standardised in way that everybody can access all types of information. As Kwok et al.'s[36] implementation shows, the databases depends on purpose, user group and other issues. As a result, access restrictions or even different databases could be possible. For example, the same EPC could be used in different databases. It is, however, desirable to maximise the benefits of RFID. Martinez-Sala et al.[35] therefore suggested the centralised back-end data warehouse for their RFID storage unit. Not all information from the centralised back-end data warehouse are intended to be visible and accessible for everybody. Different access rights for retailers, wholesalers, producers, customs or consumers enable individualised views of the overall data.

The topic of how centralised databases in the background work, who operates them or how the access is exactly implemented are out of scope of this research. Whether there is one centralised database or many, the user can access the database (back-end data warehouse) with a individualised software on the smartphone. The EPC can be used as an identifier to request the information from the database(s) and personalised filtering is used to display relevant information for the user on their smartphones. NFC smartphones can read the RFID tags and access the stored data, which in this context is likely to be the EPC. The EPC is then resolved to request

specific product related information from the database(s). The following subsection covers the benefits from having RFID readers built into smartphones and using this technology for product identification.

2.2.3. RFID built-into smartphones improving usability and adding features

RFID enabled smartphones have an RFID reader built in. Technically, various radio frequency bands could be addressed (HF, UHF, VHF), but the majority of RFID enabled smartphones operate on the 13.56MHz band (HF). RFID enabled smartphones operating on 13.56MHz are referred to NFC smartphones. An NFC smartphone is a more advanced RFID solution, because the smartphone allows the user to control the reader directly and also to change between operation modes. The NFC smartphone is capable of three different operation modes:[26][10][37, p. 64-68]

1. Basic reader mode is when an NFC device operates as a simple RFID reader by creating an electromagnetic field that powers tags and allows them to transmit their ID and possibly data. This is basically a normal RFID operation.

2. *Peer-to-Peer mode* is when two NFC devices communicate with each other through an electromagnetic field. One device will be the master and controls the communication, whereas the second one responds. The roles can change during a peer-to-peer session.

3. *Card emulation mode* is when an NFC device works as a tag. The NFC device depends on the commands of another external reader. In this mode, the NFC device can be passive and obtain power only from the electromagnetic field of the external reader or it can be active and independently supply itself with power. Furthermore, the additional security features allow authentication and encryption.

If operating in the basic reader mode, NFC follows the ISO14443A and ISO14443B standards. That allows communication with tags that are also used for high-frequency RFID communication[26]. Therefore an NFC smartphone is able to read HF RFID tags and can also access the tag's data (e.g. EPC). There are various different applications where NFC smartphones are already being used, for instance mobile ticketing[12], smart stickers with additional product information in theatres, pubs and restaurants[7], office workflow optimisation[10], multimedia content storage[9], mapping support for tourists[8], sales assistant[11] or payment applications[25]. The maximum operating range of NFC smartphones is up to 20 centimetres[26], in many cases even less. That means the user has to place the NFC smartphone very close

to the tag in order to establish communication. For the user it feels as they interact by almost physcially touching the object[10]. The ticketing solution of German rail company Deutsche Bahn is called Touch & Travel[12]. Sanchez et al.'s[9] multimedia file container is named Touch & Share. Hardy and Rukzio's[8] public display map implementation is called Touch & Interact. Isomursu et al.'s[7] smart stickers with additional product information in theatres, pubs and restaurants is called Touch & Access. The touch interaction is central part of NFC applications and is therefore part of the application names. The touch interaction provides the user with minimal interaction effort[10].

In terms of minimal interaction effort, NFC is better than existing identification methods such as barcode scanning, voice recognition or user interface input. That is because aligning the camera to the barcode takes more effort, because the angle must be within certain limits and the barcode must be clearly visible. O'Neil et al.[31] found NFC to be easier to use than 2D barcodes (QR code) after an initial training period. Voice recognition is influenced by background noises and heavily depends on the words the user speaks. User interface input such as typing the product's name or selecting from a set of lists becomes more time consuming and complex with a larger databases. NFC offers a more intuitive, easy and fast way of identifying products. NFC product identification improves the usability.

A NFC mobile shopping assistant is a solution that enables personalised presentation of food product information. The solution allows to retrieve information from various sources. The product identification is more intuitive and minimal interaction effort is required. As the NFC mobile shopping assistant has not been released, evaluated and tested yet. It is desirable to know what the user's acceptance of this new technology approach is.

2.3. User acceptance of new technologies

The user acceptance of new technologies is measured in order to predict the actual use and to identify issues of the technologies. In the field of computer and information technologies there are various user acceptance models available. The technology acceptance model (TAM)[38] has been widely used in many contexts and it has been confirmed, extended as well as improved. TAM2[39], TAM3[40, 41] are direct successors of TAM. The unified theory of technology acceptance (UTAUT) is also based on key aspects of TAM. Similar to TAM2 and TAM3, UTAUT includes many more aspects and influencing variables than the original TAM.

TAM was first proposed by Davis in 1986[42] and redefined in 1989[38]. TAM has

the purpose to predict a users behavioral intention of using a computer system on a job. TAM consists of two major variables, namely perceived usefulness and perceived ease of use. If a system's user perceives the system as useful for a particular job, then the behavioral intention to use the system is positively influenced. In addition, the user's attitude to using the system becomes positive as well. A user's perception of the ease of use positively influences the attitude to using it. Perceived ease of use also influences the perceived usefulness, in a way that if a system is too difficult to use, then it would not be of much use. Finally, the attitude influences the behavioral intention and the behavioral intention is a predictor of the actual use. That is illustrated in figure 2.1.

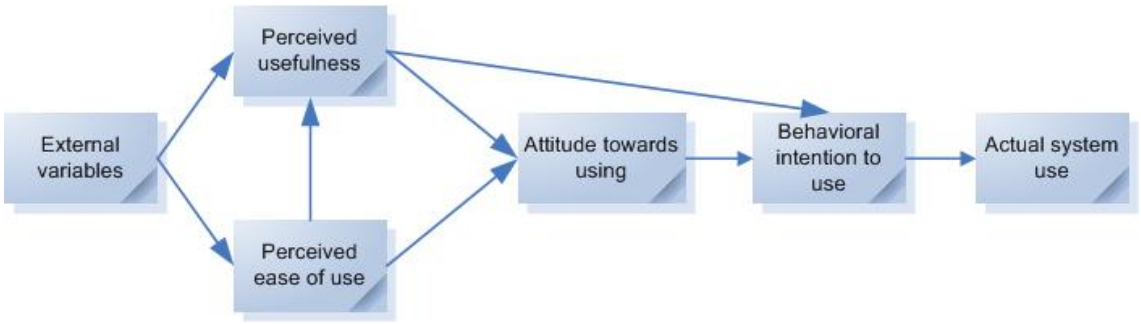


Figure 2.1.: Technology acceptance model (Source: [38])

The above description and illustration of TAM outlines the basic and general model. After TAM was proposed by Davis, TAM went through the three phases of validation, extension and elaboration[43]. The validation phases confirmed TAM's validity but also discovered a generally low explanation power of about 40%[44]. In order to increase the explanation power, TAM was extended and context specific external variables were included. Eventually, during the elaboration phase, direct successors such as TAM2[39] and TAM3 were introduced.

TAM2 and TAM3, in contrast to the original TAM, do not measure the user's attitude towards using a technology. In fact they directly measure the user's behavioral intention to use a technology. Both TAM2 and TAM3 also use perceived ease of use and perceived usefulness as main variables. However, the models include sub-variables for both main variables. TAM2 adds key sub-variables for perceived usefulness, whereas TAM3 adds key sub-variables for perceived ease of use. All three versions of TAM have perceived ease of use and perceived usefulness as main prediction variables. TAM2 and TAM3 only emerged recently and the sub-variables have not been widely applied nor have they been confirmed. Furthermore, a weakness of the original TAM is the necessity to extend it with context relevant variables[32, 43]. This also applies for TAM2 and TAM3, because their core model structure is similar. However, TAM2 and TAM3 suggest more granular sub variables for perceived ease

of use and ease of use. A more granular use of the original TAM has also been suggested by Lee et al.[43]. Granularity is related to the context of the particular study. Therefore, various technology acceptance studies use various additional variables to measure the user acceptance of the specific technology.

Technology acceptance studies of NFC mobile shopping assistants have not been undertaken yet. Hence the additional influencing areas (variables) of the technology acceptance are unknown. The aim of this study is to identify the issues and challenges of NFC mobile shopping assistants that influence the technology acceptance from a user perspective. The strategy to identify relevant issues and challenges for technology acceptance of NFC mobile shopping assistants is to use existing technology acceptance studies of related technologies as the basis. Based on their additional acceptance variables (areas), a discussion about the relevance for the particular NFC mobile shopping assistant is undertaken. The following subsection discusses technology acceptance variables of closely related technologies.

2.3.1. Technology acceptance variables

The following discussion of technology acceptance variables follows four steps. First, about 31 existing research publications from credible journals and databases have been discovered based on a number of search strings and key words as well as the title, abstract and publication date. Results are presented in table 2.1. Second, each publication is further analysed and its suitability is determined. A publication is identified as not suitable for various reasons as explained in table 2.1 as well. Third, suitable papers are then analysed by focusing on the technology context and technology acceptance variables. An overview of included publications, the publications technological context and the technology acceptance variables is provided in table 2.2 commencing on page 24. Finally, based on the selection of highly relevant publications, the researcher discusses the impact and relevance of technology acceptance variables.

The initial selection of publications includes technology acceptance studies that are in similar or closely related fields to that of a NFC mobile shopping assistant. The proposed NFC mobile shopping assistant is related to fields such as RFID, smartphones, mobile applications and mobile services. Technology acceptance studies are such that directly use TAM. In addition, studies that apply mixed models (TAM and TRA, TPB, IDT, TTF etc.) or other models (e.g. UTAUT) that include TAM's main variables (perceived ease of use, perceived usefulness) are within the range of consideration. The focus is, however, on technology acceptance. Hence search strings for the first publication selection include the following terms or their

combinations: RFID, NFC, mobile, mobile services, applications, apps, smartphone, technology acceptance, TAM, technology acceptance model, user acceptance, user, user intention. Only recent (2005 and later) publications are included in order to make sure that the technology context is not outdated. The search strings were applied to journal databases and publication index such as IEEE Xplore, ACM Digital Library, Science Direct, Google Scholar and similar. Table 2.1 presents the publications from the initial selection.

Table 2.1.: Initial selection of technology acceptance publications (Source: author)

#	Reference	Author	Year	Title	Status
1	[45]	Cheong and Park	2005	Mobile internet acceptance in Korea	not included because mobile internet has significantly changed between 2005 and present
2	[46]	Gao et al.	2008	Mobile Services Acceptance Model	included
3	[47]	Ha et al.	2007	Determinants of adoption of mobile games under mobile broadband wireless access environment	not included because paper's focus is on mobile games
4	[48]	Hong et al.	2006	Understanding continued information technology usage behavior: A comparison of three models in the context of mobile internet	not included because paper focuses on comparisons of different models instead of technology
5	[49]	Hong and Tam	2006	Understanding the Adoption of Multipurpose Information Appliances: The Case of Mobile Data Services	included
6	[50]	Hossain and Prybutok	2008	Consumer Acceptance of RFID Technology: An Exploratory Study	included
7	[51]	Jeong and Yoo	2007	A Study of Adopting Warshaw's Purchase Intention Model in Mobile-RFID Services and on Moderating Effect of Personal Innovativeness	not included because paper focuses on purchase intention
8	[52]	Kim et al.	2007	Value-based Adoption of Mobile Internet: An empirical investigation	included
9	[17]	Kowatsch and Maass	2010	In-store consumer behavior: How mobile recommendation agents influence usage intentions, product purchases, and store preferences	included
10	[53]	Kuo and Yen	2009	Towards an understanding of the behavioral intention to use 3G mobile value-added services	included
11	[54]	Lopez-Nicolas et al.	2008	An assessment of advanced mobile services acceptance: Contributions from TAM and diffusion theory models	not included because paper focuses on linking IDT variables to TAM variables
12	[55]	Lu et al.	2005	Personal innovativeness, social influences and adoption of wireless Internet services via mobile technology	not included because paper has strong focus on technology adoption and social aspects
13	[56]	Luarn and Lin	2005	Toward an understanding of the behavioral intention to use mobile banking	not included because the paper has very strong focus on banking with a mobile context
14	[57]	Mallat et al.	2009	The impact of use context on mobile services acceptance: The case of mobile ticketing	included
15	[58]	Meso et al.	2005	Towards a model of consumer use of mobile information and communication technology in LDCs: The case of sub-Saharan Africa	not included because paper focuses on a particular location (sub-Saharan Africa, Kenya, Nigeria)
16	[59]	Min and Dong	2007	An Empirical Research on Online Infomediary Based on Extension of the Technology Acceptance Model (TAM2)	not included because paper has very low citation figures
17	[60]	Mueller-Seitz et al.	2009	Customer acceptance of RFID technology: Evidence from the German electronic retail sector	included
18	[61]	Nysveen et al.	2005	Explaining intention to use mobile chat services: Moderating effects of gender	not included because paper focuses on mobile chat services

Continued on Next Page…

Table 2.1.: Initial selection of technology acceptance publications (Source: author)

#	Reference	Author	Year	Title	Status
19	[62]	Park and Chen	2007	Acceptance and adoption of the innovative use of smartphone	not included because paper limits the user group to doctors and nurses
20	[63]	Pedersen	2005	Adoption of mobile internet services: An exploratory study of mobile commerce early adopters	not included because paper incorporates TPB much more than TAM, hence TAM is not main research model
21	[64]	Revels et al.	2010	Understanding consumer intention to use mobile services	not included because paper was not available in full by the time the literature review was conducted
22	[65]	Shin	2009	Towards an understanding of the consumer acceptance of mobile wallet	included
23	[66]	Tan and Qi	2009	An Acceptance Model of Wireless Mobile Data Services in China: Combining TAM with Consumer Behavior Model	not included because paper concentrates on China
24	[67]	Thiesse	2007	RFID, privacy and the perception of risk: A strategic framework	included
25	[68]	Verkasalo et al.	2010	Analysis of users and non-users of smartphone applications	included
26	[69]	Wang et al.	2006	Predicting consumer intention to use mobile service	included
27	[70]	Wu et al.	2010	User acceptance of wireless technology in organizations: A comparison of alternative models	not included because the paper is an accepted manuscript only and has not been published in a credible journal yet
28	[71]	Wu and Wang	2005	What drives mobile commerce?: An empirical evaluation of the revised technology acceptance model	included
29	[72]	Wu et al.	2007	Mobile computing acceptance factors in the healthcare industry: A structural equation model	not included because paper focuses on health care industry
30	[73]	Yen et al.	2010	Determinants of users' intention to adopt wireless technology: An empirical study by integrating TTF with TAM	not included because paper has a strong focus on task technology fit, which is not scope of this study
31	[74]	Zhang et al.	2007	Empirical Research Based on TAM in Acceptance of Mobile Homecare Systems	not included because paper focuses on task technology fit of mobile homecare systems

A number of initial publications are not considered (status: not included) for further discussion, because the publication's technology context was not exactly suitable, the technology acceptance was not in primary focus or the publications had certain limitations such as too location specific or very specific user group and industry focus.

As a result, 13 publications are considered relevant to the technology context and they are focused on technology acceptance. The consequent discussion reveals the importance of a number of different influencing variables. The specific variables depend on each publication's specific technology. As the selection of existing technology publications is closely related to the NFC mobile shopping assistant, it will be helpful to identify the NFC mobile shopping assistant's relevant technology acceptance areas. Relevant areas will then be used to collect data specifically for an NFC mobile shopping assistant.

Table 2.2 contains an overview of 13 different technology acceptance studies on a selection of 14 context relevant topics.[1] For each study, the influencing user acceptance variables are presented. Plus (+) represents positive influence, minus (-) represents negative influence and n.s. means non-significant influence towards the user acceptance. An empty field means that the variable was not investigated in the corresponding study.

[1] One study has been investigated from the perspective of two different topics.

Table 2.2.: Acceptance variables in context related technology acceptance studies (Source: author) (+ positive; - negative; n.s. not significant)

#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Reference	[68]	[68]	[53]	[57]	[65]	[71]	[50]	[60]	[75]	[67]	[52]	[49]	[46]	[69]
Author(s)	Verkasalo et al.	Verkasalo et al.	Kuo and Yen.	Mallat et al.	Shin	Wu et al.	Hossain et al.	Mueller- Seitz et al.	Kowatsch and Maass	Thiesse	Kim et al.	Hong and Tam	Gao et al.	Wang et al.
Year	2010	2010	2009	2009	2009	2005	2008	2009	2010	2007	2007	2006	2008	2006
Topic	Smart-phone map app	Mobile internet	Mobile internet	Mobile ticketing	Mobile wallet	Mobile com-merce	RFID	RFID	RFID smartphone-app	RFID	Mobile internet	Mobile data services	Mobile services	Mobile services
Acceptance variables influence														
Perceived usefulness	+	+	+	+	+	+		+	+	+	+	+	+	+
Mobility				+										
Perceived ease of use			+	+	+	+		+	+	+		+	+	+
Technicality											-			
Technical barriers	-	-												
Service availability												+		
Convenience							+							
Perceived enjoyment	**n.s.**	+									+	+		
Use context				+									+	
Cost			-			-					-			
Financial resources														+
Monetary value												+		
Perceived risk						+				-				
Perceived Security					+									
Security threats							-	-						
Trust					+					+			+	
Credibility														+
Perceived privacy							**n.s.**	-						
Culture							+							
Personal innovativeness			+										+	
Behavioral control	+	+												
Social norm	+	+												
Social influence					**n.s.**									
Self efficacy					**n.s.**									+
Regulation							**n.s.**							
Compatibility				+		+								
Need for uniqueness												+		

The selection of 13 different studies represents similar and related technologies. In total 27 acceptance variables have been identified. The majority of acceptance variables have a positive influence, which means that an improvement in their context will improve the user's technology acceptance. The opposite applies for negatively influencing acceptance variables. The first discussion of selected acceptance variables does not go much into detail about the positive or negative influence, since it is more important to outline the relevance of each acceptance variable in general. A discussion about the influence direction (positive or negative) takes place mainly in subsection 2.3.3. Among the 27 technology acceptance variables, perceived ease of use and perceived usefulness are the most common as they are the main variables of TAM.

The remaining 25 acceptance variables are discussed below. First, since some studies combined TAM with the theory of planned behavior (TPB)[76], variables originating from TPB have been listed in table 2.2. However, TPB does not focus entirely on technology acceptance[76]. Therefore, TPB related variables are excluded. Those are behavioral control, social norm, social influence and self efficacy. In addition, social influence and self efficacy were found to be not significant in study #5[65]. Regulations were found to be not significant in study #7. All three non significant variables are excluded from further discussion as well.

The need for uniqueness as used in study #12 by Hong and Tam[49] refers to "the individual's tendency to seek uniqueness through the adoption and use of symbolic products or innovations for the purpose of enhancing the self-concept"[49, p. 167]. The need for uniqueness is excluded from further discussion, because it is closely related to self-aspects and the social status, which are excluded as well. Furthermore, Hong and Tam state that the need for uniqueness influences the technology adoption rather than technology acceptance. The aim of this study is not to focus on adoption issues, simply because the proposed technology including the environment setup as such are not in place yet. At this stage acceptance is the prime focus, because adoption becomes more relevant only once acceptance is ensured.

Verkasalo et al.[68] found perceived enjoyment to be positively influencing for mobile internet services (study #2). In addition, Kim et al.[52] (study #11) and Hong and Tam[49] (study #12) found perceived enjoyment to have a positive influence on the technology acceptance. Perceived enjoyment has been found to be important in regards to perceived usefulness[49, 52] and perceived ease of use[49]. In contrast, Verkasalo et al. found that perceived enjoyment does not apply for certain useful applications such as map applications (study #1). Verkasalo et al.'s finding in study #1 are interesting because a map application is usually used in very distinct and rare situations of either being lost or preparing a route. In both situations the user's

main aim is to find the directions. Other factors may become less important, which explains the findings of study #1. However, if a map application is used to find directions and at the same time the user perceives it as enjoyable, then acceptance of that particular map applications increases. A map application can be regarded similarly to the NFC mobile shopping assistant, because the particular situational context and the importance of particular information are comparable. Therefore perceived enjoyment is unlikely to be highly important, but the findings of Kim et al, Hand and Tam and Verkasalo et al. also suggest relevance of perceived enjoyment towards TAM's two main variables. Hence perceived enjoyment is investigated in this study as part of perceived ease of use and usefulness.

Personal innovativeness as used by Kuo and Yen[53] (study #3) and by Gao et al[46] (study #13) refers to a certain group of users that are regarded as innovative and therefore more open to new technologies, which was found to positively influence the acceptance. The selection of innovative and less innovative participants is particularly important for quantitative studies, because they influence the result. In a qualitative investigation the participant's deep perception or understanding highly contributes, that is why a distinction between different innovativeness levels among the participants is desired but not necessarily required. Hence, innovativeness is not regarded as a highly relevant variable but more an attribute of participants. See subsection 3.4.4 regarding participant criteria on page 47.

Culture is similar to perceived innovativeness. As used in study #8, culture "is defined as the beliefs, value systems, norms, or behaviors of a given organisation or society"[50, p. 318]. Hossain et al.[50] found a significant positive influence of perceived culture towards the intention to use RFID technology. As culture also refers to the individual attributes of users, it is relevant for participant selection. See subsection 3.4.4 on page 47 for further details on cultural participant criteria.

Service availability as used in study #12 by Hong and Tam[49] refers to the ability of technology to be accessible and fully functional at any time when the user intends to use it. "Without the guarantee of pervasive and timely connections, the unique usefulness of information appliances would be seriously undermined."[49, p. 166] In other words, if the advantages of a technology (e.g. ease of use and usefulness) cannot be used because the service (technology) is not available, then the usefulness is threatened[49]. Hence service availability is a key requirement for a NFC mobile shopping assistant. A high degree of availability is desired but to what degree the user accepts non-availability can hardly be researched without the existence of a complete realistic environment. Service availability is a desired key requirement of an NFC mobile shopping assistant. In this research however, service availability is not investigated nor is it tested, because service availability is so fundamental that

it is regarded as a must. Consequently, as part of this research service availability is regarded as important but is not investigated. Future work will need to investigate this and determine the user's tolerance threshold.

Mobility as used in Mallat et al.'s[57] mobile ticketing study (#4) expresses the advantages of mobile technology, which are flexibility in time, location and service of use. Mobility is closely aligned with usefulness[57]. Mallat et al. refer usefulness to a more general aspect, whereas mobility is referred to the mobile technology in particular. Hence, mobility can be regarded as a part of perceived usefulness in the context of this study.

Mallat et al.[57] (study #4) also introduced use context, which is closely linked to the mobility aspect. They regard the use context as a mediator for perceived usefulness and mobility. Use context represents the environmental conditions while using mobile applications and services[57]. As the use context is seen as a mediator, its environmental boundaries need to be clearly defined for the user and researcher. That is because using a technology in two different environmental and situational contexts can result in different perceptions. This study sets clear boundaries for the use context of the proposed NFC mobile shopping assistant. The main limitation is the use for the specific purpose of retrieving food product information inside the grocery store while doing regular shopping. Therefore, researcher and user have a clear understanding of the technology's use context, which mediates perceived usefulness and the mobility aspects. Gao et al.[46] applied the use context as a mediator for perceived usefulness and ease of use. In other words, perceived usefulness and ease of use are investigated in a particular use context, which also has been generally suggested for TAM studies in order to improve the explanation power[32, 43].

Mallat et al.[57] (study #4) furthermore use compatibility as a determinant of technology adoption, so do Wu et al.[71] for their mobile commerce study (#6). Compatibility originates from the diffusion of innovation theory (IDT)[77]. IDT variables have been combined with TAM in order to add IDT's adoption prediction aspect. As of IDT's five main variables, only compatibility, complexity and relative advantage were found to be consistent influencing variables on adoption[71]. Wu et al. argue that complexity is similar to perceived ease of use and relative advantage can be compared to perceived usefulness. "Compatibility is the degree to which the innovation is perceived to be consistent with the potential users' existing values, previous experience, and needs"[71, p. 721] Compatibility therefore makes the difference between IDT's adoption prediction and TAM's acceptance prediction. As IDT contains acceptance aspects (complexity and relative advantage), compatibility enhances it. As technology adoption is not in focus, compatibility aspects are excluded.

Convenience, as used in study #7 by Hossain et al.[50] was defined as comfortable, free of effort and fit for performing a task. Hossain et al. structure comfortability and free of effort as ease of use. They further regard the task fitness as usefulness. Convenience represents ease of use and usefulness at the same time, hence it is very relevant for this study. However, a distinction between ease of use and usefulness is needed to reflect more depth and granularity, hence convenience as such is not used, but its aspects ease of use and usefulness are used.

Technicality (study #11) and technical barriers (study #1 and #2) have been used to represent non-monetary technical sacrifices or barriers towards user acceptance[68, 52]. Both were found to have a negative influence. Kim et al.[52] (study #11) included ease of use, connectivity and efficiency in their definition of technicality for mobile internet. Connectivity is referred to an instant and straightforward mobile internet connection (3G)[52]. Efficiency is the loading and response time while using a mobile internet connection[52]. Verkasalo et al.'s[68] understanding of technical barriers refers to the difficulties in finding, installing and configuring smartphone applications as well as poor usage performance[68]. Technical barriers of a technology can be seen as the negative impact on ease of use, because the difficulties make it less easily to use. Usage performance, connectivity and efficiency are similar and can be regarded as a part of ease of use as well. Hence, those are relevant areas of investigation for this study. Technical barriers of a NFC mobile shopping assistant solution are likely to occur in the following areas. Connectivity refers to two data connections: first, the mobile internet connection to retrieve food product information and second the connection between NFC smartphone and RFID tag on the product. Efficiency is also relevant for NFC-RFID communication and the mobile internet data request. Furthermore, efficiency plays a role at the software application. That is because using the application is related to usage performance. Less important are configuration, installing and selection of the smartphone application. These are less important because they usually only take place once and therefore could be done with the assistance of technical people. Also, the recently emerged smartphone application stores (e.g. Apple App Store or Google Android Marketplace) make finding, installing and the configuration of smartphone applications easier.

Perceived costs of using a technology or service has been found to be negatively influencing the acceptance[53, 71]. Both Kuo et al.[53] (study #3) and Wu et al.[71] (study #6) argue that there are different types of costs. The main cost categories are equipment costs[71, 53], access costs[71, 53], transaction fees[71] and conversion costs[71, 53]. Conversion costs occur when the user changes methods of using a technology, e.g. when switching from e-commerce to mobile commerce[53]. Conversion cost can cover cost for new equipment (equipment cost) but also for changing work-

flow and other processes. For the NFC mobile shopping assistant, there are likely to be low conversion costs, because a transition from one technology to another does not take place. In the case of this study, the NFC mobile shopping assistant is introduced as an additional or better way of retrieving information. Other information access options are already present. In contrast, direct equipment costs, access costs and transaction fees are likely to play a more important role. Even though this study focuses on the user perspective, cost is a more complex construct. That is because the food product information provider, the grocery stores, smartphone manufacturers, software developers and other directly involved parties provide equipment and access for the user. Equipment, access or support services incur costs, which can directly be charged through fees. In addition to direct monetary payment, there is the option of non-monetary and hidden fees. For example, if a service appears to be free of charge, advertisements are often used to cover the cost of this service. In the retail environment, loyalty cards are often used to give customers discounts. In return, the customer pays with loyalty and personal data, which is used for customer profiling. Summarising, there are a number of important aspects in the area of costs. First, even if the customer or user is not expected to pay for a service or device, there are still costs. Those costs can be hidden in other fees (e.g. higher product prices) or in non-monetary costs (consumer data, use contracts). Consequently, all involved parties need to be covered in the cost investigation. Third, the type of costs can vary. For instance, a more expensive device price in the beginning may already include access fees, or the other way around. In the context of an NFC mobile shopping assistant and the required RFID equipment structure inside grocery stores, there is no clear cost and payment model agreed on. That is mainly because the technology has not been put in place yet. As Kuo et al.[53] and Wu et al.[71] have shown, costs were found to have a negative influence on the user acceptance. Study #14 investigates the cost aspects with the same implication but from an opposite perspective. High financial resources of the user can cover the costs of the technology and service[69]. Therefore and because of a not-existing payment and fee models, costs is also a subject of investigation in this research. This also includes payment options and models.

The cost investigation focuses on the user perspective, but acknowledges the role of grocery stores, device manufacturer, information provider or software developer. Equipment costs are likely to occur for RFID tags and RFID infrastructure inside the grocery as well as costs for NFC enabled smartphones. Access costs play an important role for the food product information access. There are two types of access cost: first, costs for accessing the actual information from the food product information provider and secondly, fees for data connection (3G mobile internet etc.). For the user to accept the NFC mobile shopping assistant, it is important to know how the user perceives the mentioned costs and also whether there might

be other costs that have not become visible at this early stage of the technology. This ensures that the negative influence and the possible threat towards technology acceptance can also be considered.

One aspect of costs (indirect payment through customer profiling, personal shopping data) links into the privacy field. Hossain et al.[50] (study #7) and Mueller-Seitz et al.[60] (study #8) investigated the user perception of privacy. Privacy is closely linked to security. Security and privacy are also relevant to concepts of risk and trust. Therefore, security, privacy, risks and trust are discussed together below.

RFID studies #7 and #8 investigated the acceptance influence of both security and privacy. Security refers to RFID threats and privacy refers to personal information privacy[50]. The mobile wallet study #5 investigated trust and security. Trust was investigated by Gao et al.[46] in study #13. Trust is the user's belief that the provider (information provider, grocery store, mobile phone manufacturer, software developer) performs according to the user's expectation[65]. Similar to trust is Wang et al.'s understanding of credibility. In Wang et al.'s study, credibility refers to user's believe that a technology is free of privacy and security threats and hence the technology can be trusted[69].

In studies #7 and #8 RFID security threats were found to have a negative influence[60, 50]. Study #5 found perceived security to be positively influencing, which means that security threats existed but countermeasures were in place[65]. Without those, security threats would have been negatively influencing as well.

Privacy threats were found to have a negative[60] and no significant influence[50]. No significance contradicted Hossain et al.[50] expectations. Hossain et al. suggest the following possible reasons for no significant impact of privacy: first, a low awareness of privacy issues, second a differring understanding of privacy issues among the participants and thirdly a very low participant's perception of RFID's privacy risks in comparison to its benefits.

RFID security threats and personal privacy threats are based on the characteristics of RFID technology and the implementation of involved devices and software. RFID security threats[2] are distinguished in low- and high-level[78]. High-level security threats are sniffing, tracking, spoofing, replay attacks and denial of service. Low-level security threats are buffer overflow and code insertion[79, 78]. Both types can be used to disturb RFID communication, to manipulate data and background systems, to retrieve data without permission and to disturb the overall function of the entire system. Security threats that influence privacy are sniffing and tracking

[2] Appendix section D.1 commencing on page 163 contains further information about RFID security threats

(high-level), all low-level attacks and the operators of back-end data warehouses (e.g. food product information provider). Sniffing and tracking can be used by an intruder to aggregate personal data without the user's knowledge. In addition, personal data can be aggregated by the back-end database owner[80]. That becomes possible due to RFID's characteristics and the general RFID implementation in grocery stores (hidden placement of tags and readers, unique identification, profiling and massive data aggregation)[80]. The data aggregation can happen with or without the user's knowledge. The user has to trust the back-end database owner that privacy is not violated and that security measures are in place to prevent successful low-level attacks[65].

The NFC mobile shopping assistant uses RFID technology as its central communication technology for food product identification. Hence RFID security and privacy threats are relevant as they have negative influence on the technology acceptance. The expected negative influence of privacy threats was not confirmed in study #7, which has been explained with low participant awareness or insufficient knowledge about privacy threats. It is therefore even more important to understand the role and influence of privacy in the greater context of RFID.

RFID high- and low-level security threats also apply to the NFC smartphone, because the NFC smartphone is the central technology object and combines RFID and software. Furthermore, the NFC smartphone communicates with the food product information provider. Hence the full range of RFID security threats apply to the NFC smartphones as well. In addition, the software is technically able to collect, store and transmit personal information and therefore enables privacy violations. The group of trusted entities is extended to the software and NFC smartphone device. Trust in general includes technical and non-technical aspects[65]. In the NFC mobile shopping assistant context, technical trust can be seen as the belief that all three NFC smartphone, software application and RFID technology work accordingly. Non technical trust is underpinned by beliefs that the food product information is correct and reliable. Both technical and non-technical aspects are relevant for this study. That is because the general security threats of RFID can influence both trust aspects. Trust towards the general correctness of food product information and the credibility of food product information provider is scoped out, because it does not directly refer to the technology. In addition, for the purpose of this study the food product information provider and the structure of the back-end databases is an assumed black box. The role of trust and RFID's security as well as privacy threats, which are perceived as risk, have been confirmed in study # 10 by Thiesse[67] and underpin their relevance.

Security and privacy threats, as they relate to technology (RFID, smartphone,

software) pose a risk for the overall system's integrity and are therefore of particular interest. Security and privacy threats can influence the technology acceptances negatively, as shown in studies #8 and #14. Security and privacy threats furthermore damage the credibility of involved parties[69].

2.3.2. Summary of context related technology acceptance variables

The discussion of context related technology acceptance variables revealed relevant areas of user acceptance for an NFC mobile shopping assistant based on acceptance studies of RFID, NFC smartphones, software applications, mobile services and mobile internet. In summary, from a user perspective five wider areas were found to be relevant, namely perceived usefulness, perceived ease of use, costs, security and privacy.

For each of the five wider technology acceptance areas, a number of sub-aspects were found as well. It was found that the use context, mobility characteristic, perceived enjoyment and service availability of the NFC mobile shopping applications are part of perceived usefulness. Technicality and technical barriers are part of ease of use, because technical barriers influence the perceived ease of use negatively. In addition, usage performance, connectivity, efficiency, use context and perceived enjoyment describe ease of use aspects. Equipment costs, transaction fees and access costs occur as part of overall costs. Also, how the fees and costs are payed relates to payment options and models. Security issues of RFID and smartphones create vulnerabilities, which can influence the technology integrity and therefore influence usefulness and ease of use. The user's privacy can be affected by security vulnerabilities and the NFC mobile shopping assistant design. Furthermore, the personal data collection through RFID technology and food product information requests pose a threat to the user's personal information privacy.

This study approaches the user's technology acceptance in a more open and less narrow way in order to be able to identify benefits, issues and challenges that may have not been identified before. Therefore, only the five wider technology acceptance areas are actively explored in this study. This particular selection of five wider technology acceptance areas is supported by Massoud et al.[81], who found ease of use, security, privacy, usefulness and affordability (costs) as most important.

This study's research model is outlined in figure 2.2.

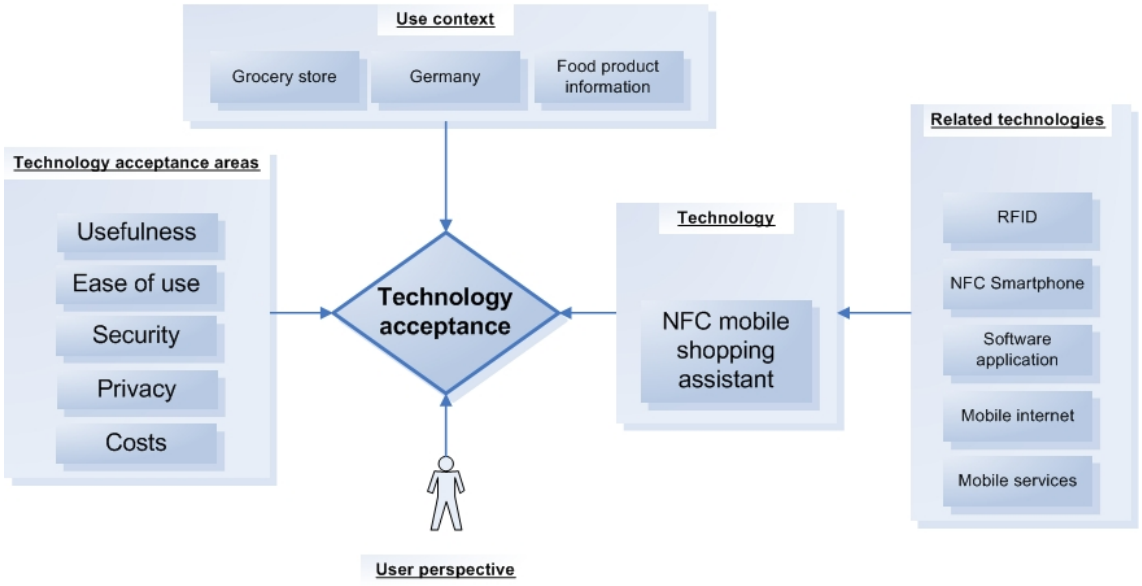


Figure 2.2.: Research model (Source: author)

The research model illustrates the focus of this study. The technology acceptance of the NFC mobile shopping assistant is investigated from the user perspective with the five technology acceptance areas are in focus. The use context specifies the technology environment. The technology as such is not fully available to the general public, therefore related technologies play an important role, as they define the NFC mobile shopping assistant.

Innovativeness and culture were found to be influential too. Since both refer to characteristics of users and this study does not aim to compare the acceptance among different cultures or groups of people, innovativeness and culture are regarded as fixed attributes for participant selection. See subsection 3.4.4 commencing on page 47 for details relating to the participant criteria.

2.3.3. Positive and negative technology acceptance areas

The previously outlined and discussed technology acceptance areas were represented by technology acceptance variables. The variables had positive or negative influence on the technology acceptance. The majority of variables were assumed and found to be positively influencing. TAM's two key variables perceived ease of use and usefulness have a positive influence, which means that higher usefulness leads to higher acceptance. However, negatively influencing variables were used in a number of studies. The majority of negative variables are based on an opposite point of view. For example, technicality and technical barriers have a negative influence. They can be regarded as the opposite to perceived ease of use. That is similar to perceived

security and security threats or costs and financial resources. The direction (negative or positive) depends on the focus of the research.

Combining positive and negative acceptance variables in one study has been done by Kim et al.[52] (study #11). Early technology acceptance studies investigated the user's acceptance of technology on the job. That implied a certain constraint level, because if an employee does not accept a new technology, then the he/she may have to fear consequences[52]. That is why Kim et al.[52] proposed a value proposition of positively and negatively influencing factors towards technology acceptance. The main difference is the voluntary acceptance based on benefits (positive) and sacrifices (negative). Acceptance is mainly voluntary in Kim et al.'s scenario of mobile internet, because users were free to accept it and user did not have to fear major consequences. That is very similar to a NFC mobile shopping assistant, because users are not forced to use it. Users are free to use other sources (stationary internet, books, product labels). However, negative aspects of using the technology may exist. Consequently, the relevant user acceptance areas for a voluntary system acceptance need to cover positive and negative aspects, similar to Kim et al.'s[52] value proposition of voluntary technology acceptance. Kim et al. base the value proposition on Zeithaml's[82] definition of value:

"Perceived value is the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given."[82, p. 14]

Zeithaml's[82] definition of perceived value is widely accepted in academic business and marketing research, because it is based on literature, company focus groups and in-depth consumer interviews. Depending on the context, benefits and sacrifices vary for each consumer. A consumer's benefits can be quality, quantity or convenience, whereas sacrifices can be time, effort, energy or money[82].

The approach of balancing positive and negative acceptance variables and investigating benefits and sacrifices at the same time ensures that the research focus is realistic, in particular for a voluntary environment. According to Zeithaml's definition of perceived value, the overall assessment of benefits and sacrifices is relevant. That means beneficial aspects (positive influence on technology acceptance) are put in contrast to sacrifices (negative influence on technology acceptance) and if the benefits outweigh the sacrifices, then acceptance is higher[52].

The previous discussion of technology acceptance variables argued that perceived usefulness, ease of use, security, privacy and costs represent wider acceptance areas for context related technologies. Usefulness and ease of use were always observed in the literature to be positively influencing. Cost was found to be negatively influencing. Privacy threats were once found non significant and once negatively influencing.

As stated above, that has been explained by the possible low awareness of privacy issues. Security threats were found to be negatively influencing in study #7 and #8 and indirectly by study #5.

As outlined in section 2.2, the NFC mobile shopping assistant has the potential to improve the visualisation of food product information and also includes multiple additional information sources. That is achieved with NFC smartphones (mobility), during grocery shopping (use context) and while walking along the shelves (mobility, use context). The NFC mobile shopping assistant's usefulness comes from the combined implementation of RFID technology, a specific software applications and the NFC smartphone. Those have also the potential to make it easier to use, more intuitive and faster than existing solutions. Usefulness and ease of use represent the benefits of the NFC mobile shopping assistant, as they are perceived as positive.

On the other hand, negative technology aspects such as privacy and security threats as well as costs represent the sacrifices, which a user has to make in order to use the system. They can be regarded as issues and challenges, which must be overcome or at least balanced with benefits in order to have the user accepting the technology.

The clear separation between benefits and sacrifices (challenges and issues) gives a good indication for a overall balanced approach, which was found to be important for voluntary technology acceptance[52].

However, ease of use and usefulness are not necessarily always on the beneficial side, because the NFC mobile shopping assistant may not be perceived as useful and easy to use in every situation. For example, if a product is bought regularly, then additional food product information may not be of particular interest and hence not highly useful. Also, if grocery shopping takes place under time pressure, the NFC mobile shopping assistant may be perceived as too inefficient and slow for this particular situation. On the other hand, a good security concept may be beneficial, as they were found to be in study #5. Furthermore, if the overall value assessment is positive (high usefulness, high ease of use, low risk perception of security and privacy threats), then costs may become the relevant point. In a particular situation, the fast access to additional food product information (e.g. list of allergies the product can cause) becomes very useful, because the user buys grocery for a dinner party and one of the guest is allergic to certain nuts. The usefulness of having fast access to information is high and therefore avoiding a possible allergic reaction of one of the guest is clearly beneficial. Consequently, the NFC mobile shopping assistant's user might be willing to pay more for service. Also, a high product or service price is often perceived as better quality (perceived monetary value)[49]. In other situations the overall benefits may not be that great and therefore the fee of using the service

becomes lower. The value proposition and balance between benefits and sacrifices (issues and challenges) shows the importance of investigating negative and positive sides in order to represent the voluntary use and acceptance of a technology.

A NFC mobile shopping assistant is a new technology solution, which has not been implemented for and used in a real existing environment. The benefits, issues and challenges of the technology in the five wider technology acceptance areas have not been investigated. Furthermore, the balance among the five areas in different situations is unknown as well.

Hence, the research question that guides the investigation of benefits, challenges and issues can be formulated as shown below.

2.4. Research question

What are the benefits, challenges and issues of a NFC mobile shopping assistant in the grocery environment from a user's perspective?

3 Methodology

3.1. Introduction

In order to answer the research question and in order to have enough evidence to support the answer, a suitable research approach has to be selected. This chapter describes and justifies the research approach. The chosen exploratory research approach is justified in section 3.2. Section 3.3 outlines the qualitative research method. Section 3.4 describes fully the research design and section 3.5 presents the data analysis method. Finally, section 3.6 explains how the overall quality of this research is ensured.

3.2. Research approach

In order to answer the research question with strong supporting evidence, an exploratory research approach has been selected. Exploratory research is often undertaken at the first stage of a wider study, because it can be used to gather information that supports the process of problem definition. The output of exploratory research can be suggestions of hypotheses for a specific research problem and a much deeper understanding of a phenomenon.

Chapter 2 outlined existing research of technology related to an NFC mobile shopping assistant such as RFID/NFC, mobile applications and mobile services. As indicated in that chapter, little is known about the customer's acceptance of an NFC mobile shopping assistant and what challenges, issues and benefits the technology has. An exploratory approach is chosen and conducted through interpretive research. Interpretive research allows researchers to deepen their understanding of a phenomenon (e.g. NFC mobile shopping assistant) within a context under the as-

sumption that people interact with the environment and create their own meanings of it[83].

Based on philosophical assumptions such as "our knowledge of reality is a social construction by human actors"[84, p. 376], fully objective data is difficult to obtain. That makes qualitative research methods a frequent contributor to interpretivism[83]. "Interpretive research does not predefine [...] variables, but focuses on the full complexity [...] as the situations emerge."[85, online chapter 3]

Exploratory research from an interpretevist perspective offers various methods, which can be categorised into quantitative, qualitative or mixed methods.

3.3. Research method

Qualitative research methods, in contrast to quantitative, are more flexible and versatile. They originated from social science and are designed to help us understanding people and their contexts[86]. They also emphasise on the description of a phenomenon and try to explain relationships in deep and detailed way. In contrast, quantitative methods are less flexible, because standardised measures are often used in order to validate and generalise perspectives and experiences of people[87]. Qualitative research can be applied if a phenomenon is new and innovative and therefore often changes its focus. Qualitative research allows to closely follow fast moving phenomenons, because extensive literature review of uncertain aspects of the phenomenon right at the beginning of a study is not necessary[87]. The wider field of applied NFC services is currently emerging and quickly moving in different directions. Therefore, a qualitative research approach is suitable.

Qualitative research can be undertaken in a number of ways. By nature qualitative research is more inductive, rather than deductive[88]. However, Maxwell[89] suggests to give qualitative research a more structured approach, in contrast to the conventional unstructured way. The advantage of enhanced structuring lies in data comparability across a set of criteria. In addition, a structured and slightly narrowed approach helps to focus on certain key issues. Considering the typical scope of a Masters Thesis, it appears that focusing on a set of key issues is a suitable approach. In contrast, an inductive and loosely designed research requires very experienced researchers and time to explore every possible direction[89].

This research starts with structural guidance from a theoretical model and is then carried out in a deductive manner. The supporting theoretical model is TAM in conjunction with three other technology acceptance areas. TAM has been used in

various contexts when it is unmodified, its explanation power is limited to 40%[44]. As pointed out in section 2.3, TAM should be modified and tailored for the specific context in order to achieve satisfactiory explanation power. The majority of existing TAM studies apply TAM (and modifications of TAM) in a quantitative way. This study, however, will apply TAM in a qualitative way and therby follow Sun and Zhang's[32] suggestions. The literature review in chapter 2 suggests that security, privacy and costs in addition to TAM's default key aspects, usefulness and ease-of-use, are likely to influence the user acceptance of the phenomenon (NFC mobile shopping assistant).

The modified TAM approach that is adopted for this research has not been validated in the specific context. This research does not aim to validate the modified version of TAM as the majority of existing TAM studies does. This research aims to create an understanding of the five aspects (ease of use, usefulness, privacy, security, costs) and their relation in the specific context of the phenomenon. The investigation towards understanding the phenomenon is guided by TAM. Consequently, the outcome of this study aims to provided a starting point for future quantitative studies that could test and validate the findings as well as the modified TAM. This overall research approach follows the typical exploratory research paradigm, which very often marks the beginning of total research.

This exploratory research approach relies on data. As previously outlined, little research has been done in the field of the phenomenon and therefore existing data is not suitable for secondary analysis. Primary data needs to be collected. Primary data will be collected through structured interviewing. The interview structure is based on the modified TAM approach. Mostly open-ended questions are used to obtain the user's input of usefulness, ease-of-use, security, privacy and costs related to the phenomenon with the overall goal to explore the phenomenon deeper.

In order to conduct a high quality exploration of the phenomenon, the qualitative research design has to follow criteria of trustworthiness. The research design and the data analysis method are discussed in sections 3.4 and 3.5 respectively. In order to judge the quality of the research approach and design, the trustworthiness criteria and how they relate to this research are further discussed in section 3.6.

3.4. Research design

"Moving away from the notion of 'design selection' and towards an emphasis on design construction" is Trochim and Land's suggestion to design good research, which is grounded in theory, situational, feasible, redundant and efficient[90, last

paragraph]. The quality of designed research is judged by trustworthiness and the associated criteria credibility, transferability, dependability and confirmability[88, 91, 92].

This study is designed to be situational, feasible, redundant, efficient and grounded in theory in order to meet all trustworthiness criteria. Section 3.6 on page 55 explains how the proposed research follows the guidelines and ensures trustworthiness.

Figure 3.1 depicts the main aspects of the research design. Framed boxes denote the major aspects that are discussed in detail in the following subsections.

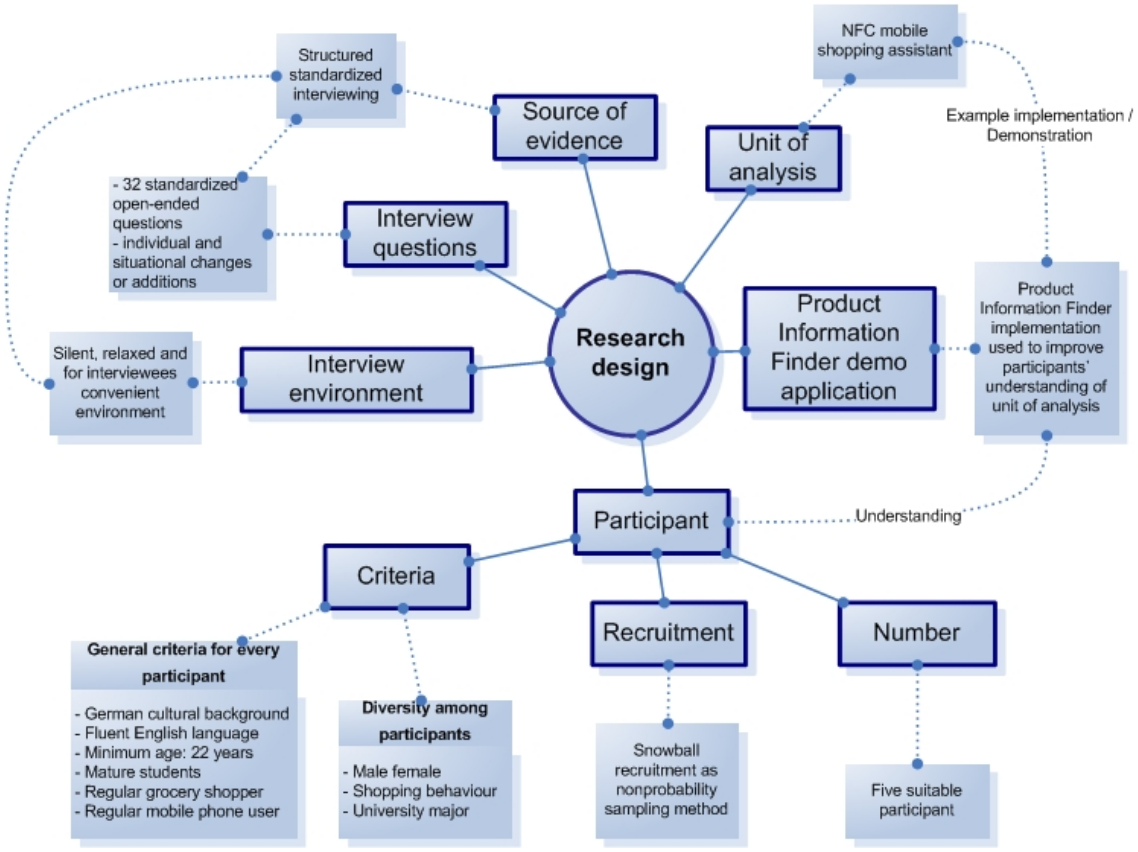


Figure 3.1.: Research design (Source: author)

3.4.1. Source of evidence

Primary data for qualitative analysis can be gathered through observation or interviewing[93, 87]. Both are able to generate textual data that can be analysed. An advantage of observation is to get an insight of the observed subject's behaviour in a specific context. Disadvantages, on the other hand, are that observations are highly selective and inexperienced observers are likely to miss facts. Furthermore, observation is considered very time-consuming too[94]. From a practical point of view, there is also the problem of not having a complete and mature NFC mobile shopping envi-

ronment available. The researcher would have to invest a huge amount of resources to create such an environment.

Interviews by contrast, do not necessarily require a realistic environment for data collection. Interviews are the most common source of evidence and highly important as a data collection method[95]. According to Patton, "the purpose of interviewing is to find out what is in and on someone else's mind"[87, p. 278]. Interviewing as source of evidence fits the aim of this research as well as the overall circumstances. Interviewing is used to source the evidence in this research.

There are different types of interviews and each type serves different purposes. Patton[87] describes four main interview variations, which are summarised in table 3.1

Table 3.1.: Interview types (Source: [87, p. 288-289])

1. Informal conversational interview	
Characteristics	Questions emerge from the immediate context and are asked in the natural course of things; there is no predetermination of question topics or wording.
Strengths	Increases the salience and relevance of questions; interviews are built on and emerge from observations; the interview can be matched to individuals and circumstances.
Weaknesses	Different information collected from different people with different questions. Less systematic and comprehensive if certain questions do not arise "naturally". Data organization and analysis can be quite difficult.
2. Interview guide approach	
Characteristics	Topics and issues to be covered are specific in advance, in outline form; interviewer decides sequence and wording of questions in the course of the interview.
Strengths	The outline increases the comprehensiveness of the data and makes data collection somewhat systematic for each respondent. Logical gaps in data can be anticipated and closed. Interviews remain fairly conversational and situational.
Weaknesses	Important and salient topic may be inadvertently omitted. Interviewer flexibility in sequencing and wording questions can result in substantially different responses from different perspectives, thus reducing the comparability of responses.
3. Standardized open-ended interview	
Characteristics	The exact wording and sequence of questions are determined in advance. All interviewees are asked the same basic questions in the same order. Questions are worded in a completely open ended format.
Strengths	Respondents answer the same questions, thus increasing comparability of responses; data are complete for each person on the topics addressed in the interview. Reduces interviewer effects and bias when several interviewers are used. Permits evaluation users to see and review the instrumentation used in the evaluation. Facilitates organization and analysis of the data.
Weaknesses	Little flexibility in relating the interview to particular individuals and circumstances; standardized wording of questions may constrain and limit naturalness and relevance of questions and answers.
4. Closed, fixed response interview	
Characteristics	Questions and response categories are determined in advance. Responses are fixed; respondent chooses from among these fixed responses.
Strengths	Data analysis is simple; responses can be directly compared and easily aggregated; many questions can be asked in a short time.
Weaknesses	Respondents must fit their experience and feelings into the researcher's categories; may be perceived as impersonal, irrelevant, and mechanistic. Can distort what respondents really mean or experienced by so completely limiting their response choices.

Questions in *closed, fixed response interviews* have pre-defined answers, which may not express what the interviewee wants to express. This interview type is also not in accordance with the exploratory research approach of this study. At the other end of the spectrum, an *informal conversational interview* without any major pre-defined structure increases the risk of missing relevant topics or of loosing focus. Between the two extremes of the interview range, there are two additional interview types.

An *interview guided approach* provides more structure to make sure that certain topics are covered. Furthermore, it offers the interviewer the flexibility to ask additional questions during the interview in order to gain a deeper insight.

In *standardised open-ended interviews* each interviewee will be asked the same set of questions in the same order. This is particularly useful when interview data is analysed in a quantitative way.

All four interview types have disadvantages: that is why Patton suggests to incorporate various interview types and tailor them for the specific research question[87, p. 290]. The researcher follows this recommendation and chooses a combination of standardised open-ended interview approach and interview guided approach. The majority of questions are worded in advance in an open-ended form to ensure the interviewee can express his/her own opinion and does not have to chose from something that the researcher assumes. The researcher intends to ask the same questions in the same order to all participants. In order to incorporate flexibility, to pick up emerging topics during the interview and to ask clarification questions, the researcher may ask additional non-prepared questions. Also, some of the pre-worded questions may not be asked, if for instance an interviewee has already given an answer in a similar context. The structure and aim of the questions reflect the research focus by targeting the five technology acceptance areas (usefulness, ease of use, privacy, security, costs). Subsection 3.4.7 on page 50 contains further details regarding the interview questions.

The structured standardised interview with open-ended questions prepared in advance aims to be a guide for the interviewer, because the researcher's little experience in academic interviewing may otherwise result in poor data. Nevertheless, this does not mean that each interviewee will be asked the same questions in the same order. In fact, if during the interviews some questions do not make sense anymore, because the interviewee clearly stated something contradicting before, then questions will be rephrased, ignored or asked in a different context. This also means that the researcher (interviewer) is furthermore encouraged to ask follow-up questions regarding topics that just emerged from previous answers. Finally, at the end of the interview, the interviewee can also suggest topics and ask questions in order to raise

issues or cover aspects that should have been covered. That enables the interviewee to contribute new topics freely.

The chosen combination of interview types ensures a primary data collection that is structured and well situated within the area of investigation. It also ensures flexibility to obtain a deep understanding and incorporate individual personalities.

3.4.2. Unit of analysis

The focus of this study is to explore benefits, issues and challenges related to the phenomenon of an NFC mobile shopping assistant. The unit of analysis is the NFC mobile shopping assistant. Individual participants or the human nature behind them are not the focus. Individual humans are however the unit of observation. The unit of observation is used to explore the technology. The individuals need to match the participant criteria (see section 3.4.4 on page 47) in order to support the unit of analysis.

3.4.3. Demonstration: Product Information Finder

Until the time of this research the number of NFC mobile applications has been relatively low. In chapters 1 and 2 existing NFC mobile applications have been introduced. Nevertheless, it is likely that the majority of people do not know yet what NFC stands for nor that payment, ticketing or check-in/check-out can be possibly done with a mobile phone. Hence, it is important to inform the interviewees about the NFC mobile shopping assistant and how it works. Otherwise it could happen that interviewee and interviewer have a very different understanding of the phenomenon, which consequently could lead to poor data.

For the purpose of this researcher, the researcher developed the Product Information Finder (PIF), which represents a demo implementation of a possible NFC mobile shopping assistant and therefore a possible interpretation of the unit of analysis. The PIF is demonstrated right at the beginning of the interview to introduce the technology. The demo application is presented by the interviewer. During the presentation of the prototype, the interviewer explains context (grocery shopping) and how the NFC smartphone is used. Furthermore, the researcher emphasises the prototype status. In addition, the researcher stresses that structure, example data, colours, design, layout, speed, performance, functionality etc. are very likely to vary in future applications.

The PIF has been entirely developed by the researcher only for the purpose of

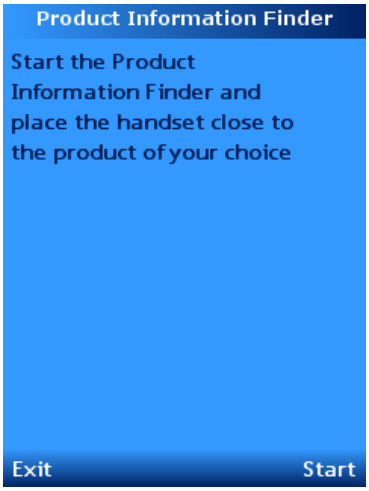
this research. The complete source code and runtime files are not attached. They can be obtained from the researcher. PIF is a Java-ME application, optimised for Nokia mobile devices with NFC support. As discussed in section 1.1, a large number of existing research projects have used the Nokia 6131 NFC mobile phone as target platform. Their successful implementations and the researcher's personal experience with the Nokia platform were the two main reasons for developing the PIF specifically targeting a Nokia smartphone. Auckland University of Technology's AURA Lab provided the researcher with a Nokia 6131 NFC mobile phone (figure 3.2a) and nine RFID/NFC tags (figure 3.2b).

(a) Nokia 6131 NFC (Source: [96]) (b) NFC tag (Source: [97])

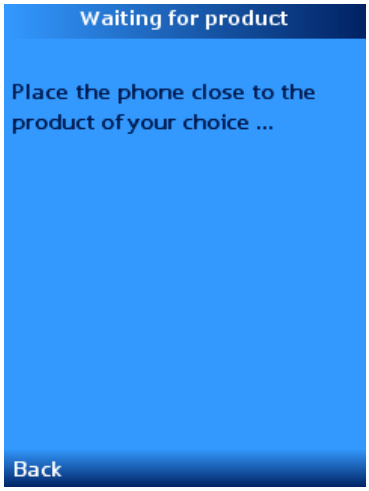
Figure 3.2.: Nokia 6131 NFC mobile phone and NFC tag

An NFC reader features the Nokia 6131 NFC mobile phone. The reader is built into the mobile phone and its antenna is placed inside the flippable display part. Figure 4.1 on page 69 illustrates the interaction between a RFID/NFC tag and a Nokia 6131 NFC mobile phone during the product identification.

PIF consists of six relatively simple screens. A few sample products and product information have been added to the PIF in order to add more realistic content. Each screen has a headline at the top and one or two interaction buttons at the bottom. Figures 3.3 and 3.4 represent the main and most important screens.



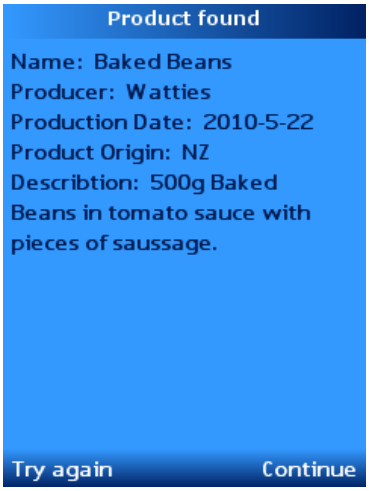
(a) Program start



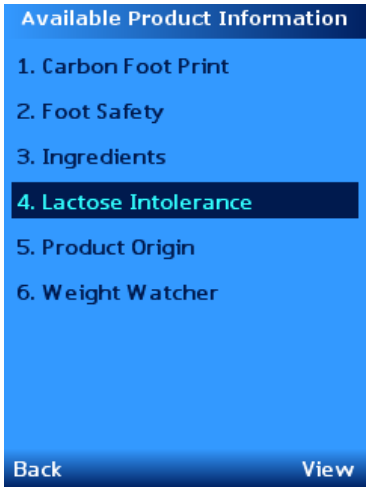
(b) Waiting for product

(c) Product found but no information available

Figure 3.3.: PIF screens - Start, searching for product and product without information found (Source: author)



(a) Product found and information available



(b) Available information

(c) Food product information

Figure 3.4.: PIF screens - Product found and information displayed (Source: author)

After the PIF is physically installed on the Nokia 6131 NFC mobile phone, an application shortcut leads to the start of PIF. Once PIF is started, the actual *start screen* (figure 3.3a) is visible. It briefly informs the user how to use it. Available menu options are *Exit* and *Start*. *Exit* will close the application. *Start* will trigger the NFC reader to read tags and the next screen is displayed (figure 3.3b). In the background the reader will read any NFC tag that comes in the reading range. If an NFC tag is identified as a known product, then the *product found screen* (figures 3.3c or 3.4a) is displayed.

Figure 3.3c is shown when product information is not available. On the other hand, figure 3.4a is shown when product information is available. In this case, the *product found screen* contains very basic product information for the user to match with the scanned product. At this stage the close proximity of the mobile phone (NFC reader) to the product (NFC tag) is not required anymore. The basic product information represents the scanned product or, in other words, the product that the user wants to know more about. The user decides whether the basic product information matches the scanned product. In case it does, then the user can chose to *continue* and select the type of *additional food product information*, which he/she is interested in (figure 3.4b). The user can simply use the up/down buttons of the phone to navigate between available product information. By pressing the *view* menu button, the selected information will be displayed as illustrated in figure 3.4c. The *food product information screen* (figure 3.4c) consists only of a single menu button that will navigate the user *back* to *the available product information screen*. This enables quick access to a variety of information. It is also important to be able to quickly scan a new product (tag). Hence the *product found screen*, which contains the very basic information and has a menu button for rescanning (*Try again*). The appendix section E.2 commencing on page 167 contains the full structural workflow chart of the user interaction with PIF.

3.4.4. Participant criteria

For qualitative research, the selection of participants is important to increase the value of the study. Qualitative research and in particular the exploratory approach aims to investigate a phenomenon. Not every person is suitable to contribute with his/her knowledge and experience. For qualitative research it is not a must to include a wide range of different people. Qualitative research cannot generalise to a wider population, but it can use participants with specific knowledge or relevant experience to explore a phenomenon. Therefore, this study has nine criteria for selecting participants to ensure a maximum data quality through including a wide range but also focusing on key aspects at the same time.

The nine participant criteria for this research are stated further below and their relevance for this research is explained as well. Criteria one to seven emphasise the focus on key participant attributes and can be regarded as a set of very minimum participant criteria. Criteria eight and nine emphasise on a wider range of participant attributes to ensure variety.

1. The *cultural background* of all participants needs to be *German* for two main reasons. Firstly, the study aims to explore the NFC mobile shopping assistant

in a German grocery environment. Therefore the participants should be familiar with the shopping situation in Germany. Secondly, Walsham[98] suggests that the interviewer should be very familiar with the culture of the interviewees in order to improve the interview quality and understand culture-related issues. The researcher in this study is also the interviewer and his nationality is German, therefore participants must be German as well. See section C.2 on page 162 for an example case of cultural differences between Germans and New Zealanders.

2. All German participants must *fluently speak English*. This study is conducted and written in English language. Interviews will not be translated from German into English, because important information could get lost or the meaning of a statement could be changed inadvertently. Therefore, the interviews will be conducted in English and the participants will answer in English. An advanced level of English is required to maintain a fluent conversation.

3. The number of *male and female* participants should be roughly equal.

4. The participant's *minimum age must be 22 years*. Younger people are likely to still live with their parents and therefore they most likely do not do regular grocery shopping. For the purpose of this research some shopping experience is useful. The researcher believes that people at the age of 22 are very likely to have lived independently away from their parents. Additionally, in some countries other than Germany the legal drinking age is 21 years. Due to the fact that alcohol products can be bought in grocery stores, a younger participant who lives in a country with the legal drinking age of 21 might not be able to say anything related to alcoholic purchases. Literature does not suggest any relevant relation of alcoholic products, but the researcher does not want to limit the study on this issue.

5. All participants should be *mature students* in their fourth or fifth year of university. Mature students are approached to participate in this study for three main reasons:

   Firstly, students have most likely experienced what research and interview data collection is about. They are familiar with the importance of data for the research. In contrast, it is possible random people, who may not have academic background do not understand the importance of the interview. Due to the fact that the interviews for this study are likely to consume 60 minutes of the participant's time, the recruitment of random people could easily become difficult. The participants should have free time for the interview and they should be relaxed in order to contribute[87]. Approaching random people in

or around a grocery store is very to be unsuccessful. Sixty minutes of time is just too much for the usual customer. Furthermore, the grocery environment is not really suitable for conducting and recording interviews. Students, on the other hand, know about the importance of the research and are likely be persuaded more easily to give an hour of their time. Also, they are very likely to be more flexible in regards to the the interview date and location. In addition, a motivated and interested participant is more likely to contribute with better data than somebody who is not motivated. Students, especially when they are towards the end of their postgraduate education, are very likely to do regular grocery shopping. That is why they can be considered as normal grocery shoppers too.

The second main reason for choosing students as interviewees is that they are considered open minded towards new technology and they can possibly understand the idea of NFC quickly. An early adopter thinking and innovative mind in participants could possibly contribute to better data. Kuo and Yen[99] and Gao et al.[46] found innovativeness positively influencing the perceived ease of use of a technology.

6. All participants need to do *regular grocery shopping*. This is a minimum requirement to make sure that participants are familiar with grocery shopping and can contribute rich data.

7. All participants need to use their mobile phones or smartphones on a regular basis (at least once every two days for either making/receiving phone calls or text messages).

8. Participants should have a variety of educational backgrounds. The *diversity of participants* is important to cover a wider range of aspects. For instance, if five information technology students are interviewed, this would very likely result in comprehensive covering of security, privacy and technology issues. On the other hand, usefulness and ease-of-use might not be covered that well.

9. Participants need to have *diverse shopping behaviour* in order to cover a wider range of aspects. Different shopping behaviour means for instance: the amount of money spent and the amount of products bought during an average shopping session; the type of products (home brand, brand) preferably bought; who the shopping is done for (only for the participant or also for family or partner).

3.4.5. Theoretical saturation: number of participants

Research based on qualitative interviewing can get enough information from a small number of participants[87]. This of course relies on the research design as well as on the knowledge and contribution of participants. Having put the previous strategies in place (nine participant criteria, demo application), the researcher believes that three well chosen participants can be enough. However, to make sure that the collected data is sufficiently rich, the number of participants is increased to five. It is also accepted that if during or after data collection or data analysis the data appears to be not rich enough, then the number of participants will be increased and the analysis conducted again.

3.4.6. Sampling method: participant recruitment

Based on the qualitative nature of this study and the first seven participant criteria, certain groups of people are not suitable for participant selection. Therefore, a nonprobability sampling method is required. Participants who meet the participant criteria have a number of attributes in common (criteria one to seven), which also makes them likely to be socially connected. This social connection is used for purposive recruiting of participants. Snowball recruitment is applied. That is, the researcher will approach a potential participant and in addition, the researcher will ask him-her for recommendations on who else to approach until the researcher has five participants recruited. The first peer is a former AUT MCIS fellow student, who meets the participant criteria.

3.4.7. Interview questions

The 32 interview questions are available in the appendix, section F.1 commencing on page 169. The questions are organised in a tabular structure (table F.1). Each question is affiliated with one or multiple categories. The categories result from the literature review, where five main technology acceptance areas were identified. The categories are usefulness, ease of use, costs, security and privacy. The categories provide additional structural guidance for the interview questions. In addition to the five categories, there are a few questions that are intended to ask for related topics such as food product information types or smartphone software applications. They are categorised as *other* and support the five main categories (technology acceptance areas).

3.4.8. Interview environment, time and location

Walsham[98] emphasises the importance of a relaxed and convenient interview environment, particularly for the participants, in order to limit factors causing poor data quality. The researcher suggests an interview location but will leave the final decision for the interviewee. However, the location should be quiet to reduce the background noise for the conversation and recording.

Furthermore, Walsham stresses the importance of not overstaying the interviewee's time. The communicated estimated interview time of 60 minutes includes about 15 minutes of contingency. If an interview session takes longer than the 45 minutes (researcher's estimate), then it will be still within the communicated 60 minutes and therefore the interview candidate is unlikely to feel irritated or pressured.

3.4.9. Bias by design

The proposed research design aims to increase the richness of data and hence the outcome of the study as well. However, it also influences the data analysis and introduces bias. The data analysis will consider and acknowledge the potential bias from design features, participant criteria and sampling. Section 3.6 commencing on page 55 contains further information about how trustworthiness is assured. First section 3.5 introduces the data analysis method.

3.5. Data analysis method

In qualitative research, the border between data collection and data analysis is not clearly definable. In some cases, during data collection the researcher finds himself/herself in the state of already analysing data[87]. In this study, even though it is a qualitative study, the researcher wants to separate collection and analysis as much as possible in order to make the data collection independent from data analysis and allow other researchers to collect similar data for verification, comparisons and reproduction of results. Strategies for analysing interview data depend on research type, research question, the type of interview and interview questions asked. Furthermore, different strategies can be incorporated to suite a particular need[87].

Qualitative content analysis is applied to interpret the collected interview data, as it "goes beyond merely counting words or extracting objective content from texts to examine meanings, themes and patterns"[100, p. 1]. Content analysis has been

most commonly used in positivism and with quantitative methods. However, Patton describes content analysis as a possible way of organising and reporting qualitative data[87]. In addition, recently qualitative content analysis has become more popular as it helps to overcome weaknesses of typical quantitative content analysis by executing analysis in an inductive way, grounding topics, themes and connections in the data[100].

"Qualitative content analysis pays attention to unique themes that illustrate the range of the meanings of the phenomenon rather than statistical significances of the occurrence of particular texts or concepts."[100, p. 2] Themes and categories rise from the data in an inductive way. However, deductive reasoning and incorporation of quantitative content analysis operations improve the result[100]. Depending on the degree of inductive reasoning, there are three qualitative content analysis approaches (conventional, directed and summative). Figure 3.5 illustrates all three qualitative content analysis approaches and focuses in particular on the directed approach.

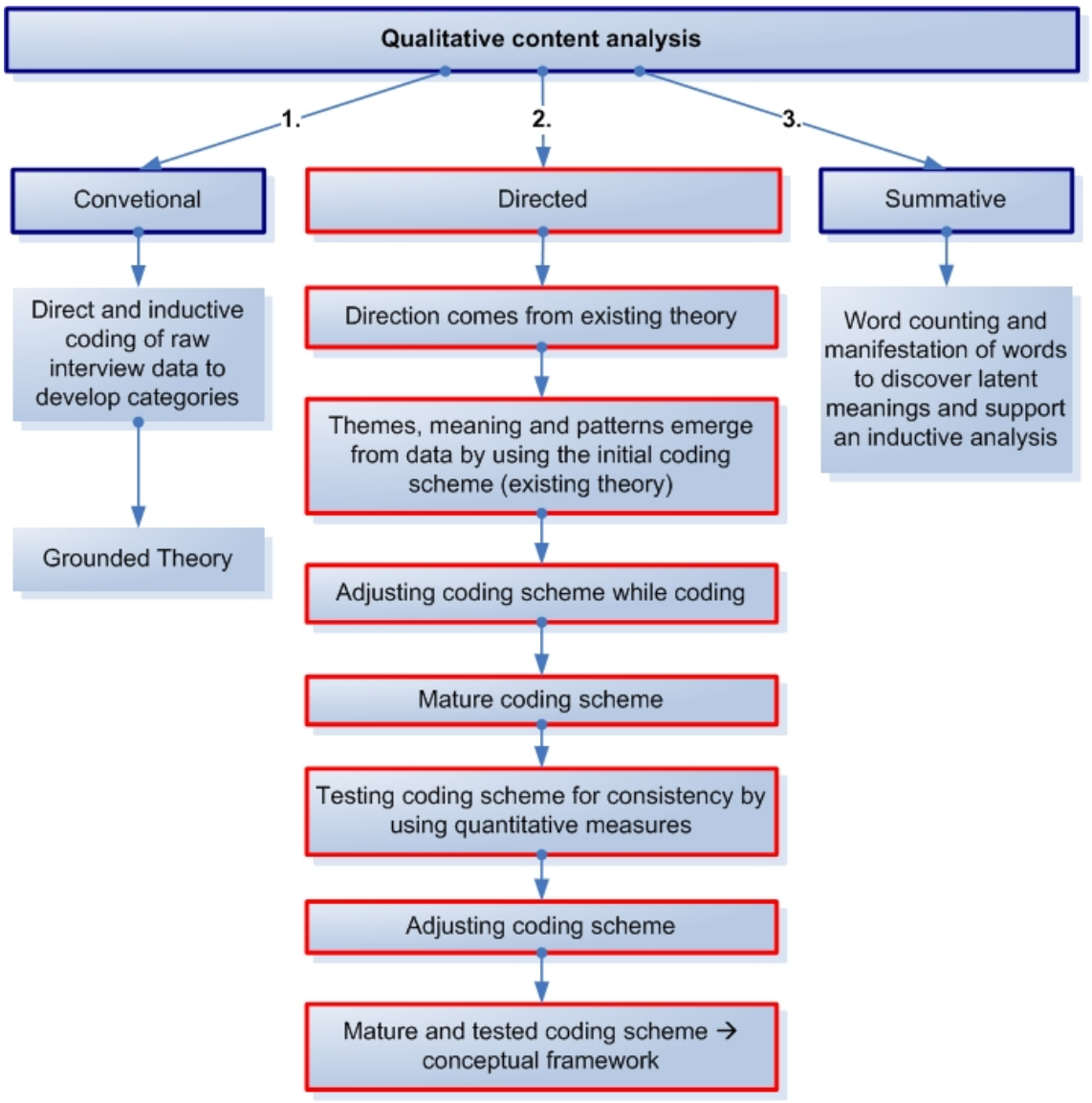


Figure 3.5.: Qualitative content analysis (Source: author)

The researcher chooses directed content analysis, because it is usually used to "validate or extend a conceptual framework or theory"[100, p. 2]. Finding benefits, issues and challenges of the NFC mobile shopping assistant are based on technology acceptance variables of existing and related technologies can be regarded as the extension of an existing conceptual framework. In addition, the other two content analysis approaches (conventional and summative) aim to develop theory grounded in data, respectively to explore the usage of words and indications. Conventional and summative content analysis are therefore not suitable. Directed content analysis starts with existing theory and research findings for the initial coding stage. After the initial coding stage, themes, meaning and patterns arise directly from the raw data and create the final overall conceptual framework[100]. Directed qualitative content analysis guides the data analysis process, but only during the first data coding iteration.

Interview data coding requires data preparation and definition of the unit of analysis[100]. That has been defined in subsection 3.4.2 as the NFC mobile shopping assistant. The data is collected from interviews. Interviews are recorded and in preparation for the coding the interviews are verbatim transcribed literally. Sounds, background noises, pausing or audible behaviours are excluded, as the spoken language is not the focus of the investigation and qualitative content analysis usually does not focus on linguistic[100].

According to Zhang and Wildemuth[100], the next step is development of category and coding scheme. Directed qualitative content analysis starts with initial categories derived from existing research. Therefore, the initial categories are those identified through literature review. Categories change during the coding process. New categories emerge, existing categories merge or become redundant. Therefore, the coding scheme in directed qualitative content analysis changes constantly. In qualitative content analysis, coded text does not have to be exclusively assigned to only one category. Nevertheless, Zhang and Wildemuth[100] suggest internal homogeneous and external heterogeneous categories.

For this particular research, only one person (the researcher and also interviewer) will code the small number of interviews (five), hence a coding manual is not created.

Also, the coding scheme should be tested before all interview data is fully coded. As Zhang and Wildemuth[100] as well as Patton[87] suggest, adjustments according to the actual research structure and research aim are recommended. Instead of testing the coding scheme on a sample text before all interviews are coded, the researcher tests the coding scheme after all interviews are coded and initiates adjustments afterwards. The researcher has decided to do so for a number of reasons. First, the interviews are already structured in a way that they support the initial coding scheme. Second, the initial coding scheme only aims to direct the early stages of the content analysis. During the actual coding, emerging, vanishing or merging categories constantly change the coding scheme. A full coding scheme will not be available unless a major part of the data has been coded. Third, the number of interviews is relatively low (five). After coding five interviews, the coding scheme is more mature as it has been constantly changing. The coding scheme is also going to be different to the initial coding scheme. It will be more complex and reflect the actual data. Testing a mature coding scheme is more beneficial. The developed mature coding scheme is tested for consistency by using quantitative measures such as number of codes per category, number of codes per interview, number of categories per interview, following Zhang and Wildemuth[100] suggestion to mix qualitative and quantitative content analysis methods. As a result, inconsistency can be identified, with subject to the small number of interviews. Inconsistency of

categories is used to further develop the coding scheme and recode affected parts of the interviews. The final coding scheme could be used in future research, if more interviews are carried out. For the purpose of the five interviews of this research, the final coding scheme is developed during the coding iterations.

Patton[87] suggests two ways of coding interviews, which depend on the research focus and type of raw data. This study does not aim to compare the data from different participants, nor does it represent each participant as a unique case. Hence, a comparative data analysis and coding is not required. Instead, all interviews are fully coded by following the same coding scheme. Themes, thoughts, ideas or aspects of the NFC mobile shopping assistant are coded. As mentioned before, themes, thoughts, ideas or aspects can be assigned to multiple categories at the same time. During the coding, the coding scheme (categories) changes. After coding has been completed, it is therefore important to check the coding consistency and initiate recoding if needed. After coding completion, conclusions are drawn from data and finally reported as a concept. The participants (interviewees) are individuals. They have different backgrounds and varying opinions. This research acknowledges the individual background and considers the individual aspects for data analysis, but an individual case by case comparison is not the research focus. Following Patton's[87] recommendation, a cross interview analysis is applied in the case of this research.

3.6. Trustworthiness

The quality of good research is judged by reliability and validity of the research design and analysis. The terms reliability and validity, however, are used as criterion for quantitative research. For qualitative research on the other hand, trustworthiness is used as a criterion for judging the research quality[91, 88].

The concept of trustworthiness is related to credibility, transferability, dependability and confirmability[88, 91, 92]. Each of these can be achieved by various strategies, which should be in accordance with the overall research approach. In the following subsections, the strategies to ensure credibility, transferability, dependability and confirmability within this research are outlined.

3.6.1. Credibility

Patton argues that credibility of a qualitative research is especially dependent on the credibility of the researcher because the researcher is the instrument of data collection and the centre of the analytic process[87, p. 461]. That also includes

techniques and methods used for gathering high quality data and the credibility of the participants.

Credibility of the researcher: The researcher has been active in the field of mobile software for more than three years. The researcher's academic interests have been focused on RFID, information security, ubiquitous computing and mobile software development were in focus. From a professional perspective, the researcher has been working for large international IT consulting companies. As part of the engagement, he designed, implemented and tested various small and large scale software. Recently he has been developing a mobile application incorporating RFID to achieve indoor navigation for people with traumatic brain injuries. Therefore the researcher is familiar with technical aspects, usability issues and constraints of larger ecosystems. See subsection 3.6.4 regarding further details about researcher bias.

Credibility of the participants: As outlined in section 3.4.2, the participants have to meet certain criteria in order to be considered as credible. The most important is that real people are participating with their own opinion. Also, the participants need to be relevant to the study. That is achieved by choosing only those who fit the participant criteria. In addition to providing their individual perspectives, the participants have different backgrounds, they have different shopping behaviours, the gender mix is balanced and all of them are familiar with the German grocery environment. Those criteria enable a wide, open-minded but also focused approach to answering the research question. That is in accordance with the overall research approach. A snowball approach is used as recruitment method. That limits the researcher's bias towards participants[101].

Credibility of the method for data collection: Interviews are a very common method for qualitative data collection[87]. Furthermore, the interviews are structured and consist of mostly open-ended questions. Open-ended questions allow the researcher to obtain the interviewee's perception and opinion of a phenomenon. Structural guidance is used to focus the interview on certain key topics and to enable cross-interview analysis. As an important aspect of the interviews, the researcher developed a demo application, which is shown to the interviewees prior to the interview. The aim is to provide the interviewee with a certain understanding of an emerging technology. That minimises the threat of misunderstandings during the interview and supports focusing on key topics and the phenomenon.

The research is designed to easily enable and incorporate triangulation on various levels. Most importantly the separation of data collection and analysis is a key feature. As acknowledged in section 3.5, there is not a clear border between data collection and analysis in most qualitative research. However, this study starts the data analysis only after all data was collected. Therefore, possible data from other

sources could be incorporated. Furthermore, PIF as a prototype of the phenomenon introduces the option of obtaining triangulation data as well. Participants could be observed while they use PIF. In this research, observation on how the participants use the demo application is not incorporated, but it could be incorporated to support at least the key topic of ease-of-use.

As part of the data collection strategy only those participants are accepted that are genuinely willing to contribute freely. Additionally, the interviewer emphasises his neutrality and that there is no right and wrong. Consequently the interviewees can fully contribute personal opinions and their perceptions.

3.6.2. Transferability

Shenton[101] argues that transferability in qualitative research is difficult to achieve, since the researcher only knows the sending context. In order to create the possibility of transferring certain aspects to a different audience, to a different environment or, generally speaking, to a different context, the researcher needs to provide an extensive description of the research environment. The description will enable other researchers to decide which parts and aspects could possibly be transferred. The description of the research environment contains the context in which the work was undertaken, the phenomenon and the following six sets of information:[101]

1. "The number of organisations taking part in the study and where they are based"[101, p. 70]
2. "Any restrictions on the type of people who contributed data"[101, p. 70]
3. "The number of participants involved in the fieldwork"[101, p. 70]
4. "The data collection methods that were employed"[101, p. 70]
5. "The number and length of the data collections session"[101, p. 70]
6. "The time period over which the data was collected"[101, p. 70]

This research reports all of the above information to allow other researchers to judge the extend to which the data, design and analysis are transferable.

The context of this work and the phenomenon are described in chapter 1 and section 2.2. The number of organisations taking part in the study and where they are based can be found in subsection 4.3.1. Subsection 3.4.4 contains the general restrictions on the type of contributing participants. Subsection 4.3.1 contains the actual number of participants and each participant's demographic information. The

data collection method that was planned is described in section 3.4, the actual data collection protocol is discussed in subsection 4.3.2, which also includes the number and length of data collection sessions as well as the time period of data collection.

3.6.3. Dependability

In qualitative studies, dependability is closely related to credibility and by demonstrating a high level of credibility, dependability is ensured. In practical terms the research process needs to be reported in detail to enable future researchers to repeat the work, to gain similar results and to judge the research practice[101].

The research design is described in section 3.4 and data collection and interview coding are presented in chapter 4. In particular the details of the data collection through interviews are available in section 4.3.

3.6.4. Confirmability

"Confirmability is the qualitative investigator's comparable concern to objectivity"[101, p. 72]. The researcher (investigator) should minimise any biases as much as possible. It is important that the participants rather than the researcher contribute the data. Similar to the previous trustworthiness strategies, triangulation and a detailed description of the research design and activity are suitable methods to reduce bias in order to allow future researchers to judge the study. Furthermore, the researcher's predisposition and beliefs should be known to any reader of the study in order for them to analyse to what extend the researcher influenced the study. That is important, because bias cannot be completely ruled out, since interview questions, demo application and the actual conducted interviews are developed and carried out by human beings[101].

Details about triangulation and a detailed research description were presented as part of previously introduced strategies. The researcher's credibility is briefly outlined in section 3.6.1. In addition, section 4.2 contains a description of the researcher's believes and views of the phenomenon and related topics.

3.6.5. Validity of research design

Qualitative research can be seen as valid if it represents the perception of people through real, rich and deep data[88]. In addition, qualitative research requires less

front-end-work and rapid reconnaissance allows to move quickly with emerging topics and stay close to the phenomenon[87]. An early exploration of an emerging topic, such as NFC and a very volatile market, such as the smartphone segment sets the basis for future research. Therefore, a good research design is essential for valid research. Good research design should be at least theory-grounded, situational, feasible, efficient and flexible[90]. The proposed research design of this study respects those five criteria as outlined below:

- *Theory-Grounded*: Incorporating a modified version of TAM by focusing on ease-of-use, usefulness, security, privacy and costs. A modified version of TAM that is tailored to the specific phenomenon has been suggested in existing research reports. See section 2.3 for further details.

- *Situational*: The use of a demo application to illustrate a real example is particularly useful for focusing the interviewees to the situation and context. In addition, the use of mostly open-ended interview questions allows the interviewees to express their perception, experience and opinion.

- *Feasible*: Feasibility is achieved with a research design that can be implemented and carried out in practice. The PIF demo application and structured mostly open-ended interview questions are clearly feasible for the scope of this study. Potential problems such as introduced bias or not rich enough data were considered in the research design.

- *Flexibility through redundant design features*: Duplication of essential design features avoids invalidity of the entire study, if one design feature fails. From a wider perspective, there are possibilities to apply multiple design features, such as follow up interviews, additional individual case studies or replications. However, the scope and aim of this study does not offer such option. Instead, the number of participants has been increased from three to five. Furthermore, a number of questions are flexibly designed. For instance, question 12 asks for the particular interest in food product information of people known to the participant. Even if the participant has no interest in food product information, then at least the opinion of friends, partners, family members or fellow students can be contributed. The research design allows incorporation of other design features such as observation.

- *Efficient*: To strike a balance between redundancy and over design, a number of duplicate design features, such as replication of interviews, follow-up interviews or observation have not been included in the design. They have not been included because this research is regarded as a initial research about the phenomenon. Existing research suggests areas where benefits, issues and

challenges are highly present. It is, however, uncertain whether the findings of this study support the suggestions. Therefore, this research is designed to use the powerful feature of qualitative interviewing. Future work can, depending on the outcome of this research, incorporate redundant design features. This research design provides the basis for incorporating redundant design features.

3.7. Chapter summary

Exploratory research in a qualitative manner to collect interview data from five suitable students through a structured, standardised open-ended set of questions is the methodology approach for this research. Suitable participant criteria and a prototype demo application (PIF) contribute to a better data quality. Chapter 4 discusses how the methodology approach outlined in chapter 3 is applied.

4 Data collection and interview coding

4.1. Introduction

The data collection for this research is conducted by the researcher who is at the same time interviewer, interview transcriber and data analyser. The researcher's perspective is important to be known for readers to have sufficient information to judge the credibility and confirmability of data collection and analysis. This chapter provides the researcher's perspective in section 4.2. Section 4.3 describes the actual data collection phase, covering the demographics of interviewees in subsection 4.3.1 and the interview protocol in subsection 4.3.2. After the interviews are conducted, data analysis starts by developing a coding scheme and coding the transcribed interviews as discussed in section 4.4.

A note regarding used terms: A participant of this research is referred to as interviewee. Each interviewee was interviewed only once. The first interview number corresponds to the first interviewee number. *I1* refers to either interview number one or interviewee number one depending on the context.

4.2. Researcher's perspective

At the time this study was planned, executed and reported the researcher was in his mid twenties and was in the final year of his Master of Computer and Information Sciences study at Auckland University of Technology.

About three and a half years before the submission of this thesis, the researcher started working with NFC and RFID technology as well as developing software for various mobile phone platforms. Prior to this, the researcher had successfully deployed various software development projects in academic and professional envi-

ronments.

The researcher believes that a software (no matter which kind) first of all has to fit a specific need. The software, and in a wider sense the hardware as well, need to support a process and improve it. A software should not change a process workflow or the user's way of doing things. However, there are areas within the greater field of software usage, where a change of common software usage is required. For example security and privacy aspects of software are often not clearly communicated to the user. That is possibly because the average user has little interest or understanding of them. Furthermore, a software can be designed to be simple and easy to understand, so that first time users have little difficulty to use it. Nevertheless, over the time and with experience the software functionality might become limiting and usability as well as usefulness decrease. The researcher believes that finding a possible balance between easy to use software and complex, feature-rich software is one of the greatest challenges of software interface development.

In terms of future life style, the researcher believes that smartphones will play a much bigger role in the future. They will be used for many more applications areas beyond what has been and will be outlined in this study. Therefore, security, privacy and usability aspects are going to play a greater role.

The increasing use of smartphones and a change in the way people use them in their environment are in contrast to what the researcher believes about software (software has to fit a need and should not change the workflow). This will be a future challenge, especially for generations of people who have not grown up with computers or smartphones.

4.3. Data collection phase

In early July 2010 the researcher used snowball recruitment of interviewees by approaching people from the researcher's personal network. The minimum interviewee requirements (fluent English, regular grocery customer, regular mobile phone user, 22 years or older, German ethnicity) were communicated. The first contact who agreed to participate could himself recruit two additional interviewees. The fourth interviewee came form the initial recruitment approach and could recruit the fifth interviewee from his own personal network. Subsection 4.3.1 contains details about the interviewee demographics.

After all five interviewees had agreed to participate, appointments for each interview were negotiated. The researcher suggested a time in the later afternoon in

order to make it more suitable for the interviewees. The researcher also suggested a possible interview location. However, it was made clear that time and location could be changed in order to make it more suitable and relaxed for the interviewees.

Data collection took place in three different German cities between 18th and 27th of July 2010. Subsection 4.3.1 contains further details about the different interview locations as part of table 4.1.

The actual recorded interviews were between 25 and 40 minutes long. For each of the five cases the total time spent was not longer than 60 minutes. Further details are in subsection 4.3.2 on page 68, which contains a description how the interviews were conducted (interview protocol).

4.3.1. Demographic

In order to explore issues and challenges of the phenomenon in depth, the interviewees' backgrounds and characteristics reflect a wide range in certain aspects. However, all interviewees have certain characteristics in common. This section presents common characteristics, differences and a profile overview of the interviewees. Table 4.1 commencing on page 66 contains details of all five interviewees. All information refers to the time when the interviews were carried out.

Shared characteristics are:

- Ethnicity: German;
- Main place of residence: German city with population of 600,000 or more;
- Regular grocery shopping;
- Occupation: recently graduated from university or active student in fourth or fifth year of university;
- All interviewees have lived in a country other than Germany for at least 4 months;
- Fluently spoken English;
- Interviewees are in their mid to late twenties, i.e. between 24 and 29 years.

The advantage of shared characteristics among all interviewees is the enhanced comparability of the data. All interviewees are Germans, they shop regularly, they are not too young, they had lived abroad in the past and they were living in Ger-

many at the time of the interviews. Consequently, they are familiar with the current German grocery environment. They also have been exposed to different shopping environments and habits while living abroad. Those aspects increase the interviewees' awareness of grocery shopping.

Their main places of residences are German cities with a population above 0.6 million people[1],[2],[3]. Highly populated areas have a higher number of large grocery stores nearby. Therefore, all interviewees can choose between multiple grocery stores. Also, as outlined in appendix section C.1 commencing on page 154, the number of very small grocery stores is relatively low. Instead, larger grocery stores are more common. Larger grocery stores are more likely to implement RFID solutions, have a higher number of customers and a wider product range. All interviewees are familiar with larger grocery stores.

The interviewees' spoken English language is fluent, which makes the interview run easier. Furthermore, interviewees are confident enough to make themselves well understood.

All interviewees are familiar with the academic environment. They know about the importance of good primary data as the basis for this study and, because they are genuinely willing to freely contribute, the data quality increases[87].

In contrast to common characteristics, differences in interviewees' background in terms of their major at university, shopping behaviour, shopping quantity or gender help to widen the point of views and to explore more issues and challenges in different situations. Important differences are the majors of their university studies, age and gender. All together they provide a rough idea about each interviewee's perspective. Shopping frequency, grocery stores, grocery selection and quantity all add to the profile of each interviewee.

There were three male and two female interviewees. Four interviewees were between 24 and 25 years old. One interviewee was 29 years old. At the time of the interviews four interviewees were actively studying, whereas one interviewee recently had graduated and started working. The four students were mature students towards the end of their studies. The university majors were in the area of computer science, engineering, business, law and comparative literature.

Overall, the interviewees' shopping profiles cover various aspects. The shopping quantity ranges from little (for one person) up to family size (for four people). The shopping interval ranges from multiple times per week to once every week. The

[1]Stuttgart: 601,646[102]
[2]Frankfurt am Main: 671,927[103]
[3]Berlin: 3,440,441[104]

selection of products bought varies from very basic and prepared dishes to a wide range and fresh products.

The following table 4.1 contains an overview of the interviewees' demographics. Column one contains the criteria. Columns two to six contain the details related for each interviewee to each criterion.

Table 4.1.: Interviewee demographics at the time of the interviews (Source: author)

Criterion	I1	I2	I3	I4	I5
Age	24 years	25 years	24 years	24 years	29 years
Gender	male	male	female	female	male
Occupation	engineer who recently graduated	active student in 5th year	active student in 5th year	active student in 4th year	active student in 5th year
University major	mechanical engineering	computer science	business and law	comparative literature	business computing
Grocery selection	fresh fruit, milk, bread prepared dishes	basic food, prepared dishes (meat and sides), soda and drinks	fresh vegetables, fruits and meat, sometimes prepared dishes	a lot of fresh fruit and vegetables preferably from the market, ecological food if not too expensive	many milk products, prepared dishes, fruits, vegetables
Grocery stores	same smaller grocery store “Edeka”	same discount supermarket most of the times	same large supermarket “Kaufland”	mostly a medium-sized and medium-price supermarket just around the corner, sometimes a little cheaper/more expensive 5min away	same large supermarket “Real”
Shopping frequency	2 times a week	2-3 times a week	once a week	3 times a week	1-2 times a week
Shopping quantity per purchase	20 Euro, for 1 person	mostly for 1 person, 10 to 15 Euro	70 to 100 Euro, for 4 people	15 to 20 Euro, for 1-2 persons	20 to 25 Euro, for 1-2 people
Ethnicity	German	German	German	German	German
Foreign experience	has lived 30 months abroad	has lived 24 months abroad	has lived 6 months abroad	has lived 18 months abroad	has lived 6 months abroad
Main place of residence	Stuttgart	Frankfurt am Main	Berlin	Berlin	Berlin

Continued on Next Page…

Table 4.1.: Interviewee demographics at the time of the interviews (Source: author)

Criterion	I1	I2	I3	I4	I5
Interview location	Stuttgart, participant's apartment	Frankfurt am Main, participant's apartment	Berlin, participant's apartment	Berlin, public cafe	Berlin, participant's apartment

4.3.2. Interview protocol

As Walsham[98] recommends, a good interview environment is necessary to increase the data quality. Prior to each interview, the interviewer made sure that it took place in an relaxed atmosphere with only a low level of background noise. The interviewees were told that they could pause the interview at any time to take phone calls or go to the bathroom. However, all five interviews went along without any interruption. In addition, prior to each interview, the audio recording device was tested. The researcher's Nokia E71 smartphone was used as a recording device.

Before the actual interview and recording started, the interviewee information sheet was given to the each interviewee and the interview session was outlined. After that the consent form was handed over for signing and the minimum of demographic information was collected. As the final step before the actual interview, the demo application Product Information Finder (PIF) was introduced by the interviewer.

The PIF presentation consisted of three parts. The first part was a verbal description of the context. The second part was the physical demonstration of the PIF and finally each interviewee was allowed to ask questions. The verbal description of the context was as follows:

> The following presentation is a prototype presentation, which outlines how a future technology could be applied. The mobile phone has a NFC/RFID reader built-in, which is able to read tags that are attached to grocery products. As part of the software, example product information is used, which is not necessarily related to the actual product. That is however only because of the prototype status.
>
> A system like this could be used in future grocery stores. Products are likely to have NFC/RFID tags attached that could be read by modern mobile phones. The phone and its built-in NFC/RFID reader would be used to identify the product and to assist in finding and presenting product information.
>
> Product information could be anything. Some information might already be available on the product label. On the other hand, some information might not be available on the product and is only available from different sources. The phone aggregates the information and presents it to the customer.

The physical demonstration of the PIF included actual grocery products, which had NFC tags attached. Figure 4.1 exemplifies the presentation. The interviewer

presented the interaction with the software to the interviewees according to possible usage scenario (figure E.2 on page 168). See section 3.4.3 on page 44 for screen shots of the PIF related to the usage scenario.

(a) (b)

Figure 4.1.: PIF demo application presentation (Source: author)

After the interviewer finished the presentation, the interviewee could then experiment with the device and software and ask questions. All interviewees chose to experiment with the device and all interviewees briefly performed a basic usage scenario of the PIF. During the test, only I1 raised a question. He wanted to know whether this prototype was fake or actually working. The interviewer explained that software, device and tag were real and the communication among them did take place. However, the interviewer pointed out that the PIF is only a prototype and that the product data displayed by the software was hard coded and not necessarily related to the corresponding product.

After the demo, the interviewer asked whether the interview could begin and all interviewees agreed. The audio recording began. It was made clear that from that moment on the interview would be recorded.

After the interviews finished, the audio recordings were stopped. Immediately after that it was checked whether the recording has been successful. In all cases, the audio file quality was good. The last part of the interview session was to thank the interviewees for their time and contribution.

The next step was then literal verbatim transcription of the interview audio recordings. That was executed by the interviewer (researcher) shortly after the interviews

took place. The software Express Scribe[4] was used to support the transcription.

Transcribed interviews are the basis for the following data analysis.

4.4. Data Analysis

Data analysis took place shortly after transcription. Directed qualitative content analysis, as described in section 3.5, was applied. The software QSR NVivo 8.0 supported the data analysis, in particular the coding part, restructuring of categories (coding scheme) and reporting.

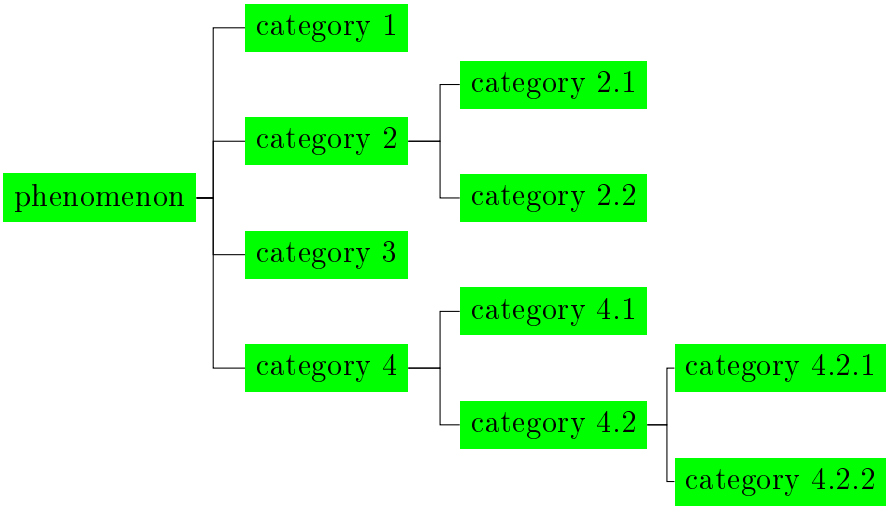
The interview data analysis is structured into four stages. The first stage, described in subsection 4.4.1, starts with the initial set of categories. All five transcribed interviews are fully coded and the coding scheme develops as coding progresses. Stage two, three and four test the emerged coding scheme by checking the coding scheme's consistency. Stage two (subsection 4.4.2 commencing on page 74) checks for less used categories. Stage three (subsection 4.4.3 commencing on page 76) checks highly used categories. Stage four subsection 4.4.4 commencing on page 77) checks the coding density. Finally, subsection 4.4.5 commencing on page 78 presents the coding summary.

4.4.1. Coding stage 1: Initial categories and coding scheme development

The coding scheme is similar to a tree structure. Figure 4.2 provides an example of a tree structure representing a generic coding scheme:

[4]Express Scribe is a software that can play, pause and reply audio files in a quick and easy way.

Figure 4.2.: Example of a tree structure that is used for coding (Source: author)



The root node represents the phenomenon under investigation. Children of the root node represent the first level of categories. Those are the main categories. Different iterations of the interview data coding create subcategories (children and grand children of the first level categories).

Tables are used to illustrate and report the coding scheme tree, because tables use less space and can present this information more clearly. The visual difference between table and tree illustration of the coding scheme is minor. The following table 4.2 contains the transformation of the example tree 4.2 into the table format.

Table 4.2.: Example of a tree structure organized in a table (Source: author)

Code
category 1
category 2
category 2.1
category 2.2
category 3
category 4
category 4.1
category 4.2
category 4.2.1
category 4.2.2

If a category has subcategories (children), then it is not used for coding because subcategories represent details and aspects of the corresponding parent category.

Instead only its children are used for coding. In other words, only the leaves of a tree structure will are used for coding, whereas nodes are not. In the case of the example tree 4.2 and table 4.2, only category leaves 1, 2.1, 2.2, 3, 4.1, 4.2.1, 4.2.2 can be used for assigning key points. In contrast, category nodes 2, 4 and 4.2 are not used because they have children (subcategories).

Within continuous text paragraphs and in order to outline from which category a quote, thought or key point emerged, the path to a leaf (children or subcategory) will be reported in the following style: [category→subcategory→sub-subcategory] In the case of the example tree, if a key point emerges from leaf 4.2.2, then the reporting will be: [4→4.2→4.2.2]

The directed qualitative content analysis started with the initial five technology acceptance areas that were identified from existing literature. They represent the first main categories in the coding scheme. Following Patton's[87] recommendation, the transcribed interviews were then fully read. As a result, additional five main categories emerged (6 to 10). The full list of initial main categories is as follows:

1. Usefulness
2. Ease of use
3. Security
4. Privacy
5. Costs
6. Alternatives: interviewees' suggestions for alternative and/or co-existing solutions to a NFC mobile shopping assistant
7. Grocery environment: interviewees' comments regarding grocery stores, the layout of grocery stores, features of grocery stores
8. Mobile phone: general and technical aspects, usability issues, etc. of mobile phones and smartphones
9. Motivation: interviewees' drive to use, not to use or to utilise a NFC shopping assistant or interviewees' shopping habits and preferences
10. NFC, RFID: past, present and future use of NFC/RFID technology (application areas), arguments for and against NFC/RFID

In addition to the main categories, some subcategories emerged as well. Out of the five initial categories, only usefulness and ease-of-use have a comprehensive set

of subcategories. This, however, was expected because usefulness and ease-of-use are key areas in general technology acceptance. Security and privacy do not have subcategories at this point. Costs has only one subcategory. The following table 4.3 reports the coding scheme and coding statistics after all five interviews have been coded for the first time. The column *References* in table 4.3 reports how often each category has been used for coding. The column *Sources* contains the number of interviews out of the total five that support each category.

Table 4.3.: Coding scheme after first coding stage (Source: author)

Category		Sources	References
Alternatives		3	11
Costs			
	Paying for information	5	31
Ease of Use			
	Device, hardware, phone	4	15
	Food product identification	5	23
	Overall	5	31
	Software	4	21
Grocery Environment		3	7
Mobile Phone		5	27
Motivation		4	16
NFC, RFID			
	Application areas	5	19
	Contra	2	2
	Pro	5	6
Privacy		5	17
Security		5	10
Usefulness			
	Additional applications	4	33
	Additional information	5	73
	Independent information	4	8
	Not using the system	3	5
	Overall	4	10
	Phone is part of daily life	5	12

The next stage uses each category's number of sources as a starting point for consistency tests of the coding scheme.

4.4.2. Coding stage 2: Less used categories

In order to increase the coding scheme quality and consistence, the researcher wants to make sure that each category has enough support from the data. Therefore, every category that only occurred in fewer than four of the five sources was under investigation. The following categories were effected: Alternatives, Grocery environment, Contra NFC/RFID and Not using the system as part of usefulness. Table 4.4 represents how often each of the categories was used in each of the five interviews (I1 to I5).

Table 4.4.: Categories that occurred in fewer that four interviews (Source: author)

Category		I1	I2	I3	I4	I5
Alternatives		0	1	4	6	0
Grocery environment		0	1	0	2	4
NFC, RFID	Contra	1	1	0	0	0
Usefulness	Not using it for	0	2	2	0	1

In response to the information presented in table 4.4, each interview that did not use those categories was then analysed again. Each interview was analysed at a time for one category only. The aim of this consistency test was to make sure that all categories were significant and strongly supported by the interview data. The analysis process for additional coding was carried out in the following steps:

1. Coding I1 for *Alternatives*, *Grocery environment* and *Not using it for*
2. Coding I3 for *Grocery environment* and *Contra NFC/RFID*
3. Coding I4 for *Contra NFC/RFID* and *Not using it for*
4. Coding I5 for *Alternatives* and *Contra NFC/RFID*

Table 4.5 shows which thoughts from the participants' interviews (I1, I3 and I4) have been additionally coded to the respective codes.

Table 4.5.: Recoding of less used categories (Source: author)

Interview	Category	Interview quote
I1	Alternatives	“Maybe you could have a screen in front of the shelf, but that’s probably not very sophisticated." [from participant 1]
I1	Not using it for	“I don’t think so because when it comes to grocery store shopping there is a certain range of products I buy over and over. I know the products which I like and even if there is new stuff on the market I would not use the new product unless somebody comes to me and suggest it to me. For anything else I would use the internet. For instance buying a new laptop, I would use the internet for research and comparison or simply go to the store." [from participant 1]
I3	Grocery environment	“Because in the supermarket everybody can have a look in your bag and shopping cart." [from participant 3]
I3	Grocery environment	“However you need to find a member of the supermarket team and this person needs to be qualified and needs to know the information I’m after. And honestly there are thousands of products and people working in the supermarket are usually not PhD students with super brains. So they can’t know everything about each product." [from participant 3]
I4	Not using it for	“ then I would consider it. But not when I have to pay for every single information." [from participant 4]

As a result from the second coding iteration, only one subcategory has been used in fewer than four of the five interviews. This particular subcategory covers opinions and arguments against NFC/RFID technology [NFC,RFID→Contra]. This means that two out of five interviewees contributed arguments against NFC/RFID and the other three did not mention anything negative about it. Even though the aim of the second coding iteration was to determine categories through a high level of usage, this subcategory was kept. It was seen as important as it reflects also the disadvantages of the technology. In addition, this type of study could theoretically obtain relevant information from only one source because of its exploratory qualitative nature.

4.4.3. Coding stage 3: Highly used categories

At this stage, categories with a high number of references were under investigation. There are no suggestions in literature how often a category should be used. This also heavily depends on the context, individual interview structure and research topic. After the second coding, there was a total of 20 categories including all subcategories (see table F.2 on page 217 for details). An average 4.5 sources (interviews) have been used for each category. In total the 20 identified categories have been used 382 times. This study is not a quantitative text analysis, however the average of 19.1 uses per category is used as a selection criteria for highly used categories. Considering the fact that the category Additional information has 73 references, the average use per category would be around 16 if the 73 references would have been ignored. It is important to have a smaller number of codes per category, because a large number of codes means that the category's definition is too broad and hence difficult to grasp. A small number of references provides the category with a distinct meaning, which in later stages makes it easier to create concepts and relations between categories as well as structure the data. Hence, highly used categories that have more than the average 19 codes are split into subcategories, so that the category still exists but different aspects are collected in subcategories. The categories under investigation are:

- Ease of use→Paying for information
- Ease of use→Food product identification
- Ease of use→Overall
- Ease of use→Software
- Mobile phone
- Usefulness→Additional applications
- Usefulness→Additional information

The updated coding scheme is visualised in table F.3 on page 218. Major changes were conducted in the following main categories (level one):

- Alternative has four subcategories (Devices, Food product identification, Software, Source of information).
- Costs has four subcategories relating to 3G mobile data plans, Positive and Negative participant opinions regarding Paying for information, Payment handling and Payment model.

- Ease of use has four subcategories. Two relate to Positive and Negative opinions regarding the general Ease of use of a NFC shopping assistant. Another subcategory relates to Positive aspects and possible Problems of Food product identification. The fourth subcategory covers Requirements for a NFC mobile shopping assistant in order to be easy to use. The Requirements are structured in sub-subcategories regarding General, Information, Mobile phone, Software and Tag.

- The two subcategories of Usefulness, Additional applications and Additional information, were restructured. In the initial coding both subcategories were used separately because the researcher could not distinguish whether participant's request for additional information can be integrated into the existing prototype or whether an entire additional application would be necessary in order to increase the usefulness. At this stage, it still is not clear how additional product information should be integrated. Therefore, the coding of Additional applications and Additional information is merged in a newly created subcategory named Extensions. Extensions itself consists of nineteen sub-subcategories, which represent different types of extensions. In addition to Extensions, subcategories for Positive and Negative participant perceptions as well as General Requirements were created.

In the next stage, the coding density is checked.

4.4.4. Coding stage 4: Coding density

The first coding scheme was followed by consistency checks and consequently major recoding rounds took place. That has helped to develop a more mature coding scheme and also a set of categories that explains the data. In particular the previous coding iteration (coding stage 3) drastically changed the structure at the subcategory level (level 2). Categories were changed, reassigned or removed. Because of major restructuring and recoding it is necessary to make sure that all relevant raw interview data is still coded into at least one category. Therefore a coding density test is undertaken.

The software NVivo supports this process by displaying coloured bars indicating the status of coding for each line of the raw interview data. Interview by interview is analysed for not coded text. In addition, already coded interview text is also checked. A few minor recordings are made. A list of interviewees' thoughts and phrases (interview data) that are not coded at all, is available in the appendix subsection F.4.2 on page 222. The updated coding scheme after the fourth coding stage (density test) is illustrated in table F.4 commencing on page 220.

4.4.5. Summary of coding

Directed qualitative content analysis has been applied on five transcribed interviews. Beginning with five main categories from existing literature, the initial coding scheme was developed from reading the five interviews and consequently adding categories to the coding scheme. The initial coding scheme was then used to code all five interviews, which updated the coding scheme again. Coding stages two to four are considered coding scheme tests, where the consistency of the coding scheme was analysed and updated. Consequently, the transcribed interview data was recoded according to the respective latest coding scheme. The second coding stage (less used categories) did not change the overall category structure much. In contrast, the third coding stage did change the coding scheme by creating many sub-subcategories (level 3) and by reorganising many level 1 and level 2 categories. The fourth coding stage (density check) only added a small number of references to some categories and therefore did not change the overall structure much.

The consistency tests and recoding created output that is useful in two regards. First, a coding scheme has been developed and tested. The final coding scheme could potentially be used for coding additional interviews collected under standards that are similar to those for of the first five interviews. Secondly and most importantly, all five interviews are now fully coded and the organisation of categories (coding scheme) can support the consequent concept creating and findings report.

4.5. Chapter summary

A thick description of the researcher's viewpoint, the data collection and data analysis was provided in this chapter in order to allow other researchers to follow the process but more importantly to judge the research quality.

Interviewee recruitment was successful and the interviewees met the set criteria (participant criteria). The PIF was introduced and interviews were carried out successfully. Interview transcription was conducted shortly after the interviews took place so that memories were still present. A coding scheme was then developed iteratively through applying directed qualitative content analysis. At the same time, during the coding scheme development, the interviews were fully coded. The interview data and coding scheme quality were satisfactory so that additional data collection was not required.

The coding scheme development and interview data analysis were directed by existing research findings as presented in chapter 2. In particular, the five main

technology acceptance areas (usefulness, ease of use, security, privacy and costs), as well as the value proposition comparison of benefits (advantages) and sacrifices (disadvantages, challenges, issues) directed the data content analysis.

The structure of the coding scheme supports the consequent reporting of results and the findings resulting from the analysis of the interview data.

5 Results and findings

5.1. Introduction

In this chapter, results from the data analysis are presented in two ways. First, a concept (section 5.2) is developed by incorporating the structure of the coding scheme and major parts of the actual coded data. The concept outlines relations between categories. The concept also creates a framework, which is used to report the entire data findings and to guide later chapters.

The second way of presenting the results from the data analysis is the full report of all findings. Section 5.3 reports the data findings in full detail based on the developed concept structure all.

5.2. Concept creation

The concept creation is split into nine steps. Step one and two deal with usefulness, step three and four with ease of use and food product identification. Step five to seven deal with costs, security and privacy. Step eight is for restructuring and simplification. Finally, step nine summarises the concept creation.

The visual evolution of the concept is illustrated by graphical figures. Later evolution stages of figures get more complex. Red colour is use to highlight important changes.

To begin with an entry point, external variables that strongly influence either usefulness or ease of use are under investigation. Therefore the direct subcategories of usefulness (step one and two) and ease of use (step three and four), which emerged from the coding, are under investigation.

5.2.1. Step 1: Usefulness 1/2

Subcategories of *Usefulness* are *Extensions*, *Independent information*, *Mobile phone as part of the daily life*, *Positive*, *Negative* (including subcategory *not using the system*) and *Overall aspects* as well as *Requirements*. Among these, subcategory *Extensions* is very large and the majority of its sub-subcategories are related to different types of food product information. *Independent information* is also a subcategory of *Usefulness*. Therefore, food product information is a major aspect of usefulness. In particular the type of food product information and its independence are most relevant. That is strongly supported by the following interviewee statements:

- I1: "The only advantages I can see is to get manufacturer independent information."
- I5: "I think it is important to know whether the system is from a certain store and whether the information is independent in order to avoid supermarkets influencing your shopping."

In this context, I2 refers to the security aspects meaning that there is a mistrust towards the grocery store, which in the first place wants to sell products.

- I2: "I'm not really familiar with the security concept you use, but also the supermarket could provide false information. For instance the backend realizes that potatoes are outdated and alter the best before date."

Continuing with food product information, there are different types of direct food product information:

- Calories, nutrition, ingredients;
- The carbon footprint of the product and production;
- Whether it is organic food;
- The products origin, producer, production conditions;
- Product price.

In the wider sense, there are health recommendations and information for particular groups of people:

- Relating the healthiness of a product;
- Whether people with certain allergies should be concerned;

- Whether people who suffer from diabetes should be concerned.

In a much wider sense, the food product information relates to recipes or recommendations for other products that suit the customer well.

Based on different types of food product information, interviewees suggested to have basic information free of charge and pay for additional information:

- I5: "Well it could be that basic information are for free. Additional and very useful information could be charged."
- I4: "Well for example the allergies information could be free whereas the recipes could costs something."

Hence, costs and payment are connected to food product information. Subconcept depicted in figure 5.1 illustrates what has been outlined so far.

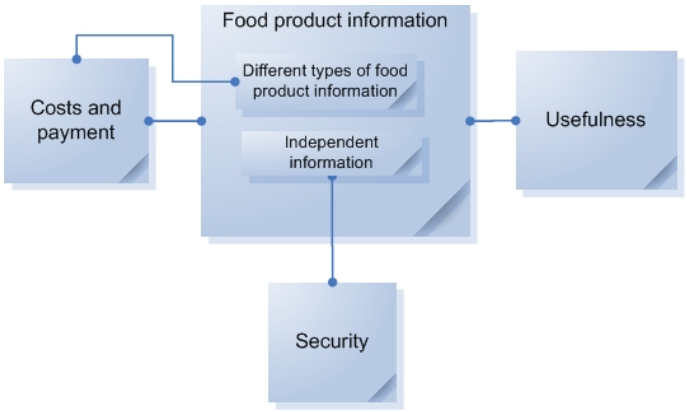


Figure 5.1.: Concept creation step 1: Usefulness and food product information (Source: author)

Costs and payment will be explored and further incorporated into the concept during a later stage. See sub-subsection 5.2.5 on page 87 for findings related to costs.

5.2.2. Step 2: Usefulness 2/2

The analysis continues by focusing on strong subcategories of *Usefulness*, in particular on *Requirements*. Interviewees want to have relevant information and information that is not easily available from the product label. The information has to add benefits (value).

- I1: "The phone does offer the opportunity but the information must be of

high value and the information on the phone must add value. It doesn't make sense if the information from the label is available in the mobile phone."

- I2: "I mean it always depends on the type of information. You don't want to have information you are not really interested in."

The interest in certain information and the benefits from information are different for each customer, product and shopping session. Therefore, the interviewees suggested to have custom settings and filter options for individualisation.

- I3: "Yes, as I've mentioned earlier it might be very useful to have some sort of filter for the information."
- I2: "Some kind of having some types of information pre selected and categorized so you don't need to browse through all the data."
- I3: "Meaning that you have some preferences of information types you are interested in and the phone only displays those information."
- I4: "It would be also good if you have some sort of settings and personal information you can setup. This could contain the ingredients you are generally allergic to. Then the software tells you whether you are likely having an allergic reaction with this product."

The filter and custom settings refer to different types of food product information. They include the basic food product information such as nutrition or ingredients, but also information related to allergies or diseases such as diabetes.

The mobile phone is the facilitator, grocery customers carry it with them and they are familiar with the user interface:

- I4: "Well, because every body has a mobile phone and you carry it always with you. And if you would use just another device, people actually had to carry devices around."
- I5: "Firstly I think most of the people take their mobile phones with them so it's not an extra device to carry around. Secondly it has all the functions and features built-in, which are necessary for this purpose. Such as display, keypad, internet connection and so forth."

Since the mobile phone is also used for presenting the food product information, the filter and custom settings are closely connected with the software on the mobile phone. By filtering and applying custom settings, the software structures and organ-

ises the available information and creates individual benefits for customers. Benefits are also created by information provision through the NFC mobile shopping assistant that is not available or easily accessible through the label. The following figure outlines the created concept at this stage:

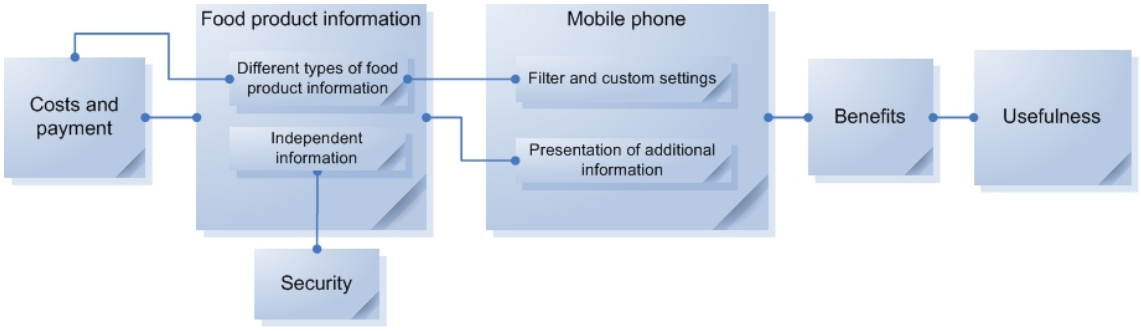


Figure 5.2.: Concept creation step 2 (Source: author)

There are many more aspects of usefulness, for example the positive and negative perceptions or when and why individual interviewees would not use an NFC shopping assistant. However, at this stage the researcher believes in the importance of creating a wider overview, therefore those aspects are presented later in subsection 5.3.1 on page 94. Instead, the category *ease of use* is under investigation next.

5.2.3. Step 3: Ease of use 1/2

Ease of use consists of four subcategories. They are *Food product identification*, *Positive* and *Negative* aspects as well as *Requirements*. *Requirements* are categorised into *General*, *Food product information*, *Mobile phone*, *Software* and *Tags*. Beginning with general *Positive* and *Negative* aspects regarding the ease of use of an NFC shopping assistant. Positive perceptions are:

- I4: “Because then you have your hands free and you have to think even less about the phone.”
- I4: “Very convenient. You only have to carry a mobile phone.”
- I5: “It’s small and you can hold it in one hand and in the other hand you hold the product.”

Negative perceptions of ease of use are related to either the phone or the grocery environment. I2 stated that visually impaired people might need additional audio guided systems. I2 also raised the aspect that the speed of the system might become an issue when 300 customers are using it at the same time. I4 raised the issue that

the mobile phone runs out of battery while using it and that the customer cannot use the same system in different grocery stores.

Both positive and negative aspects are related to the NFC mobile shopping assistant. The NFC mobile shopping assistant includes both hardware (mobile phone) and the software running on it and the two are closely connected. For example, a flat battery is first of all a hardware issue, although it is the software in the phone that determines the battery usage. Software even informs the user about the battery status. For the user it is sometimes difficult to tell whether something is hardware or software related.

Hence, at this stage the mobile phone is viewed as a single object consisting of at least hardware and software. A distinction between hardware and software aspects will be discussed at a later stage. However, both components are regarded as major aspects of mobile phones.

Another major subcategory of *Ease of use* is *Food product identification*.

5.2.4. Step 4: Ease of use 2/2, Food product identification

Participants found the process of identifying a food product with the mobile phone fast, easy and intuitive.

- I5: "And the workflow of holding the phone next to product is fairly easy."
- I1: " It was really easy. You just have to start the software and hold it next to the RFID tag and get the information."
- I5: "It was really fast, it only took one or two seconds and I got all the information."

The food product identification involves software and hardware aspects as well. The hardware detects NFC/RFID tags and passes the information onto the software. The software uses the NFC/RFID information to present the final food product information to the user. Everything takes place inside the mobile phone.

Within step 2 of the concept creation, the mobile phone was used as a facilitator since it filters and presents a wide range of food product information in order to create benefits. Within usefulness, mainly aspects of food product information presentation were under investigation. On the other hand, within ease of use the period before the food product information presentation is relevant too. Figure

5.3 outlines the mobile phone's role regarding usefulness and perceived ease of use in three distinct stages. The stages are prior, during and after the food product identification.

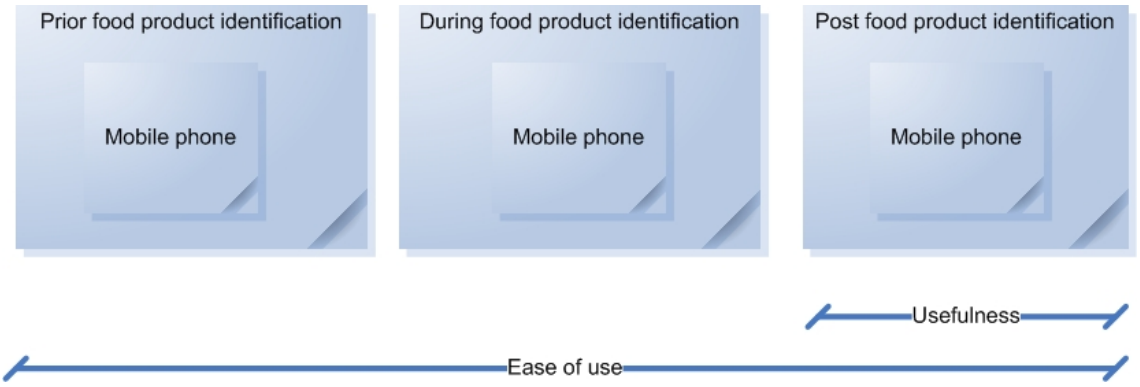


Figure 5.3.: Concept creation step 4: The mobile phone prior, during and after the food product identification (Source: author)

In contrast to the positive perception, all five interviewees encountered issues and challenges during the food product identification:

- I4: "Maybe if everybody is using it and people standing in the way."
- I5: "Maybe I'm too small and the product is placed on the top shelf and I cannot reach it."
- I5: "Other than that there are a lot of people around me and all of them use the same program and there can be some interference."
- I1: "I think the problem is the amount of different products with the same specifications, for instance products of the same type but from different producers."
- I2: "Especially if the reading range is pretty close you really need to find the tag first. I can imagine it is a little bit annoying if you can't find the tag."
- I3: "Perhaps but even that could be a problem. Perhaps it could be that the products are to close to each other and the phone picks up the wrong product."

The problems stated by the interviewees refer to the hardware (interference and reading the wrong RFID tag) and to the grocery environment in wider sense. That includes the position of the tag on the product, the position of the product on the shelf and the number of customers using the NFC mobile shopping assistant at the

same time in the same area.

The subcategory *Requirements* [Ease of use→Requirements] contains different practically oriented aspects of the NFC mobile shopping assistant related to easy of use. Those will not influence the concept creation at this stage. They will be incorporated during a later stage.

For now, the results and sub concepts and their relationships identified in the previous steps are depicted in figure 5.4.

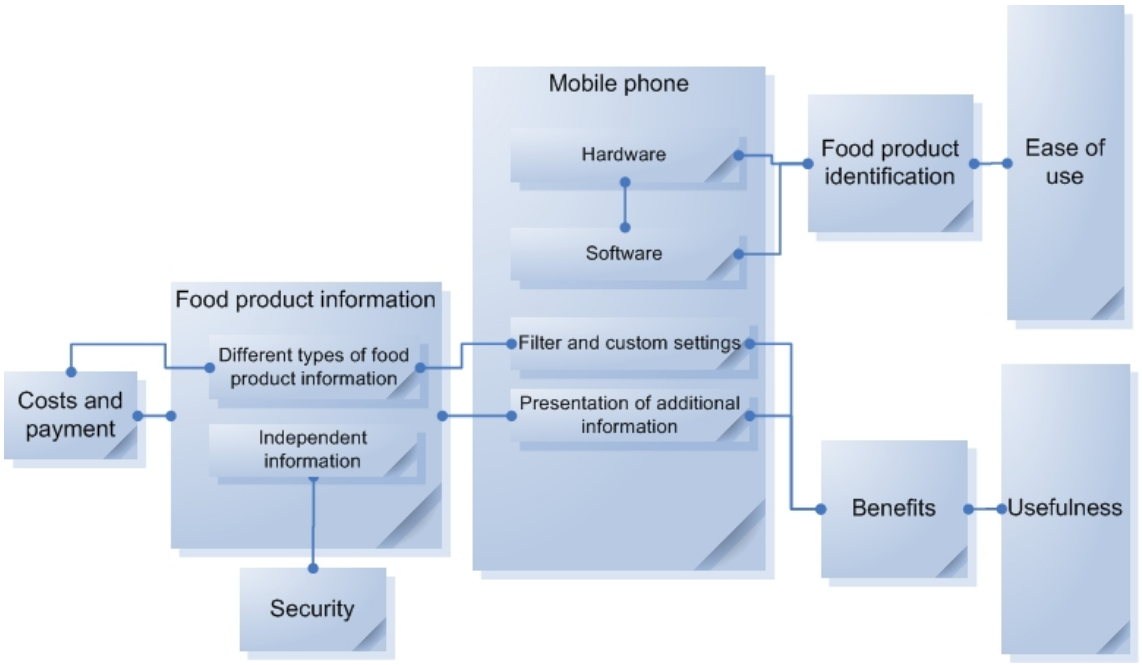


Figure 5.4.: Concept creation step 4 (Source: author)

At the end of step four, strong aspects and direct subcategories of *Usefulness* and *Ease of use* were identified. In the consequent steps, the remaining three main technology acceptance areas, namely security, privacy and costs are under investigation.

With the increasing complexity of the concept, the concept evolution from step to step is highlighted in red color in order to allow easier tracking of changes.

5.2.5. Step 5: Costs

The category of *Costs* consists of four subcategories. They are *whether interviewees would or would not pay for information*, *Payment model*, *Payment method* and costs related to a *3G mobile data plan*. Beginning with the category *Paying for information*, interviewees contributed aspects and arguments for and against payment. Statements against payment are:

- I5: "I would say, it must be free of charge and it should remain a service."
- I1: "I would not pay"
- I3: "I think for me personally not in general."

Statements pro payment are:

- I5: "Yes I would use it. But the price for it must be acceptable."
- I3: "I think it really would depend on this information because if I have an illness, as mentioned before the diabetes, then I would pay for it."
- I3: "Yes maybe, I mean if the product is high priced product you probably would use it [NFC mobile shopping assistant] because there is more to lose."

The interviewees did not like the idea of subscription (general payment) for food product information. Under certain circumstances, payment would be acceptable. Those circumstances are that the benefits from the information are really high and that the price is acceptable.

The subcategory *3G data plan* has only one reference. I2 said, that possible hidden costs, such as a mobile data plan does not matter in his opinion, because "data plans are already common and people who are interested in such sort of information are probably willing to pay a bit more".

The two remaining subcategories of *Costs* contain practical aspects regarding the *Payment process* and *Payment model*. They will be incorporated at a later stage. Incorporating the findings of step five, leads to the following updated concept 5.5

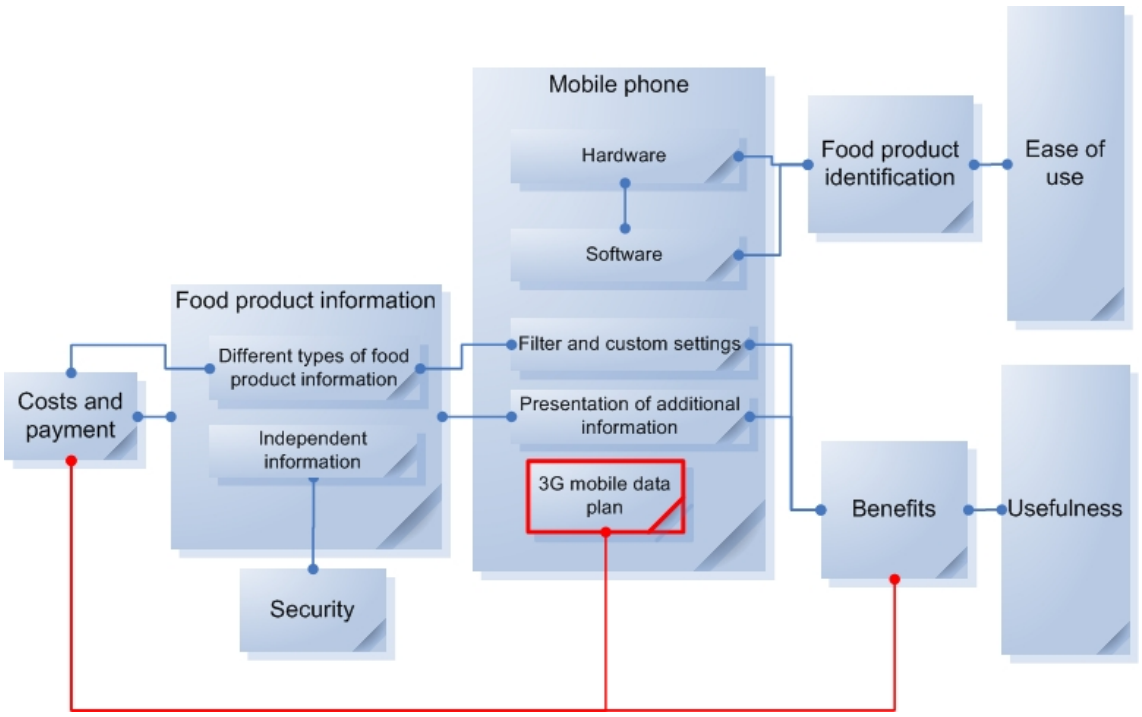


Figure 5.5.: Concept creation step 5: Costs and payment (Source: author)

5.2.6. Step 6: Security

Security has been mentioned by I2 in relation to independent food product information. In addition, there are three areas of security concerns that the interviewees mentioned.

Firstly, I4 and I5 mentioned that people could get distracted more easily while using the NFC mobile shopping assistant and at the same time could pay less attention to their personal belongings. Thieves could take advantage of that. In the same context, I3 mentioned that grocery stores have video surveillance and therefore pickpocketing should not be a problem. Comment made by I5 are also related to this issue. He said that because a user of the NFC mobile shopping assistant uses actively an expensive mobile phone, potential thieves could notice it and make conclusions about his/her wealth. However, he added that the use of expensive mobile phones in public is common and therefore it should not be a greater security risk.

Secondly, I1 mentioned that certain people could create profiles of your shopping behaviour and shopping times. They then could use this information to "break into your house".

Thirdly, I2 mentioned a number of security aspects technically related to the mobile phone and wireless communication. He first stated that a longer reading

range could be used to intercept the NFC/RFID communication, but then said that in the case of a short range "it might not be such a problem". Furthermore, he added that wireless connections such as 3G/UMTS to request the data could be vulnerable and therefore needed protection. In addition, I3 rejected the existence of technical related mobile phone security issues, because her understanding is that the mobile phone only receives information and does not send out data.

In summary, there are four security aspects that emerged from the interviews:

1. Protection of independent and authentic food product information;
2. Theft and robbery of customers due to distraction or exposure of expensive mobile phones;
3. Burglary due to shopping profile creation;
4. Technical mobile phone security for NFC/RFID reading and 3G/UMTS data connection.

I1 mentioned that somebody could create a shopping profile and abuse it. He also replied to the question about what his security concerns are: "Besides the personal data and personal information, there is no security concern". This indicates a close connection between the interviewee's understanding of security and privacy. Therefore, the aspect of profile creation is treated as an privacy issue, and the possible resulting burglary as security issue. Profile creation is closely linked to the software because either or both of the mobile phone software or the software at the food product information provider is/are able to aggregate customer information and create a profile.

The updated concept is depicted in figure 5.6.

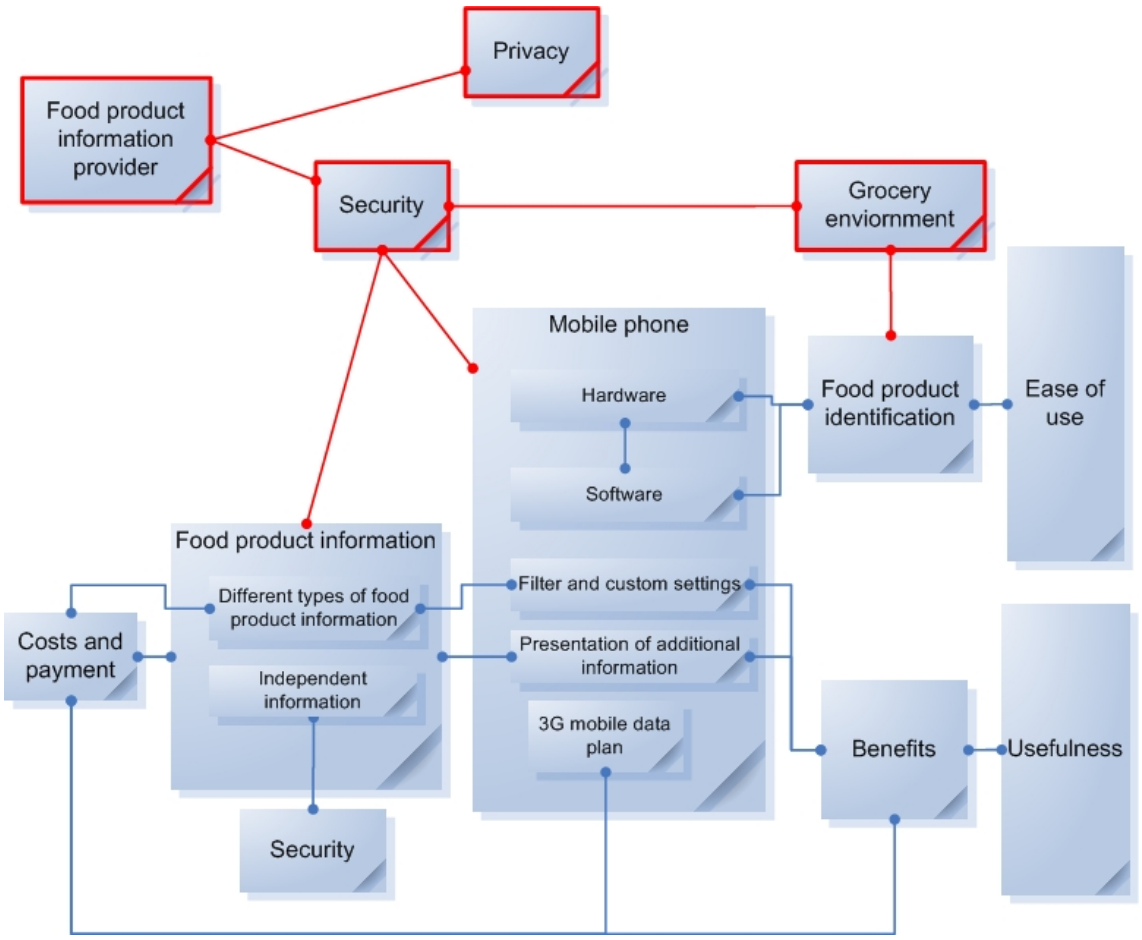


Figure 5.6.: Concept creation step 6 (Source: author)

5.2.7. Step 7: Privacy

In the previous step, customer related information used for profiling was mentioned in the context of security and privacy. The category *Privacy* contains key points from all five interviewees. I3 and I4 were not concerned about private data that they would reveal while shopping. In fact I4 did not "think it's really something private. Because in the supermarket everybody can have a look in your bag and shopping cart". I3 even stated that if the grocery stores would know what her shopping behaviour is and would accordingly create special offers, then she would like that.

On the other hand, the three male interviewees were more concerned about their personal data.

- I5: "I want to know before using it what they are doing with my data. I request information of certain products. I want to know what they are doing with those profiling data. I think it is important to know that I won't get spam. It's quite important that I give my consent to this."

- I1: "They [grocery store] see what you are interested in and start sending you commercials."

- I2: "I don't want to reveal more private data then I already do. So far supermarkets don't have personal data about me, so I would like to keep it that way."

Among the privacy concerns, there are worries that too much personal data could be revealed. In the case of I1, he was worried about receiving personalized advertisement and offers. In contrast I3, would like to receive personalised offers. Therefore, personalised advertisement is a link between privacy and the grocery environment.

Also, the profile creation of customers that use NFC mobile shopping assistants would be closely linked to the food product information provider. This has already been incorporated into the concept during the previous step. Nevertheless, I2 linked the grocery store with the food product information provider. I2 was also the interviewee who raised security concerns regarding the independence of food product information. His suggestion to link the food product information provider with the grocery store is not incorporated into the concept, because the presented NFC mobile shopping assistant prototype did not provide any details about the information source. In addition, the food product information provider is out of this research's scope. However, the security of independent food product information is now linked with the food product information provider to acknowledge the connection.

Within the category of *Privacy*, there are some additional key points that refer to the types of personal information the interviewees would reveal in order to use such system. I4 mentioned that her bank details for payment would be needed and therefore she would provide them. Therefore, a link between costs and payment and privacy is established.

The updated concept diagram after step 7 is depicted in figure 5.7.

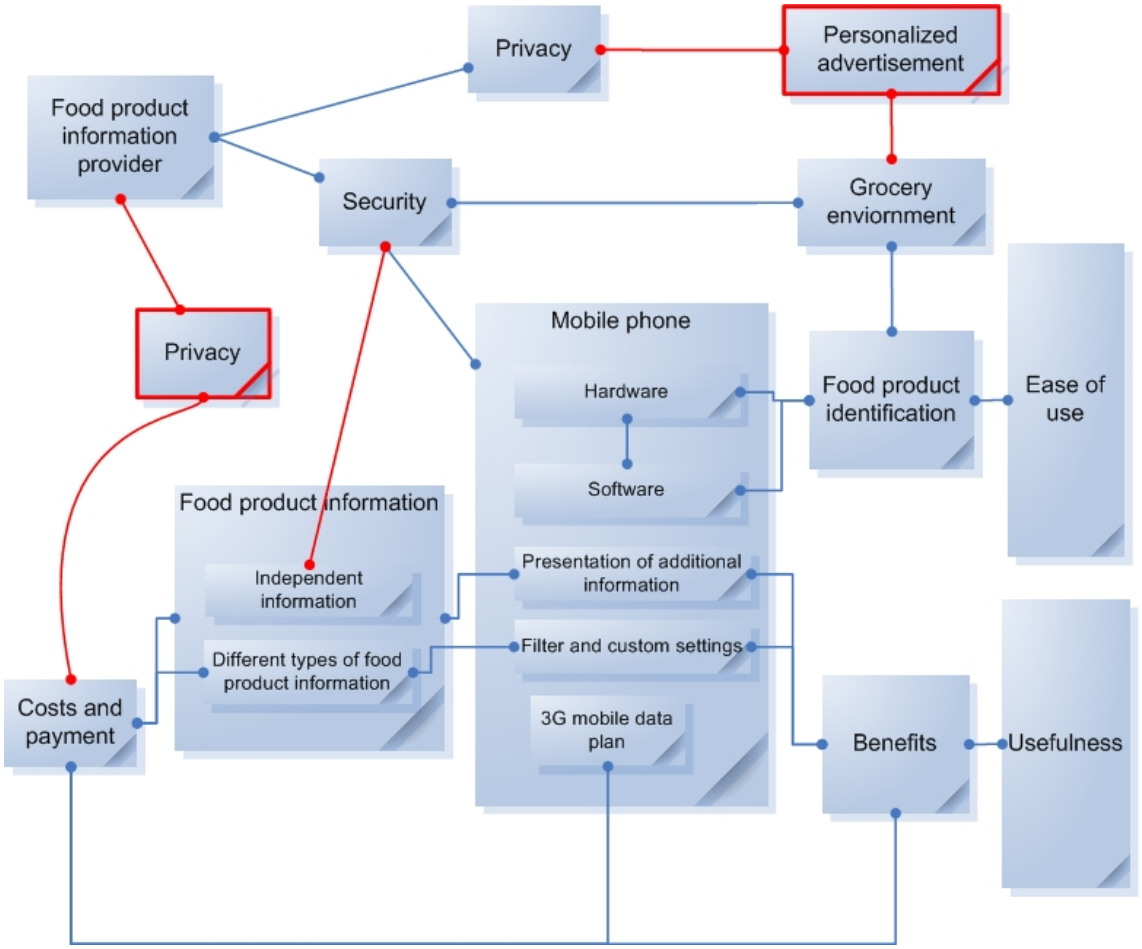


Figure 5.7.: Concept creation step 7 (Source: author)

5.2.8. Concept summary

The previous seven steps created a concept map that incorporates the major aspects from the interview data. Mainly the five key technology acceptance areas (usefulness, ease of use, costs, security and privacy) have been incorporated. Table F.5 in the appendix section F.4.3 on page 223 outlines which categories have been incorporated for concept creation so far.

Summarising the concept, there are a number of major findings. First, the NFC mobile phone (NFC smartphone) as the central technology is involved in all three major stages (prior, during and post food product identification). The influence of the NFC mobile phone on ease of use takes place in all three stages. Usefulness is only majorly effected post to food product identification. In detail, that is when the food product information is presented. Therefore, food product presentation on the NFC mobile phone is a major connecting point between usefulness and ease of use. The central role of the NFC mobile phone is illustrated in figure 5.3. Second finding is the complexity of food product information. Additional food product

information and improved food product information presentation create a benefit for the user. Independent food product information is essential and therefore must be secured. Certain food product information is perceived as basic and therefore should remain free of charge. Very useful and additional food product information on the other hand can cost a certain amount. In addition, customised and personalised food product information presentation creates benefits as well. The food product information is provided by a food product information provider. The food product information provider, its databases and how it operates are out of scope. However, interviewees see benefits and also some privacy threats from the involvement of the food product information provider. Thirdly, privacy and security threats may not be entirely caused by the technology, but could be present also within the grocery environment.

Categories and subcategories that have not been incorporated yet have mainly very practical implications. The findings from all categories are discussed in the next section 5.3.

5.3. Findings report

Previously, a concept was created from the collected data. This concept outlined the connection and relation between major aspects and technology acceptance areas of the NFC mobile shopping assistant. However, the concept only incorporates major aspects and it does not rely on all categories of the final coding scheme. This section reports all the findings from data analysis by following the structure of the created concept and major findings. This section contains 18 subsections (subsections 5.3.1 to 5.3.18). Each subsection reports the findings related to a major aspect or technology acceptance area.

Within each subsection, the path to each category and subcategory is presented as a reference, following the introduced style guide (subsection 4.4.1 commencing on page 70). The following findings are reported in bullet points in order to maintain a better readability.

5.3.1. Usefulness

Positive as well as negative aspects and perceptions of the NFC mobile shopping assistant solution are: [Usefulness → Positive] and [Usefulness → Negative]

Table 5.1.: Positive and negative perceptions of usefulness (Source: author)

Positive	Negative
Fast access to information	Food product information are not useful to some customers
Access to information that are not available on the label	Not much use if information additional to the food product label is displayed
Information can help finding what is good for the customer	All useful food product information is available in the grocery store
Increasing the awareness during shopping	Customers try out products and judge what is best for them
Especially useful for customers with special requirements	Food product information will not tell the taste of the product
Access to additional information	Food product information can not tell for how long the product can be consumed
	Food product information is too simple

Reasons and occasions why/when the NFC mobile shopping assistant would not be used: [Usefulness → Not using the system]

- When costs occur for every single set of information;
- More exclusive and expensive items require preliminary online research upfront and consultation with store staff;
- While buying familiar products that have been bought in the past;
- System is time consuming, therefore customer would not use it for every product;
- Very cheap products are not worth the effort of using the system;
- Simple products.

Overall aspects and perceptions of the NFC mobile shopping assistant are: [Usefulness → Overall] and [Usefulness → Extensions] and [Usefulness → Requirements]

- System is useful to people with a specific interest in the information;
- System comes in the format of a mobile phone, which is small and can be hold in one hand, the product in the other hand;
- System is an extra feature: customer can but does not have to use it, regular shopping is still possible;

- Grocery store is a good place to use the system;
- System is useful for daily purchases;
- Food product information need to add value (see subsection 5.3.3);
- The software should display different types of food product information;
- The software should enable comparisons, offer discounts, display special offers, recommend related products;
- Advertisement and SPAM are not desired;
- The software should work in various grocery stores;
- The software should incorporate a shopping list and enable to share food product information with other people or family members;
- More application areas of mobile NFC would lower the costs of using it.

5.3.2. Benefit (Value)

If food product information can create a general benefit (value) for the customer, then the NFC mobile shopping assistant can be useful. Food product information need to be independent and provide additional value. I1 says that if there is no information available in addition to what already is printed on the label, then there would not be much use. The presentation of the food product information on the mobile phone should be customised to allow different people to utilise it individually. The latter is part of mobile phone software, see subsection 5.3.13.

5.3.3. Food product information

Different types of food product information emerged: [Usefulness → Extensions]

1. Basic information: calories, nutrition, ingredients, carbon footprint, origin, producer, producing conditions, price, the level of organic food;
2. Health information: how healthy a product is and if people with certain conditions such as allergies or diabetes should be careful;
3. Recommendations such as recipes or products that taste particularly well in combination with this product.

5.3.4. Food product presentation

The food product presentation on the mobile phone relates to software aspects of the mobile phone (see section 5.3.13).

5.3.5. Ease of use

Ease of use has two major contributors: food product identification and food product presentation. Both are supported by mobile phone software and hardware. [Ease of use→Positive] and [Ease of use →Negative]

Table 5.2.: Positive and negative perceptions of ease of use (Source: author)

Positive	Negative
The mobile phone is not an extra device which has to be carried around or can be forgotten, it is almost always with the customer	The system relies on the mobile phone, if it has been forgotten at home or the battery is flat then it will not be of much use
Each customer has his/her mobile phone, queues in front of in store built-in terminals (alternative) can be avoided	Changing the system for different grocery stores does not seem useful
The mobile phone is very convenient, product information are instantly available	The system in its current state might not be useful to people with special requirements (e.g. disabled people who need audio guidance)
It is time efficient	The RFID/NFC tag might be not easy to find
It is easily understandable how the NFC mobile shopping assistant works	

Consequently, the interviewees suggested requirements and features to improve the easy of use features of the NFC mobile shopping assistant: [Ease of use →Requirements]

- A NFC mobile shopping assistant should not force the customer to change his/her shopping behaviour;
- Mobile phone software requirements (see section 5.3.13);
- Mobile phone hardware requirements (see section 5.3.12).

5.3.6. Food product identification

Food product identification is a major part of perceived ease of use. [Ease of use→Food product identification→Positive]

The interviewees' positive perceptions of food product identification with an NFC mobile shopping assistant are that it is fast and easy. On the other hand, the following problems could occur in a real environment: [Ease of use→Food product identification→Problems]

- Other customers standing in the way;
- Products are placed out of the customer's reach (too high on the shelves);
- NFC/RFID interference due to too many customers using the system at the same time;
- Different products with the same specifications (products of the same type but from different producers);
- Product needs to be taken off the shelf and NFC/RFID tag needs to be located (see section 5.3.18 for an alternative solution to overcome this problem);
- If the NFC/RFID tag cannot be found easily, the customer might become annoyed;
- Products are located too close to each other and the phone would read the NFC/RFID tag from the wrong product and consequently the wrong information could be shown.

5.3.7. Security

Security concerns emerged in four areas: [Security]

1. Protection of independent and authentic food product information;
2. Theft and robbery of customers due to distraction and/or exposure of expensive mobile phones;
3. Burglary due to shopping profile creation;
4. Technical mobile phone security for NFC/RFID reading and 3G/UMTS data

connection.

5.3.8. Privacy

The privacy concerns and privacy related aspects are the following: [Privacy]

- Aggregation of personal data and creation of customer profiles while using an NFC mobile shopping assistant. Customers do not want to reveal too much data;
- Participants do not want to reveal more than the minimum of personal data;
- Participants want to know what the personal data is used for.

Following the interviewees desire to reveal as little data as possible, the following personal data could be revealed if required:

- Bank details for payment of food product information requests;
- Mobile phone number;
- Where and when products have been bought (similar to loyalty cards);
- Age;
- Area of residence;
- Special food requirements.

In order to reduce the amount of personal data involved, I2 suggested to keep the NFC mobile shopping assistant anonymous. He suggested using user name and password to authenticate the food information request. Payment could be done upfront via bank transaction. He says that personal data such as name or address are not really necessary.

5.3.9. Security and privacy

Within the field of security, I1 worried about a shopping profile that would be created while using an NFC mobile shopping assistant and that would be used to break into his house. In the context of privacy, interviewees expressed their concerns about the profile creation which could be abused for advertisement or spam.

The similarities among security and privacy are that in both contexts the interviewees worried about profile creation. The differences lie in the possible consequences (burglary and abuse of personal data).

5.3.10. Costs

[Costs] In the field of costs, there are different viewpoints on whether costs should be charged for using the NFC mobile shopping assistant and for requesting food product information. The interviewees do not like the idea to pay. Under certain circumstances, some interviewees would accept payment. Those circumstances are that the value of the food product information is really high and that the price is acceptable. Interviewees suggested to have certain information for free, whereas some additional information could be obtained at a cost. For instance, allergy information is for free, while recipes could cost. Furthermore, the product value needs to be worth the costs of a request. On the other hand, some interviewees said that the food product information must be free and the NFC mobile shopping assistant should remain a service.

In addition, a 3G data connection during the food product information request causes costs. However, I2 believes that 3G data plans are now common and this cost factor does not matter anymore.

5.3.11. Payment

In the area of payment, there are interviewees' suggestions in which way the costs for an NFC mobile shopping assistant and food product information requests are paid ([Costs->Payment model]) and how the payment is handled ([Costs->Payment handling]).

A payment model describes how charges for a food product information requests or the use of a NFC mobile shopping assistant could be handled. The following options emerged:

- Pay per request;
- Flat rate for extensive use;
- Payment option related to the product price (the higher the product price, the higher the cost of the request);
- Different prices for different types of information:

  - I4: "some information are more valuable so the price could be higher");
  - I4: "the allergies information could be free whereas the recipes could costs something";
  - I5: "it could be that basic information are for free. Additional and very useful information could be charged";
- Single payment for the software, no regular or usage based costs;
- Monthly payment;
- I2 thinks that paying per request is not user friendly and a flat rate option might be user friendly and convenient.

In addition, I2 suggested to incorporate more application areas of the NFC technology in order to split costs among various services. This however, was directed towards the costs of the phone. I2 also mentioned that the grocery store should be involved in the payment process depending on its interest.

The following payment handling options were suggested:

- Withdraw from bank account;
- Extra charge in combination with mobile phone contract;
- Payment via mobile phone bill, because the mobile phone is already involved;
- Upfront payment via bank transaction.

5.3.12. Mobile phone hardware

Hardware requirements of the mobile phone emerged from different categories throughout the coding process. The following mobile phone hardware requirements emerged in the area of ease of use: [Ease of Use→Requirements]

- Larger screen (than the Nokia 6131 NFC) in order to have more food product information visible at a time;
- Readable display;
- Light weight, small device because mobile phone is carried around;

- Multifunctional (listening to music, writing emails, browsing, taking pictures);
- Nice appearance;
- Good battery life;
- Easy to handle;
- Good hardware performance, because a big database of food products is stored on the phone (I2).

The requirements of the mobile phone are as I2 said, a "compromise of screen size and having a portable device". In addition different interviewees have different preferences. For instance I3 liked touch screens and found them very convenient. On the other hand, I2 did personally not care about the size of the screen, but mentioned that for an NFC mobile shopping assistant the screen size is vital. I1 liked a particular mobile phone manufacturer (Nokia) because of previous positive experience. Furthermore, I1 thought that users are familiar with their phones.

I5 thinks that a "new system shouldn't force you to change the shopping behaviour in a big way".

I2 mentions that the mobile phone might become slow if a large database of products and corresponding food product information is stored on the mobile phone.

The previous two points are also related to software aspects of the mobile phone. Familiarity with the use of the phone is related to the mobile phone operating system. The performance of the mobile phone with a large food product database can be influenced by the way the database is organised and used.

5.3.13. Mobile phone software

Software requirements of the mobile phone mainly emerged from the categories ease of use and usefulness. The requirements can be separated into general aspects of mobile phone software and improvements and issues specifically of the Product Information Finder software.

[Ease of Use→Requirements] and [Usefulness→Requirements]

General mobile phone software requirements:

- Font size for older people might be too small and difficult to read, can

be overcome with changing display resolution and icon size;

- Easy to handle;
- Quick typing;
- Fast;
- Simple;
- No spam and advertisements, because they are annoying.

Specific Product Information Finder software requirements:

- Split the ingredients list and display a few at a time;
- Time to start the software and get it to the point where NFC/RFID tags can be read needs to be short, otherwise the convenience decreases;
- Keeping the software simple (I4: "It seems pretty simple. I wouldn't make it more complex by changing it to a fancier way");
- Font size of the software needs to be larger than font size on the food product label
- Content should be easy to read;
- At the first stage the software should provide a broader overview of the food product with a picture, the price and some key facts;
- Software should not annoy the user if the wrong NFC/RFID tag has been read;
- Sending selected food product information to somebody else;
- Simple recommendation whether the product is or is not good for you;
- User should have a choice which food product information he/she wants to read;
- Personal settings in order to avoid browsing through all the information.

Personal settings of the Product Information Finder should enable the following:

- Grouping information regarding allergic reactions, because there are many different allergic reactions;

- Filtering information of interest;
- Pre-selecting information types of interest;
- Categorising information.

5.3.14. Food product information request

I2 raised the aspect of how the food product information comes to the mobile phone. I5 also contributed some aspects.

There are two different ways how the food product information could get to the mobile phone:

1. Every food product identification triggers a 3G data request to the food product information provider. The food product information is then transferred just in time;
2. The mobile phone has a local database that contains the food product's information.

I2 believes, that the first option is the best way. I5 also suggests that a 3G synchronisation should take place.

The second option has its challenges related to updating the local database. I5 suggests that the local database can be updated via synchronisation with the private computer in order to get up-to-date information. He also suggests to use a 3G data connection for synchronisation. On the other hand, I2 suggested that the local database could be updated automatically when approaching the grocery store. He is not in favour of terminals that are located at the entrance or inside the grocery store. He thinks that the synchronisation has to take place on the way to the grocery store without stopping at a terminal.

5.3.15. NFC/RFID

Contactless range technology (NFC/RFID) is perceived as useful, helpful, "cool", efficient and as the future. Only I1 and I2 mentioned the following concerns:

- I1 is very critical and believes that RFID is the first step towards a glass customer. He does not like to have RFID implemented around the ankle or under the skin just to have a car key, the credit card and apartment

key with him. “I don’t think it’s a direction we should go.”

- I2 is concerned about longer range RFID technology, where attacks based on data interception is possible. He states that the short reading range of NFC might not be such a problem in contrast to longer range RFID;
- I2 says if RFID is used for payment or toll collection, then there are big risks in terms of privacy and security.

In addition, I1 thinks that the radio frequency emissions of NFC are not very high and hence not a concern.

The interviewees named the following application areas for NFC/RFID in regards to possible future use or existing use:

- E-ticketing, using the mobile phone at special ticket points on train stations;
- Theft prevention with RFID and alarms at the store’s door;
- Swipe cards to access workplace;
- Payment in university restaurants;
- E-ticketing for bus and train;
- Public transportation time table with RFID senders at the stops to get the current time table on the phone;
- E-ticket sale at the bus/train stop;
- RFID implemented on the ankle or under the skin to use it as credit card, car key and apartment key;
- Automobile manufacturing to identify locations of parts and keeping track of mounting process;
- Speed measurement in Formula 1;
- Tagging items in the apartment and using a special device to locate and find items;
- Passport;
- Payment;

- Toll collection;
- Book check-out in the library;
- Payment to replace cash;
- Automatic payment in stores, RFID attached to products is used to automatically sum up the shopping cart.

5.3.16. Grocery Environment

The following issues relate to the grocery environment:

- Other customers could stand in the way when NFC mobile shopping assistant is used;
- Different grocery stores require different versions of the Product Information Finder / NFC mobile shopping assistant;
- Interference if a lot of customers use the NFC mobile shopping assistant at the same time;
- If customers do not have NFC enabled mobile phones, the grocery store could rent / provide some;
- The grocery store can already create a customer profile by analysing credit card details and shopping card content;
- Every customer can have a look in your shopping cart;
- Employees in the grocery store are usually not helpful to provide specific information about products. They are not qualified and trained to provide information for thousands of products.

5.3.17. Motivation

The following issues relate to the interviewees' motivation for using or not using mobile applications, future technology, an NFC mobile shopping assistant or buying/not buying certain products. Those issues could not be fitted into the categories of perceived ease of use or usefulness.

- Participant 1:

  - A combination of product price and the product manufacturer influence his decision whether to buy a product. I1 does not always buy the cheapest or most expensive product, but considers who the manufacturer is in order to decide on the quality of the product. The product manufacturer's name and brand influence his buying decision;
  - While doing grocery shopping, he buys a certain range of products over and over. He knows the products that he likes. He would only use new products if somebody suggests them to him.

- I2:
  - He would use an NFC mobile shopping assistant probably for products he has not bought before;
  - He would not use an NFC mobile shopping assistant for really cheap products.

- I3:
  - She would consider using an NFC mobile shopping assistant for high priced products, because there is more to lose. "On the other hand cheap products don't come with the risk of losing too much money in case they are not worth it." She does research on really expensive products before she goes to the store;
  - She likes "the idea of utilizing the phone or computer to use it for more than the initial purpose.";
  - She would like to help local farmers and her own country by buying their products. In addition, news report food product scandals from certain countries. Those two aspects influence her food product buying decision. An NFC mobile shopping assistant can support her decision process by providing food product information regarding the origin and processing location.
  - She is interested in the "real company" behind a product, because often she cannot see the real producers. In addition, all companies, "which are part of the production" are of interest to her.

- I4:
  - She is really interested in recipes, would not pay for food product information and does like the idea of having personalised advertisements.

- I5:
  - If using an NFC mobile shopping assistant increases the shopping time (e.g. by an extra hour) then he is not interested;
  - He would feel special when he receives customised offers that are not available for everyone;
  - He is already using a similar software (iPhone Bar code scanner) that provides him with basic food product information as a result of identifying the food product with the mobile phone's camera and the bar code.

5.3.18. Alternatives

Negative perceptions of the NFC mobile shopping assistant and the Product Information Finder software, as well as additions to them in order to further improve usefulness and ease of use, lead to possible alternatives.

Alternative sources of information can be:

- The internet, accessed from home (with a personal computer);
- Grocery store employees.

Alternative ways to identify food products can be:

- Use of a bar code scanner and the mobile phone's camera instead of a NFC reader;
- NFC/RFID tag is attached to the price tag on the shelf instead of being attached to the product item.

Devices alternative to the NFC mobile phone can be:

- Wrist watch: I4 comments that a watch is not too heavy and is also carried around all day long, but then she comments that not every one has a watch;
- Existing price terminals that are already set up in larger stores: I4 mentions that the existing price terminals could be utilised, but she sees the problem of generating queues of customers lining up. Also, walking up to the terminal takes time. Therefore, she believes it would not be so fast and customers would waste time.

- Screen attached to the shopping cart: I4 thinks that a screen attached to the shopping cart would have the advantages of having the hands free and think less about the phone. She sees the shopping cart screen as an addition to the mobile phone. It can be used if the phone has been forgotten or is low on battery. She also mentions that when customers do not buy many items then they just take a small shopping basket, which does not have a screen. In this case the mobile phone "becomes handy again";
- I4 thinks that the mobile phone, the screen on the shopping cart and terminals should co-exist;
- The customers without an NFC mobile phone could rent devices for the time of shopping;
- A screen in front of the shelf: I1 thinks that this is probably not very sophisticated;
- Audio guidance systems for visually impaired people;
- Device attached to the shopping cart: I2 thinks that a device could be attached to the shopping cart. This could be utilised to also display the balance of all items. He thinks that the device would enable many features but it could increase the cost of shopping carts. Those cost would be passed on as additional cost to customers;
- Apple iPad, because it is becoming popular;
- Netbook.

Software related alternatives or extensions are:

- Search engine;
- Product comparison features

5.4. Chapter summary

This chapter contains a concept creation, which is used as a framework to better structure and understand the data. As part of the concept creation, relations and connections between major aspects and areas were described. Finally, a detailed report of all the findings was provided.

The next part in this research is to discuss major findings and relations between different areas in the context of existing literature reviewed in chapter 2.

6 Discussion

6.1. Introduction

Chapter 2 provided analysis of the existing research in areas closely related to the NFC mobile shopping assistant. Five main areas have been identified as important for technology acceptance. Those are usefulness, ease of use, security, privacy and cost aspects of the technology. A number of concrete benefits, issues and challenges (sacrifices) had already been known before the data collection started. The known benefits and sacrifices are, however, linked to closely related technologies or similar solutions. They were not directly linked to the NFC mobile shopping assistant for the grocery environment. As part of this research, primary data has been collected, analysed and reported specifically for the NFC mobile shopping assistant. Benefits, issues and challenges in different areas were identified and reported in chapter 5. In this chapter, the particular findings of this research are discussed and linked back to the main categories of existing research.

6.2. Discussion

The technology acceptance investigation in this research is based on Kim et al.'s[52] value proposition for voluntary technology acceptance. The value proposition considers a technology's benefits and sacrifices together. If the benefits outweigh the sacrifices, then the user's acceptance is higher. The aim of this research is to find out what the benefits and sacrifices (issues and challenges) are in order to help future researchers investigating the individual impact. Also, the identification of issues and challenges aims to provide a starting point for future implementations of solutions similar to the NFC mobile shopping assistant. This chapter discusses the proposition of benefits and sacrifices (challenges and issues). A comprehensive list of

requirements and improvements for the NFC mobile shopping assistant is discussed in section 7.5.3 commencing on page 128.

The majority of interview findings in the area of usefulness were positive and therefore add a benefit for the user. The positive findings in the area of usefulness support findings in existing technology acceptance literature discussed in chapter 2. Interviewees consider particularly useful access to additional and existing information in order to determine the quality of a product and its ingredients. That is important, because Hermanussen et al.[29] found labeled food product information to be incorrect. The findings also reveal that the NFC mobile shopping assistant is not genuinely useful in every case and for every user. They were very beneficial for customers with special diet or food requirements. Customers without those special requirements would only benefit if they are really interested in the information. The type of information and product plays an important role as well. In particular, it would be very useful to access via the NFC mobile shopping assistant food product information that is not available from the label. The product types identified by the interviewees were two: more exclusive/expensive and very cheap products. In both cases, the solution is not regarded highly beneficial. That supports Hong and Tam's[49] findings of the influence of usefulness and monetary value on technology acceptance. In the case of very cheap products, the effort of using the solutions is not proportional to the product price. On the other hand, more exclusive and expensive products may require detailed research at home (online) or consultation with specialised sales staff. Kowatsch and Maass[75] found a similar solution (NFC mobile recommendation agent) to be useful for expensive consumer electronics. The substantial difference to the NFC mobile shopping assistant is that their solution recommends additional equipment and articles. Hence, the buying decision for the expensive consumer electronics is already felt to be in contrast to the NFC mobile shopping assistant. In addition, familiar products that have been bought before are unlikely to require the use of an NFC mobile shopping assistant request. In summary, the criteria of when and on which food product the NFC mobile shopping assistant is used, can depend on the individual needs and preferences of the user, the price of the product and type of information that can be displayed.

In the area of ease of use, the majority of interview findings were positive, which confirms findings from existing technology acceptance literature. Three ease of use aspects were mentioned. First, each user (customer) owns a personal mobile phone / smartphone, it is most of the times with the user and therefore familiarity with the smartphone makes the NFC mobile shopping assistant easier to use. Secondly, the speed of accessing information was perceived as fast. Thirdly, the NFC product identification was easy to understand. O'Neil et al.[31] found barcode identification to be quicker for untrained users. In contrast, trained users were found to be

quicker with NFC identification[31]. The five interviewees in this research were not trained, but a brief introduction and demonstration was given prior to the interview. Therefore, they can be considered familiar with the technology. In addition, the five interviewees considered innovative, based on their relatively young age and familiarity with modern technology in general. Higher innovativeness positively influences technology acceptance[46, 53] and in the case of Kuo and Yen[53] personal innovativeness even positively influences perceived ease of use. Hence, the findings of this research support existing research investigated in chapter 2.

Hossain et al.[50] combined usefulness and ease of use to convenience and found convenience to be positively influencing. This can be confirmed with findings from this research. In particular the fact that the user can use the same personal smartphone for usual tasks (calling, texting, email, online services etc.) and also as an NFC mobile shopping assistant links ease of use and usefulness. Ease of use is linked because the user is already familiar with the smartphone and its operating system. Usefulness is linked because there is no additional device required and just another service (NFC mobile shopping assistant) is added to the list of already available services and applications.

The monetary price of the food product (monetary value - Hong and Tam[49]) was found to be relevant to usefulness. Other cost-related findings of this research are in the area of NFC mobile shopping assistant usage fees. Generally, users would prefer not to pay for the service and prefer it to be free. That is in line with existing research of Kuo and Yen[53], Wu et al.[71] as well as Kim et al.[52], who found a negative influence of costs on technology acceptance.

Personal data privacy threats, similarly to costs, have a negative influence towards technology acceptance, as it was found by Mueller-Seitz et al.[60]. In contrast, Hossain et al.[50] found no significant influence of privacy. Hossain et al. explain their findings with a general low awareness of personal data privacy threats. In this research, the interviewees generally only want to reveal the minimum of required personal data, but when asked which type of data they would reveal, a range of very personal data was mentioned. For instance, mobile phone number, age, area of residence, special food requirements and the shopping statistics were among them. Although this study cannot generalise based on the data, some interviewees did not appear to have any privacy concerns. Others suggested a fairly anonymous approach, were payment for the service of using an NFC mobile shopping assistant can be done upfront with cash or bank transaction on a pre-paid basis. A combination of username and password then allows using the pre-paid credit and no direct link to the user's real name and demographics would be needed. The fairly anonymous approach was suggested by I2, who studies computer science. Other participants,

who are not very familiar with technological aspects and privacy threats did not mention major privacy concerns. The findings of this research in regards to privacy and risk perceptions support the findings of privacy threat's negative influence. The findings also confirm Hossain et al.'s[50] findings about low threat awareness.

Security issues are often mentioned together with personal data privacy threats because technical security vulnerabilities can enable personal data privacy violations. Mueller-Seitz et al.[60] and Hossain et al.[50] investigated both privacy threats and security threats at the same time. In this research, the interviewees did not have any knowledge of the smartphone application architecture and security features. Nevertheless, privacy and security threats were linked, starting from personal data aggregation (shopping profile) through the NFC mobile shopping assistant or connected background services (food product information provider, grocery store). Some interviewees feared that the collected shopping and customer data might lead to an abuse of personal data (privacy) from the background service provider. Others in contrast, feared that the shopping profile might be analysed and used by third parties to commit crime, e.g. a burglary. Security issues unrelated to privacy were found in this research as well. The obvious and constant use of an expensive smartphone may attract thefts.

Cultural aspects of technology users were found to be influential towards technology acceptance by Hossain et al.[50]. This research cannot confirm the cultural influence, because the primary data (interviews) was gathered from only one cultural group. The nature of this research methodology does not allow generalisation. This research did not investigate across different cultures in order to compare them. However, the interviewees are of German background which assumes a high level of education, standard of living and familiarity with key aspects of this research. Additional major participant criteria aimed to ensure that the interviewees are familiar with modern technology and that an innovative mindset is present. The findings of this research confirm that an innovative mindset and understanding of modern technology is important for contributing credible input. It is unknown whether a different cultural group and different participant criteria would have yield different findings. The focus on participants of Germans background is a limitation of this research (see section 7.4.4) but also a benefit. It is a benefit because future work can collect and analyse data from a different cultural group and then compare the results with this research findings. That is outlined in section 7.5.6.

In addition, the cultural focus was beneficial for data collection and data interpretation, because the researcher was highly familiar with the interviewees' culture and the research could understand certain German-specific aspects. That confirms Patton's[87] suggestion for improving data quality through high cultural familiarity.

There are some additional aspects that could have been discussed in this chapter. The researcher, however, decided to discuss them in the context of the implications for academia, which can be found in subsection 7.3.1 commencing on page 121.

Overall, the very majority of findings can be linked back to existing literature and support the findings from similar and related technologies acceptance studies. The research questions that emerged from the identified gap in existing literature remains to be answered. The next chapter will finally answer the research question and discuss the limitations and future work.

7 Conclusion

7.1. Introduction

Findings from this research support existing research, as the discussion in previous chapter 6 has outlined. This chapter finally concludes this research by answering the research question (section 7.2), by outlining implications (section 7.3) from this research for various groups, by discussing limitations (section 7.4) and by outlining future work (section 7.5). At the very end, the researcher provides his very personal statement in section 7.6.

7.2. Research proposition and answers

The research question "What are the benefits, challenges and issues of an NFC mobile shopping assistant in the grocery environment from a user's perspective?" is finally answered in this section.

The researcher's understanding of benefits, challenges and issues was defined in section 1.4. Benefits, challenges and issues are discussed in dedicated subsection.

7.2.1. Benefits

The benefits of the NFC mobile shopping assistant solution are that the solution is going to work with existing smartphones that the user already uses and is familiar with. Using the user's existing smartphone for the NFC mobile shopping assistant increases the smartphone's utility. In addition, the familiarity with the smartphone and smartphone operating system makes the software more familiar. The product

identification vian NFC/RFID is fast and easy to understand. The NFC mobile shopping assistant can provide fast access to various information. Three types of information emerged to be of particular interest. The first type is, basic product information such as ingredients, calories, origin, carbon foot print or price. Second, information regarding the healthiness in general or for people with special food requirements (e.g. allergies, diabetes). Third, recommendations for recipes or similar products. The usefulness of various information is a major benefit of the NFC mobile shopping assistant. Existing information that is printed on the food product label can be displayed on the smartphone with improved typography and in a better structure. In addition to existing information, previously unavailable information that comes from alternative information sources can also be displayed. Additional information is useful to users who have a particular interest. The particular interest and usage situation depends on product (type, price, value), the motivation of the user and the situation. As the NFC mobile shopping assistant is with the user anyway and its use is not required for shopping, the NFC mobile shopping assistant can be used when desired. Individual, independent and situational usage options allow maximum flexibility.

The interviewees' perceptions of the NFC mobile shopping assistant's benefits are very similar to the researcher's initial assumptions (section 2.2 commencing on page 11). In order to improve the proposed technology solution, it is more important to identify and consequently solve issues (problems) and overcome challenges.

7.2.2. Issues

The NFC mobile shopping assistant's issues are in different areas. Some areas are directly related to the design or nature of the NFC mobile shopping assistant, while other areas are related to the environment (grocery store), smartphones in general or NFC/RFID. The latter ones are presented first.

The grocery environment influences the user of an NFC mobile shopping assistant in a sense that crowded stores and the stores' layouts can lower the benefits. For instance, crowded stores may create interference or overload of the network. The general availability of a network connection is partially influenced by the grocery store but also by the network provider.

As outlined in chapter 1 and 2, NFC is in many regards very similar to RFID. NFC and RFID are different terms but the user might see them as the same thing because of many similarities. Consequently, negative perceptions of RFID might also be associated with NFC. Even though NFC has higher security standards (shorter operating range, encryption features), but poor implementation or basic violation

of common security best practices could create security vulnerabilities and privacy threats. Some users have a negative perception of existing RFID projects, mainly because personal data is often invisibly aggregated, stored and used to create profiles. This perception currently mainly applies to RFID only, because NFC is not common, not widely known and not widely implemented yet. The risk is that either its reputation is projected to NFC as well or that NFC security threats and privacy violations occur and its reputation is damaged. Both cases are crucial to the NFC mobile shopping assistant.

Privacy and security threats are possibly not only caused by the NFC technology, but also the smartphone, the software and involved parties (food product information provider, grocery store) are possible causes for privacy and/or security violations. Users do not want their personal information stored unnecessarily. Furthermore, users want to know what the data is used for. A benefit for the food product information provider and grocery store, that has not been discussed yet, is the aggregation of all possible data for various purposes, such as store improvement, marketing or advertisement. The issue lies in the contradiction of access to the food product information' via smartphone and the user's interests to protect privacy. Unnecessarily stored information or a major loss of customer data due to attack are crucial to user's trust.

A security issue of different nature was found to be related to the public, obvious and increased use of smartphones in the grocery stores. Distraction while using the NFC mobile shopping assistant may lead to an increase in thefts of handbags. Also, the obvious use of an expensively perceived device may attract thieves.

Whether users should be charged for using an NFC mobile shopping assistant and if so in which way the payment would be handled, is a major issue. Generally, users want free access to the service, but certain very useful information (e.g. recipes, allergy information) could attract costs. Increased costs for mobile data usage via 3G might occur as well. Identifying which type of information can be provided for free and what the price for payed information is, remains a key issue. Interviewees of this research suggested different options for prices, payment models and payment handling such as different prices for different information, prices in relation to the product value, pay per request, flat rate, automatic bank withdrawal, one-off fee with the purchase of the smartphone or software and monthly payment via mobile phone contract.

In case the smartphone is low on battery, it has been left at home or it is currently used for other purposes, then it cannot be used as an NFC mobile shopping assistant.

Issues that are directly related to the NFC mobile shopping assistant solution are

the individual perception of the food product information usefulness. One interviewee stated that he buys products based on criteria such as taste or price and pays little attention to the food product information. Furthermore, just providing the existing label information without additional information does not add much usefulness for the user.

Other directly related issues are in the area of food product identification. If the RFID/NFC tag cannot be located or two products are too close, then the food product identification is not as easy anymore.

7.2.3. Challenges

In the area of usefulness, the food product information is important. Not only basic food product information, which could be found on the product labels, should be available through the NFC mobile shopping assistant, but also additional information such as carbon footprint, producing conditions, degree of organic food, product origin, healthiness information, allergy significance, recipes and further product recommendations. Furthermore, product comparisons, integration of discounts and special offers should also be available. These information and features should be available in different stores and also sharing information with family members should be possible. At the same time, advertisements and SPAM are not desired. Including additional information that is not available yet is a major challenge because the information has to be created and assigned to the products on a large scale. Databases of the food product information provider need to be maintained. The increasing variety of information types has also implications for the NFC mobile shopping assistant software, as further usability issues (higher complexity with more information type) could arise. Software-related challenges and suggestions for improvement of the Product Information Finder software are discussed in subsection 7.5.3.

Software-related challenges are also relevant in the area of ease of use. The software needs to be accessible to people with specific needs and disabilities. Smartphone hardware-related challenges to improve the NFC mobile shopping assistant are discussed later as well.

Security and privacy threats are a major challenge to the overall benefits of the NFC mobile shopping assistant. Personal data privacy threats can occur in multiple parts of the entire solution. As outlined before, both the food product information provider and the software of the NFC mobile shopping assistant can aggregate data. In addition, both operate computers (server, smartphone) that might be vulnerable to security attacks. Security attacks can disrupt the NFC mobile shopping assistant

and/or steal customer data and hence breach privacy agreements. The involved computer (server, smartphone) and software can be developed following best practices of secure software, which will not, however, provide a 100% secure system. In addition, secure software is more expensive. Higher expenses for the development of the entire NFC mobile shopping assistant solution would affect the usage costs, which were identified as a major issue.

In addition to costs that occur for the development and securing the IT infrastructure (software and hardware), 3G data plan costs and food product information request costs are likely to occur. The users want to use the service for free or only pay a small amount for very useful information. On the other hand the costs for infrastructure, support and information have to be covered. Advertisement can be an alternative way of funding. However, effective advertisement relies on customer shopping profiles. This research found that effective advertisement as a promising way of funding the NFC mobile shopping assistant would be very challenging, because different users have different perceptions and desires. Finding alternative ways of funding is a key challenge.

The Product Information Finder, as a prototpye implementation of the NFC mobile shopping assistant runs on a Nokia 6131 NFC device. In direct comparison to this particular device but also based on their personal preferences, the interviewees suggested a number of requirements regarding the software and hardware of the handset device (NFC smartphone). The requirements for the software and hardware are contradicting. For instance, a large screen, readable displays, a good battery and good performance are desired but also light weight and small size are requested. This is a reflection of the latest hardware development of smartphones. Smartphones are becoming more powerful, touch-screens and larger displays have become more popular. On the other hand, current high class smartphones have shorter battery capacities, so recharging has to take place more often. Low battery compromises the usage of an NFC mobile shopping assistant and hence remains a challenge. Also new device categories (e.g. tablet computer) have recently attracted attention. One interviewee suggested tablet computers as alternative devices. Tablet computers have larger screens but NFC functionality and other communication channels are not widely available.

Software challenges for an NFC mobile shopping assistant are generally a simple, fast and easy to use interface. On the other hand, to increase the degree of usefulness, more information types and more complex features were suggested. Providing such features along with the growing amount of data could affect negatively the interface performance. Creating an interface that can cope with that and still be simple, fast and easy to use is a challenge too.

7.3. Implications

This research has investigated the NFC mobile shopping assistant in order to identify benefits, issues and challenges that influence the user acceptance. Implications from this research are in various fields and for various stakeholders. First, implications for academia are related to this research methodology and framework. Second, implications for future grocery customers are based on the collected interview data. Third, for grocery store owners and other involved businesses a number of implications can be drawn from the interview data. Fourth, implications for future development of PIF are based on the development process prior to the interviews and also on the interviewees' feedback.

The following four subsections cover the outlined implications for each group in more detail.

7.3.1. Academia

This research has followed some suggestions found in three well cited TAM studies. First, it follows Lee et al.'s[43] recommendation to use technology acceptance areas that are suitable for the technology under investigation. Chapter 2 discussed which technology acceptance areas are relevant. Future research can be based on this research literature review (chapter 2) and use privacy, security and costs in addition to usefulness and ease of use for technologies similar to the NFC mobile shopping assistant. In addition, Lee et al.'s general recommendation was found to be very useful, as a discussion of similar and related technologies helped to gain and maintain focus. The researcher perceived maintaining focus as particularly difficult, due to the lack of other direction giving studies related to the NFC mobile shopping assistant.

Secondly, this research investigated usefulness, ease of use, privacy, security and costs under the assumption of the user's voluntary acceptance. The original TAM by Davis[42, 38] operates in a less voluntary environment where an employee is asked (indirectly forced) to use a new technology. The compulsory environment meant that previous research investigated mostly advantages (benefits, positive aspects) of a technology. In contrast, Kim et al.[52] argued that if a technology is used with a voluntary motivational background, then both positive and negative (benefits and sacrifices) need to be under investigation. This research followed Kim et al.'s recommendation by investigating security, privacy and costs mainly as possible sacrifices in contrast to positively perceived usefulness and ease of use. This research findings support Kim et al.'s approach, because investigating positive and negative user acceptance aspects enabled a much deeper investigation and created a more complete

picture of the technology. Furthermore, a number of direct relationships between positive and negative technology acceptance aspects were discovered. Hence, Kim et al.'s approach is highly beneficial for technology acceptance studies with voluntary user acceptance.

Thirdly, this research applied TAM in a qualitative way, in contrast to most TAM studies that predominantly apply TAM in a quantitative way. Sun and Zhang[32] argue, that applying TAM in a qualitative manner to explore and identify technology acceptance areas of new technologies is a valid approach and gives TAM a new direction. This research has followed Sun and Zhang's suggestion successfully. The implications for future researchers are that an explorative and qualitative TAM study can be conducted and that this opens new research directions for a research model that is more than 20 year old.

In addition to the three TAM related suggestions, there is a fourth implication for academia. The use of a prototpye application (PIF) for demonstration purposes in order to improve the interviewees' understanding of the technology is very useful. High data quality was achieved and data triangulation was prepared, but, most importantly, the research and data collection were perceived as more realistic and exciting for the interviewees. Both the researcher and the interviewees were more involved and enjoyed the research.

7.3.2. Customers

Between the beginning and end of this research, the technology has developed further and technology key player have changed focus. Just recently, Research In Motion introduced an NFC smartphone. Nokia has sold its Symbian operating system, which was capable of NFC and for future smartphones Nokia wants to focus on Windows 7 mobile, which has no NFC support yet. Google Android has become the new market leader in smartphone operating systems. Mobile payment, a key application area of NFC is developing further too. The NFC/RFID infrastructure is improving as more and more additional application areas are rolled out.

The very recent developments show progress in the NFC/RFID infrastructure and application areas. On the other hand, Nokia's decisions on operating systems, as mentioned above, is likely to influence the technical NFC operating system side, because NFC software developers are likely to change platforms. In addition, different smartphone operating system platforms (Andorid, iOS, Symbian, Blackberry Os, Windows Mobile etc.) require individual software applications. Therefore, users of very common operating systems that also support NFC, are likely to be the first real life users of an NFC mobile shopping assistant.

Google Android, which is currently the most popular in terms of new sales, has the second largest number of available third party software applications. The "das ist drin Scanner" is a German software application for Google Android. The "das ist drin Scanner" is very similar to an NFC mobile shopping assistant, as it provides the user with basic food product information and an indication about the product's healthiness. The "das ist drin Scanner" achieves the product identification via barcode scanning, which, as outlined in chapter 2, has some disadvantages. By the time of submitting this research Master thesis, widely penetrated RFID tags on products were not common in Germany. Hence, the "das ist drin Scanner" remains the only functioning solution until NFC can be used. The "das ist drin Scanner" and other similar barcode scanner applications have already been used by interviewee five (I5). Implications for customers are that the mobile operating system vendors and smartphone manufacturers have to provide a solution that is capable of NFC and widely accepted by the user community. Google Android is going to be capable and it is currently widely accepted. The next few months will provide further indication whether Google is capable of rolling out an NFC-capable device and also provide software developers with a suitable framework. Customers interested in NFC smartphones should wait a few more months before purchasing new devices.

The research found that some interviewees did not see any privacy and security threats while using an NFC mobile shopping assistant. The lack of awareness can be caused by a number of reasons. It is likely that lack of knowledge and understanding of technological aspects are among the main reasons. The literature review (chapter 2) and contributions of interviewee two (I2) confirm that. Hence, customers should seek education in the field of personal data privacy and basic countermeasures for security threats in order to understand and prepare for current and future technologies and their risks.

7.3.3. Grocery store owner, food product information provider and involved businesses

The grocery store owner, as the examples of Metro and Wal-Mart show, are preparing their stores for RFID item-level tagging, which is the key requirement for an NFC mobile shopping assistant. They need to progress further and also work on minimising security and privacy threats.

The food product information provider has been identified as an entity that provides the food product information. The structure and workflow of such an entity are out of scope of this research. However, it is a key entity for an NFC mobile shopping assistant and hence it must fulfill its role. The gathering and organisation

of information are particularly important.

The grocery store owner, food product information provider and other businesses can highly benefit from the NFC mobile shopping assistant. As outlined in section 7.5, new business opportunities can emerge. In order to benefit from new business opportunities, all of the above need to actively participate in the development process.

7.3.4. Software developers and the PIF application

PIF has been developed for demonstration purposes in order to improve the interviewees' understanding of the NFC mobile shopping assistant and to enable as well as prepare triangulation of data for future research. The PIF is ready to use for additional data collection. However, findings from this research suggest further improvement (subsection 7.5.3 on page 128) of the software will be needed. Those suggested improvements should be implemented in order to use the PIF for future professional NFC mobile shopping assistant software applications.

As mentioned in subsection 7.3.1, the use of a prototype application created a number of benefits. To increase the impact and to gain even more benefits from a prototype application, the prototype demonstration could be improved. First, a more realistic test environment with a number of different products and more detailed information would be the initial step to involve the participants (interviewees, observes) much more. Subsection 7.5.5 provides some further details. In addition, the interviewees could be asked to use and trial the prototype not only before the interview but also afterwards. This would provide the interviewees with additional time to reflect on the technology.

From a software developer's point of view, recent announcements that Nokia no longer supports Symbian means that support for the current devices and future improvements is unlikely to be ongoing. As it is important for software developers to have ongoing support from vendors and manufacturers, future platform considerations are likely to exclude Nokia. Hence the actual source code of the the PIF may become obsolete. However, for research purposes it still can be used and there are also plenty of Nokian NFC devices available. Regardless which device manufacturer and operating system vendor future NFC applications will use, the work of software developers will always be required. In particular, proof of concepts and prototypes are greatly beneficial to obtaining an initial understanding of a related research field. Hence, software developers in an academic environment are confronted with challenging and ever changing software requirements, but do not have to complete the time consuming full software development process of requirements gathering, design

phase, implementation and test. Agile software development methodologies can be applied very well in contexts similar to this study. Agile software development offers great benefits for software developers.

7.4. Limitations

This research has a number of weaknesses that the reader must be aware of in order to judge the findings. In addition, weaknesses outline fields of improvement that can be addressed in future research.

7.4.1. Segregation of roles

The nature of the topic as well as the scope and timing of this research made segregating the roles of the person collecting the primary data, analysing the data and conducting the overall research very difficult. Instead, the same person conducted all three tasks. That has possibly introduced bias based on the personal opinion of the researcher. As part of the methodology, a number of precautions have been put in place to minimise bias. Please refer to section 3.6 commencing on page 55 for further details of how trustworthiness of both the research and researcher is assured.

7.4.2. Weaknesses of directed content analysis

In the first stages of this study's data analysis, existing research findings were use for the directed content analysis approach. Consequently, the findings are not entirely grounded in the data, as the initial direction determines an early research focus. The consequent limitation comes from the possible threat of not drawing certain findings from the data. In contrast, non-directed content analysis is more open and analyses data inductively. It therefore could possibly uncover some other aspects. Non-directed approaches are often used to form a theory that is purely grounded in the raw data[100]. However, only the first stage of the data analysis has been directed and the consequent analysis iterations were entirely based on the data.

7.4.3. Sample size

The sample size of this research was limited to five interviewees. The aim of this qualitative research approach was to gain deep, rich and meaningful data. Therefore

the quality of interviewees is more important than the number. Nine participant criteria (see subsection 3.4.4 on page 47) are put in place to ensure very suitable candidates. A larger number of interviewees in combination with more diverse characters, backgrounds and motivations could have brought about some additional findings. In addition, interviewee profiles in greater detail would possibly have provided a better understanding of each interviewee's motivation and shopping goals. Hence, a suggestion for future work lies in the area of interviewee profiling and is discussed in detail in subsection 7.5.1.

7.4.4. Cultural focus

Hossain et al.[50] found the influence of culture to be significant for user acceptance. This research only gathered data from German interviewees and limited the cultural diversity. There are two reasons for limiting the interview data to a German cultural background. First, the German grocery environment has Metro as an innovative retail player that started using RFID about ten years ago. Metro already trialled various RFID implementations on the sales floor and therefore Metro is likely to be among the first retailers to push for the full RFID penetration. The interviewees of this study had to be familiar with the German grocery environment. Secondly, the interviewer should be familiar with the culture of the interviewees, in order to achieve better results[98]. The researcher and interviewer of this study is the same person and is of German cultural background.

Even though all five interviewees are Germans, all of them have lived in a foreign country for at least 6 months and are therefore familiar with other cultures, grocery environments and shopping behaviours. It is therefore quite likely that the interviewees directly or indirectly contributed experience from foreign grocery environments.

7.4.5. Weakness of prototype

The use of a prototype aimed to help providing the interviewees with a better understanding of the technology. However, the prototype software application could have been more realistic. Please see section 7.5.3 for a list of improvement suggestions of the PIF. In addition to a more realistic prototype, its presentation could have been more realistic too. For instance, the prototype could have been presented in an existing grocery environment.

7.5. Future Work

This qualitative research created a deeper understanding of a NFC mobile shopping solution. Future work needs to be done in a number of areas, which are outlined in this section. Future work can be categorized into two main areas. First, more and more specific data should be collected in a number of subareas. Secondly, the findings from this research and additional data should then be tested in quantitative studies and by focusing on specific populations in order to confirm and generalise the findings.

The following subsections cover subareas of additional and more specific data collection.

7.5.1. Detailed customer shopping profile

The participant criteria applied in this research should be extended in a few ways. First, cultural background, age group and occupation should include a much wider sample of the population in order to prepare a more general statement about the usability and ease of use.

In this context, it is desirable to research and include the grocery customer's shopping motivation. That is because the relatively small sample of five participants has already shown that a highly diverse and situational shopping motivation exists. Furthermore, a focus on the situational motivation is highly relevant because an NFC mobile shopping assistant is not going to be used in every situation and a better understanding helps to improve future solutions.

In subsection 7.4.3 the researcher suggests some initial customer profiling approach to identify various shopping motivations and possible NFC mobile shopping assistant usage patterns. Some of the following profile properties were already collected from the interviewees, but further extension and detailed analysis are required. The following six profile properties could be used as a starting point for future research:

- Age group;
- Family and relationship situation (single, number of persons in household);
- Eating habits and shopping preferences (instant food, cooking with fresh ingredients, eating out);
- Shopping circumstances (regular e.g. once or twice per week, depending on stock, depending on other commitments);

- Price range of products (home brands / cheapest, medium price range, best quality / most expensive);
- Product purchase variation (same products every week, new products every now and then, high variation).

Based on the six customer profile properties, a six-dimensional matrix could be created to reflect every possible combination. Consequently, the matrix can be used to recruit participants and create an initial understanding of the profile properties and their influence on technology acceptance.

7.5.2. Business perspective

This study focuses on the user perspective. As outlined in chapter 1 and chapter 2, more parties are involved such as the grocery store, the food product information provider and members of the food product supply chain. All of them can benefit from the NFC mobile shopping assistant as well (more customers, customer profiling, new advertisement channel). Furthermore, the grocery store and food product information provider are already directly involved and they could contribute highly to the success of the NFC mobile shopping assistant. Hence, there is a need for a business case analysis and also detailed risk evaluation (security and privacy). In particular, the conflict between customer profiling and personalised advertisement as business benefits and customers' concerns over personal data privacy and security threats outlines a major field of future work.

Another field for research of the NFC mobile shopping assistant from the business perspective is in the area of advertisement. Interviewee four (I4) mentioned she was interested in customer profiling for personalised advertisement purposes. As personalised advertisement can be a promising business case for an NFC mobile shopping application, it requires more research. Personalised advertisement exists in other fields, e.g. online shops. Knowledge and understanding in existing fields should be used and put in use in the context of smartphones and grocery environment to fully understand all implications.

7.5.3. Product Information Finder improvements

The PIF software has been developed only for this research, mainly to give the interviewees a better understanding of what the researcher is investigating. When the PIF was introduced, its prototype status was clearly communicated. However, the interviewees still judged the PIF software. A number of improvements for the

PIF software were suggested. The improvements are also related to issues and challenges of the NFC mobile shopping assistant software in a way that the suggested improvements advance future usefulness and ease of use aspects. The improvements are presented below.

The example ingredients list on the PIF software appeared to be too long for a sample product that was used. Hence an interviewee recommended to split the longer ingredients list and display it in parts. Also, the font size is requested to be bigger than the label font-size to make reading easier. Prior to the ingredients list and other food product information types, an interviewee suggested to have the entry product identification screen (figure 3.3c on page 46) featured with a picture of the product, the price and very basic key facts.

A feature that was introduced as a major advantage of the NFC mobile shopping assistant in chapter 2 was the capability of the smartphone to be highly individualized and customized for each user. That refers to favorite applications, colours, font sizes and many other features. The PIF software did not have any personalisation features, but interviewees suggested to have personal settings for various aspects such as favorite food product information types and other settings. Other settings include allergic reactions and individual grouping and structuring of information types.

Another feature that could improve the PIF is providing recommendations about the product in regards to a healthy food choice. The idea of indicating in a simple way how healthy a food product is, exists in various countries. Incorporating those can be done as an additional type of food product information. Finally, interviewees suggested that information could be sent to family members and other people. This feature requires additional integration of the PIF into the smartphone's operating system in order to use available data communication channels (email, text messaging or other online services such as twitter or instant chat).

In future work an improved PIF can be assessed under usability aspects in order to identify issues in the areas of ease of use and usefulness. Usability results could then be used to further advance the PIF and create an even more useful and easy to use tool for grocery customers.

7.5.4. Service availability

Hong and Tam[49] found service availability influenced user acceptance. In the context of this research, it was always assumed that the service has a high availability, simply because a high service availability is a must for any technology. In reality,

however, technical interruptions occur and can be caused by the device and technology, the food product information provider or the telecommunication provider. A risk assessment and the influence on the acceptance of an NFC mobile shopping assistant needs to be investigated on various levels. That includes the possible causes for poor service availability but also the situational impact. Results from a service availability study might influence the PIF improvements, the business cases and also quantitative confirmation studies. The researcher suggests to test the customer's tolerance threshold of service (un)availability in order to identify the level of redundancy needed in the involved computer systems and technologies.

7.5.5. Observation in real grocery environment

With the support of an improved PIF, possible future research could be carried out as an observational study. Various user are asked to use the PIF and interact with the environment. Observation would enable triangulation of data, which improves the credibility. This study has been designed to easily incorporate other data perspectives and hence they should be used. Observation of customers might also reveal more issues and could help to determine how RFID tags should be placed and whether an interim solution of tagging the shelf instead of tagging all products would be feasible. The observation of customers using an NFC mobile shopping assistant (e.g. PIF) would also help to confirm or disprove ONeil et al.'s[31] findings of NFC vs. barcode usability. That is going to have implications on how customers who are new to NFC technology are trained.

Alternative devices need to be investigated further as well. In particular in situations where the smartphone battery is flat, the smartphone is used for calling, the smartphone has been forgotten at home, the person does not have an NFC enabled smartphone or does not want to reveal personal data, alternative devices can still provide the information to the grocery customer. Future work should investigate which alternative devices are feasible and how they can achieve similar benefits while co-existing, as interviewee four (I4) suggested.

7.5.6. Quantitative confirmation

Some limitations of this research are caused by the nature of a qualitative approach. Generalisation based on a wider range and higher number of participants is usually achieved with quantitative studies. After more initial qualitative work has been done and various aspects of the NFC mobile shopping assistant and the environment are better understood, a quantitative confirmation and analysis of the importance is

desired. The quantitative confirmation should be extended to populations of cultural background other than German and to participants other than students.

7.5.7. Customer education on security and privacy

This research found and hence confirmed that the understanding and the awareness of security and privacy issues are low. Future work should investigate reasons, develop countermeasures and test educational approaches to improve the customers' understanding of security and privacy issues and to increase awareness.

7.6. Personal statement

When looking back at the past year of conducting research and writing this Master thesis, I realized that I have gained a much better understanding of the technology in general and a more detailed understanding of RFID/NFC and smartphones. The way I see technology shifted from being interested how it exactly works and what is possible with it towards what the implications of technology are. Aspects such as what are the disadvantages of using the technology or what are the alternatives became, more appealing. I suppose the question how technology works can in most cases be answered by relating to the basic computing principles. Also, whether an operating system is designed for a personal computer, vending machine, in-car entertainment system or a smartphone does not change much the basic principles. In contrast, what changes with every new technology and system is how people use it, where people use it, when people use it and what the implications are. All this has been dramatically changed with the emergence of smartphones. Many new application areas and purposes have emerged and will emerge. Smartphones are used almost everywhere and more and more people own one. NFC services are among the services that are going to be very present in our lives. They offer great possibilities since they are useful, handy, easy to use and cool. On the other hand, impressed by all the great advantages people forget, ignore or simply do not realise the disadvantages. In the case of this research, the low awareness of privacy and security threats was surprising to me. In addition, it made me realise that personal data privacy is threatened on a regular base and not a single technology is secure enough to prevent this. Recent examples of large international corporates losing up 70 Million of their customer accounts through security vulnerabilities confirm that. The more aggregated personal data exists in the digital world, the more data can get stolen and the higher the chance for my privacy to be violated. The findings of this research about the privacy and security threats raised awareness of

existing technology disadvantages and I am unlikely to use an NFC mobile shopping assistant. Only major security improvements, anonymous food product information requests, no personalised advertisement and no mobile payment options would make me change my mind. Overall, I am glad that this research raised my awareness and I hope to be able to apply this critical thinking for other technologies and circumstances as well.

The improvement of my critical thinking ability has been driven by the research methodology of this research. Understanding what different research philosophies and approaches try to achieve and how good research can be judged, will help me in my future professional, academic and private life. In particular the importance of a deep qualitative investigation in order to understand a phenomenon prior to any further quantitative investigations was probably the biggest knowledge gain from this research.

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A

Appendix

A.1. Introduction and structure

The appendix aims to provide the reader with background information, raw data, calculations and copies of relevant documents.

Section B.1 and B.2 contain background information about the smartphone market and structure.

Section C.1 provides those readers, who are not familiar with the German grocery market, with a comprehensive understanding of its structure. Section C.2 outlines an example of cultural differences between New Zealanders and Germans during shopping.

Section D.1 explains RFID security threats.

Section E.1 contains an illustration of the Nokia 6131 NFC device during product identification. Section E.2 illustrates the workflow of the PIF software application.

Section F.1 contains a table with the standardised open-ended questions that were used as guidance during the interviews. Section F.2 contains the official AUTEC correspondence, participant information sheet and the consent form.

Section F.3 contains the five transcribed interviews.

Section F.4 contains some statistic tables and less relevant interview data analysis iterations.

Appendix

B.1. Gartner's mobile phone statistics

Gartner, Inc. is an information technology research and advisory company, mainly providing the professional business segment with analysis and forecast data. The majority of their studies are only available to Gartner's clients or to people willing to pay a hefty price for the information. For advertising reasons, Gartner presents some key information in freely available press releases. The researcher analysed commonly available press releases from 2007 to 2010 and filtered total mobile phone and total smartphone sales for fourteen consecutive quarters starting in quarter one of 2007. Due to the nature of press releases, detailed information regarding Gartner's methods of data collection, the data source and analysis are not provided. In addition, Gartner uses the terms 'mobile phone' and 'mobile terminal' interchangeably. Gartner does not provide details of what their understanding of mobile phones, mobile terminal and smartphones is. Nevertheless, the researcher decided to extract information from Gartner's press releases to create charts illustrating the smartphone market penetration over the last three and a half years. The researcher has chosen to do so because Gartner has a credible reputation in the professional business environment. Recently, the researcher had access to non-smartphone related Gartner studies that were at high quality in terms of methodology. The assumption is that Gartner conducted the mobile phone market share studies in a similar manner and that Gartner did not change the sources of raw data over the relevant period of time[1]. Therefore, Gartner seems to be a reasonable, credible and consistent source. In addition, the information about historical development of smartphone and cell phone markets has not been available anywhere else. Finally, Gartner's statistics are not the central discussion point of this thesis. They are only used to underpin a well known trend of the growing importance of the smartphone market.

[1] without taking side effects into account

Column two and three of table B.1 on page 150 contain the actual data extracted from Gartner press releases. In five cases Gartner press releases provided slightly different data for the same period. That is the case for total smartphone sales of Q3-2007, Q1-2008, Q2-2008, Q3-2008 and Q1-2009 as well as total mobile phone sales of Q3-2007. The researcher decided to use the more up-to-date data by ignoring previously released figures. He did so, because most likely mobile phone manufacturers corrected their sales figures due to updated inventory information or similar. Furthermore, the researcher assumes that Gartner included those updates in subsequent press releases. In addition, the highest discrepancy is only less then 1%. Coloumn four (*cell phones*) contains callculated data, based on the assumption that Gartner understands only cell phones and smartphones as the sub categories of mobile phones. Hence the figures in column *cell phones* represent is the difference between *mobile phones* numbers and *smartphones* numbers. *Growth* and *market share* are calculated shares. *Total global sales* are rounded to three decimal figures, because some data was not provided in a greater detail. *Growth* and *market share* are rounded to two decimal figures, but their calculations are based on non-rounded data.

Table B.1.: Global total sales of mobile phones, smartphones and cell phones: Mobile phones include smartphones and cell phones (Source: author, data from Gartner)

Time	Total sales			Growth			Market share	
Quarter	mobile phones	smartphones	cell phones	mobile phones	smartphones	cell phones	smartphones	cell phones
Q1-2007	259.039m[105]	24.941m[106]	234.098m				9.63%	90.37%
Q2-2007	272.604m[107]	27.855m[108]	244.749m	5.24%	11.68%	4.55%	10.22%	89.78%
Q3-2007	291.142m[109, 110]	32.753m[111]	258.389m	6.80%	17.59%	5.57%	11.25%	88.75%
Q4-2007	330.055m[112, 113]	36.766m[114]	293.289m	14.23%	12.25%	14.48%	11.14%	88.86%
Q1-2008	294.283m[115, 105, 116]	32.315m[115, 106]	261.968m	-10.84%	-12.11%	-10.68%	10.98%	89.02%
Q2-2008	304.722m[117, 107]	32.273m[117, 108]	272.450m	3.55%	-0.13%	4.00%	10.59%	89.41%
Q3-2008	308.533m[118, 109]	36.557m[118, 111]	271.976m	1.25%	13.13%	-0.16%	11.85%	88.15%
Q4-2008	314.708m[112]	38.143m[114]	276.565m	2.00%	4.34%	1.69%	12.12%	87.88%
Q1-2009	269.120m[119, 115]	36.507m[119, 115]	232.613m	-14.49%	-4.29%	-15.89%	13.57%	86.43%
Q2-2009	286.122m[120, 117]	40.972m[120, 117]	245.151m	6.32%	12.23%	5.39%	14.32%	85.68%
Q3-2009	308.869m[118]	41.068m[118]	267.802m	7.95%	0.23%	9.24%	13.30%	86.70%
Q4-2009	357.125m[121]	58.826m[121]	298.299m	15.62%	43.24%	11.39%	16.47%	83.53%
Q1-2010	314.654m[119]	54.301m[119]	260.352m	-11.89%	-7.69%	-12.72%	17.26%	82.74%
Q2-2010	325.557m[120]	61.649m[120]	263.908m	3.47%	13.53%	1.37%	18.94%	81.06%

B.2. Gartner's smartphone statistics

For the first and second quarter of 2009 Gartner provided two different smartphone sales statistics. Table B.2 contains the global total sales of smartphones by hardware manufacturers. On the other hand, table B.3 contains the global smartphone sales by operating system vendors for the same period of time. The total of both statistics varies by 112,209 total sales or 0.14%. Reasons could be simirlar to variations in table B.1. B.1 provides further explanation. However, both tables are particularly good to illustrate the diversity and constraints of the smartphone hardware and OS market. Data sources other than Gartner could not provide the direct relation between hardware and OS, as they only provide information about either hardware or OS. Furthermore, many available metrics focus only on particular markets such as North America or Europe. For instance, AdMob provides metrics about the OS market penetration based on mobile advertisment statistics. Certain advertisment clients of AdMob focus on particular operating systems (e.g. Apple iOS) in the USA. Hence the metrics will be heavily influenced and not suitable for representing a global cross-section.

Table B.2.: Global total smartphone sales in Q1 and Q2 of 2009 by hardware manufacturers (Source: author, data from Gartner)

Company	Q1-2009	Q2-2009	Q1 and Q2 2009
Nokia	14.991m[115]	18.441m[117]	33.432m
Research In Motion	7.234m[115]	7.679m[117]	14.913m
Apple	3.939m[115]	5.435m[117]	9.374m
HTC	1.957m[115]	2.471m[117]	4.428m
Fujitsu	1.387m[115]	1.249m[117]	2.636m
Others	6.896m[115]	5.688m[117]	12.585m
Total	36.404m	40.963m	77.367m

Table B.3.: Global total smartphone sales in Q1 and Q2 of 2009 by OS vendors (Source: author, data from Gartner)

OS	Q1-2009	Q2-2009	Q1 and Q2 2009
Symbian	17.825m[119]	20.881m[120]	38.706m
Research In Motion	7.534m[119]	7.782m[120]	15.316m
iPhone OS	3.848m[119]	5.325m[120]	9.173m
Android	0.575m[119]	0.756m[120]	1.331m
Microsoft Windows Mobile	3.739m[119]	3.830m[120]	7.568m
Linux	2.541m[119]	1.901m[120]	4.442m
Other OSs	0.446m[119]	0.497m[120]	0.943m
Total	36.507m	40.972m	77.479m

Table B.4 contains the latest global smartphone operating system sales, also based on Gartner press releases.

Table B.4.: Global total smartphone sales in Q2 of 2010 by OS vendors (Source: author, data from Gartner)

OS	Q2-2010
Symbian	25.387m[120]
Research In Motion	11.229m[120]
Android	10.606m[120]
iOS	8.743m[120]
Microsoft Windows Mobile	3.096m[120]
Linux	1.503m[120]
Other OSs	1.085m[120]
Total	61.649m

The following figure B.1 illustrates the market shares among smartphone hardware manufacturers and OS vendors based on the previous three tables. On the left side of figure B.1 the market shares of hardware manufacturers is illustrated. The right side illustrates the market shares of OS for the same time period.

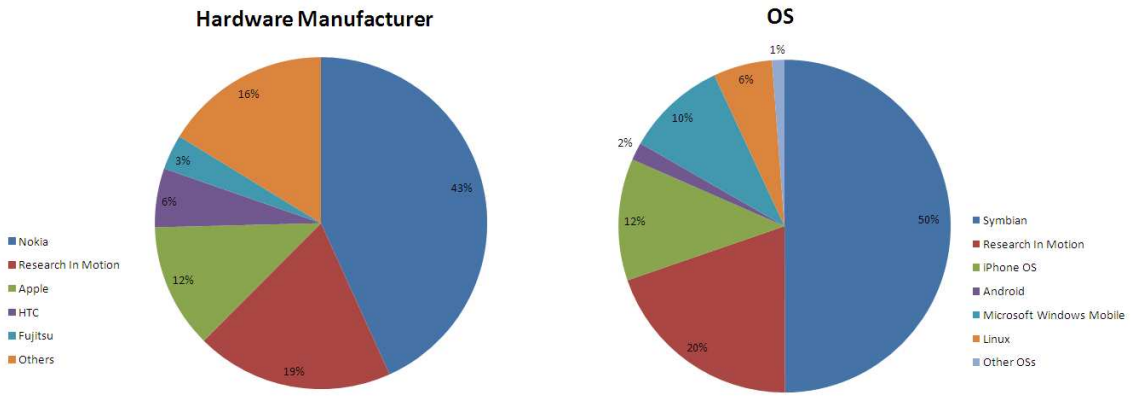

Figure B.1.: Global market shares of smartphone manufacturer and smartphone OS bases on accumulated sales figures from Q1 and Q2 2009 (Source: author, data from Gartner)

Three different conclusions can be drawn out figure B.1:

1. There are OS running on devices of various manufacturers: Symbian and Android are two examples of OS being used by multiple manufacturers. Symbian[2] is mainly used by Nokia, but also Samsung, Sony Ericsson, LG, Fujitsu and Motorola.[125, 126, 127]

2. There are OS only running on devices of one manufacturer and also manufacturers only using a single OS: Apple only uses the iPhone OS (iOS) for all its iPhones. So does Research in Motion (RIM) only use the BlackberryOS. Palm's[3] OS is also intended to run only on Palm's hardware.[128, 129, 127, 130]

3. Some manufacturers are using multiple OS: Taiwanese device manufacturer HTC provides devices for Microsoft Windows Mobile and Android. Although Nokia mainly uses Symbian as their distributed OS, Nokia's N900 smartphone runs on Linux.[131, 132, 127]

[2]Recently Sony Ericsson and Samsung announced not to use Symbian anymore and Nokia has gained full control of Symbian by acquiring the Symbian OS in 2008[122, 123, 124]. Hence, Symbian can be seen as a OS only used by Nokia. However, Nokia is using multiple versions of Symbian and also working on a Linux based OS.

[3]Palm has been acquired by HP in April 2010.

C Appendix

C.1. German grocery environment

The retail structure of various countries is different and depends on multiple factors such as population density, income level, taxes or cultural aspects, just to name a few. A reader of this study may not be familiar with European and in particular German retail structure as well consumer and shopping behavior.

In order to understand the results of this research data collection and in order to follow the implications, the author highly recommends a basic understanding of the German retail structure. For readers who have not lived in Germany for a longer period of time, this section will cover basic structural details of Germany's grocery retail as well as German consumer and shopping behavior. This entire section is based on a market analysis from The Nielson Company (Nielson), which collects market information, conducts surveys and interviews people in order to produce reports and analysis. Nielson sells the their market analysis to members of the retail chain, that includes every company from the supplier of the producer to the retail store. Their audience is not academic nor is the market analysis used as a basis for this research. The market analysis is used to give the reader a general understanding of the German grocery retail sector.

Particularly used for this section is The Nielson Company's "UNIVERSEN 2010 Germany" report, which originally is only fully available in German (see [133]). A shorter version containing only the main findings is available in English (see [134])

This section contains five sub sections, which cover different aspects of German grocery retail environment. First, sub section C.1.1 covers the retail store structure. Second, sub section C.1.2 puts the structure into a European context. Third, sub section C.1.3 introduces a model of categorizing food products and how it is relevant to Germany. Fourth, sub section C.1.4 covers household and population structure.

Finally, sub section C.1.5 combines the previous four sub sections by covering the average German consumer purchase behaviour of products and in grocery stores.

C.1.1. Types of grocery stores in Germany

Nielson's understanding of grocery store types is based on the size of the store. Furthermore, Nielson distinguishes between supermarkets, discounters and drug stores.

Supermarkets and also hypermarkets sell food and non-food (near food) articles on a self-service basis. They offer a wide range of products and brands. Depending on the sales floor size, Nielson uses the following terms:

1. A hypermarket has a sales floor of 2,500m^2 or more.
2. A large supermarket has a sales floor from 1,000 to 2,499m^2.
3. A small supermarket has a sales floor from 400 to 999m^2.
4. A superette has a sales floor from 100 to 399m^2.

Super- and hypermarkets offer a wide range of food product types and brands. They offer multiple brands and sizes of the same product. Non food products such as cleaning, body care and other household products are available from multiple manufacturers (brands) and in different sizes as well. Depending on the size, articles such as non-prescriptive drugs, a wide selection of perfume, garden and house products or tools are offered as well. Generally, the bigger a store, the more articles and types of products are available.

Discounters mainly sell food articles based on the discount principle. The discount principle offers the cheapest prices and only a limited range of products and brands. Discounters are not distinguished by sales floor size. According to Regber[1], who has worked several years as store and regional manager for German discounters ALDI respective LIDL, the combined share of non-food articles, such as cleaning, body care or other household products is about 15 to 20%. 80 to 85% of the total number of articles are food products and drinks.

Drug stores are retail stores that only sell products of the following categories: Cleaning, body care, non-prescriptive drugs, cosmetics, baby food, perfume. Food products are usually not sold.

On 01/01/2010 there was a total of 47,534 hypermarkets, supermarkets, discoun-

[1]Mr. Sebastian Regber is currently a AUT Master of Business student.

ters and drug stores in Germany. In 2009, the total sales revenue was 153 billion Euro.

Hypermarkets and larger supermarkets had a combined market share of 13.5% and contributed 39.7% of the German total 2009 sales revenue. Discounters' marketshare was 33.6% and their total sales revenue 38.2%. Small supermarkets and superettes had 26.1% marketshare and 13.9% sales revenue. Drug stores had 26.9% marketshare and 8.2% sales revenue. Compared to 2008, Small supermarkets, superettes and drug stores lost market share, wherease the others gained market share. Only hypermarkets, large supermarkets and durg stores could increase their sales revenue from 2008 to 2009.

The average sales revenue per store within the store categories was in 2008 and 2009 as illustrated in figure C.1.

Figure C.1.: Average revenue 2008 and 2009 per store in thousand Euro (Source: [134])

C.1.2. Germany in Europe

Within Europe and over the past 28 years, the annual sales revenue shifted from small and specialised stores (butcher, vegetable store) to hyper- and supermarkets. Since 1992, hypermarkets and larger supermarkets had at least 50% of the total European sales revenue.

Germany's complete retail store structure is unique in Europe. However, Sweden, Poland, Switzerland and Spain have similar sales revenue shares of hypermarkets. In

Austria, large supermarkets have similar sales revenue shares compared to German large supermarkets. Small supermarkets and discounters have a similar sales revenue share in Germany, Norway and Austria.

Within Europe, Germany, Norway and Belgium have the highest sales revenue share of discounters, as illustrated in figure C.2.

Figure C.2.: Discounters in Europe: Development of Sales revenue (Source: [134])

From 1992 to 2009, the number of discounters and their share of the total sales revenue has steadily been growing.

C.1.3. Food product categories

The following figure C.3 illustrates the market share of hypermarkets, supermarkets, discounters (Aldi, Lidl, Norma) and drug stores in sales revenues of food and nearfood (non food) products.

Figure C.3.: German 2009 food and nearfood market share by channel (Source: [134])

Nearfood (non food) product categories are body care, paper products/ hygiene, pet food & -care, housekeeping & cleaning, detergents, hair care, baby food & -care, health & fitness, oral care, household products and household foil. For the purpose of this study, the nearfood articles are not in focus. Therefore nearfood related figures and statistics are not discussed furthermore.

Only 2% of total food sales revenue comes from drug stores. Supermarkets and hypermarkets contribute with 54%. The remaining 44% is contributed by discounters.

The following figure C.4 illustrates the TOP 15 food product categories, based on the total sales revenue in 2009. The highest categories are beverages (non-alcoholic, wine, sparkling wine, beer, spirits) confectionery, dairy, tobacco and read-to-eat meals. Alcoholic beverage sales were 58.9% of the total beverage sales.

Figure C.4.: Sales of products by food categories in 2009 in million Euro (Source: [134])

C.1.4. German household, citizien structure and population development

Germany has about 82 million citizens and about 40 million households. In 2010, 18.3% of the population was younger than 20 years. 20.5% was older than 65 years. The remaining 61.1% was covered by citizens ages between 20 and 65 years.

In Germany, 65 years is considered as the age where retirement begins. The education of high school and college students ends at the age of 15-20. Therefore the age group of 20 to 65 is often considered as working population. Which is not entirely correct, because many Germans begin retirement before the age of 65, the majority of students graduates in their late twenties and there are also unemployed, sick or disabled people who are not working.

The following figure C.5 illustrates a forecast of the German population development. First of all the total number is expected to decline from 82 million to 69 million. Furthermore the age groups 0 to 19 and 20 to 65 are expected to shrink, whereas the age group of >65 grows.

In 2010 there was a total of 16 million people older than 65. In 2050 it is expected to be 22 million.

Figure C.5.: German Population development until 2050 (Source: [134])

C.1.5. German consumer expenditures and purchases

"Discounters have the highest acceptance amongst consumers - as well in relation to the consumer base as in the level of expenditure."[134]

98% of German households spend on averrage 1,285 Euro in discounters. Customers do not entirely shop in discounters or hypermarkets. They more or less shop in different stores. Therefore 89.3% of the households spend on averrage 882 Euro in hypermarkts, 74.% on averrage 445 Euro in large supermarket, 65.7% on averrage 272 Euro in small supermarkets and superettes and 85.6% on averrage 189 Euro in drug stores.

The following figure C.6 provides further inside in German household shopping behaviour. On average 70 shopping session, each worth 18.40 Euro have discount shoppers undertaken in 2009. There are less sessions for hypermarkets, small and large supermarkets and drug stores. Furthermore, compared to the discounter, only the hypermarket's average shopping session value was higher.

Figure C.6.: German households expenditures per purchase and number of purchases (Source: [134])

Indications from the food and nearfood analysis as well as the previous figures reveal, that the biggest part of consumer goods is purchased in discounters. The following figure C.7 provides a complete picture.

Figure C.7.: German share of requirement for consumer packaged goods in 2009 (Source: [134])

Figure C.7 includes food and nearfood products. The indication given in figure C.7 is also correct if only food products are included and nearfood products excluded.

That is because discounters only sell a limited selection of product types and brands. Their market share of stores and total sales revenue is lower than those of super- and hypermarkets (see C.1.1). But discounters sell almost as many food products as hypermarkets and supermarkets (see C.1.3).

C.2. Example of cultural difference between German and New Zealand grocery stores

On 02/01/2010 the reseracher went shopping at a German hypermark located in Berlin and on the 24/03/2010, the researcher went shopping at a New Zealand supermarkt in Auckland. The researcher noted the following difference of customer service:

> German customers of small and large grocery stores put purchased items into bags themselves. There are usually no free plastic bags given by the cashier. Customers have to either bring their own bags or purchase quite solid plastic bags for about 0.15 Euro (circa. 0.25 NZD) each.
>
> In New Zealand, most grocery stores provide free plastic bags. The cashier puts the purchased products into the bags. In some places, discount is given when the customer uses reusable bags.

New Zealanders shopping in Germany might find the service unfriendly and would miss good customer service. Some New Zealanders probably would not understand why they have to pay for plastic bags. On the other hand, Germans shopping in New Zealand might want to put their items in a certain order or prefer to keep frozen products in a specific bag in order prevent them from thawing. Also getting a large number of free plastic bags each time they went shopping, is considered environmentally unfriendly.

D

Appendix

D.1. RFID security threats

RFID has security threats that are not unique for the technology and most of them are common in other technology areas as well. "There is no philosophical difference between an RFID tag and a floppy disk"[79, p. 35]

Rieback et al.[78] categorised RFID security threats into high-level and low-level misuse of RFID. The difference between high- and low- level misuse is that high-level security issues occur with correct and non-manipulated RFID equipment. In contrast, low-level security issues are based on manipulated data (e.g. on the RFID tag).

High-level security threats are sniffing, tracking, spoofing, replay attacks and denial of service. Low-level security threats are buffer overflow, code insertion and SQL injection.[79, 78]

The various security threats are explained below and how they can be exploited in a grocery environment is also explained.

1. **Sniffing** refers to RFID tag reading by a third party without the knowledge of the tag bearer. This can be used to secretly track and trace customers or goods that customers have purchased and poses a threat to privacy. In addition, sniffing can be used for espionage.[79, 78]

2. **Tracking** can be based on secretly reading of tags (sniffing) or it can take place with the knowledge of the tag bearer (e.g. customer). Either way, the unique identification of a tag, strategically placed readers and data exchange between the readers allow the tracking of a tag (customer or good). This poses a privacy risk to customers or people carrying RFID equipped items (passport,

credit cards, student IDs etc.).[79, 78]

3. **Spoofing** refers to cloning RFID tags by copying the data of the original RFID tag to a blank one. This could be used to clone and abuse a customers loyalty card. It could also be used to manipulate the identity of goods (e.g. placing tag information from a cheap product onto an expensive product in order to save money or bypass restrictions).[79, 78]

4. **Replay attacks** refer to a "Man in the middle" who records a data transmission and replays it in order to get access at a later point of time. In a grocery environment this could be used for payment fraud (in case RFID is involved in the payment process) or getting access to restricted areas. Authentication measures between RFID tag and back-end system can decrease the risk. [79, 78]

5. **Denial of service** refers to an attack, where a system is prevented from functioning properly. The attacks can be an increased number of request to overstrain the system. A Faraday cage (e.g. aluminium foil or liquids) can prevent proper tag reading and denial of service from functioning. In an RFID grocery environment, theft-prevention can be bypassed. Any type of RFID communication could be blocked or at least disturbed by jamming RFID commands. This would interrupt RFID communication. [79, 78]

The previous five threats are high-level threats, which use and utilise correct and non-manipulated equipment. On the other hand, if an attacker manipulates the equipment or uses fraud tags, then low-level threats such as buffer overflows, code insertion or SQL injections become possible. The low-level attacks exploit vulnerabilities in software, which uses data from modified RFID tags.[78] For instance, a middleware software or a food product information terminal expect the RFID tag ID to be passed over, which usually consist only of Latin letters and Arabic digits (alphanumeric). If the software does not validate the pattern of the RFID tag ID, then attackers could insert special control characters such as ($< > : \% \&$) to the RFID tag. Those control characters have a special meaning in many programming languages and therefore are able to change the behaviour of the software. In addition, there are software programming functions that expect the RFID tag ID to have a certain length. If the RFID tag ID is longer or shorter and the software does not validate the input, then the software can be disrupted or even manipulated[79].

Besides middleware software or terminals, also mobile phones or any other device (e.g. a shopping cart) that is actively reading RFID tags, uses software that is theoretically vulnerable to low-level attacks.

For an NFC mobile sales assistant both low- and high-level threats are relevant. They can be used to interrupt and disturb the communication between NFC smartphone and RFID tags. Wrong data can be transmitted, also an attack on the product information database can manipulate the actual information. RFID tags on products could be manipulated or even replaced and can cause the NFC smartphone to crash or perform unintended tasks.

As cited at the beginning of this sub section, Knight says that "There is no philosophical difference between an RFID tag and a floppy disk"[79, p. 35]. The low-level threats are known to software developers and security expert. However, most of the external data sources (floppy disk, USB key, CD/DVD, email, internet) have been around and exploits in existing software have been fixed. Since RFID is relatively new and unknown exploits are expected. Nevertheless, privacy concerns in application areas involving customers and goods are more worrisome then the other threats.[79]

E

Appendix

E.1. Nokia 6131 NFC during product identification

Figure E.1 illustrates a Nokia 6131 NFC mobile phone during product identification.

Figure E.1.: Nokia 6131 NFC during product identification (Source: author)

E.2. Product Information Finder work flow

Figure E.2 represents the work flow and user interaction with PIF:

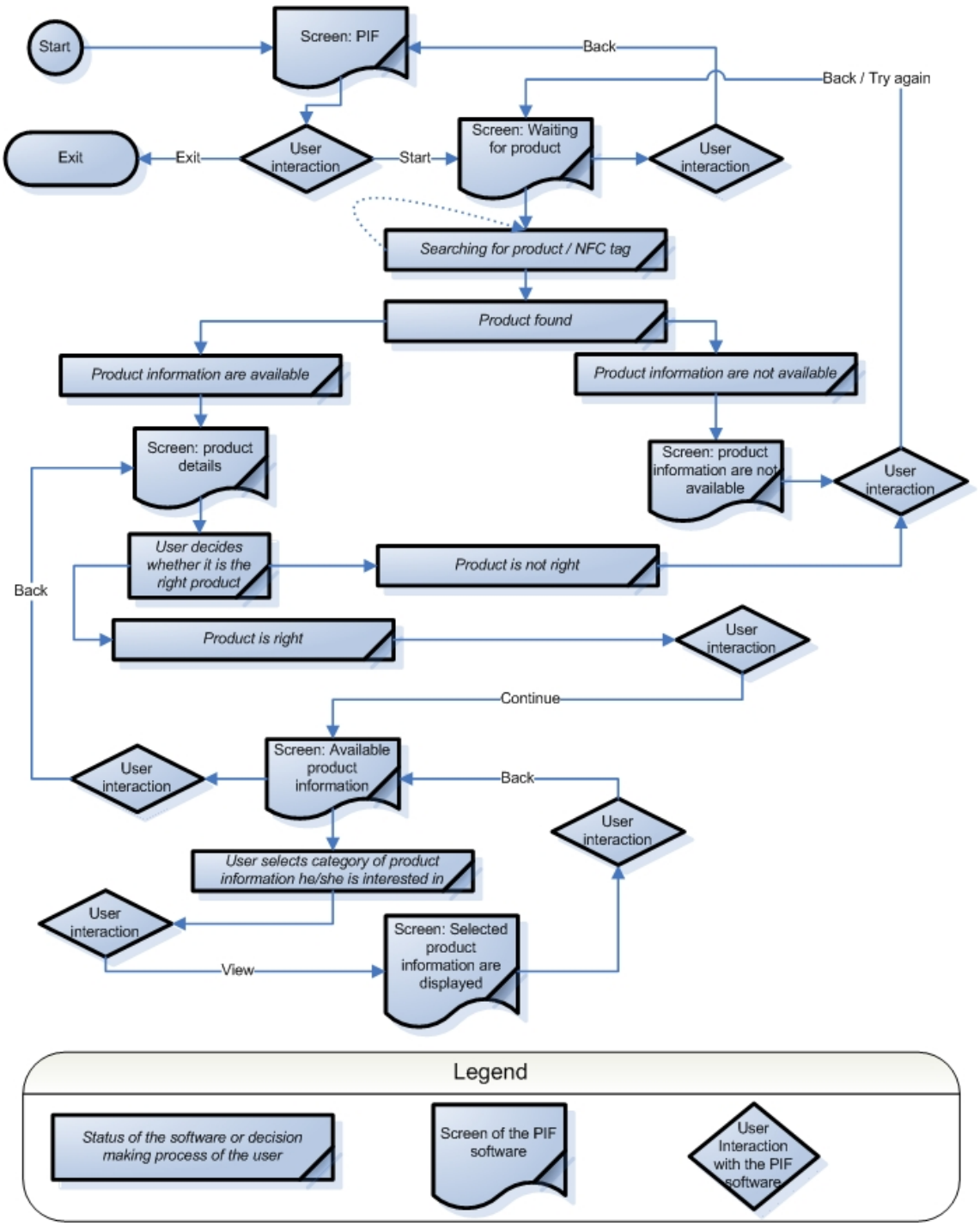

Figure E.2.: Work flow and user interaction of Product Information Finder (Source: author)

E.3. PIF source code

The source code and required executable files to run or modify the PIF can be requested from the researcher. Please send a formal request to info@erikbast.com.

F Appendix

F.1. Interview questions

The following table F.1 contains 32 open questions. The table has eight columns. Column one contains consecutive numbering, which reflects the intended order of the interview. Please see section 3.4 for further explanation why the question number does not necessarily represent the questions position in the interview. Column two contains the actual question. Column three to seven contain the affiliation of each questions to the five main categories usefulness, ease-of-use, security, privacy, costs. Column eight contains the affiliation of each question to everything else then the main five categories. Other could be current or future integration of RFID/NFC, smartphone applications, different types of food product information or likes and dislikes of smartphone / mobile phone properties. "Other" is not exclusive. A question's intention can be related to one or multiple aspects at the same time. It is also possible that a question's intention is in the categories security and privacy and also other.

Question number 1 to 28 are intended to cover mainly the five aspects. However, some questions could related to something different from the five aspects, therefore a few questions are also affiliated to other.

Questions 29 to 31 are intended to ask about specific mobile applications. Their main intention is other, but answers could contribute some useful insights to some of the main aspects. Question 29 to 31 are optional and will only be asked if the interviewee is likely to use an smartphone, so he/she could be able to answer them.

Question number 32 is the final open questions, which allows the interviewee to rise topics that have not been covered.

Table F.1.: Interview questions and related categories

Question		Related to:					
#	**Text**	**Usefulness**	**Ease-of-use**	**Security**	**Privacy**	**Costs**	**Other**
1	What do you think in general about the ease of identifying a food product with the mobile phone?		yes				
2	What difficulties in terms of food product identification would you expect in a real grocery environment?		yes				
3	What do you think about the speed of identifying a food product?		yes				
4	What do you think about the contactless close range technology in general?	yes	yes	yes	yes	yes	yes
5	Do you have any concerns about contactless technologies?			yes	yes		
6	In your opinion, where are similar contactless identification technologies already in use?	yes					yes
7	In your opinion, where could similar contactless identification technologies be used in future?	yes	yes				yes

Continued on Next Page...

Table F.1.: Interview questions and related categories

Question		Related to:					
#	**Text**	**Usefulness**	**Ease-of-use**	**Security**	**Privacy**	**Costs**	**Other**
8	For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen?	yes	yes				
9	In your opinion, what do you think are the advantages of a mobile phone in the context of food product information request in grocery environments?	yes				yes	
10	The food product information being presented in the prototype application only outlines examples. In your opinion, how useful are additional food product information in general?	yes					yes
11	Which type of food product information are you interested in?	yes					yes
12	Which type of food product information could people you know be interested in?	yes					yes

Continued on Next Page...

Table F.1.: Interview questions and related categories

Question		Related to:					
#	**Text**	**Usefulness**	**Ease-of-use**	**Security**	**Privacy**	**Costs**	**Other**
13	The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options?	yes	yes	yes	yes	yes	yes
14	What are important characteristics of a mobile phone when you had to choose a new phone?		yes				yes
15	The mobile phone used in the prototype system has a smaller display. Many of the emerging phones come with larger displays. What do you prefer?		yes				yes
16	As discussed earlier, there are various types of food product information. How do you think about paying a certain amount for obtaining very useful information?					yes	

Continued on Next Page...

Table F.1.: Interview questions and related categories

Question		Related to:					
#	**Text**	**Usefulness**	**Ease-of-use**	**Security**	**Privacy**	**Costs**	**Other**
17	If you had to pay for certain information, which payment model would you prefer?					yes	
18	How would you feel about your privacy and personal data while using the proposed system in a real environment?				yes		
19	Which personal data would you provide in order to be able using the proposed system?				yes		
20	What/where are your privacy concerns?				yes		
21	What/where are your security concerns?			yes			
22	In your opinion, how useful is the proposed system?	yes					
23	Could you see yourself using a more mature system of the prototype?	yes	yes	yes	yes	yes	
24	How convenient would the use of proposed system be for you?		yes				
25	What would you do with the system?	yes	yes	yes	yes	yes	yes
26	What would you not do with the system?	yes	yes	yes	yes	yes	yes

Continued on Next Page...

Table F.1.: Interview questions and related categories

Question		Related to:					
#	**Text**	**Usefulness**	**Ease-of-use**	**Security**	**Privacy**	**Costs**	**Other**
27	How should the proposed system be change in order to make it more convenient for you?		yes				
28	When you saw the presentation of the prototype system, how difficult to understand has it been for you?		yes				
29	Which sort / type of mobile Apps do you use?	yes	yes				yes
30	Which sort / type of mobile Apps do you not use?	yes	yes		yes	yes	yes
31	Which sort / type of mobile Apps would you like to use?	yes	yes	yes	yes	yes	yes
32	This is the last questions. It is open to everything related to this prototype. What would you like to add? What would you like to comment on?	yes	yes	yes	yes	yes	yes

F.2. AUTEC documents

The following pages are copies of Participant Information Sheet, Consent Form and the AUTEC approval.

Participant Information Sheet

Date Information Sheet Produced:

15/07/2010

Project Title

NFC mobile value added services in grocery environments

An Invitation

Erik Bast, currently in his second year in AUT University is inviting you to participate in an emerging research topic as part of his master degree in Computing and Information Science. The research is in the area of mobile phones using Near Field Communication technology (NFC) to identify food products and in addition mobile phones displaying food product information.

Your participation is voluntary and without any financial remuneration. Your contribution will be vital and important to the outcome. You will get the chance to get to know a technology and prototype application, which is going to influence our shopping experience in future.

There are not conflicts or constraints with your participation, you can withdraw your contribution at anytime before the data analysis is completed and if you decided to do so, there will be no disadvantage for you.

What is the purpose of this research?

The purpose of the research is to identify the user's perception of NFC mobile value added services in a grocery environment.

How was I identified and why am I being invited to participate in this research?

You have been identified as an AUT Master of Computer and Information Science student or somebody interested and willing to actively participate in research. You could also be a friend of mine or somebody I personally know. You have been invited because of your particular interest in technology. However, if you are directly working together with any member of the research team (e.g. student of Dr. Judith Symonds) you cannot participate in this research.

What will happen in this research?

You will be interviewed by me (Erik Bast). The interview will be recorded on an audio file and additional field notes will be taken.

First I will present and demonstrate a prototype application to you. After, you are encouraged to ask questions to clarify your understanding of the prototype application. Then the interview starts and I will ask you a number of open ended questions aiming to get your perception, opinion and feeling about the demonstrated prototype. In addition your experience about topic related aspects will be asked.

What are the discomforts and risks?

There are no discomforts or risks expected. However, the interview takes about 60 minutes of your time.

How will these discomforts and risks be alleviated?

You can have short breaks at any time for answering phone calls, going to the bathroom or any other personal need.

What are the benefits?

There will be no compensation, financial incentive or any kind of remuneration. You benefit from actively participating in research and getting to know a topic that might be new and exciting for you. Your contribution is an important part of my Master Thesis, which is part of my Master of Computer and Information Science degree.

How will my privacy be protected?

Your privacy will be protected at all times. Your personal data remains confidential. In order to achieve privacy and confidentiality, the interview and audio file will be identified only be a meaningless unique code.

Also your name, address or any other personal data will not be used for analysis or contribution to the research. Nor will your personal data used for any other purpose.

What are the costs of participating in this research?

You are expected to participate for about 60 minutes covering the entire interview process.

What opportunity do I have to consider this invitation?

From the point of invitation to the point of acceptance of invitation, you will have at least 24 hours to consider this invitation.

How do I agree to participate in this research?

In order to participate you need to read, understand, agree and sign the attached consent form. If you refuse to sign the consent form, you cannot be part of the research.

Will I receive feedback on the results of this research?

Feedback is available to every participant. The consent form contains an option box and space for contact details to express your interest in receiving feedback. The feedback will be send to you after completion of the master thesis. The researcher expects this to happen in February 2011.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr. Judith Symonds, judith.symonds@aut.ac.nz, +64 9-921 9999 x5879

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Whom do I contact for further information about this research?

Researcher Contact Details:

Erik Bast, fsc0329@aut.ac.nz

Project Supervisor Contact Details:

Dr Judith Symonds, judith.symonds@aut.ac.nz, +64 9-921 9999 x5879

Approved by the Auckland University of Technology Ethics Committee on *07 July 2010*, AUTEC Reference number *10/119*.

Consent Form

For use when interviews are involved.

Project title: ***NFC mobile value added services in grocery environments***

Project Supervisor: ***Dr Judith Symonds***

Researcher: ***Erik Bast***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 15/07/2010
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Participant's signature: .....

Participant's name: .....

Participant's Contact Details (if appropriate):

……..

……..

……..

……..

Date:

Approved by the Auckland University of Technology Ethics Committee on 7 July 2010, AUTEC Reference number 10/119

Note: The Participant should retain a copy of this form.

MEMORANDUM

Auckland University of Technology Ethics Committee (AUTEC)

To: Judith Symonds
From: **Madeline Banda** Executive Secretary, AUTEC
Date: 24 June 2010
Subject: Ethics Application Number 10/119 **NFC mobile value added services in grocery environments.**

Dear Judith

I am pleased to advise that the Auckland University of Technology Ethics Committee (AUTEC) approved your ethics application at their meeting on 14 June 2010, subject to the following conditions:

1. Provision of an assurance that the supervisor's students will be excluded from the study and inclusion of advice about this in the Information Sheet;
2. Alteration of the first sentence in the section titled 'Will I receive…' to indicate simply that a summary of the research results will be available to all participants.

AUTEC commends the applicant on the quality of the application.

I request that you provide the Ethics Coordinator with a written response to the points raised in these conditions at your earliest convenience, indicating either how you have satisfied these points or proposing an alternative approach. AUTEC also requires written evidence of any altered documents, such as Information Sheets, surveys etc. Once this response and its supporting written evidence has been received and confirmed as satisfying the Committee's points, you will be notified of the full approval of your ethics application.

When approval has been given subject to conditions, full approval is not effective until *all* the concerns expressed in the conditions have been met to the satisfaction of the Committee. Data collection may not commence until full approval has been confirmed. Should these conditions not be satisfactorily met within six months, your application may be closed and you will need to submit a new application should you wish to continue with this research project.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 8860.

Yours sincerely

Madeline Banda
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Erik Bast fsc0329@aut.ac.nz

From the desk of …
Madeline Banda
Executive Secretary
AUTEC

Private Bag 92006, Auckland 1142
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E-mail: ethics@aut.ac.nz

Tel: 64 9 921 9999
ext 8044
Fax: 64 9 921 9925

F.3. Transcribed interview data

F.3.1. Interview 1

INTERVIEWER: Thank you for participating in this research. In the following I will ask you about 30 questions. What do you think in general about the ease of identifying a food product with the mobile phone?

RESPONDENT: In general the system runs pretty easy and it's easy to use. It's very intuitive and you don't need a manual to use it.

INTERVIEWER: What difficulties in terms of food product identification would you expect in a real grocery environment?

RESPONDENT: I think the problem is the amount of different products with the same specifications, for instance products of the same type but from different producers.

INTERVIEWER: Can you explain this in detail please?

RESPONDENT: I mean many similar products from various producers. The products are all about the same price but I don't know which to buy because you can't tell the difference.

INTERVIEWER: Do you think the proposed system could help you?

RESPONDENT: Yes maybe, if you get some more information you can figure out what is best for you.

INTERVIEWER: We will come back to the specific types of food product information in a later question. What do you think about the speed of identifying a food product?

RESPONDENT: With this system it is ok.

INTERVIEWER: Is there anything in your mind that could improve the speed of the prototype? Anything that could make it fast, more convenient, better?

RESPONDENT: You could just go to the shelf and hold the phone close to the price tag.

INTERVIEWER: What do you think about the contactless close range technology in general?

RESPONDENT: I'm very critical, because it's the first step towards a glass customer and it's going to be that every person has RFID implemented in their ankle or under their skin, which contains a car key, credit card, apartment key. I don't think it's a direction we should go.

INTERVIEWER: Do you have any concerns about contactless technologies? Is there anything else besides Big Brother and the glass customer as you just have mentioned?

RESPONDENT: I don't think so. The radio frequency emissions are not very high with this close contact technology.

INTERVIEWER: In your opinion, where are similar contactless identification technologies already in use?

RESPONDENT: For instance in automobile manufacturing for identifying locations of parts and keeping track of the mounting car parts. I don't know maybe in speed measurement in Formula 1.

INTERVIEWER: In your opinion, where could similar contactless identification technologies be used in future?

RESPONDENT: Basically anywhere. Any part in your apartment could be tagged with a RFID chip. For instance if you are searching your car keys or some old books, somewhere in shelf or box and you could just search for it with a specific device.

INTERVIEWER: For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen?

RESPONDENT: Because your study deals with mobile phones.

INTERVIEWER: Anything else?

RESPONDENT: Because the mobile becomes more and more your everyday partner, not only for telephoning but also for listening to music, writing emails, surfing

the internet, opening doors ... that's why.

INTERVIEWER: Just following up, what do you think are the advantages of a mobile phone in the context of food product information request in grocery environments?

RESPONDENT: The advantages is that you always have the phone in your pocket and that the phone is the all in one device you carry around all the time and you can easily not only telephoning but also identifiying food products.

INTERVIEWER: The food product information being presented in the prototype application only outlines examples. What food product information are you interested in? What food product information could people you know be interested in?

RESPONDENT: Price, the land origin, the amount of calories, the place where it should be stored, expiry date

INTERVIEWER: In particular, which type of food product information are you interested in?

RESPONDENT: Mostly the price, maybe the manufacturer, because I don't always buy the cheapest stuff or the most expensive, so I kind of take a look at the manufacturer in order to conclude to the quality of the product.

INTERVIEWER: So you are directly connecting the manufacturer's name and its brand image with the quality of the product?

RESPONDENT: Yes

INTERVIEWER: Which type of food product information could people you know be interested in such as your parents, friends, family?

RESPONDENT: Basically the same as mine.

INTERVIEWER: The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options?

RESPONDENT: Displaying it somewhere else?

INTERVIEWER: Let's say you are still in a grocery environment but you are not using the prototype phone in the proposed way. Any alternative to what has been presented to you?

RESPONDENT: Maybe you could have a screen in front of the shelf, but that's probably not very sophisticated. I think the price tag and product information on the product label are enough information. The only advantages I can see is to get manufacturer independent information. The product itself is always a kind of commercial and there would not be much use in such a system if you just display information that are available on the label anyway. Also the information are not independent and biased from the manufacturer. The use I would see is to have indepented information, for instance if you have bananas from Chiquita. They are produced in these countries under these conditions.

INTERVIEWER: So stuff like carbon foot print, eco-friendly production and so on.

RESPONDENT: Exactly, Fairtrade and so on

INTERVIEWER: Let's now talk about the actual device. The mobile phone used in the prototype system has a small display. Many of the emerging phones come with larger displays. What do you prefer?

RESPONDENT: It always depends on purpose ... overall I prefer a small phone, because I don't want to carry around a big device. But for the purpose of gathering the product information, I would switch to a larger screen. But I only use the mobile phone for writing text messages and calling, so I wouldn't switch to a larger phone.

INTERVIEWER: You have mentioned that you are using you phone only for texting and calling. Are there any other characteristics of a mobile phone that are important to you?

RESPONDENT: I kind of rely on the experience I have had with certain manufacturers. For instance I have had only positive experience with Nokia. Because that's the brand I'm tended to use. Actually there should be a camera and calling and texting is important. Playing music and some other fun stuff is required too.

INTERVIEWER: Do you use the mobile web?

RESPONDENT: No

INTERVIEWER: Coming back to the food product information. As discussed earlier, there are various types of food product information. How do you think about paying a certain amount for obtaining very useful information? Regardless how much you have to pay ...

RESPONDENT: Paying money to get this information on your phone ... I would not pay

INTERVIEWER: Even though there might be some information that are very useful to you. You still would not pay for?

RESPONDENT: All the information that seem useful to me are available in the supermarket. I just need to look at the product.

INTERVIEWER: So you wouldn't pay, but just in case there are information which are not available on the label and you are interested in and you had to pay for, which payment model would you prefer?

RESPONDENT: Credit card

INTERVIEWER: Ok, thanks, the question is more directed towards paying per request, per month, as a flat rate and so forth.

RESPONDENT: Paying per request.

INTERVIEWER: How would you feel about your privacy and personal data, when using the proposed system in a real environment?

RESPONDENT: As long there is data of products I'm looking at stored somewhere, I wouldn't be concerned.

INTERVIEWER: Which personal data would you provide in order to be allowed using the proposed system?

RESPONDENT: Maybe my name and address, only if they really need it. But from this point of view and time, I wouldn't use such a system.

INTERVIEWER: What/where are your privacy concerns? I mean you have men-

tioned earlier that you don't want to have the supermarket logging your favourites and request. What else?

RESPONDENT: That's basically the big problem. They see what you are interested in and start sending you commercials. And people know what time you are going to the super market and other people might get access to the data and know what time you are not at home and break into your house. It's also how you spend your day/time

INTERVIEWER: What/where are your security concerns?

RESPONDENT: Besides the personal data and personal information, there is no security concern.

INTERVIEWER: In your opinion, how useful is the proposed system?

RESPONDENT: From present point of view / the grocery shopping situation, I don't think it would be of any use for me. I don't know about the future but for now in my environment it's not useful. Because of you always have to try out products and see for yourself what the best is. The information will not tell you if this product tastes or for how long you can consume the product.

INTERVIEWER: Could you see yourself using a more mature system of the prototype?

RESPONDENT: I don't think so because when it comes to grocery store shopping there is a certain range of products I buy over and over. I know the products which I like and even if there is new stuff on the market I would not use the new product unless somebody comes to me and suggest it to me. For anything else I would use the internet. For instance buying a new laptop, I would use the internet for research and comparison or simply go to the store.

INTERVIEWER:How should the proposed system be change in order to make it more convenient for you?

RESPONDENT: It is already very convenient. It's just that the basic idea of the system is a problem for me. I simply wouldn't use it. But the actual way to use it is already very convenient.

INTERVIEWER: When you saw the prototype system presentation, how difficult

to understand has it been for you?

RESPONDENT: It wasn't difficult at all.

INTERVIEWER: This is the last questions. It is open to everything related to this prototype. What would you like to add? What would you like to comment?

RESPONDENT: This kind of system might make more sense for products of higher value and greater technical detail. Because grocery products are very simple products. They don't have 10 pages of data specifications. Let's say I want to buy a TV station worth 1000 Bucks and I want to compare different models. Then I would go with such a system to the different models and compare them. Let's say having a list with 3 columns for comparing certain criteria. But for grocery shopping I would be interested.

INTERVIEWER: You have mentioned earlier that you can't find any information on the phone, which will not also be available on the label of the product. But let's just take this can of Baked beans. The space on the label is quite limited. There are information such as nutritions, ingredients and best before. For a bottle of water there is probably a little bit more space, but a small can of jam has less space for the label. But doesn't the phone offers the opportunity to display exactly the information that didn't fit on the label?

RESPONDENT: Yes, that's exactly what I'm saying. The phone does offer the opportunity but the information must be off high value and the information on the phone must add value. It doesn't make sense if the information from the label is available in the mobile phone. Stuff like product place or country of origin are interesting

INTERVIEWER: A vital part of my research is in the area of food product information. During the interview we have been talking about several aspects. Now at the end, do you have suggestions for food product information you would be interested in?

RESPONDENT: I would be interested in place and circumstances under which the product has been manufactured. Because that kind of the reason I don't shop in discounters because I know that products sold there are produced under inhumane circumstances.

INTERVIEWER: Thank you very much for your participation.

F.3.2. Interview 2

INTERVIEWER: What do you think in general about the ease of identifying a food product with the mobile phone in the proposed way?

RESPONDENT: It seems pretty easy and easy to use. And the prototype can suddenly provide more information than just the product package.

INTERVIEWER: What difficulties in terms of food product identification with a mobile phone would you expect in a real grocery environment?

RESPONDENT: The difficulty might be that you need to take the product out of the shelf. You also need to find the RFID tag and place your phone close to it. Especially if the reading range is pretty close you really need to find the tag first. I can imagine it is a little bit annoying if you can't find the tag.

INTERVIEWER: Anything else?

RESPONDENT: Yes, what happens if the software doesn't recognize the product or something is wrong with the tag? This could happen and might annoy the user.

INTERVIEWER: What do you think about the speed of identifying a food product?

RESPONDENT: The phone reacts immediately and that's pretty convenient. But like I said before, you need to find the tag first.

INTERVIEWER: What do you think about the contactless close range technology in general ... like RFID, NFC and so on?

RESPONDENT: From a technology point of view?

INTERVIEWER: It doesn't matter, all aspects off interest.

RESPONDENT: It's generally pretty cool and easy to use, but there are some security issues. I mean if it is as close as a few centimetres I might not be such a problem. But considering longer ranges ... people can intersect and read what you read.

INTERVIEWER: Later we will come back to the topic of security. Do you have any other concerns about contactless technologies?

RESPONDENT: No

INTERVIEWER: In your opinion, where are similar contactless identification technologies already in use?

RESPONDENT: Barcode and actually our passport and there is a lot of research going on about it.

INTERVIEWER: In your opinion, where could similar contactless identification technologies be used in future?

RESPONDENT: For payment and toll collection, pay as you go. In this fields there are also big risks in terms of privacy and security.

INTERVIEWER: For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen?

RESPONDENT: Probably because you always carring it with you. That's probably the reason. You don't want to have another device.

INTERVIEWER: In your opinion, what are the advantages of a mobile phone in the context of food product information request in grocery environments?

RESPONDENT: You could also use the mobile phone to make a list of items you want to buy. Then you can combine the information [from the NFC tag] you get with the electronic grocery shopping list.

INTERVIEWER: The food product information being presented in the prototype application only outlines examples. In your opinion, how useful are additional food product information in general?

RESPONDENT: I mean it always depends on the type of information. You don't want to have information you are not really interested in. So for instance if I'm overweight I might be interested in calories or stuff like that or how I can add the product to my diet. But if I'm more the sports person I might be interested in types of vitamins or what ever. So kind of having some types of information pre selected and categorized so you don't need to browse through all the data.

INTERVIEWER: What type of food product information are you interested in?

RESPONDENT: Seriously, I never had a look at them. I buy stuff I like.

INTERVIEWER: Which type of food product information could people you know be interested in? You have mentioned earlier vitamin information or some sort of weight watcher points. What else can you think about?

RESPONDENT: Origin of the product. Let's put the question until later.

INTERVIEWER: Yes of course. We will come back to this question at a later stage. The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options?

RESPONDENT: Other than the phone?

INTERVIEWER: Yes, for example

RESPONDENT: Maybe for disabled people, they may want to have audio guided systems. Besides that there might be the option of the device attached to your shopping cart. There is also the idea of displaying the balance of your current shopping cart. Then you could add lots of features. But at the same time it makes the shopping cart an expensive item. This might be limiting for the supermarket.

INTERVIEWER: Thank you for your contribution.

INTERVIEWER: What are important characteristics of a mobile phone when you had to choose a new phone?

RESPONDENT: Considering the application we are talking about right now, it might be quite useful to have a larger screen to have more information visible at the same time. What I personally prefer. I don't care much about the size of the screen. And with this type of application you are not putting in much information so you are downloading the data and therefore a large screen is vital. Considering the aspect that you have to have the mobile phone with you might lead into the compromise of screen size and having a portable device. Another aspect could be the battery life. I mean the iPhone's battery lasts a single day and maybe the NFC reader takes some more energy. So battery lifetime is important as well.

INTERVIEWER: As discussed earlier, there are various types of food product information. How do you think about paying a certain amount for obtaining very useful information?

RESPONDENT: As I said before, until today I have never really had a look at the information printed on the product. So personally would value the information, probably not as much that I would pay for it. But maybe other people see a higher value and pay for it.

INTERVIEWER: What about the hidden costs, like a mobile data plan or a slightly more expensive devices with a built in NFC reader?

RESPONDENT: I don't think that matters. Because data plans are already common and people who are interested in such sort of information are probably willing to pay a bit more. Also if you could find more application areas for NFC software you could share the price of the phone among them, kind of splitting.

INTERVIEWER: Considering you would be willing to pay for the information, which payment model would you prefer?

RESPONDENT: As we are talking about the mobile phone, it would probably the easiest to just charge your mobile phone bill, but that's also not very transparent. Time wise probably paying monthly because you are going fairly regularly to the supermarket. And also I don't really want to think about the costs of a request, so some sort of flat rate option might be user friendly and convenient.

INTERVIEWER: How would you feel about your privacy and personal data while using the proposed system in a real environment?

RESPONDENT: We haven't really talked about where the information comes from. In terms of the NFC communication with the RFID tag, I mean it's pretty close range in this regards. But if we request data from server, they might be information flowing through the air that should be protected. Privacy is always an issue and nobody can guarantee it.

INTERVIEWER: Are you more concerned about that some hackers get to know your shopping behaviour or that the supermarket knows what you are interested in?

RESPONDENT: Probably it's more relevant for the supermarket to know what people are interested in. But I think the supermarket knows that anyway, because

when you check out they get the information. Especially when you pay by credit card, they can fetch the shopping cart content and your name and profile you quite well.

INTERVIEWER: Which personal data would you provide in order to be able using the proposed system?

RESPONDENT: As little as possible. You could do it fairly anonymously. You could use some sort of username and password and then pay by bank transaction or upfront. You wouldn't really need personal information like name or address. If you can avoid too much personal data this would adds up to privacy.

INTERVIEWER: Summarizing, what are your privacy concerns?

RESPONDENT: I don't want to reveal more private data then I already do. So far supermarkets don't have personal data about me, so I would like to keep it that way. So basically add more features but don't risk more.

INTERVIEWER: What/where are your security concerns?

RESPONDENT: Hackers could interfere with the backend system and manipulate the information. And I mean I'm not really familiar with the security concept you use, but also the supermarket could provide false information. For instance the backend realizes that potatoes are outdated and alter the best before date.

INTERVIEWER: In your opinion, how useful is the proposed system?

RESPONDENT: I think it's pretty useful because you can't obviously display all the information on the label. But if you put the mobile phone on the product you can get more information of the product itself. It's probably easier to have the information on the phone.

INTERVIEWER: Anything else?

RESPONDENT: No, not really.

INTERVIEWER: Could you see yourself using a more mature system of the prototype?

RESPONDENT: It depends on the effort and also what it is going to cost me.

I'm a student. That's probably the main argument. I mean if I get it for a fair amount of money I'd probably use it.

INTERVIEWER: Just in case you would use such as system. What would you do with the system? You have mentioned that you would combine your shopping list with and follow up the shopping list. Anything else where you could combine the functions of the prototype?

RESPONDENT: Nothing I can think about.

INTERVIEWER: What would you not do with the system?

RESPONDENT: I probably would not check every product. It certainly takes some time to browse the information.

INTERVIEWER: You said you wouldn't check every product. Which product in particular could be interesting for checking?

RESPONDENT: Probably the products I haven't bought before. In contrast I wouldn't check really cheap products. And there is also the idea of comparing low price and high priced products or low quality versus high quality.

INTERVIEWER: That something you would or would not do?

RESPONDENT: I would do the comparison stuff.

INTERVIEWER: Considering some of the disadvantages of the proposed system, what would you change / how should the proposed system be change in order to make it more convenient for you?

RESPONDENT: Not much, it was pretty convenient to me. Maybe you said you need to download the information form the internet or need to have all the data on the phone. You could download the data of the supermarket while approaching the store.

INTERVIEWER: So some sort of pre shopping data synchronisation?

RESPONDENT: Yes, I mean you demonstrated the prototype and it was fairly quick, but we only have been using a small range of products. Considering the fact of having a few thousand products, it might become slower. And also having 300

customers requesting data at the same time.

INTERVIEWER: Would you actually spend some time on a terminal to synchronize the phone with the special supermarket database?

RESPONDENT: No not. the think is I want to have that on the way. You don't want to stop and synchronize your phone. How do you want to get the data on the phone anyway?

INTERVIEWER: With the prototype it is simply hard coded data. With a real system, we probably would use a 3G data connection and request the data per items.

RESPONDENT: Yeah it's probably the best way.

INTERVIEWER: Which application are you using with your mobile phone?

RESPONDENT: I personally use mailbox and mail software and navigation software as well as browsing.

INTERVIEWER: Is there software available on your phone which you don't use or you don't like?

RESPONDENT: Well, let me think about ... there is something I've just got to know. Ads on the phone really annoy me. So I don't want to have spam or stupid advertisement. But on the other hand that's something for the supermarket. Something were the supermarket could get some money in order to cover the costs of the NFC device application. It depends a little bit on what the supermarket is interested in and how they advertise their products.

INTERVIEWER: When you saw the prototype system demonstration/presentation, how difficult to understand has it been for you?

RESPONDENT: The prototype has not been complex. It was pretty easy to understand. I didn't have any problems to understand.

INTERVIEWER: This is the last questions. It is open to everything related to this prototype. What would you like to add? What would you like to comment?

RESPONDENT: Let me think about it for a second ... No not really.

F.3.3. Interview 3

INTERVIEWER: What do you think in general about the ease of identifying a food product with the mobile phone?

RESPONDENT: In general I think it is a good idea, because you get a lot more information than you usually would get. So it's easier to find out important stuff about a product and perhaps it's like shopping with a higher awareness of your products.

INTERVIEWER: And in particular how easy has it been to identify the product with the mobile phone and to get the information?

RESPONDENT: I think it was very easy, assuming that the technology worked properly.

INTERVIEWER: What difficulties in terms of food product identification would you expect in a real grocery environment?

RESPONDENT: Perhaps that some products are out of your reach in terms of how far they are away for small people.

INTERVIEWER: Ok, that's a good point, but don't you need to get the product out of the shelf anyway?

RESPONDENT: Perhaps but even that could be a problem. Perhaps it could be that the products are to close to each other and the phone picks up the wrong product. For example if you have two sorts of cream next to each other and you try to get the information of one then the information of the other one is shown. This could be a problem.

INTERVIEWER: Anything else you can think about?

RESPONDENT: No, sorry not at the moment.

INTERVIEWER: What do you think about the speed of identifying a food product?

RESPONDENT: I think in our test case it was very very fast.

INTERVIEWER: The technology we have been using here is called NFC. It is similar

to RFID. What do you think about the contactless close range technology in general?

RESPONDENT: I think it's pretty cool. It is very useful. I like it for example in the library where all the books have RFID chips and you borrow them without spending much time at the checkout counter.

INTERVIEWER: Do you have any concerns about contactless technologies?

RESPONDENT: No.

INTERVIEWER: In your opinion, where are similar contactless identification technologies already in use, besides the example of libraries that you just have mentioned?

RESPONDENT: In the supermarkets, they use it for alarms and theft protection. No I don't remember anything else.

INTERVIEWER: In your opinion, where could similar contactless identification technologies be used in future?

RESPONDENT: I don't know, perhaps you will find it in clothes and retail stores. And I don't know what the technology is capable of but maybe you can pay with NFC and avoid using cash. Stuff like you are just leaving the store and the systems detects what you have bought. After an automatic payment is initiated.

INTERVIEWER: For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen?

RESPONDENT: I think because everybody has a mobile phone and you have it in your bag all the time, so it's a device you don't need to buy only for this purpose. So it's also very easy.

INTERVIEWER: In your opinion, what are the advantages of a mobile phone in the context of food product information request in grocery environments?

RESPONDENT: Perhaps because you could also send this information to somebody. No nothting else.

INTERVIEWER: The food product information being presented in the prototype

application only outlines examples. In your opinion, how useful are additional food product information in general?

RESPONDENT: I think they could be very useful. Especially for people who have special requirements, such as people who have problems with milk or traces of milk. You can perhaps see very fast and for every product whether you can eat it or not. Also whether it is good for you or not and I think it gives you a good overview of the products to make a good healthy choice.

INTERVIEWER: Which type of food product information are you interested in?

RESPONDENT: Ingredients are very important for me. Perhaps what you could do as well are providing examples for recipes. Also how old the product are, because you usually only get to know the best before date but it's hard to find how long the product has been in store. For instance with an egg you can see when it was laid. This could be important to.

INTERVIEWER: Anything else?

RESPONDENT: No,sorry.

INTERVIEWER: Which type of food product information could people you know be interested in?

RESPONDENT: Especially for my grand mum, products without sugar. The system could be improved the way that you hold the phone and it tells you whether a certain limit is reach or whether the amount of sugar is too high for diabetics.

INTERVIEWER: So it's basically related to special ingredients. What else?

RESPONDENT: I don't know has there been the price available in the system?

INTERVIEWER: No it hasn't been yet, but from a technical point of view it's possible.

RESPONDENT: So the price would be good.

INTERVIEWER: Ok thank you. However the plan is that the technology does not replace the price tag. So you always will have a price tag and the system is just targeting food product information, which are not on the product label. But

technically the price could be an option.

RESPONDENT: Ok, this would be good and the ingredients are very important. Because you sometimes can't see what the product really is made of.

INTERVIEWER: The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options?

RESPONDENT: Maybe the iPad, it becomes more and more popular, maybe netbooks and perhaps for older generation such as our grandparents you could lend the devices at the supermarket door, because usually they don't have modern fancy phones.

INTERVIEWER: What are important characteristics of a mobile phone when you had to choose a new phone?

RESPONDENT: I need to have a good camera next to the usual stuff. It has to be able to provide me with internet access, very important. It needs to look nice. I think the size of the screen is very important.

INTERVIEWER: What do you prefer, smaller or larger?

RESPONDENT: Larger, of course ... My previous phone had a touch screen and it has been very convenient. I liked it.

INTERVIEWER: As discussed earlier, there are various types of food product information. How do you think about paying a certain amount for obtaining very useful information?

RESPONDENT: I think for me personally not in general. I think if I really would depend on this information because I have an illness, as mentioned before the diabetes, then I would pay for it. But at the moment I don't have a real need, so I wouldn't pay.

INTERVIEWER: If you had to pay for certain information, which payment model would you prefer?

RESPONDENT: I would like to pay for every request or maybe buy a package

of requests. I think a flat rate would mean that while you are away for some vacation you can't use it. But it always depends on how much it is.

INTERVIEWER: How would you feel about your privacy and personal data while using the proposed system in a real environment?

RESPONDENT: Honestly I don't really think about privacy, because I don't think it's really something private. Because in the supermarket everybody can have a look in your bag and shopping cart. So for me it doesn't matter.

INTERVIEWER: Which personal data would you provide in order to be able using the proposed system?

RESPONDENT: I'm not sure. I think the best would be if I don't need to provide any information. Because then you don't have any risk. But if they need some data to do research or data analysis, I think I would provide my age, the area where I live and additionally perhaps which special requirements if have. E.g. I can't eat pig or I'm a diabetic.

INTERVIEWER: What/where are your security concerns?

RESPONDENT: In terms of what?

INTERVIEWER: When you use the proposed system you might change your shopping behaviour and you might do thinks different in the supermarket. Can you see security risks caused by the new shopping behaviour?

RESPONDENT: No, I don't think so. If I understand the system correctly, it is not sending out any data, it is just getting information. So the risk that somebody else is using my phone at this moment like trying to get information from my phone ... no.

INTERVIEWER: And any non technical security risks?

RESPONDENT: Ahh, because I'm walking with my expensive phone?

INTERVIEWER: Yes, for instance, anything else?

RESPONDENT: I don't think so, because if you use the system many people will use it and many people will display their expensive phones. And there is also video surveillance in the supermarket. So I feel quite safe.

INTERVIEWER: In your opinion, how useful is the proposed system?

RESPONDENT: I think it's very useful. I think I would use it.

INTERVIEWER: Could you see yourself using a more mature system of the prototype?

RESPONDENT: Yes sure. But it depends on the price model and information available.

INTERVIEWER: How convenient would the use of proposed system be for you?

RESPONDENT: It would highly convenient. Because alternatives are asking supermarket employees or googleing it before the shopping. However you need to find a member of the supermarket team and this person needs to be qualified and needs to know the information I'm after. And honestly there are thousands of products and people working in the supermarket are usually not PhD students with super brains. So they can't know everything about each product. And also looking it up before you go to the supermarket isn't quite a good idea, because it's very stressful and it's not proven you find the information you after. I think the convenient way would be to use such a cell phone.

INTERVIEWER: What would you not do with the system?

RESPONDENT: You wouldn't use it for every product, for example if I'm only allowed to eat certain meat, then I probably would only use it for meat product information and I wouldn't use it for toilet paper. Also products which are so simple and you buy them quite often. Mainly because you know all about the product.

INTERVIEWER: Does this decision using it only for certain products stand in relation with the price of the products?

RESPONDENT: Yes maybe, I mean if the product is high priced product you probably would use it because there is more to lose. On the other hand cheap products don't come with the risk of loosing to much money in case they are not worth it. Let me think ... when it comes to really expensive equipment I research before I go to the store.

INTERVIEWER: How should the proposed system be change in order to make

it more convenient for you?

RESPONDENT: I can't think about anything. As I understood it, it was really easy and it would be convenient.

INTERVIEWER: When you saw the prototype system presentation, how difficult to understand has it been for you?

RESPONDENT: I was very easy to understand.

INTERVIEWER: Do you use so called Apps on your phone?

RESPONDENT: Honestly I don't. So far I haven't had the time to look for some interesting. But generally I like the idea of utilizing the phone or computer to use it for more than the initial purpose. So I'm pretty sure there will be some useful stuff available for me and I'm going to check it out soon.

INTERVIEWER: Food product information, coming back to this. Towards the end of the interview, is there something that you want to add?

RESPONDENT: Ingredients, yes I've talked a lot about the ingredients.

INTERVIEWER: Yes. You've said that the ingredients should be available and be in relation or connection to the allergies or illnesses of the customers. Anything else?

RESPONDENT: Perhaps where the product is from, because you would like to help your own country and support your local farmers. Or sometimes from the news you know that certain food from certain countries isn't good ... this way you can decide whether to by or not. Perhaps also which real company is producing the product because quite often you can't see the real firms behind it. Also all the companies which are part of the production. Maybe some environmental aspects, and also BIO products. They aren't important for me and I think there is a lot of fake with the BIO labels ... some of the BIO products aren't BIO.

INTERVIEWER: This is the last questions. It is open to everything related to this prototype. What would you like to add? What would you like to comment?

RESPONDENT: Yes, as I've mentioned earlier it might be very useful to have some sort of filter for the information. Meaning that you have some preferences of information types you are interested in and the phone only displays those infor-

mation. Also keeping it simple, like telling you this product is good for you, this product isn't good for you. In addition I think it depends on which product you buy. If you would use it also for drugs it could show you this drug isn't good to use with this one. You could also do this with food products ... let me think, for example don't mix beer and vine or never eat ice cream and drink a beer after. Or recommendation for children ... food that isn't good for children ... also customizing it for people doing a diet. For example a doctor could recommend the patient how many calories per day and which sort of food is good and then the phone tell during the shopping whether the selected item fits the doctor's recommendations. That would be everything.

F.3.4. Interview 4

INTERVIEWER: What do you think in general about the ease of identifying a food product with the mobile phone?

RESPONDENT: In general I think it is a really good idea because you get information you wouldn't get so quick otherwise. And without the information on the phone you probably have to go home and check the information on the internet. And so you have it right while you shop?

INTERVIEWER: What difficulties in terms of food product identification would you expect in a real grocery environment?

RESPONDENT: Maybe if everybody is using it and people standing in the way.

INTERVIEWER: What do you think about the speed of identifying a food product?

RESPONDENT: It was very fast, I couldn't imagine any faster.

INTERVIEWER: What do you think about the contactless close range technology, in other words NFC and RFID in general? Do you like it?

RESPONDENT: I think it is very useful.

INTERVIEWER: Do you have any concerns about contactless technologies?

RESPONDENT: No, I don't.

INTERVIEWER: In your opinion, where are similar contactless identification tech-

nologies already in use?

RESPONDENT: Well, I think at certain train stations you have special tickets and you swipe it and it also works with your mobile phone. Also at the counter in the supermarket, there are sometimes such tags to prevent theft.

INTERVIEWER: In your opinion, where could similar contactless identification technologies be used in future?

RESPONDENT: Apart from the supermarket?

INTERVIEWER: Yes

RESPONDENT: At workplaces where you have to get in and out. Otherwise I don't know.

INTERVIEWER: For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen?

RESPONDENT: This particular one?

INTERVIEWER: No, mobile phones in general.

RESPONDENT: Well, because every body has a mobile phone and you carry it always with you. And if you would use just another device, people actually had to carry devices around.

INTERVIEWER: In your opinion, what are the advantages of a mobile phone in the context of food product information request in grocery environments?

RESPONDENT: You already know how to use your phone, you know which buttons to press and you are familiar with the software.

INTERVIEWER: The food product information being presented in the prototype application only outlines examples. Can you think about any other type of food product information?

RESPONDENT: You can extend it to recipes. Not sure if it is too much but it could become useful. It could also provide hints to other products that are in the

supermarket or other brands for example, like competitive products.

INTERVIEWER: Which type of food product information are you interested in?

RESPONDENT: Well, I don't really need information about competitive products, but the recipes would be quite useful.

INTERVIEWER: So what do you think in general about additional food product information which you can't find on the product label, but which could become available to you through the mobile phone?

RESPONDENT: I think it's really good. You can use the additional information if you want to, but you don't have to. And it becomes quite handy if you suffer from some sort of allergic food reaction then you can check whether this product will harm you.

INTERVIEWER: So can we add detailed ingredients and allergic indicator to the list of additional interesting food product information?

RESPONDENT: Yes, the allergic stuff is very important too.

INTERVIEWER: What allergies could you think about?

RESPONDENT: That could be anything, certain fruits, lactose intolerance. You can be alergice to almost everything.

INTERVIEWER: Do you think it is too difficult by having all the ingredients on the small screen? Can you think about another way of displaying the ingredients information?

RESPONDENT: Particularly for older people it might be difficult to read the small words from the ingredients list. But usually you can change the display resolution and icon size of phones. This is something that would be helpful for certain people. Or you could split the ingredients into bricks and only display a few at a time.

INTERVIEWER: Can you think about things you would change on the current prototype in order to make it more accessible and easier to use for older people and allergic persons?

RESPONDENT: Well, since there are so many allergic reactions. It should be

somehow grouped. It would be also good if you have some sort of settings and personal information you can setup. This could contain the ingredients you are generally allergic to. Then the software tells you whether you are likely having an allergic reaction with this product.

INTERVIEWER: Which type of food product information could people you know be interested in?

RESPONDENT: No, not really. It is probably the allergy thing that helps the most people. Maybe some of my friends are keen to buy ecological food and low carbon foot print items. So some sort of green and bio-ecological indicator could be interesting.

INTERVIEWER: You as a student probably do not spend a lot of money per week on your grocery shopping. However if you think about power shoppers, who regularly buy food worth a couple of hundreds dollars a week, Can you think about an application that would be interesting them?

RESPONDENT: They could get discounts, but this needs to be interchangeable among different supermarkets.

INTERVIEWER: The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options?

RESPONDENT: What do you mean?

INTERVIEWER: Well, let's say the NFC/RFID tag is still attached to the product and you would seek a solution replacing the phone or using it different. On the other hand you could keep the phone and replace somehow the NFC/RFID tag.

RESPONDENT: Ok, we already said that having an extra device is difficult because you need to take it with you and it's probably heavier to carry around. And otherwise it should be something you are always having with you and I couldn't think of something, maybe a watch or so. But not every one carries a watch. Well what you could do is using the already existing terminals, which show you the price of the product, e.g. Warehouse has them. But the problem I can see is that there might be queue and you have to look for the terminal, walk to the terminal, so it's not that fast and you are losing time.

INTERVIEWER: Anything else? Something out of the box?

RESPONDENT: When we take larger supermarkets as an example then you could have a screen somewhere at the shopping cart. This would be personal and it would be better than the mobile phone?

INTERVIEWER: Why do you think so?

RESPONDENT: Because then you have your hands free and you have to think even less about the phone. For example if you forget your phone or it runs flat on battery, you can always rely on the screens at the shopping cart. But on the other hand if you are not buying a lot and don't take a shopping cart then you wouldn't have the screen. That's when the phone becomes handy again.

INTERVIEWER: So you are having multiple options in mind?

RESPONDENT: Yes, there could be the thing with the phone, the screen at the cart and also some terminals.

INTERVIEWER: What are important characteristics of a mobile phone when you had to choose a new phone?

RESPONDENT: It's important to have something easy to handle but you get used to everything. And that you can type quickly. And the display is good, I mean readable. I don't care much about taking pictures with the phone.

INTERVIEWER: The mobile phone used in the prototype system has a smaller display. Many of the emerging phones come with larger displays. What do you prefer?

RESPONDENT: The display size should be big, but not too big because then the phone becomes big and you don't want that.

INTERVIEWER: Summarizing, you want something small, but a larger screen and it needs to be easy to handle?

RESPONDENT: Yes, but I think that changes among different age groups.

INTERVIEWER: As discussed earlier, there are various types of food product infor-

mation. How do you think about paying a certain amount for obtaining very useful information?

RESPONDENT: I think I wouldn't pay for it because I think I could get it on the internet for free.

INTERVIEWER: You mean on the internet from at home?

RESPONDENT: Yes

INTERVIEWER: But then you wouldn't have the information instantly while you are shopping?

RESPONDENT: No I would not. But I don't care so much about the information, so I still would not pay.

INTERVIEWER: Ok, let's assume you would pay for it, because the information is very valuable and important to you, which payment model would you prefer?

RESPONDENT: They just should withdraw it from my bank account.

INTERVIEWER: And in terms of paying for the service, there could be a flat rate option, a time limited option etc ... What would you suggest / prefer?

RESPONDENT: Paying per request would be the easiest and maybe flat rate if you use it a lot.

INTERVIEWER: Any other payment model you can think about, maybe suitable to other people?

RESPONDENT: Let me think ... well there could be something price related. I mean the more expensive the product, the more the request costs. Or maybe some information are more valuable so the price could be higher.

INTERVIEWER: How could these different prices for different information look like?

RESPONDENT: Well for example the allergies information could be free whereas the recipes could costs something. But it's not that important.

INTERVIEWER: How would you feel about your privacy and personal data while

using the proposed system in a real environment?

RESPONDENT: I'm not concerned about these things.

INTERVIEWER: Which personal data would you provide in order to be able using the proposed system?

RESPONDENT: Well, if it's necessary then my bank details because they have to withdraw the money.

INTERVIEWER: Thanks, nevertheless have in mind that there are other possibilities to pay for the information. Your bank details are not necessarily required to make a payment.

RESPONDENT: Well, then as less as possible. My mobile phone number maybe. Other than that, why do they need to have any of my data?

INTERVIEWER: What/where are your privacy concerns?

RESPONDENT: Well they know what I'm shopping. Otherwise I don't really care about that because it doesn't affect me. I don't know if they change the supermarket offers according to my needs it would even help me. I would like that. They only know what I'm buying, so not really.

INTERVIEWER: What/where are your security concerns?

RESPONDENT: Not really. You only hold your mobile phone in your hand but you have that anyway. Otherwise some people might steal you stuff while you are scanning the products. But I don't think this would really happen. For older people it is a big issue that you are less careful with your things. You scan the products, you are distracted and you don't pay attention to what happens around you. Stuff like pickpocketing would become easier.

INTERVIEWER: In your opinion, how useful is the proposed system?

RESPONDENT: I think it is very useful but it's not really necessary. Especially for people that are allergic it is really handy.

INTERVIEWER: Do I understand you right that people who are interested in information, which the system can provided, the approach is kind of useful.

RESPONDENT: Yes, definitely. That's the best way to get those information.

INTERVIEWER: Could you see yourself using a more mature system of the prototype?

RESPONDENT: Yes, why not. I wouldn't pay, I would use it but not paying for. Or maybe if my mobile phone contract ends and I have to get a new one and they setup the extra charge with the contract, then I would consider it. But not when I have to pay for every single information.

INTERVIEWER: What about the fact that some data/information could be requested from the internet and you need to have a mobile data plan to make this happen. What about extra costs that occur with a mobile data plan?

RESPONDENT: Well mobile phones are changing anyway. A lot of people already have a mobile data plan and then it is ok. But if only for this information you need to have a data plan and it costs you extra then it's not a good solution.

INTERVIEWER: How convenient would the use of proposed system be for you?

RESPONDENT: Very convenient. You only have to carry a mobile phone.

INTERVIEWER: Anything in particular that is convenient, that isn't convenient?

RESPONDENT: Particularly convenient is that you have all the information you need in your hands. Well and I don't know how fast I can start the software and how easy it will be. So if it takes me a while to get the point to scan the product, then it might not be so convenient.

INTERVIEWER: What would you not do with the system?

RESPONDENT: Well, no not really.

INTERVIEWER: Is there any sort of information your are definitely not interested in / you definitely do not want to know?

RESPONDENT: Well, you should always have the option to choose which information you want and if you don't want a particular information, then just don't chose it.

INTERVIEWER: Just imagine you are about to buy a chocolate bar and the system tells you that product has this high number of weight watcher points and cause caries. So it tells you something you might not want to hear. What do you think about this?

RESPONDENT: I think it is still alright. I mean you should always know. I mean there is also some government crusading going on. Even telling something bad about a chocolate bar would support the effort of healthy eating.

INTERVIEWER: How should the proposed system be change in order to make it more convenient for you?

RESPONDENT: It seems pretty simple. I wouldn't make it more complex by changing it to a fancier way. Maybe you could have a picture.

INTERVIEWER: What do you mean? Can you explain that please?

RESPONDENT: Well, having a picture of the product when you scan it, to see if you scanned the right one. But well this doesn't really make sense. You have the product in front of you anyway and all you need to do is read the basic information. So no picture isn't a good idea.

INTERVIEWER: When you saw the prototype system presentation, how difficult to understand has it been for you?

RESPONDENT: I'm not sure, if I got all the technical aspects. Other than that it was pretty easy. You just scan it. I don't know where the information comes from and how the entire thing works.

INTERVIEWER: The information is most likely coming from an internet server and the phone would connect the internet and download the information needed.

RESPONDENT: Ok, well then there is the problem that you need to change it for different supermarkets, which isn't so good.

INTERVIEWER: Do you use apps on your phone?

RESPONDENT: No.

INTERVIEWER: This is the last questions. It is open to everything related to this prototype. What would you like to add? What would you like to comment?

RESPONDENT: No, nothing.

F.3.5. Interview 5

INTERVIEWER: What do you think in general about the ease of identifying a food product with the mobile phone?

RESPONDENT: I think it's a good thing. It can help me to get more information about a product. Normally you have to read what's printed on the label. But often the font size is quite small and you don't find easily what you're looking for. And the workflow of holding the phone next to product is fairly easy. You only need to start the software on the phone and after you can start with the tool.

INTERVIEWER: What difficulties in terms of food product identification would you expect in a real grocery environment?

RESPONDENT: Maybe I'm too small and the product is placed on the top shelf and I cannot reach it. Other than that there are a lot of people around me and all of them use the same program and there can be some interference. Also it cannot give me the information I really need. And also I cannot really specify what I'm looking for and as a result I'll receive quite a lot of information. So it could be hard the very important part.

INTERVIEWER: What do you think about the speed of identifying a food product with the mobile phone, how fast was it?

RESPONDENT: It was really fast, it only took one or two seconds and I got all the information.

INTERVIEWER: What do you think about the contactless close range technology in general?

RESPONDENT: Yes, I think it is really the future. You can use it for so many thinks, especially for some restaurants like in university to pay for your meal. I can be really helpful.

INTERVIEWER: Do you have any concerns about contactless technologies?

RESPONDENT: No.

INTERVIEWER: In your opinion, where are similar contactless identification technologies already in use?

RESPONDENT: As mentioned the payment in restaurants. In addition payment at fuel stations. Every point where you go and buy stuff on a regular base.

INTERVIEWER: In your opinion, where could similar contactless identification technologies be used in future?

RESPONDENT: Maybe buying bus and train tickets. And you can also get information about the train stations and bus stops. You could put a RFID sender at every bus stop and get the current timetable on your phone. Also the ticket sale could be done at this point.

INTERVIEWER: For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen?

RESPONDENT: Firstly I think most of the people take their mobile phones with them so it's not an extra device to carry around. Secondly it has all the functions and features built-in, which are necessary for this purpose. Such as display, keypad, internet connection and so forth.

INTERVIEWER: In your opinion, what are the advantages of a mobile phone in the context of food product information request in grocery environments?

RESPONDENT: It's small and you can hold it in one hand and in the other hand you hold the product. And again it's not an extra device.

INTERVIEWER: The food product information being presented in the prototype application only outlines examples. In your opinion, how useful are additional food product information in general?

RESPONDENT: If you have some kind of illness, it can really help you to find out whether there is some sort of ingredients in it, which will harm you. However it is an extra feature. You still can do shopping as you have been used to it. Sometimes additional information comes in handy. For example I encounter the problem of not

finding the exact price of the product. The mobile phone could assist. Additionally advertisement of special offers or certain products could be a market.

INTERVIEWER: Which type of food product information are you interested in?

RESPONDENT: Maybe a feature to compare one product with others of the same range. And also special offers like: Buy 2 items of this, get one free. I might feel like that this offer is only customized for me and not for everyone and I would certainly feel special.

INTERVIEWER: Which type of food product information could people you know be interested in?

RESPONDENT: Maybe some sort of what you can use the product for, e.g. meal suggestions. And maybe the healthiness of the product and whether it has an organic farming and sustainable background.

INTERVIEWER: Anything else you can think about?

RESPONDENT: Yes, sometimes I open the fridge and take out something and shortly after I have to realize that the product is already expired and sometimes I have to throw it away. So the phone could remind me of certain best-before dates of products I've purchased.

INTERVIEWER: The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options?

RESPONDENT: I think your mobile is quite a good idea. It's your private one and you can get customized information based on your profile. Other than that, maybe people who don't have new fancy phones could rent out some devices for the shopping.

INTERVIEWER: Also, the mobile phone used in the prototype system has a smaller display. Many of the emerging phones come with larger displays. What do you prefer?

RESPONDENT: Larger display, I also like touch screens.

INTERVIEWER: What are important characteristics of a mobile phone when you had to choose a new phone?

RESPONDENT: I must have a large display, not to heavy, heaps of storage capacity.

INTERVIEWER: As discussed earlier, there are various types of food product information. How do you think about paying a certain amount for obtaining very useful information?

RESPONDENT: I would say, it must be free of charge and it should remain a service. The money should come through advertisement. This means the shop owner needs to have an interest in the system in order to sponsor it.

INTERVIEWER: If you had to pay for certain information, which payment model would you prefer?

RESPONDENT: In my opinion it should be a single payment for the software and no regularly or usage based costs.

INTERVIEWER: Can you think about any other payment options?

RESPONDENT: Well I could be that basic information are for free. Additional and very useful information could be charged.

INTERVIEWER: How would you feel about your privacy and personal data while using the proposed system in a real environment?

RESPONDENT: That's a good point. I want to know before using it what they are doing with my data. I request information of certain products. I want to know what they are doing with those profiling data. I think it is important to know that I won't get spam. It's quite important that I give my consent to this.

INTERVIEWER: Which personal data would you provide in order to be able using the proposed system?

RESPONDENT: I think I can provide the information where and what I bought. It's similar with other loyalty cards. However normally I don't' that they want my personal information, like name and address and then you get all the spam mail you don't want. So as less as possible would be fine.

INTERVIEWER: What/where are your privacy concerns?

RESPONDENT: Not really, I don't think that someone steals my mobile and they can really use this information against me. So it's not that much of concern.

INTERVIEWER: What/where are your security concerns?

RESPONDENT: Well for thieves it could be a good way to find out who has expensive phones. And also while I'm reading the information I'm distracted and thieves can take advantage of it and steal my wallet. I have to be sure that no one is around you. Hover you are using your phone in public anyway. So shouldn't be that much of a concern.

INTERVIEWER: In your opinion, how useful is the proposed system?

RESPONDENT: I think I really can be helpful to have extra services for my shopping trip. Some of the information introduced with the prototype would usually never been accessible for you.

INTERVIEWER: Could you see yourself using a more mature system of the prototype?

RESPONDENT: Yes I would use it. But the price for it must be acceptable.

INTERVIEWER: Is there a situation where you wouldn't use it?

RESPONDENT: I think the grocery store is a good point to use it. In contrast if you are more interested in exclusive and expensive items you usually ask the store staff or you research upfront on the internet. It's more useful for daily purchases.

INTERVIEWER: What would you do with the system?

RESPONDENT: I don't know if it is really the purpose of the system. Nevertheless you could compare stuff. Like comparing prices with other stores, stores which are close by.

INTERVIEWER: How convenient would the use of proposed system be for you?

RESPONDENT: It's convenient because it's quite important to not waste time with such things. So they must work fast, must be easy and simple to use and the

information must be not useless. And I believe a new system shouldn't force you to change your shopping behaviour in a big way. For example if the shopping takes an extra hour just because I use such a system, well then it's not off particular interest for me. But well, that always depends on the person using it and how often you use it.

INTERVIEWER: How should the proposed system be change in order to make it more convenient for you?

RESPONDENT: First I want to have a broader overview maybe with a picture and the price and some key facts. And then it would be cool to have a profile set up, which filters the information you are interested in. So this way it could exactly fit my needs and I don't get spammed with additional not useful information. And all the information should be easy to read. I'm using a barcode scanner on my iPhone and this software also gives you basic information about a product. It also uses GPS to find out where else to get this product near by.

INTERVIEWER: When you saw the prototype system presentation, how difficult to understand has it been for you?

RESPONDENT: It was really easy. You just have to start the software and hold it next to the RFID tag and get the information?

INTERVIEWER: On your iPhone, do you use additional applications, so called apps?

RESPONDENT: Yes.

INTERVIEWER: Which application in a similar area of the proposed system, are you using?

RESPONDENT: I use a barcode scanner, which also gives you information about the product, price and a possible place to buy it. I'm not sure if you can use this for getting deeper information. Never tried to use it for this purpose.

INTERVIEWER: Anything else?

RESPONDENT: No, only basic stuff like search engine, and global product comparisons, which take a lot of time. Because you need to identify the product first, click heaps of links and select categories.

INTERVIEWER: This is the last questions. It is open to everything related to this prototype. What would you like to add? What would you like to comment?

RESPONDENT: I think it is important to know whether the system is from a certain store and whether the information is independent in order to avoid supermarkets influencing your shopping.

INTERVIEWER: What about the issue that you possibly have to update the database of the phone.

RESPONDENT: I think it should work with some updates, but if you use an older versions you just don't have up-to-date information. The current versions contains all the new information and possibly more options. It also should synchronize with the computer and connect via 3G.

F.4. Interview data analysis

F.4.1. Coding schemes

Table F.2.: Coding scheme after second coding stage (Source: author)

Category		Sources	References
Alternatives		5	13
Costs			
	Paying for information	5	31
Ease of Use			
	Device, hardware, phone	4	15
	Food product identification	5	23
	Overall	5	31
	Software	4	21
Grocery Environment		4	9
Mobile Phone		5	27
Motivation		4	16
NFC, RFID			
	Application areas	5	19
	Contra	2	2
	Pro	5	6

Continued on Next Page...

Table F.2.: Coding scheme after second coding stage (Source: author)

Category		Sources	References
Privacy		5	17
Security		5	10
Usefulness			
	Additional applications	4	33
	Additional information	5	73
	Independent information	4	8
	Not using the system	5	7
	Overall	4	9
	Phone is part of daily life	5	12
Sum		90	382
Mean		4.5	19.1

Table F.3.: Coding scheme after third coding stage (Source: author)

Category			Sources	References
Alternatives				
	Devices		5	11
	Food product identification		2	2
	Software		2	4
	Source		2	3
Costs				
	3G data plan		1	1
	Paying for information			
		Negative	5	11
		Positive	5	8
	Payment handling		2	4
	Payment model		5	15
Ease of Use				
	Device, hardware, phone			
	Food product identification			
		Positive	5	9
		Problems	5	17
	Negative		3	5
	Overall			
	Positive		5	18

Continued on Next Page...

Table F.3.: Coding scheme after third coding stage (Source: author)

Category			Sources	References
	Requirements		4	8
		General	3	3
		Information	3	6
		Phone	5	18
		Software	5	28
		Tag	1	1
	Software			
Grocery Environment			4	8
Mobile Phone				
Motivation			4	16
NFC, RFID				
	Application areas		5	19
	Contra		2	2
	Pro		5	6
Privacy			5	17
Security			5	10
Usefulness				
	Additional applications			
	Additional information			
	Extensions			
		Allergies	3	8
		Best before dates	3	4
		Bio food	3	4
		Calories, nutritions, ingredients	4	9
		Carbon foot print	4	6
		Comparisons	3	5
		Country of origin, producer, production conditions	3	9
		Custom settings	4	9
		Diabetes	2	4
		Discounts and special offers	2	4
		Healthiness	2	6
		Price finding	4	5
		Product finding	2	4
		Recipes	2	3
		Recommendations	4	7
		Sharing information	1	1

Continued on Next Page...

Table F.3.: Coding scheme after third coding stage (Source: author)

Category		Sources	References
	Shopping list	1	3
	Storage conditions	1	1
	Various grocery stores	1	1
	Independent information	4	9
	Negative	2	6
	Not using the system	5	8
	Overall	4	9
	Phone is part of daily life	5	12
	Positive	5	11
	Requirements	5	13
Sum			411
Mean		3.403846154	7.903846154

Table F.4.: Coding scheme after fourth coding stage (Source: author)

Category		Sources	References
Alternatives			
	Devices	5	11
	Food product identification	2	2
	Software	2	4
	Source	2	3
Costs			
	3G data plan	1	1
	Paying for information		
	Negative	5	11
	Positive	5	8
	Payment handling	2	4
	Payment model	5	15
Ease of Use			
	Food product identification		
	Positive	5	9
	Problems	5	17
	Negative	3	5
	Positive	5	19
	Requirements		

Continued on Next Page...

Table F.4.: Coding scheme after fourth coding stage (Source: author)

Category			Sources	References
		General	4	4
		Information	3	6
		Phone	5	18
		Software	5	28
		Tag	1	1
Grocery Environment			4	8
Motivation			4	18
NFC, RFID				
	Application areas		5	19
	Contra		2	2
	Pro		5	8
Privacy			5	17
Security			5	12
Usefulness				
	Extensions			
		Allergies	3	8
		Best before dates	3	4
		Bio food	3	4
		Calories, nutritions, ingredients	4	10
		Carbon foot print	4	6
		Comparisons	3	5
		Country of origin, producer, production conditions	3	9
		Custom settings	4	9
		Diabetes	2	4
		Discounts and special offers	2	4
		Healthiness	2	6
		Price finding	4	6
		Product finding	2	4
		Recipes	2	3
		Recommendations	4	7
		Sharing information	1	1
		Shopping list	1	3
		Storage conditions	1	1
		Various grocery stores	1	1
	Independent information		4	9
	Negative		2	6

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Table F.4.: Coding scheme after fourth coding stage (Source: author)

Category		Sources	References
	Not using the system	5	8
	Overall	4	9
	Phone is part of daily life	5	12
	Positive	5	11
	Requirements	5	13
Sum			413
Mean		3.411764706	8.098039216

F.4.2. Un-coded raw interview text

- I1: "INTERVIEWER: Do you use the mobile web? RESPONDENT: No"
- I1: "INTERVIEWER: Which type of food product information could people you know be interested in such as your parents, friends, family? RESPONDENT: Basically the same as mine."
- I1: "INTERVIEWER: For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen? RESPONDENT: Because your study deals with mobile phones."
- I2: "INTERVIEWER: What do you think about the contactless close range technology in general ...like RFID, NFC and so on? RESPONDENT: From a technology point of view? INTERVIEWER: It doesn't matter, all aspects off interest."
- I2: "INTERVIEWER: Yes of course. We will come back to this question at a later stage. The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options? RESPONDENT: Other than the phone? INTERVIEWER: Yes, for example"
- I2: "INTERVIEWER: Anything else? RESPONDENT: No, not really."
- I2: "RESPONDENT: Nothing I can think about."

- I3: "RESPONDENT: No, sorry not at the moment."
- I3: "INTERVIEWER: Anything else? RESPONDENT: No,sorry."
- I4: "INTERVIEWER: In your opinion, where could similar contactless identification technologies be used in future? RESPONDENT: Apart from the supermarket? INTERVIEWER: Yes"
- I4: "INTERVIEWER: For this prototype demonstration a mobile phone as medium for identifying the product and displaying product related information has been used. In your opinion, why has a mobile phone been chosen? RESPONDENT: This particular one? INTERVIEWER: No, mobile phones in general."
- I4: "INTERVIEWER: The visualisation, presentation, visibility and use of food product information on a small mobile phone display can be challenging. Within the presented prototype one possible solution has been presented. Can you think about other options? RESPONDENT: What do you mean?"
- I4: "INTERVIEWER: Do you use apps on your phone? RESPONDENT: No. INTERVIEWER: This is the last questions. It is open to everything related to this prototype. What would you like to add? What would you like to comment? RESPONDENT: No, nothing."

F.4.3. Incorporation of categories

Table F.5 outlines which categories have been used to create the concept. The last column provides a reference to the step of the concept creation, where the respective category has been used. Empty fields mean that those categories have not been used for concept creation.

Table F.5.: Categories' incorporation in steps of concept creation

Category		Incorporated in step
Alternatives		
	Devices	
	Food product identification	
	Software	
	Source	
Costs		
	3G data plan	5

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Table F.5.: Distribution of codes after fourth coding iteration

Category			Incorporated in step
	Paying for information		5
		Negative	5
		Positive	5
	Payment handling		
	Payment model		
Ease of Use			
	Food product identification		4
		Positive	4
		Problems	4
	Negative		3
	Positive		3
	Requirements		
		General	
		Information	
		Phone	
		Software	
		Tag	
Grocery Environment			
Motivation			
NFC, RFID			
	Application areas		
	Contra		
	Pro		
Privacy			7
Security			6
Usefulness			
	Extensions		
		Allergies	1
		Best before dates	1
		Bio food	1
		Calories, nutritions, ingredients	1
		Carbon foot print	1
		Comparisons	
		Country of origin, producer, production conditions	1
		Custom settings	2
		Diabetes	1
		Discounts and special offers	*7

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Table F.5.: Distribution of codes after fourth coding iteration

Category			Incorporated in step
		Healthiness	1
		Price finding	1
		Product finding	
		Recipes	1
		Recommendations	
		Sharing information	
		Shopping list	
		Storage conditions	1
		Various grocery stores	
	Independent information		1
	Negative		
	Not using the system		
	Overall		
	Phone is part of daily life		2
	Positive		
	Requirements		2

*7 Discounts and special offers were incorporated from a privacy perspective but not directly as part of extensions (usefulness).