APPLYING SITUATION-SERVICE FIT TO PHYSICAL ENVIRONMENTS ENHANCED BY UBIQUITOUS INFORMATION SYSTEMS

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Abstract

Ubiquitous Information Systems (UIS) embedded in everyday environments are required to provide means for supporting complex behavioral task requirements. With the concept of a situation, we propose a knowledge level that can be used by users for understanding UIS-enhanced environments. It is discussed how the concept of situation differs from the concept of context. Situations are used to identify supporting services. At the core of this paper, we present how the Situation-Service Fit construct is used in early design stages (study 1) and later during the prototype phase (study 2). In study 2 we introduce an instrument for three more detailed fit constructs, i.e., Behavior-Service Fit, Modality-Service Fit, and Spatial-Service Fit. By additional evaluation of constructs known from various technology acceptance theories, we provide an innovative instrument for investigating UIS during the whole design cycle.

Keywords: situation-service fit, task-technology fit, ubiquitous information systems, design science empirical study, adoption of innovation.

1 Introduction

Ubiquitous Computing, Pervasive Computing, and Ambient Intelligence have been characterized in many different ways. For instance "'Ambient Intelligence' implies intelligence that is all around us" (Maeda and Minami 2006) or "A vision of future daily life […] contains the assumption that intelligent technology should disappear into our environment to bring humans an easy and entertaining life" (Crutzen 2006). The diverse definitions assembled by (Cook, Augusto et al. 2009) highlight features that are expected from these technologies: context-aware, personalized, anticipatory, adaptive, transparent (i.e. disappearing), ubiquitous, and intelligent (Aarts 2004; Cook, Augusto et al. 2009).

With increasing use of information services for real-world environments, such as Google Street View etc., the question arises which guidance for designing these systems can be given by IS research. Several publications cope with qualitative and conceptual issues of Ubiquitous Computing and its impact on Information Systems in general (e.g., (Lyytinen and Yoo 2002; Yoo 2010)) but whether such systems fit to individual and group needs within particular situations is rarely investigated.

Recently Yoo framed this research under the umbrella of Experiential Computing (EC) and emphasized that resulting Information Systems will most likely have more impact on non-work situations than on traditionally focused work situations (Yoo 2010). By separation of three levels, i.e., organization, artifact and infrastructure, he poses six research opportunities for EC research by adopting a design science perspective: 1. Integration of digital and physical aspects of digitally mediated experience in everyday life, 2. Experience of small groups, 3. Impact on organizational structures, 4. Change the way we experience communities, 5. Material properties of digitalized everyday artifacts, and 6. Embedding of digitally mediated environments into existing environments. Information itself is perceived as part of artifacts that can process, communicate and store information.

Having this in mind, this does not open up just a new class of IS but a completely new domain. Previous understanding of IS in work situations where individual users sitting in cubicles interact with others via digital artifacts needs to be extended by situations where actors walk around in real-life situations, interact with physical entities, talk to friends, and start thinking about some future situations. The question is whether Ubiquitous Computing and other technologies can support actors in their daily lives, whether corresponding services are accepted, and whether they fit to requirements envisioned by actors for work and private situations.

Next we describe the theoretical background and deduce our concept of situation-service fit and a description of an example for an environment enhanced by a Ubiquitous Information System (UIS). In section 3, an empirical study for this UIS-enhanced environment is presented that combines technology acceptance with situations-service fit. In section 4, we discuss results and implications before we close with a summary (section 5).

2 Conceptual Development

2.1 Theoretical Background

Digital environments are increasingly embedded into everyday environments by computing technologies and thus utilize users in a wide range of activities (Yoo 2010). Bodily, physical, and extended individual and social experiences become important elements when designing Ubiquitous Information Systems (UIS) (Yoo 2010). In contrast to other Information Systems, UIS are not generally provided by a single point of contact, e.g. a PC input-output device, but by a set of artifacts. Thus, UIS adopt a more organic approach by which interactions with users are supported by multiple artifacts. For instance, a user starts communication with a remote user via a voice channel embedded into a table but after moving to a different room this communication channel is seamlessly provided by a TV set and now supported by an additional video stream. As part of this, UIS connect physical artifacts with digital worlds and also connects local services with remote services. Therefore orchestration and adaptation of physical artifacts, services, and contents to user behavior and user needs are core functionalities of any UIS (Lyytinen & Yoo 2002, Yoo 2010).

An intrinsic part of everyday life is it's variability and unpredictability that contrasts with organized environments, such as firms (e.g., (Lyytinen and Yoo 2002)). Thus designs for service systems in UIS can only make reduced assumptions at design time and must provide flexibility and adaptivity to cope with changed environments. In contrast to traditional Information Systems, UIS in everyday life cope with weakly structured environments. The human cognitive system has learned to handle resulting complexities by selection mechanisms, e.g., attention giving, knowledge chunking, short-term, and ultra-short-term memories (e.g., (Simon 1974; Baddeley 1999; Logan 2002)). In an analog way, researchers on Ubiquitous Computing have introduced 'context' as a key concept. According to Dey's influential understanding, "[c]ontext is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." (Dey 2001). Thus, context is a representation of all relevant entities in a situation. Relevance indicates that not all context information must be used in a particular situation but provides a superset of information. In order to understand the concept of a situation, we define it as follows: a situation is any information that is used to describe the active part of a context of an entity. An entity is a person, place, or physical or information object that is considered relevant to the actual interaction between users and services. Several remarks shall be given for this definition. First, similar to context a situation is a model that can be coded by a representation. Second a situation is only instantiated by those entities of a context that are directly used. Thus, the concept of a situation relates to discourse in language processing (Grosz and Sidner 1986). Third and in extension to Dey's context definition, we distinguish between physical objects and information objects. Information objects, such as a news item coded on the physical object paper, can be part of a situation itself while the description of a situation references its existence independent of the information object as such. Therefore we distinguish between information objects as part of an informationsphere and situations. Note that the latter can become part of an informationsphere if the description of a situation becomes accessible via an external representation, e.g. a written novel. Fourth, applications are replaced by services because applications emphasize the computational program aspect that "performs one of the major tasks for which a computer is used" (Merriam-Webster) while "services are deeds, processes, and performances" (Zeithaml and Bittner 2008) that emphasizes more its importance for users rather than computational machinery. Fifth, a situation is directly used to guide enactment of user behaviors and services' performances. In summary, context describes the potential in an environment while situations are used for actual behavior and performances. In a nutshell, context is an informational superset of descriptions of situations but this relationship might be more complex.

2.2 Situation-Service Fitness

Situated communication and collaboration of user groups in highly dynamic and context-dependent physical environments are far more complex than well-structured online environments (Dey and Abowd 1999). UIS-enhanced environments adopting the concept of situations must not only support logically coherent activities of users by its functionality but also with respect to requirements on contents, social organization, interactions, and supporting services (Maass and Janzen 2011). This will be elaborated with respect to services.

Interactions with environments can be either social, i.e. used for interaction and in particular communication with other social actors, or individual, i.e. use of services provided by a particular environment. Social interactions can be direct if actors are present or co-present during interactions. Otherwise interactions are indirect. A similar distinction can be made for services. An interaction with a service is direct if the actor can use an interface that she perceives as being an integral part of a service. These services are called interface services. Other services are hidden from direct interactions and require interface services for indirect interaction by the actor. It is a question of design whether a service is provided as an interface service or as an indirect service. All services that can be used in a particular context are part of a service system. Service systems can dynamically change dependent or independent of user activities. In general actors have learned to regularly update their mental representations of the available service system in a context and a situation. Adaptive environments try to reverse this perspective by reconfiguration of services according to actor behaviors. It shall be noted that reconfiguration of services should not conflict with an actor's mental service representation because this would increase service misfit that, in turn, would lead to a misfit between an actor's intentions and services provided in a particular situation. Eventually an increased misfit between an actor's expectations towards a services system for achieving certain goals and actually provided services lead to reduced performance within a situation. Therefore, we expect that perceived situation-service fitness is an indicator how well a service is perceived to support user requirements for achieving particular goals in a situation.

Task-technology fit theory (TTF) argues that the better the fit between a technology and a task the better the performance (Goodhue and Thompson 1995; Fuller and Dennis 2009). TTF is defined as the degree to which a technology complies with the requirements of the task and the ability of the individuals performing it (ibd.). Contrary this means that poor fit induces poor performance. Thus, technology fit is an antecedent for performance. Tasks are descriptions of activities in the sense that they are "behavioral requirements for accomplishing stated goals, via some processes, using given information" (Zigurs and Buckland 1998). Technology is the means by which individuals implement tasks (Goodhue and Thompson 1995). Fit describes the match between requirements given by the task and the perceived capability of the particular technology to fulfill these requirements (Goodhue and Thompson 1995).

In contrast to controlled situations in business environments, everyday life situations are rarely structured by well-defined tasks. In a household, for instance, a user quickly switches between many tasks and even running various tasks in parallel. Some tasks, such as keeping a baby calm, are even not rationalized, barely structured, and based on implicit knowledge. Actors switch between situations such as actors on stage switch between one act and another. It is not a task that poses direct behavioral requirements but a complete situation. Different competing tasks might be implemented for accomplishing one particular goal in a situation while the situation itself is agnostic to task implementations. This complies with Yoo's concept of Experiential Computing that calls for a reorientation of the focus from task performance and information processing to lived experiences of everyday life activities that are digitally mediated (Yoo 2010). He adds: "[u]ser needs are, therefore, much broader than informational needs for task performance in organizations, reflecting deeper basic human needs and values." (Yoo 2010). Hence, situations can be understood as patterns that constrain and orchestrate complex interactions of actors based on service systems, informationsphere and physical object systems.

Technology as a term is loosely defined in TTF. It can encompass just functional interfaces but also systems of software applications and even hardware (Goodhue and Thompson 1995). Because in UIS the unique type of physical objects subsumes physical entities, we distinguish between services as performances provided to actors and physical objects. Hence, we abstract from underlying technologies as envisioned by researchers on Ubiquitous Computing.

Pulling everything together, we can define Situation-Service Fit (SSF) as a perceived degree of match between a service and a situation. Following TTF, SSF theory hypotheses that the better the match between service and situation, the better the individual or group performance within a situation.

Because situations are complex descriptions consisting of subordinated ontological entities (Maass and Janzen 2011), evaluation of SSF needs to be broken down into finer matches. This approach resembles the eight factors approach proposed by (Goodhue and Thompson 1995):

- *Behavior-Service Fit*: measures the match between a service with individual or group behavior.
- *Modality-Service Fit*: measures the match between a modality used by a service for content presentation and interaction with requirements of a situation (particularly resembles the factors of quality and compatibility in TTF (Goodhue and Thompson 1995)).
- *Spatial-Service Fit*: measures the degree of match between the physical location of a service and requirements of a situation (resembles the locatability factor in TTF (Goodhue and Thompson 1995)).
- *Situation-Service Fit*: measures an individual's perception of the match between a service and requirements of a situation in general.

This approach could be extended by the TTF's reliability factor. Other factors, such as authorization and production timeliness tend to be a bit out of scope for UIS. The technology acceptance model can be used to test TTF's ease of use for a service within a situation.

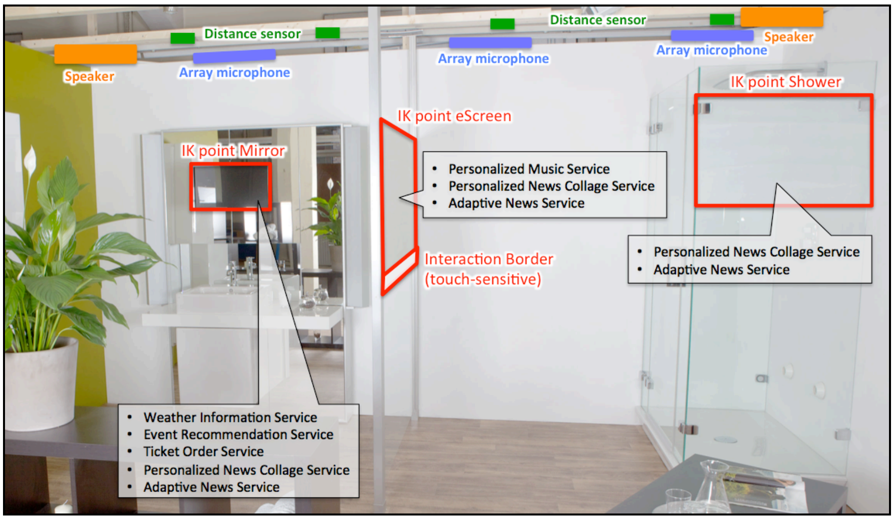

Fig. 1. *Spatial placement of the six information and communication services*

In the following section, we briefly describe the physical environment and the embedded UIS of an *Intelligent Bathroom* (IB) before we present the empirical study.

2.3 Example: Intelligent Bathroom

There are diverse settings in which UIS can impact human's life, for instance education, smart homes, health monitoring and assistance, workplaces. (Cook, Augusto et al. 2009) present an overview of research projects addressing the different settings. An intelligent bathroom is part of a smart home environment. Diverse artifacts and items in smart homes can be enriched with sensors to gather information and even act independently with or without human intervention (Cook, Augusto et al. 2009). (Friedewald, Costa et al.)(2005) specified four basic functions that are covered by UIS in these home environments: (1) home automation; (2) communication and socialization; (3) rest, refreshing, entertainment and sport; and (4) working and learning.

For the development of the intelligent bathroom, we will focus on functions (2) and (3). The bathroom is already characterized by well-defined activities. Based on usage analyses, Lashina (2004) identifies three main application areas especially in the bathroom: infotainment, healthcare and beauty care. In general, changes in the use of private bathroom spaces have been observed. Thus the solely functional space for personal hygiene transforms to a center of care and comfort. This tendency is confirmed by the increasing number of private Jacuzzis, allocation of rising amount of space to the bathroom, more differentiated design of bathrooms and the trend in using electronics in the bathroom (Lashina 2004).

UIS in intelligent environments support situations in which actors accomplish goals via "hands-free" interactions with services for getting access to information, communication, and entertainment (Ducatel, Bogdanowicz et al. 2001; Aarts and Roovers 2003).

3 Empirical Study Design and Conduct

The first phase on situation and service selection is only sketched for subsequent references. The second phase is based on situations and services selected in the first phase.

3.1 Phase 1: Situation and Service Selection

By workshops with product designers, a set of 12 situations were collected and empirically tested in three European countries. After normalization and formalization of these situations, all situations were empirically evaluated with a special focus on services that appear in situations (cf. Table *1*).

Rank	Situation	Service		IU1		PF	
		No	Name	Mean	SD	Mean	SD
1.	6	4	Personalized Music Service	6.28***	0.87	6.07***	1.13
2.	1	1	Weather Information Service	5.64***	1.54	4.87***	1.69
3.	6	5	Personalized News Collage Service	5.11***	1.94	4.84***	1.83
4.	1	2	Event Recommendation Service	4.65***	1.69	4.12	1.65
5.	11	6	Adaptive News Service	4.17	1.85	3.88	1.82
6.	1	3	Ticket Order Service	3.82	1.73	3.47**	1.77

Table 1. *Ranking of the six services based on the mean values of the two factors intention to use (IU1) and perceived fit (PF) averaged over all four regions (n=111). Note: *** p < .001 and ** p < .01 based one sample t-tests with a test value of 4 indicating significant differences from the mean value on the seven-point Likert scale.*

Situations with top-rated services (situations 1, 6, and 11) were selected, realized and embedded into the UIS of the Intelligent Bathroom (IB) (cf. section 2.3).

3.2 Phase 2: Empirical Evaluation of Adoption of Situations and Services

In a subsequent lab experiment, we have used traditional adoption constructs (perceived ease of use, perceived usefulness, intention to use) for a better understanding whether services within provided situations are adopted on a rational level and perceived enjoyment as an indicator for the emotional side. Furthermore we have evaluated all three situation-service fitness factors and the overall fitness factor. In the following sections, method, results and discussion of results of the lab experiment are provided.

3.2.1 Method

The evaluation procedure consisted of four steps. First, subjects were given an introduction to the project and were briefly introduced in the use of the IB environment with regard to a particular situation. Second, the subjects played through that situation twice to account for learning effects and to get more reliable evaluations afterwards. Third, each subject had to evaluate the situation and its embedded information and communication services by a questionnaire. The objective of this questionnaire was to get quantitative evaluations. In general, the subjects were allowed to ask questions throughout the experiment. In addition, the supervisor supported the subjects in case a service did not work as expected (e.g., a pre-defined speech command was not recognized).

Due to the unbalanced situation-service distribution (e.g., Situation 1 was comprised of three services whereas Situation 3 just employed one service) and the corresponding unbalanced evaluation time, we decided that each subject had to evaluate three services. Subjects were therefore assigned to either Group A (Situation 1 – three services) or Group B (Situation 6 with two services and Situation 11 with one service) in advance of each experimental run. As a result, Situation 6 and 11 were combined and each subject required no more than 30 minutes for all three steps.

Group	Situation	Textual Description	Service
A	1	Situation 1: It's Thursday morning. I get site-specific weather information when I am brushing my teeth in the bathroom. Based on weather information and my calendar, free-time event suggestions are given (e.g., Today, 8 p.m. – Sneak preview at CinemaOne). Do you want to order tickets?	Weather Information Event Recommendation Ticket Order
B	6, 11	Situation 6: Happily, it's Saturday morning. My partner takes a shower listening to his favorite music. Leaving the bathroom, I step into the room. Situation 11: I am welcomed by music from my own music collection. The music starts at the point in the playlist where I stopped listening the evening before. I stop the music by a hand gesture because I want to take a shower. While I take a shower my personal news collage is displayed. Having finished the shower, I dry myself with a towel and then brush my teeth. At the same time, I can take the news with me.	Personalized Music Personalized News Collage Adaptive News

Table 2. Experimental design, assignment of groups, situations and services

The sampling procedure was as follows. We e-mailed an invitation to all students that are studying or had studied at a department for Digital Media at a European University. Only the first 55 subjects were allowed to participate and to receive 5 Euro after the experiment. The spatial placement of the six information and communication services and the physical composition of the bathroom is shown in Fig. 1.

Table 3 provides an overview of the implemented input and output functionality for each of the six services.

#	Service	Input	Output
1	Weather Information	Distance sensor – in front of the mirror	IK point Mirror: Today's weather information is displayed
2	Event Recommendation	Distance sensor – in front of the mirror	IK point Mirror: Three events are displayed
3	Ticket Order	Step 1: Distance sensor – In front of the mirror and event recommendations are displayed Step 2: IK point Mirror: Ticket order request by touching an event Step 3: Array microphone: Acceptance or rejection of the ticket order request by voice command "yes" or "no".	Speaker: Verification question after Step 2: "Do you want to order tickets for the event …?"
4	Personalized Music	Option 1: Distance sensor – in front of the wall screen: Starts the playlist Option 2: IK point eScreen: wiping along the touch-sensitive interaction border stops the music	Speaker for the music and Wall Screen showing the current song of the playlist visually.
5	Personalized	IK point Shower: The following voice	Location A: Subject stands in front of the IK

	News Collage	command starts the personalized news collage service: "Bathroom … [brief feedback tweet by the system via speaker] … what are the news?"	point Mirror: the personalized news collage is displayed in form of text. Thus, only the mirror touchscreen is used. Location B: Subject stands in front of the IK point eScreen: the personalized news collage is displayed as a video clip. Thus, speaker and IK point eScreen present the content. Location C: Subject stands in front of the IK point Shower: the personalized news collage is displayed as a video clip. Thus, speaker and IK point Shower present the content.
6	Adaptive News	Distance sensor – in front of the IK points Mirror, eScreen or Shower.	See above, personalized news collage service. Depending on the location, the news adapt to the current location of the subject.

Table 3. Input and output functionality of the six information and communication services as implemented during the lab.

For the development of the questionnaire, we adopted Technology Acceptance constructs from (Moore and Benbasat 1991; Wixom and Todd 2005; Kamis, Koufaris et al. 2008). The constructs perceived usefulness, perceived ease of use, perceived enjoyment and behavioral intention to use were adapted from (Wixom and Todd 2005) and (Kamis, Koufaris et al. 2008). We further used the compatibility construct of (Rogers 2003) and (Moore and Benbasat 1991) to measure the degree to which the services fit to the subjects' behavior and the situation, which also includes spatial placement and modality of the services. Before the questionnaire items were presented to the subjects, a concise definition of each service was provided. Consistent with prior work we used seven-point Likert scales ranging from very unlikely (1) to very likely (7) for the items. The questionnaire items are shown in Table 4.

The interviews were finally conducted to ask for any problems the subjects had to deal with during the lab experiment. Among questions on the appropriateness of the spatial placement and modality of the various services, subjects were also asked for any improvements with regard to ease of use and missing functionality.

No.	Construct and scale item wording
	Perceived enjoyment
PEN1	Using the […] service in the bathroom was fun.
PEN2	My attitude toward using the […] service in the bathroom is positive.
PEN3	Using the […] service was in the bathroom a pleasant experience.
PEN4	Using the […] service in the bathroom was very interesting.
	Perceived Usefulness
PU1	Using the […] service in the bathroom would increase my effectiveness.
PU2	Using the […] service in the bathroom would increase my efficiency.
PU3	Using the […] service in the bathroom would increase my overall performance.
PU4	I would find the […] service useful in the bathroom.
	Perceived ease of use
PEU1	Using the […] service was easy for me.
PEU2	My interaction with the […] service was clear and understandable.
PEU3	Learning to use the […] service was easy for me.
PEU4	It was easy for me to become skillful at using the […] service.
	Intention to use
IU	I would use the […] service in the bathroom.
	Fit of service and situation, behavior, modality and spatial placement
Situation-Service Fit	The […] service fits well to the situation I just played through.
Behavior-Service Fit	Using the […] service in the bathroom would fit well to my behavior.
Modality-Service Fit	I found that the modality of content presentation fits well to the […] service.
Spatial-Service Fit	I found that the spatial placement of the contents fits well to the […] service.

Table 4. Questionnaire items. Note: […] was replaced with the corresponding service.

3.2.2 Results

Overall, 55 subjects participated in the lab experiment during the last week in June 2011. Group A (Situation 1, Services 1-3) was comprised of 10 male and 17 female subjects with ages ranging from 20 to 24 (n=19), 25 to 29 (n=4), and 30 to 34 (n=4). By contrast, Group B (Situations 6 and 11, Services 4-6) had 12 male and 16 female subjects with ages below 20 (n=1), from 20 to 24 (n=17), 25-29 (n=7), and 30-34 (n=3). The descriptive statistics are shown in Table 5 for each service.

In order to test the reliability of the measurement scales for perceived enjoyment, perceived usefulness and perceived ease of use, Cronbach's Alpha values were calculated. All values lie above the recommended threshold of .70 (Nunnally 1967) and thus, all scales for all six services can be said to be reliable. Accordingly, the aggregated scores, i.e. mean value and standard deviation have been calculated, too (cf. Table 5).

The mean values of each construct have been further tested whether they lie significantly above or below the neutral scale value of 4 (neither). The significance of these one-sample t-tests are also provided in Table 5.

Item	**Weather Inform.**	**Event Recomm.**	**Ticket Order**	**Person. Music**	**Pers. News Collage**	**Adaptive News**
	Group A, n=27			**Group B, n=28**		
Perceived enjoyment						
PEN	**5.78*** (0.94)**	**5.36*** (1.02)**	**4.87** (1.42)**	**6.26*** (0.60)**	**5.63*** (1.06)**	**6.04*** (0.76)**
Perceived usefulness						
PU	**5.77*** (0.93)**	**4.77** (1.27)**	**4.14 (1.41)**	**5.50*** (1.23)**	**4.57* (1.46)**	**4.72* (1.49)**
Perceived ease of use						
PEU	**6.21*** (0.86)**	**5.81*** (0.85)**	**5.22*** (1.36)**	**6.25*** (0.79)**	**5.55*** (1.17)**	**6.40*** (0.71)**
Intention to use						
IU	6.33*** (0.73)	4.67* (1.52)	3.78 (1.74)	6.75*** (0.52)	4.86* (1.78)	5.14** (1.56)
Fit of service and situation, behavior, modality and spatial placement						
Situation-Service Fit	6.19*** (0.96)	5.52*** (1.01)	5.19*** (1.06)	6.29*** (0.94)	5.64*** (1.31)	5.79*** (1.07)
Behavior-Service Fit	6.07*** (1.17)	4.48 (1.76)	3.93 (1.71)	6.54*** (0.79)	4.86** (1.63)	5.11** (1.64)
Modality-Service Fit	5.15*** (1.38)	5.04** (1.40)	4.74** (1.23)	5.25*** (1.53)	5.79*** (1.40)	5.36*** (1.50)
Spatial-Service Fit	5.41*** (1.60)	4.85** (1.49)	4.63* (1.52)	5.96*** (0.74)	5.68*** (1.16)	5.96*** (1.04)

*Table 5. Descriptive statistics. Note: the following format is used: Mean (Standard deviation) * = p < .05 / ** = p < .01 / *** = p < .001, where the p-values are derived from one-sample t-test with a test value of 4.*

In addition to the quantitative data of the questionnaire-based results above, the subjects' feedback related to the six information and communication services and general remarks from the interviews was categorized into four topics: (1) interaction, (2) spatial placement, (3) presentation quality, and (4) missing functionality.

3.2.3 Discussion

In this paragraph, the results of the lab experiment are discussed and suggestions for an improvement of the bathroom environment are provided. First of all and according to the results of the descriptive statistics provided in Table 5, subjects found that all services were perceived enjoyable and fun to use.

Only the ticket order service was perceived less enjoyable in comparison to the others (mean = 4.87 at the .01 significance level). This may indicate that a ticket ordering process involves a business transaction, in which rational mental processing is required and this rational factor may suppress perceived enjoyment to some degree. Second, weather information service and personalized music service were perceived as most useful, followed by the event recommendation service, personalized news collage service and adaptive news service. Only the ticket order service was not significantly perceived as useful as the other services. Third, all six services were easy to use because all aggregated ease of use scores lie significantly above the mean values at the highest level of significance ($p < .001$). Ease of use of the adaptive news service was rated highest, which can be explained by its implicit interaction, i.e. subjects had only to move around to take the news with them and thus, no explicit interaction such as a voice command or a touching gesture was required. Fourth, subjects intend to use predominantly the weather information service and the personalized music service in the bathroom. These results are consistent with the usefulness evaluations. Moreover, the behavioral intentions to use the ticket order service have been rated negatively, however, the negative ratings are not significant.

Fifth, regarding the fit of service with its offered modality and spatial placement, the bathroom situation and subject's behavior, all services performed well overall resulting in high fit scores. Only the event recommendation service and ticket order service do not fit very well to the subjects' behavior in the bathroom. One reason may lie in the current design of the implementation; another reason may be that event recommendations and related ticket purchase decisions do not fit very well with subject's morning rituals.

Finally, it must be stated that the results and implications of this experiment are based on a sample of students with a technical background. Thus, these results might be biased in the sense that technology-savvy subjects have participated. Nonetheless, those subjects are also potential customers of bath furniture companies, and in particular of those companies that will provide content-enhanced interactive bathroom environments as being tested by the IB.

4 General Discussion

Beside task characteristics and technology specifications, use context related fit has been identified as an additional significant antecedent for overall technology evaluation of mobile information systems (Gebauer and Ginsburg 2009). Compliant with these findings, our sequence of studies on UIS-enhanced environments shows that the concept of a situation is an important means for structuring complex activities in everyday life environments. In our first study it gave users a reference system for anchoring services. In our second study a test-person's understanding of a situation allowed her to use the bathroom and to provide scores on acceptance and fit of services with respect to situations. It must be noted that it was unclear at the beginning of this project three years ago whether the concept of a situation instead of the weaker concept of context will be the right level of analysis.

In both studies, acceptance constructs and in particular intention to use provided a stable anchor-point for the design of the Intelligent Bathroom. Services that scored weak in the first study, also showed deficiencies in the second study and vice versa. All services scored significantly above the mean value. The two services that ranked highest during the first study also ranked highest in the second study with an actual IB prototype. The same holds for the weakest service but it must be noted that the ticket service was already selected from a set of other services that ranked lower in the first study.

With respect to situation-service fitness both top-rated services scored highest on all three factors and overall. This could indicate that situation 1 and 6 should be merged and tested by an additional study.

Interesting are services with divergent service fit scores. For instance, mean values for the event recommendation service and the ticket order service are high and significantly above the neutral value for situation-service fit but show now significant difference for behavior-service fit. This might indicate a transfer effect of the general experience of the situation to the focused behavior-service fit valuation. Behavior-service fit is the only factor that requests an individual stance while the other factors can be answered from a neutral standpoint. If this can be confirmed by further research, divergence between situation-service fit and behavior-service fit could provide an important indicator for misleading UIS designs and even IS designs in general.

Results of these studies may support several generalizations. First, it can be argued that situational thinking is an appropriate level during all design phases for complex UIS, i.e. from textual descriptions, mock-ups, and full-scale integrations in physical environments. Therefore situations are not only used as a means for" discovery and validation of system requirements" (Sutcliffe, Maiden et al. 1998) but as a coherent understanding that guides a design team and other stakeholders throughout the whole design process. They are a means for thinking and communicating about envisioned interactions of users with UIS guided by a particular IS ontology (Maass and Janzen 2011).

Overall situation-service fit and targeted fit measures have been found to effectively support backward-linking of design decisions. They provide empirical means for cross-evaluation of design decisions of different design phases. It can be argued that our focus on services can be easily extended to other ontological entities, such as functionalities, graphical design elements, and economic types, e.g. pricing. Backward-linking of design decisions seems to be particularly important for complex and innovative IS projects that lack sufficient reference knowledge, such as UIS.

Our exploratory work in a multidisciplinary design team is far from being exhaustive. Further research should be targeted on a more complete set of empirical methods for backward-linking of design decisions. We have used traditional bathroom environments and textual, mock-ups, and full-scale prototypes for envisioned situations during our UIS design project. Virtual reality environments or theatre plays are additional means for testing UIS designs in particular design phases. Our approach of walking through prototypes needs further investigations in more detail. Other approach, such as “bodystorming” (Oulasvirta, Kurvinen et al. 2003), might enrich our understanding of envisioning innovative UIS in IS design projects.

5 Summary

Our sequence of studies provides evidence that the concept of a situation is a key element for designing UIS-enhanced environments. Constructs from traditional technology acceptance theories have proven to be robust and reliable indicators for time-series studies on a sequence of different UIS prototypes. The same conclusion holds for various perceived fitness measures. While we looked in our first study only on a single situation-service fit construct, we emphasized situation-service fit in a second study by adding three more detailed factors. Differences between overall situation-service fit and behavior-service fit might shed a light on an interesting effect that will require further research.

Even though that we were as carefully as possible to defend requirement creeps and other external forces, it is a permanent challenge to realize services exactly in a way that was intended in early design phases. Our results can be seen as an indicator for successful transfer of requirements from early phases to prototype stages. Nonetheless the complexity of UIS-enhanced environments is too high and our understanding is still in its infancies for drawing final conclusions. In subsequent studies we will work with more test-persons and conduct further in-depth cross-study analysis.

References

Aarts, E. (2004). "Ambient Intelligence: A Multimedia Perspective." IEEE MultiMedia **11**(1): 12-19.

Aarts, E. and R. Roovers (2003). IC Design Challenges for Ambient Intelligence. DATE '03: Proceedings of the conference on Design, Automation and Test in Europe. Washington, DC, USA, IEEE Computer Society**:** 1002.

Baddeley, A. D. (1999). Essentials of human memory. Hove, UK, Psychology Press.

Cook, D. J., J. C. Augusto, et al. (2009). "Ambient intelligence: Technologies, applications, and opportunities." Pervasive and Mobile Computing **5**: 277-298.
Crutzen, C. K. M. (2006). "Invisibility and the Meaning of Ambient Intelligence." International Review of Information Ethics **6**: 1-11.
Dey, A. and G. Abowd (1999). Towards a better understanding of context and context-awareness, College of Computing, Georgia Institute of Technology.
Dey, A. K. (2001). "Understanding and Using Context." Personal and Ubiquitous Computing **5**(1): 4-7.
Ducatel, K., M. Bogdanowicz, et al. (2001). Scenarios for Ambient Intelligence in 2010. I. A. Group.
Friedewald, M., O. D. Costa, et al. "Perspectives of am-bient intelligence in the home environment." Telemat. Inf. **22**(3): 221--238.
Fuller, R. M. and A. R. Dennis (2009). "Does Fit Matter? The Impact of Task-Technology Fit and Appropriation on Team Performance in Repeated Tasks." Information Systems Research **20**(1): 2-17.
Gebauer, J. and M. Ginsburg (2009). "Exploring the Black Box of Task-Technology Fit." Communications of the Acm **52**(1): 130-135.
Goodhue, D. L. and R. L. Thompson (1995). "Task-Technology Fit and Individual Performance." MIS Quarterly **9**: 213-236.
Grosz, B. J. and C. Sidner (1986). "Attention, Intention and the Structure of Discourse." Computational Linguistics **12**(3): 175-204.
Kamis, A., M. Koufaris, et al. (2008). "Using an Attribute-Based Decision Support System for User-Customized Products Online: An Experimental Investigation." MIS Quarterly **32**(1): 159-177.
Lashina, T. (2004). Intelligent Bathroom. Proceedings of European Symposium on Ambient Intelli-gence (EUSAI'04), Philips Research.
Logan, G. D. (2002). "An instance theory of attention and memory." Psychological Review **109**(2): 376-400.
Lyytinen, K. and Y. Yoo (2002). "Issues and Challenges in Ubiquitous Computing." Communication of the ACM **45**: 62-65.
Maass, W. and S. Janzen (2011). Pattern-Based Approach for Designing with Diagrammatic and Propositional Conceptual Models. 6th International Conference on Design Science Research in Information Systems and Technology (DESRIST). Milwaukee, WI.
Maeda, E. and Y. Minami (2006). Steps towards Ambient Intelligence. NTT Technical Review. **4:** 50-55.
Moore, G. C. and I. Benbasat (1991). "Development of an instrument to measure the percep-tions of adopting an information technology innovation." Information Systems Research **2**(3): 192-222.
Nunnally, J. C. (1967). Psychometric Theory. New York, McGraw-Hill.
Oulasvirta, A., E. Kurvinen, et al. (2003). "Understanding contexts by being there: case studies in bodystorming." Personal and Ubiquitous Computing **7**(2): 125-134.
Rogers, E. M. (2003). Diffusion of innovations. New York, Free Press.
Simon, H. A. (1974). "How big is a chunk?" Science **183**: 482-488.
Sutcliffe, A. G., N. A. M. Maiden, et al. (1998). "Supporting scenario-based requirements engineering." IEEE Transactions on Software Engineering **24**(12): 1072-1088.
Wixom, B. H. and P. A. Todd (2005). "A Theoretical Integration of User Satisfaction and Technology Acceptance." Information Systems Research **16**(1): 85-102.
Yoo, Y. (2010). "Computing in Everyday Life: A Call for Research on Experiential Computing." Mis Quarterly **34**(2): 213-231.
Zeithaml, V. and M. Bittner (2008). Services Marketing, McGraw-Hill.
Zigurs, I. and B. K. Buckland (1998). "A theory of task/technology fit and group support systems effectiveness." Mis Quarterly **22**(3): 313-334.