Physical Mobile Interaction in Retail: a Technology Usability Study

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ABSTRACT
Communication between smartphones and physical objects is an increasingly important topic in information technology. With more demand for information about the products we buy and rapid information exchange through the internet a digital connection between physical objects and consumer smartphones can provide this on-demand access to information. The two most used technologies to enable such a connection between consumer smartphones and retail products are explored in this paper. It outlines how customers experience QR-codes and NFC and describes their advantages and disadvantages as well as technical characteristics. While the technical characteristics have been studied in related articles and papers, there has not yet been research towards both technologies to determine a preferred choice by customers. In retail stores QR-codes are a desirable choice with less costs and an easy production. Nevertheless, a usability study including a direct comparison with 22 participants resulted in a tendency towards NFC as a preferred technology for customers to scan objects.

Keywords
Physical Mobile Interaction, Automatic Identification and Data Capture, Quick Response Code, Near Field Communication, Object Hyperlinking

1. INTRODUCTION
Mobile phones are getting smarter every year and as more people are buying handhelds there is a growing demand for mobile access to information. In the industry and especially in supply chain management, the usage of RFID tags is broad. It encourages security, access control, transportation and tracking [11, 20]. Nevertheless there is also a demand in the consumer section for real-time information and control about products [9]. Research showed that people like to interact with physical objects to get more information about them [7]. Albert Heijn, Jumbo, C&A and IKEA are some of the biggest retail stores in the Netherlands [16]. Yet there is no implementation of mobile interaction in these stores available for the consumer. A ‘tag’ in information technology describes the hardware attached to physical objects allowing digital identification [20]. Tags applied to different products can help the customer retrieve information that promotes buying a product or improve the process from entering the store until checking out [12].

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automatic identification technology we refer to technology that enables us to identify physical objects digitally. Object Hyperlinking is the term used when a unique marker technology is attached to an object in the real world. This allows interaction between the real and the digital world and is also known as automatic identification and data capture (AIDC) [20]. Using mobile devices to establish such a connection is called Physical Mobile Interaction (PMI) [7]. A tag is therefore by definition an object hyperlink.

There are two different ways a tag can be used to gain information: Physical Hyperlinks and Broadcasting [7]. Acting as a physical hyperlink, the tag is used to trigger an action. This can for example be a URL that is opened by the browser to show any information necessary and allow feedback from the customer [7]. Another way is the storage of an identifier used by an application to show custom made contents from a mobile application. The latter approach can save traffic and increase security. On the other hand it ties the customer to a specific application. With broadcasting, all the information is stored on the tag and is broadcasted to the device. This can be useful for short messages but is greatly restricted by the tags storage size.

The use of physical hyperlinks allows a two-sided communication through the internet. It enables customers to interact with information about the product, e.g. comment or rate it. A study about physical mobile interaction revealed that 92% of the participants would interact with physical objects to get more information or invoke services through hyperlinks. The process is seen as fast, simple, direct, interesting and does not require searching on the internet [7]. Additionally, in situations such as retail where the customer has to make a buying decision, the available information can have significant influence [2]. According to a DPM study concerning personal shopping support, 74% of the subjects would take product ratings provided by other customers into account when making a buying decision [12].

The principal technologies used for the interaction are barcodes and radio frequency identification (RFID). Both already have revolutionized product tracking in logistics [6, 11]. New technologies like Near Field Communication (NFC) and quick response (QR) codes become increasingly accessible for owners of a modern smartphone [15, 20].

RFID utilizes radio waves to send and retrieve data. NFC, technically a subset of RFID technology, allows radio communication on a specific frequency at a maximum distance between 2 devices of 10cm (4 inches) [20]. NFC is interesting for the private sector due to a growing number of smartphones being shipped with an integrated NFC chip; some examples are the new Nokia Lumia series and the Samsung Galaxy S3 [15, 21].

First introduced in 1974 the barcode was the first commercially accepted automatic identification and data capture technology
QR-codes are another form of barcodes, differing from the usual barcode by the use of 2 dimensions for data storage, allowing for about 300 times the amount of data to be stored [20]. Therefore QR-codes are also referred to as 2D barcodes. With appropriate software and a camera most smartphones can read these tags [10].

1.1 Problem Statement
As outlined in the introduction, existing research showed that there is demand for easily accessible information through mobile phones by the consumer. Retail stores can improve the customer experience and influence the buying decision by giving more insight in product lifecycles or provide additional data like ratings from other customers. QR-codes are inexpensive in production and available to a broad audience, while NFC delivers more security and a smoother interaction between capable devices. Therefore those 2 are considered the most suitable AIDC methods for mobile phones [20]. But the wrong choice can have an impact on the acceptance from customers which determines success or failure. There is a lot of research about RFID and NFC concerning their technical data. But those studies focus on how these methods can be implemented in the different existing programming environments or specifies their technical differences only. There is no coherent study taking into account all the aspects that are important when deciding which technology to use commercially to reach as many users as possible. To determine which technology should be preferred in retail stores to provide the customer additional information on products, technical as well as usability details have to be considered.

1.2 Research Questions
The main research question is “Which AIDC-technology should be used to provide a customer in retail stores relevant access to data?” To answer this question a couple of sub-questions derived:
1. What are the technical differences between QR-codes and NFC tags?
2. What are the limitations of these technologies based on software and hardware?
3. Which automatic identification and data capture technology is preferred by consumers?

To answer these questions a literature study will provide the basic understanding of both technologies. Chapter 3 covers all technical differences of both technologies. Chapter 4 outlines the limitations that are not covered within Chapter 3. Those are mainly accessibility and security. While literature study provides answers to the technical related research questions one and two, the last question requires a usability study with potential customers. Chapter 6 will describe the method of researching the technologies’ usability as well as their results. The conclusion finally draws a sum up of all different aspects and gives an indication on which technology to use in retail to provide customers quick access to information.

2. RELATED WORK
Several papers have already investigated the difference between QR-codes and NFC [13, 20]. Vazquez-Briseno et. al. describe both RFID/NFC and QR-code technologies. They present the methodologies and Application Program Interfaces in common smartphones to get access to both technologies [20]. While both methods are outlined, they are not compared with each other in a different context than technical details. Still they show that both methods are the most useful methods for physical mobile interaction with smartphones. There has been research about the interaction of physical objects with mobile devices by Herting and Broll and Barthel et. al [2, 7]. It is shown that in situations that involve a transaction, information that is available at the point of experience can influence the buying decision [2]. To retrieve such data on time, unique markers function as identifiers to look up additional data via the internet. The study from Herting and Broll revealed that 11 out of 12 participants would interact with physical objects to get more information about them. The interaction between mobile devices and physical objects is seen as quite simple, intuitive, fast and understandable [7]. Concerning the field of retail stores, there has been study about personal shopping support through product memories [12]. Similar to the work of Herting and Broll, it is not focusing on mobile phones but using a more varied context of AIDC technologies which is not easily accessible to a broad audience, e.g. RFID scanner. It showed that 74% of customers from a 132 people audience would take into account product ratings provided by other customers when making a buying decision [12]. While these studies demonstrate the theoretical models to link the real to the digital world, they do not specify the technology to use nor do they limit their investigations to mobile phones. Still those abstract studies show that there is demand for such technology.

3. TECHNICAL DIFFERENCES
The technical differences of QR-codes and NFC are broad. The scanning process is different in many respects as well as the general technology to use them. Still they serve as technologies to perform the same action: Automatic Identification and Data Capture. This chapter outlines the differences and similarities both technologies share to enable AIDC. AIDC techniques deliver a fast, easy and accurate method to provide data. The term Automatic is derived from the fact that the identification can be automated by computers. The first widely successful technology in this field has been the barcode, which is still common on products in retail stores. The QR-code is a derivative of the first barcode. It enhances data storage capabilities and error correction [20]. Barcodes can be printed by usual printers. Another largely adopted method for automatic identification is radio frequency identification. RFID has found broad acceptance in logistics [11]. It utilizes radio waves to send and retrieve data. NFC is a short-range high frequency wireless communication technology based on RFID. It enables smartphones with an integrated NFC chip to make use of this technology and therefore promotes RFID in the consumer market.

3.1 Quick Response Codes
The Quick Response Code is a two-dimensional (2D) barcode developed in 1994. It is an upgrade to previous 2D codes by improved reading speed. QR codes differ from traditional 1D barcodes by containing data in horizontal and vertical directions. This makes a considerable higher amount of data storage possible [20]. Several one dimensional barcodes have an ISO norm. The most common are the Universal Product Code (UPC) and the European Article Number (EAN). These codes can only contain numbers from 0-9. UPC contains 12 numbers and EAN 13, with both having one error correction check digit. QR codes on the other hand can contain up to 7,039 characters of numeric data or 4,296 characters for alphanumeric data [20].
The Quick Response Code is faster to read than other two-dimensional codes because it contains three large square patterns in the top left, top right, and bottom left corner that are used for position detection. Additionally, the QR code provides an error correction capability. With that it is possible to read the code even if the code encounters distortion or damage. Four different error correction levels exist and can be chosen while creating the QR code: Level L, M, Q and H. They provide error correction when up to 7, 15, 25 or 30% of the data is damaged respectively. In total there exist 40 versions of QR codes depending on the number of black squares (called modules). As more information is stored more modules are necessary, which increases the size of the QR code. A minimum size of 21x21 modules represents version 1 and can be increased up to 177x177 modules, representing version 40 [18, 20].

3.2 Near Field Communication
Near Field Communication was designed and marketed by the NFC Forum, an association initially found by, among others, Sony and Nokia. The NFC Forum counts more than 170 companies (May, 2013) [5]. NFC enables two supported devices to communicate at a distance of maximal 10 cm [20]. It uses the same working standards as RFID. While RFID is able to operate in long distances, NFC is not. This promotes security for sensitive information exchange and should reduce vulnerability to a minimum. Near Field Communication is standardized in ISO/IEC 18092 (NFCIP-1) [19]. It can, according to its standard, operate in active or passive mode. In active mode, the device generates an electromagnetic field that is used as an energy source for the passive device. The operating speeds defined by NFCIP-1 are 106, 212, 424 and 848 Kb/s [19]. Given this specification, NFC enabled devices are able to read different types of tags. Those tags can be passive without the necessity of their own power supply. There are 4 different types of NFC tags standardized in ISO 14443 [17].

- Tag 1 Type: read and re-write capable, 96 bytes memory, expandable up to 2 kilobyte, speed of 106 Kb/s
- Tag 2 Type: read and re-write capable, 48 bytes memory, expandable up to 2 kilobyte, speed of 106 Kb/s
- Tag 3 Type: based on Sony FeliCa, memory variable, theoretical memory limit is 1 MByte per service, speed of 212 or 424 Kb/s (manufacturers choice)
- Tag 4 Type: pre-configured at manufacture, read, re-writable and read-only (pre-configured by manufacture), 32 kilobytes memory, speed of up to 424 Kb/s

There is also a standardized data format for NFC called NFC Data Exchange Format (NDEF). On a tag, there is always one NDEF message, which can contain several NDEF records. Each record encapsulates header information and a set of data[20].

![Figure 1 - QR-code compared with traditional barcode](http://www.qrcode.com)

Figure 1 - QR-code compared with traditional barcode
(Source: http://www.qrcode.com)

Several records with different types of information simplify performing different tasks with just one tag. As an example, one tag could bring you to the app-store if a specific app is not installed, or otherwise open the corresponding app and perform a given action.

3.3 Technical Comparison
Both methods allow for more than 2000 letters of data to be stored. This amount is enough to store any URL or use it as an identifier for applications. Storing all data in one code or tag limits the information available to a few sentences. QR-codes are more widespread and some owners of a smartphone have already been in touch with them. NFC on the other hand is a modern technology in smartphones and not that broadly available yet. From the technical point of view, QR-codes are cheaper in production, can store more data and are accessible for a broader audience. NFC on the other hand is capable to store different sets of data which allows for a more complex interaction, e.g. establishing a Bluetooth connection between two capable devices. It further encourages more security and has a smoother interaction.

![NDEF Message](http://developer.nokia.com)

Figure 2 - NDEF Message
(Source: http://developer.nokia.com)

Several records with different types of information simplify performing different tasks with just one tag. As an example, one tag could bring you to the app-store if a specific app is not installed, or otherwise open the corresponding app and perform a given action.

### Table 1 - technical comparison of QR-codes and NFC-tags

<table>
<thead>
<tr>
<th>QR Code</th>
<th>NFC Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage</td>
<td>2,953 bytes</td>
</tr>
<tr>
<td>Availability in mobile phones</td>
<td>Any camera-enabled phone with appropriate software</td>
</tr>
<tr>
<td>Costs</td>
<td>can be printed by any printer</td>
</tr>
<tr>
<td>Readability distance</td>
<td>Depending on size can be several meters</td>
</tr>
</tbody>
</table>

4. LIMITATIONS

Quick Response Codes can be printed with usual printers and are accessed by the phones only visually. NFC tags on the other hand require an integrated NFC chip to supply them with power to enable data sending. Both methods have advantages and disadvantages outlined in the previous chapter. Nevertheless, the technical details do not reveal how broad the audience of both methods is. This chapter describes the
accessibility to determine which group of customers will be able to make use of physical mobile interaction. Furthermore, some security aspects are outlined that can have an influence on the preferred technology.

4.1 Accessibility
In order to decode the QR-code, a phone must be equipped with a camera and special software. Almost all smartphones released in the past years cover the requirements to install applicable software [13, 20]. This broad list of devices is a substantial advantage over NFC, which in contrast requires a phone that has NFC capability. In 2012 125 million NFC handsets have been shipped. This was already an increase of over 100% compared to 2011. According to analysts, a growth of almost 120% is expected for 2013 [1].

Almost all smartphones' devices is a cost factor. Technologies being available for retail stores from 17 to 52 with an average age of 25. The group consisted of 17 students and 5 employees from a middle-class environment, with 15 of the students studying at a university or college. Of those 15 students, only 4 have an IT related study. 18 participants owned a smartphone. The group is not restricted to smartphone users because it aims to give an indication about how usual customers in a retail store experience a new technology.

5.1 Method
To find out which AIDC technology is preferred by the customer to interact with physical products in retail stores, a small example of a store shelf was built. Four products have been placed on the shelf with each a QR-code and a clearly marked NFC sticker next to it. One half of the participants had to scan the products with NFC first followed by the QR-codes, the other half had to participate the other way around. All scanned content has been pre-cached on the device to prevent differences in the time necessary to load the content. After performing the scan, the subject had to fill in a 20-item questionnaire containing 7 multiple choice questions, with 3 of them offering the option to state their own answer. The remaining 13 questions used a 7-point Likert scale to express how far a specific statement addressing the technologies’ usability applies to the participant. A 7-point scale reduces neutral answers while remaining clearly for the user [4]. To determine the usability of one technology, “the effectiveness, efficiency, and satisfaction with which specified users can achieve goals in particular environments” is measured [8]. Effectiveness, measured by accuracy, completeness or quality of outcome, can be left behind this study. There are just two precisely specified tasks to perform and both lead to the same result. Efficiency on the other hand is measured by time, mental effort, communication effort, and usage patterns. All Likert-scale questions cover at least one of the efficiency measures. In summary, the questionnaire addressed:

- Participants age and name
- Prior knowledge about both technologies
- Preference regarding similar situation
- Expectation in battery consumption
- Speed of scanning
- Ease of use

Additionally, during the set-up of the questionnaire, two subjects were asked to line out their main concerns when using QR-codes and NFC. They did not participate in the questionnaire. One subject has IT experience while the other does not. The results were taken into account when creating the questionnaire.

5.2 Results
5.2.1 Prior knowledge
Only 2 subjects have never heard about any of the two Physical Mobile Interaction tagging methods. While 8 heard about QR-codes before, 12 heard about both technologies. There are no participants that heard about NFC before but not about QR-codes.
Surprisingly, only 2 participants have used both technologies before, 9 have used QR-codes before and the half, 11 participants, never used any of the AIDC methods to scan a tag.

5.2.2 General preference and usage

One block of questions allowed the participants to outline why they preferred the one technology over the other. All possible answers were the same for both methods to keep them comparable.

NFC counts more results because twice the amount of people preferred NFC in the first place. Obviously, battery consumption seemed not to be a significant indicator when choosing a scanning technology. If we look at the proportional distribution of all answers we can see that ease and speed are the most important factors. All participants that preferred NFC and chose “Other” stated that they were uncomfortable with opening an app each time. The remaining questions gave a more detailed view for each efficiency measure.

5.2.3 Battery

16 participants found battery consumption important, 2 neutral and 4 not important. When looking at the 6 subjects that preferred QR-codes over NFC all of them had stated battery consumption as important. Nevertheless, only one expects battery consumption of NFC to be higher than of QR-codes. On the other hand, 1 of them expected scanning QR-codes to consume more battery than scanning NFC. The remaining 4 subjects rated the battery consumption for both technologies equally. With NFC on the other hand, 8 of the 12 subjects found battery consumption an important factor. From those 8 participants, only 2 expected scanning QR-codes to consume more battery than scanning an NFC tag. Furthermore, 3 of those that stated battery consumption an important factor preferred NFC over QR-codes, but expected NFC to consume more battery than scanning QR-codes.
5.2.4 Speed
All participants assessed a quick scanning process as important or at least as neutral, with 18 choosing important and 4 rating it neutral. Figure 9 summarizes the 3 core measured aspects and gives an average answer. It lists the answers for 3 groups, one being neutral participants, one being the participants that preferred NFC over QR and vice versa. This graphic indicates that the participants that preferred QR-codes experienced the scanning as very fast while the participants that chose NFC did not. NFC resulted the other way around. Subjects that preferred NFC experienced NFC to be very fast while the other group did not.

5.2.5 Ease of use
The remaining questions addressed the ease of using one technology. The main concerns when using QR-codes are that you have to open the camera each time a code is scanned. For NFC on the other hand, people disliked the fact that the mobile phone has to be held very close to the tag to scan it. The following graphics show how both scanning methods were received by the participants.

5.3 Discussion
The usability test confirmed the assumption drawn from related work that there is demand for additional information about products, with 73% of the participants willing to use physical mobile interaction in similar retail situations to gain information (see figure 5). The results of this study revealed that there is a preference towards Near Field Communication. To determine which factors have influenced the decision, each efficiency measurement criteria is taken into account.
5.3.1 Battery
16 out of 22 subjects found battery consumption an important factor in general. This result shows that it indeed can be a factor to influence the preference for one technology. But when indicating why a choice was made, only 1 participant chose battery as a key aspect. Only 1 of the QR preferred participants thought that NFC would consume more battery than QR-codes. Furthermore, 1 participant of that group expects scanning QR-codes to consume more battery than scanning NFC, while indicating battery consumption as an important factor. From the 12 participants that preferred NFC over QR-codes, 3 expected scanning NFC tags to consume more battery than scanning QR-codes. Those 3 also indicated battery consumption to be an important factor. All other participants rated the expected battery consumption for both technologies equally. As a conclusion, it can be said that while battery consumption is important to customers, it is not the criteria relevant for choosing a method for physical mobile interaction. There are even customers that prefer a technology that they believe will consume more battery. Apparently, other factors have more influence on the decision for one AIDC method than battery consumption.

5.3.2 Speed
All subjects think of speed as an important factor, or at least rate it neutral. In consistence with Figure 8, a quick scanning was the most voted reason for choosing one technology over the other. Still, Figure 9 shows that no matter what technology was preferred, it was in both cases experienced as faster than the opponent. This might be explained by some participants thinking of speed differently than others. It could be that they refer to speed from the point of opening the QR-code application until having the results on the screen. It could also be the time from the moment the application is opened until the scan is done (because that is where the scan is actually performed), while opening the application is part of the ease of use. It is questionable in how far the participants can distinguish between speed and ease of use, as a faster scanning process requires less attention and therefore can be seen as easier, too. Yet according to figure 8, speed is a very important factor, no matter which technology is chosen.

5.3.3 Ease of use
With 77% of the participants experiencing it annoying to open an application each time to scan a QR-code, a reasonable amount was not comfortable with the ease of scanning QR-codes. Of those participants, 35% found it annoying to a strong extent. On the other hand, while by 59% holding a phone close to a tag to make use of Near Field Communication was experienced as annoying, 69% of these subjects found it only slightly annoying. Interestingly, all 12 participants that preferred NFC over QR-codes answered that they agree or strongly agree to the statement that it is annoying to open a scanning application each time to scan a QR-code. On the other hand, 5 of 6 participants that preferred QR-codes over NFC were annoyed by holding the phone close to the tag, but 4 of them were annoyed only slightly. The stronger extent to which it was experienced as annoying to use external applications are an indication for the reason to prefer NFC over QR-codes. This is in line with the results from figure 8, where all participants that answered “Other” stated they don’t like opening an external application first. Additionally, these results are coherent with the results in figure 9 where the difference between the QR/NFC preferred groups for the ease of using NFC is small.

6. CONCLUSION
We investigated several aspects that are important in business to support the decision making between the most common Automatic Identification and Data Capture technologies that are available for mobile phones, Quick Response Codes and Near Field Communication. While QR-codes are cheaper and require less effort in production, NFC can deliver more functionality and security. The usability study showed that twice the amount of participants preferred NFC over QR-codes. Battery consumption and prior experience played no role when deciding for one method. It can be concluded that ease of use and speed of scanning are the most important factors when choosing a preferred technology for AIDC. It is a manner of opinion how far one technology is easier to use than the other, but a tendency towards NFC shows that third party applications and repeating actions necessary to perform a scan are significant diminishing factors when choosing a method. QR-codes are desirable for their cheap production costs. They are recognizable and address a broader audience. With more phones being shipped with an integrated NFC chip, far more people than currently are expected to be able to scan NFC tags in the future. Because the preference depends mainly on the ease of use, when the position of the tag is difficult to reach, the preference can shift from NFC to QR-codes. On the other hand, QR-codes have some restrictions, too. While a higher distance is possible, a very close distance cannot be read by most smartphones. The lighting conditions and camera quality have a huge impact on how fast the code can be scanned. In our test, range was no issue, and there was enough light for QR-codes to function properly (both desirable conditions in retail). In such a case, the usability tends to be better for NFC. Less effort for scanning and no external application were the main reasons outlined by the participants.

7. FUTURE WORK
A group of 22 subjects is too small to give statistically relevant results. Furthermore, there has not been any investigation in retail stores to get information about how data would be saved. We expect physical hyperlinks to be the preferred choice since it provides methods for a two-sided communication that enables customers to give ratings or add comments which on the other hand can influence other customers in their buying decision. A study with a far bigger group of different ages and professions can yield in statistically more significant results. Additionally, the test should be held under real conditions in a real retail store, where environmental factors such as distance and lighting conditions apply. Those have to be taken into account when making the usability study as well.

8. REFERENCES


APPENDIX

A. QUESTIONNAIRE

You have just performed several tasks with a mobile phone to gain information about products. Hereby you made use of 2 different technologies to get your results: Near Field Communication (NFC) and Quick Response Codes (QR-Codes).

In all questions you may assume that the QR codes and NFC are used in a similar situation (e.g. in a supermarket next to the price or other retail related stores).

Please fill out all fields in this survey. By signing this paper you approve that you had a short introduction about both technologies and how to use them with the phone.

Name: 
Age: 
Signature:

Questions (just mark one answer per question):

Have you heard about these technologies before?
- o No, I haven’t heard about them
- o Yes, I heard about QR-Codes
- o Yes, I heard about NFC-Codes
- o Yes, I heard about both

Have you used these technologies before this test?
- o No, I haven’t used them before
- o Yes, I used QR-codes before
- o Yes, I used NFC before
- o Yes, I used both before

If any of the just used technologies would be available in a similar situation (say on products to open a website with additional information), would you scan it to get that information?
- o No, I would not
- o Yes, I would scan it

*ONLY if you answered the previous question with No:*

Why would you not use it to gain additional information?
- o I would search information on the internet on my own
- o I think it takes too long to get information
- o It looks stupid
- o Other:

If both technologies were available to gain information, which one would you prefer?

<table>
<thead>
<tr>
<th>QR +++</th>
<th>QR ++</th>
<th>QR +</th>
<th>Both equally</th>
<th>NFC +</th>
<th>NFC ++</th>
<th>NFC +++</th>
</tr>
</thead>
<tbody>
<tr>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>
In the following question you can mark **more than one answer**. Please mark the answers that affect you. If you marked “Both equally” in the previous question, leave out this box.

<table>
<thead>
<tr>
<th>If you preferred QR-codes:</th>
<th>If you preferred NFC:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Why would you prefer QR-codes over NFC?</strong></td>
<td><strong>Why would you prefer NFC over QR-codes?</strong></td>
</tr>
<tr>
<td>o Because I already had experience with it</td>
<td>o Because I already had experience with it</td>
</tr>
<tr>
<td>o Because it is easier to get information</td>
<td>o Because it is easier to get information</td>
</tr>
<tr>
<td>o Because it is quicker</td>
<td>o Because it is quicker</td>
</tr>
<tr>
<td>o Because I think it consumes less battery</td>
<td>o Because I think it consumes less battery</td>
</tr>
<tr>
<td>o Because it looks less stupid</td>
<td>o Because it looks less stupid</td>
</tr>
<tr>
<td>o Other:</td>
<td>o Other:</td>
</tr>
</tbody>
</table>

You will now read a couple of statements. Please specify how far these statements apply to you.

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Slightly disagree</th>
<th>Neutral</th>
<th>Slightly agree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery consumption is important to me</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>A quick scanning process is important to me</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

The following questions only apply to QR-codes:

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Slightly disagree</th>
<th>Neutral</th>
<th>Slightly agree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is annoying that I have to open the app each time I want to scan a code</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>When the camera is opened, it takes too long to recognize the code</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Scanning the QR-code is simple</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Scanning a QR-code works quickly</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>I expect the battery consumption of the scanning process (opening app, scanning code) to be high</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

The following questions only apply to NFC:

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Slightly disagree</th>
<th>Neutral</th>
<th>Slightly agree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is annoying to hold the phone so close to the tag</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>It is annoying that I have to enable NFC manually</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>It takes too long to scan the tag</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Scanning the NFC tag is simple</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>Scanning a NFC tag works quickly</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>I expect the battery consumption of the scanning process (enable NFC) to be high</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

Thank you for filling out this questionnaire and being part in my survey.