User Acceptance and Usage Continuance of Interactivity Enabling Technologies

A mixed method approach to the evaluation of acceptance and usage continuance of NFC applications

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Abstract— **This paper presents the results of an exploratory study concerning user acceptance and usage continuance in the field of interactivity enabling technologies. Participants had the chance to try Near Field Communication (NFC) technology in four different usage scenarios and thereby assuming different specified roles. In the course of this usage experience, quantitative data was collected by means of traditional standardized acceptance research instruments (technology acceptance model, unified theory of acceptance and use of technology and expectation disconfirmation theory) and qualitative data was gathered in form of user comments. The data was then compared using a mixed method approach in order to find out whether traditional instruments are applicable to acceptance research of interactivity enabling technologies such as NFC. Our results show that applying traditional instruments will cause a significant loss of valuable information and the results are of limited relevance for the design of specific applications. It is, therefore, concluded as the main output of this paper that future acceptance research in this field will need to include qualitative data, but, at the same time enable collection of huge numbers of user opinions as standardized quantitative methods will provide.**

Keywords-technology acceptance; interactivity enabling technology; mixed method; TAM; UTAUT; expectation disconfirmation theory;

I. INTRODUCTION

Technology acceptance research is a crucial task in the development process of mobile applications. Acceptance is regarded as the adoption of a new technology and its further usage as many business models in this field are based on repeated usage. Specific characteristics of mobile devices enable their usage in highly dynamic contexts [1], which require dynamic methods of acceptance research. Traditional acceptance research might not be appropriate for this dynamic task as prior research did indicate shortcomings in the area of mobile technologies in general [2]-[4]. Many new applications are based on interactivity enabling technologies such as NFC. In the context of this research project, interactivity enabling technologies are defined as technologies that support or enable interaction between humans and objects or among humans by means of mobile devices. NFC is only one example of such an enabling technology. These technologies also require acceptance evaluation, but might not be assessed by traditional methods of acceptance research as the technology itself is not a perceivable characteristic of an application or service but acts as an enabler for it. The user might, therefore, not even be aware of the technology, which is the basis for the service or application. Nevertheless, it is inevitable to find out, which enabling technologies are acceptable, and which are not. The main research question in this paper is, therefore: How can acceptance and usage continuance of interactivity enabling technologies are assessed?

The research questions in detail are:

- Will application of traditional instruments of acceptance measurement provide useful information in the context of interactivity enabler technologies such as NFC?
- Are there similarities between acceptance factors that are observed by means of qualitative research and those measured by traditional acceptance instruments?

By addressing these questions in an exploratory study, it is intended to uncover potentials for future research in the area of interactivity enabling technologies and to gain a better understanding of unique characteristics of these technologies, which affect acceptance. In order to achieve this goal, user tests were conducted and several traditional commonly used instruments were applied as well as qualitative methods of data gathering in a mixed method setting. The comparison of the obtained results is the core issue of this paper. The remainder of this paper is organized as follows. In Section 2, the state of the art acceptance models are discussed together with commonly used methods of technology acceptance research. The methodology that was used for empirical testing is presented in Section 3 and results are provided and discussed in Section 4 followed by concluding remarks and an outlook on future research activities and questions.

II. STATE OF THE ART

The most often used model in technology acceptance research is Technology Acceptance Model (TAM), which explains acceptance by means of two key factors [5]:

- Perceived ease of use
- Perceived usefulness

Almost half of all papers in the area of mobile technology acceptance are based on this model [6]. Prior research did show that application of TAM might lead to inconsistent results. This is why process theories are recommended that include experience/feedback loops [7] and [8]. They enable researchers to capture dynamic

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processes and interaction between technological and organizational structures. In the original study [5] a follow up two weeks after initial data collection did also indicate significant changes of user perceptions over time.

Unified Theory of Acceptance and Use of Technology (UTAUT) is a compound model that includes elements of TAM and seven other models [9]. Among these models are motivational, social cognitive and diffusion models. The constructs included in UTAUT are:

- Performance expectancy
- Effort expectancy
- Attitude towards using technology
- Social influence
- Facilitating conditions
- Self-efficacy
- Anxiety
- Gender, age, experience and voluntariness of use as moderators
- Behavioral intention

Expectation-disconfirmation theory [10] is used in the field of technology acceptance research in order to "move from traditional static IT usage models (e.g., TAM, TPB, TAM2) to temporal models focusing on understanding fluctuation patterns of IT usage." [11]. The theory has been applied on TAM and data were gathered ex post [12] or as a two-stage research design where expectations are captured before usage and confirmation or disconfirmation after hands-on experience [13]. Three-stage designs were used to show that expectations will experience stabilization and become more consonant with experience after longer periods. This kind of research design includes different constructs in the questionnaires at three points in time (t1, t2, t3) [11]:

- Usefulness (t1, t2, t3)
- Attitude (t1, t2, t3)
- Disconfirmation (t2, t3)
- Satisfaction (t2, t3)
- Intention (t2, t3)

Many data collection methods for dynamic capturing of user behavior limit the number of possible data sets as they are time-consuming and laborious. This is especially true for shadowing where the researcher follows the user in the field and observes and documents the user behavior. In addition to a high expenditure of time it is also probable that the user is disturbed by the researcher in his natural environment [14]. A similar case is contextual field research where ethnographers capture user activities by means of photos and communication sequences and combine them with context information on a time line [15]. User generated content enables the collection of numerous user opinions that can be analyzed quantitatively or qualitatively. Most distribution platforms of mobile applications, e.g., Apples AppStore, include user generated content in form of user reviews. These text documents benefit from the voluntariness of their provision in contrast to questionnaire-based surveys, which limit the range of possible answers by standardization [16]. Another non-reactive method is behavior tracking, where user simulations are computed [17] in order to simulate for instance minimum requirements of service quality [18] or to document user mobility behavior [19]. Automated event protocols, however, disregard motives and causes of user behavior to a large extent.

III. METHODOLOGY

An exploratory approach was chosen in order to obtain valuable insights regarding actual user acceptance factors. Therefore, the study was designed according to state of the art methods and instruments of technology acceptance research and also includes further qualitative measures.

A. *Research Design*

Trialability is an important factor of technology acceptance measurement [20]. This is why there should be hands-on experience included in the test setting. Questionnaire-based surveys that rely on mere imagination of technologies, which the participant never used himself are not as valid as those conducted after usage experience though previous studies indicated that pre-prototype usefulness measures are able to approximate usefulness measures after hands-on experience quite well [21].

There are good reasons for field studies as well as in favor of lab studies. In the context of emotion capturing it is common to prefer field studies because users should experience technology in normal usage situations and emotions may be different in artificial laboratory setups [22]. Especially mobility as a key characteristic of mobile technologies is hard to simulate in lab studies. Nevertheless most evaluations of mobile systems are designed as laboratory tests [1]. Laboratory studies are preferred in cases that require experimental control of unknown variables and they simplify data collection [1]. For evaluation of product characteristics lab tests are commonly regarded to be sufficient [23]. We decided on an experimental approach as NFC is not a widely used technology yet. Applications are rare in the field and need to be tested in a lab environment. In order to reduce disadvantages of lab studies and to foster imagination of NFC application opportunities the test setting was designed as role plays. Two participants were interacting in predefined roles that were close to reality and in that role experienced different interactive NFC applications.

There were 30 participants of which 14 were male and 16 female. The age of the participants ranged from 20 to 40 and was 28.03 years on average with standard deviation of 4.97. Concerning the general attitude regarding new technology the sample appeared to be rather technology affine as depicted in Figure 1.

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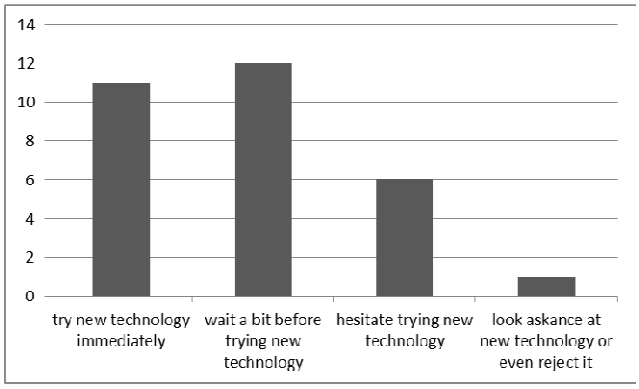

Figure 1. Technology affinity of the participants regarding their overall attitude towards new media and technologies.

B. Schedule

When the participants arrived at the test site they were introduced to interactive technologies by the example of NFC. A brief description of the technology was performed as oral presentation by the interviewer. Immediately after this introduction the participants were asked to fill in the first questionnaire concerning their expectations regarding NFC. The participants were then assigned to their roles.

In the course of the role plays, there were four tasks to perform:

- 1st task – user of social media

Imagine you are a user of Facebook. You have a Facebook account and have already updated your status and checked in at different places before. The name of your account is "Evo Laris". Further imagine you just came to our company and you would like to capture your first visit of the TecLab (laboratory with technical equipment where user tests usually take place) in form of an update status and check in.

Technical equipment: one NFC tag attached to a plain surface on the entrance door that initiates a status update and a check in when the NFC enabled mobile phone is within activation distance

- 2nd task – business meeting

Imagine you are person A (fictitious name equivalent to John Q. Public, in the following referred to as just "person A") and you meet person B (fictitious name, in the following referred to as just "person B") for business related reasons. Person B is a potential customer of person A and you never met before. After settling the details of a contract you want to interactively exchange contact information (name, phone number, email address, postal address) for further proceeding. In order to do this you can use the mobile phone.

Technical equipment: business cards for person A and person B including NFC tags that initiate the inclusion of contact data into the address book of the mobile phone when the NFC enabled mobile phone is within activation distance

- 3rd task – customer of a retailer for consumer electronics

You just bought a flat screen TV set. The device was delivered at your home and you set it into operation successfully. Your friend person B is interested in technical details concerning the device and you cannot find the manual at the moment. As the technical key points don't come to your mind immediately and the device is not self-explaining you want to get further information. In order to get this information you can use the mobile phone.

Technical equipment: one flat screen TV set with an NFC tag that is attached to its surface and initiates download of the manual when the NFC enabled mobile phone is within activation distance

- 4th task – participant of a fair

Imagine you participated in a congress. After you, person A, and your colleague, person B, entered the fair area you want to orientate yourselves. You want to get an overview of companies' display booths and their locations. Moreover you want to know who is going to present which topic and when. In order to get this information you can use the mobile phone.

Technical equipment: one NFC tag that that is attached to a plate with the conference name and NFC logo on it and initiates download of a congress program when the NFC enabled mobile phone is within activation distance

The necessary equipment for all four tasks was prepared in the TecLab and the participants were provided with NFC enabled mobile phones (Samsung Nexus S). As most participants were not familiar with the usage of this specific device they received a brief instruction to the handling and functionalities. During the tasks the interviewer took notes concerning observational data (duration of task accomplishment, did the participants try to solve the problems together, participant reactions) and some open question data (difficulty of the task, suitability of NFC for the specific situation, comments and suggestions for improvement).

Following to the tasks, the participants had to fill in the second questionnaire concerning their experiences with NFC technology.

C. Research Instruments

We used a mixed method approach including quantitative data from standardized questionnaires and qualitative data from user comments. Research instruments were adapted from traditional technology acceptance instruments. The first questionnaire was based on expectation disconfirmation theory [11] except for the construct perceived usefulness for which we used all the original TAM items [5].

The second questionnaire was based on TAM [5], UTAUT [9] and expectation-disconfirmation theory [11] and [24]. Several items of the performance expectancy scale were excluded because of redundancy with other scales and the scale for behavioral intention was also reduced as the different meanings of the three expressions were not translatable into German language. The items that were used are listed below:

Perceived usefulness [5]:

- All items from the original instrument.

Perceived ease of use [5]

- All items from the original instrument.

Performance expectancy [9]:

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- If I use NFC, I will increase my chances of getting a raise.

Attitude toward using technology [9]:

- All items from the original instrument.

Social influence [9]:

- All items from the original instrument.

Facilitating conditions [9]:

- All items from the original instrument.

Self-efficacy [9]:

- All items from the original instrument.

Anxiety [9]:

- All items from the original instrument.

Behavioural intention to use the system [9]:

- I intend to use NFC in the next <n> months.

Disconfirmation [11]:

- All items from the original instrument.

Satisfaction [11]:

- All items from the original instrument.

Attitude [11]:

- All items from the original instrument.

Intention [24]:

- I intend to continue using NFC rather than discontinue its use.
- My intentions are to continue using NFC than use any alternative means.
- If I could, I would like to discontinue my use of NFC.

In addition, the time span needed for task completion was documented as well as spontaneous reactions of the participants during the scenarios. The participants also had to grade the appropriateness of NFC technology for the specific task as well as the difficulty level of task completion on a scale ranging from 1 – very good to 5 - poor. After filling in the questionnaires they were asked to comment on the used research instruments.

IV. RESULTS AND DISCUSSION

We computed correlations among all constructs included in our questionnaire in order to find out, which constructs influence behavioral intention the most. The first step was the computation of mean values corresponding standard deviations for all constructs are listed in Table 1.

TABLE I. MEANS AND STANDARD DEVIATIONS OF ALL TESTED CONSTRUCTS

	Mean	Standard deviation	N
Disconfirmation (DIt2)	3.63	0.77	29
Perceived usefulness (PUt1)	4.43	1.63	30
Attitude (ATt1)	3.90	0.79	30
Perceived usefulness (PUt2)	3.96	1.92	30
Perceived ease of use (PEt2)	1.94	1.13	30
Attitude toward using technology (AUt2)	3.92	0.79	30
Social influence (SIt2)	2.43	1.08	29
Facilitating conditions (FCt2)	3.16	0.77	30
Self-efficacy (SEt2)	3.28	1.02	30
Anxiety (AXt2)	1.74	0.69	30
Satisfaction (SAt2)	3.96	0.64	30
Attitude (ATt2)	4.10	0.88	30
Intention (INt2)	3.82	0.91	30

TABLE II. CORRELATIONS AMONG CONSTRUCTS, N=29, *P<.05; **P<.01

	DIt2	PUt1	ATt1	PUt2	PEt2	AUt2	SIt2	FCt2	SEt2	AXt2	SAt2	ATt2
DIt2	1											
PUt1	-.35	1										
ATt1	.09	-.11	1									
PUt2	-.69**	.80**	.01	1								
PEt2	-.33	.10	-.07	.25	1							
AUt2	.74**	-.55**	.37*	-.78**	-.19	1						
SIt2	-.07	-.22	.16	-.18	-.37	0.13	1					
FCt2	-.32	-.04	-.20	.09	-.17	-.26	.36	1				
SEt2	.35	-.24	.04	-.28	-.31	.26	-.04	-.12	1			
AXt2	-.01	.05	.03	-.13	-.08	.11	.03	-.24	-.00	1		
SAt2	.56**	-.47**	.53**	-.55**	-.31	.86**	.26	-.09	.08	-.04	1	
ATt2	.37	-.34	.65**	-.36	.05	.63**	.08	-.16	.17	-.01	.66**	1
INt2	.61**	-.40*	.31	-.58**	-.04	.80**	.18	-.09	.09	-.07	.78**	.73**

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As the data were normally distributed, we applied Pearson product moment correlation [25] and found several highly significant results as listed in Table 2.

Intention to further use NFC is significantly related to the participants attitude towards NFC usage at t2 ($r = .80$, $p < .01$) as well is satisfaction ($r = .78$, $p < .01$). Social influence, facilitating conditions, self-efficacy and anxiety derived from UTAUT did not show any significant influence on other constructs.

Regarding TAM constructs perceived usefulness and perceived ease of use, the results are quite diverging. Perceived ease of use has no significant effects whereas perceived usefulness has highly significant effects at both points of measurement (t1, $r = -.40$, $p < .05$; t2, $r = -.58$, $p < .01$). The constructs from expectation-disconfirmation theory did all show at least one significant correlation with other constructs. Especially the construct satisfaction is in a highly significant correlation with attitude towards NFC usage ($r = .86$, $p < .01$) and the intention to further use NFC ($r = .78$, $p < .01$). These results indicate that expectation disconfirmation theory is more appropriate in the context of NFC acceptance than the other tested instruments as it provided more significant correlations among the constructs.

Additionally, we asked the participants for reasons why task completion was difficult/easy for them, whether they consider NFC appropriate for that particular task and further comments. 434 text items were collected in the course of that and analyzed concerning their content. The two main TAM constructs, ease of use and usefulness, occurred rather often in the user comments. Usefulness was mentioned 34 times and ease of use was addressed even 53 times, which represents more than 12 % of all comments. Nevertheless other topics were more important to the participants. The ability of NFC to act as a time-saver was named in 78 comments (18 %). Another 71 comments dealt with design issues such as font size, color, haptic characteristics etc. Other often named issues were content control concerning transferred data, performance, costs, compatibility with other technologies, fun and opportunities to automat processes. Moreover, the participants provided detailed information concerning the exact form of the different acceptance criteria like what exactly means easy to use to them. Other valuable information in the user comments were product suggestions. The most prominent suggestions were NFC applications for museums, business applications for employees of a company, library applications and NFC YouTube links.

According to these results research question two is answered as following: There are similarities between acceptance factors gathered by means of traditional acceptance research instruments and those from qualitative research, but the information users provide beyond standardized questionnaires is further detailed and also more design relevant.

These results indicated that the constructs tested in traditional acceptance research are important topics but often participants are biased because of the limited number of possible answers. A participant who highly agrees with a certain statement in a standardized questionnaire will not necessarily name this item as an important factor for further usage of the technology. Research question one can be answered as following: It is possible to apply traditional acceptance research instruments, but it will cause a loss of valuable information and neglects important acceptance factors.

V. CONCLUSION AND FUTURE WORK

Generalizability of our results is of course limited due to the relatively low number of participants, which was caused by the requirements of qualitative research but nevertheless our results indicate that traditional methods of technology acceptance research only show limited ability to capture participants' opinions concerning interactivity enabling technologies such as NFC. Acceptance of NFC seems to be a very dynamic issue and therefore expectation-disconfirmation theory provided the best results due to its dynamic (two-step) data gathering process. Standardized questionnaires are extremely useful instruments for technology acceptance research as they enable collection of numerous user opinions, but at the same time they hamper detection of really valuable information, which is uncovered by means of qualitative data gathering such as interviews or thinking aloud.

The challenge for the future will be a combination of both approaches, which enables exploration of many user opinions concerning their actual thoughts not limited to a small number of possible constructs. We, therefore, believe that it will be necessary to foster methods of automated text analysis in the field of technology acceptance research as users are providing us with an incredible amount of textual information concerning their experiences with technology in form of user generated content publicly available on the internet.

First attempts to apply this kind of data gathering methods on technology acceptance problems [16] did show that automated text analysis can be a very useful instrument and also provides in-depth insights into users actual opinions concerning technologies. Our next steps, therefore, are the further development of an automated text analysis framework in the context of technology acceptance research as well as a comparative analysis of methods available in the area of technology acceptance research in order to find out which are most appropriate for interactive technologies.

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