Acceptance of Future Workplace Systems:

How the Social Situation Influences the Usage Intention of

Ambient Intelligence Technologies in Work Environments

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This paper analyzes if, and in which extend, the social work situation influences the intention of potential users to employ Ambient Intelligence technologies in work environments. In a first step, existing application scenarios and prototype applications were analyzed to identify characteristic functionalities of future workplace systems. In the second step, it was tested whether potential end users are willing to employ the identified functionalities in different social situations. The results of the evaluation show, that the social work situation, in which a functionality is going to be used, has a highly significant influence on the participants' usage intention.

INTRODUCTION

Research in the area of information and communication technology is rapidly progressing, and a variety of new technologies are on the threshold to emerge. Some of these technologies have an immense potential to influence the design and functionality of future office technologies. Extrapolating the current development, we soon have to expect work environments, where computers are ubiquitously available in different forms and sizes. The increasing miniaturization of computer technology is expected to result in processors and sensors being integrated into more and more everyday objects, leading to the disappearance of traditional input and output media, such as keyboards, mice and screens (Bohn et al., 2005; Streitz et al., 2005). This coming 'post-PC' era will be characterized by environments, where computers no longer appear in form of a personal computer, and in which "a billion people are interacting with a million eBusinesses through a trillion interconnected intelligent devices" (Mattern, 2004).

This vision of a future, where people are surrounded by intelligent and intuitive interfaces embedded in their surrounding, is often described as 'Ambient Intelligence'. The concept of Ambient Intelligence (AmI) envisions the integration of tiny microelectronic processors and sensors into almost all everyday objects, which enables an environment to recognize and respond to the needs of users in an almost invisible way. The term Ambient Intelligence was coined within the European research community (see, e.g., Aarts et al., 2002 or Aarts and Marzano, 2003), as a reaction to the terms 'Ubiquitous Computing' and 'Pervasive Computing', which were introduced and frequently used by American researchers. In contrast to the more technical terms of Ubiquitous and Pervasive computing, Ambient Intelligence includes also aspects of Human-Computer Interaction and Artificial Intelligence. Hence, the emphasis of AmI developments is usually on greater user-friendliness, more efficient services, user empowerment and support of human interactions (Ducatel et al., 2001). Ambient Intelligence applications are characterized by a high degree of embeddedness, using computers integrated into the physical environments in order to provide a variety of context-adapted user services. Through the integration of information, communication and sensing technologies into existing office landscapes so-called 'smart office environments' will emerge. These environments will provide users with a variety of intelligent devices, which offer context-adapted services and assist their inhabitants in everyday activities.

A look at current research prototypes and application scenarios reveals, that many system designers aim to develop intelligent environments, in which networked computers anticipate user needs and proactively take actions on the users' behalf. In most cases, personalized services are automatically provided as soon as users are identified by the system. In this concept of 'Proactive Computing' (Tennenhouse, 2000), processes are fully automated and users do not have a chance to control (i.e., acknowledge or reject) the functionality that is provided. While such smart services might be helpful and appreciated in private work situations, the same types of services might lead to serious privacy violations in public work situations. Several user studies conducted over the last years show, that especially the loss of control and privacy violations, caused by missing control options, are the main concerns associate with the integration of Ambient Intelligence technologies in office environments.

RESEARCH GOAL AND APPROACH

Overall Research Goal

The main goal of this paper is to analyze if and in which extend the social situation actually influences the intention of potential users to employ Ambient Intelligence office technologies. It is expected that the social situation, in which a functionality is provided, has a significant impact on the participants' usage intention. As mentioned above, automatically providing personalized services might be appropriate in a private space, but can be a considerable privacy violation in a public or semi-public work situation (see also Friedewald et al., 2006 and Nissenbaum, 2004). Hence, the variance is expected to be especially severe for functionalities, that have the potential to violate individual user privacy.

Evaluation Concept

Over the last two decades, numerous studies about technology acceptance in work environments have been conducted. The technologies and applications being tested include, among others, e-mail programs (Davis, 1989; Straub et al., 1997; Karahanna et al., 1999; Agarwal and Prasad, 1998; Mao and Palvia, 2006), electronic commerce applications (McCloskey, 2003), word processors (Chau, 1996; Davis et al., 1989), electronic meeting systems (George, et al., 1992) and tools for computer-aided software engineering (Wynekoop, et al., 1992; Iivari, 1993).

In most cases well-established acceptance models were applied to study the adoption process of existing systems or applications, often with the goal of identifying the determinates that lead to the adoption. Hence, there are two significant differences between the overall goal of this paper and existing research in the area of technology acceptance. First, this paper aims to explore the usage intention of generic functionalities provided by future workplace systems, instead of studying a real-world adoption process. And second, most envisioned technologies are still in a prototype state or are not available at all. In some cases it would be possible to test individual services or specific system prototypes. But the insights gained in such evaluations would be application and technology specific, and therefore have only limited validity when it comes to the design of new workplace applications. Generalizing the findings obtained in these evaluations might even lead to misleading conclusions. For example, the rejection of system for personalized and context-adapted information presentation in multi-user applications does not necessarily mean, that such a system would not be appreciated by the same group of users in an individual work situation.

Therefore, it is of particular importance to abstract from specific technologies and concrete or singular application situations. This is achieved by employing a scenario-based evaluation approach instead of evaluating specific applications or systems. Using a systematically constructed application scenario enables participants to assess generic functionalities of future workplace systems, independent from the underlying technologies, interfaces and visualizations techniques. This guarantees that the feedback gained from potential users is not influenced by the way certain functionalities or user services are implemented.

However, the feedback gained in a scenario-based evaluation will only reflect the intentions of users to employ a specific functionality, but not the actual adoption of the functionality. Nevertheless, a variety of studies showed, that there is a strong correlation between the intention to use a technology and its actual usage. According to Ajzen (2002) the intention of users to use a technology defines whether they will actually use it or not. This assumption was also confirmed in several technology adoption studies (see, e.g., Lee et al., 2006). Therefore, it is assumed that the stated preference of users to employ a specific functionality will be a good predictor of their future adoption behavior.

FUNCTIONALITIES AND USAGE SITUATIONS

In a first step, an analysis of existing Ambient Intelligence literature was conducted in order to identify characteristic functionalities of future workplace systems as well as the social situations, in which they are expected to be used. The focus of this analysis was on work-related scenarios developed in Europe and the United States. During the review process it became evident, that several projects (e.g., *Amigo* or *AwareHome*) specifically concentrate on the home domain. In order to get a broader and more representative collection of scenario samples, elements of home scenarios were taken into account, if the functionalities described in these scenarios are also usable in the office domain.

Functionalities of Future Office Applications

In the course of the scenario analysis, 430 beneficial scenario elements were extracted from 63 scenario descriptions (see Röcker, 2009 for details). The scenario elements were assigned into 39 sub-groups, describing different types of functionalities (see Table 1). Depending on their functional properties, the sub-groups were clustered into six main groups. Nearly half of all scenario elements (48,38%) described either new interaction mechanisms (28,60%) or various forms of user adaptation (19,78%). The remaining scenario elements are distributed over the other four groups: Communication (18,14%), Personal Assistance (17,91%), Information (11,40%) and Office Management (5,12%).

Table 1: *Overview over main functionalities (N=430).*

Scenario Element		Percentage
A	**Communication**	**18,14%**
	A1 Synchronous Communication	3,49%
	A2 Asynchronous Communication	3,95%
	A3 Communication Support	10,70%
B	**Interaction**	**28,60%**
	B1 Input Interaction	9,77%
	B2 Information Output	17,21%
	B3 Automatic Device Configuration	1,63%
C	**Information**	**11,40%**
	C1 Activity Histories	6,98%
	C2 Easy Data Transfer	2,79%
	C3 Access	1,63%
D	**Adaptation**	**19,78%**
	D1 Personalization of Devices	2,56%
	D2 Adaptation Surrounding	9,30%
	D3 Context-Adapted Information Presentation	16,05%
	D4 Different Forms of Context-Adapted Service	1,40%
E	**Personal Assistance**	**17,91%**
	E1 Dynamic Task Scheduling	2,33%
	E2 Calendar Synchronization	1,16%
	E3 Navigation and Orientation	3,49%
	E4 Personal Reminder	3,95%
	E5 Recommendation	1,16%
	E6 Virtual Secretary	0,70%
	E7 Privacy Protection	7,21%
F	**Office Management**	**5,12%**
	F1 Facility Management	2,33%
	F2 Security and Access Control	2,79%

Usage Situations in Work Environments

The analyzed application scenarios and prototype applications show, that Ambient Intelligence technologies could be used in a variety of different contexts. Regarding the social surrounding of a user, there are three general situations, which have to be distinguished: private, semi-public and public work situations.

Private Work Situation. In private situations the user is within a personal space (usually a private office) where all her activities could neither be heard nor seen by others. The complete interaction with the system, including data input and output, is therefore not perceivable by outsiders. The private nature of the interaction is restricted to the physical world and the time the user is interaction with the system. It does not include data security aspects, like the inspection of private information through security breaches at a later point in time. Private usage situations might also take place in public or semi-public spaces, if users have private devices, which enable them to interact with personal or confidential information in such a way, that others are not able to interpret these interactions.

Semi-Public Work Situation. Within office environments, semi-public spaces describe locations, which are accessible by all members of a specific group. Depending on the size of the company, this could be the whole building or just an individual department. The members of this specific group are usually familiar with each other and jointly use the semi-public spaces. Examples for semi-public spaces include open plane offices, corridors or meeting rooms. Semi-public situations comprise all interactions, where multiple users are present in a semi-public area and which could (to a varying extend) be perceived by all people occupying this space.

Public Work Situation. Public situations are similar to semi-public situations, with the difference, that the people surrounding a user are (at least partly) unknown to him. Within the context of office environments, public situations are mostly restricted to meetings with external guests. Exceptions might occur in larger companies, where situations could maintain a public character, even if all involved persons are employees of the same company.

In theory, public situations can occur in office settings, but are relatively seldom compared to private and semi-public work situations. One notable exception are business trips. Part of the analyzed scenario elements also included work activities, which take place outside the office building in public spaces. The most prominent functionalities, described in these scenario elements, were navigation and recommendation services. Although business trips might be a considerable part of the daily routine for some office workers, the focus of this paper is on the adoption of Ambient Intelligence applications within office environments. As most work situations in office spaces are of private and semi-public nature, it was decided to only incorporate these two social situations into the study.

MATERIALS AND METHODS

Evaluation Scenario

As explained above, 39 different types of beneficial scenario elements were identified in the course of the scenario analysis. While it would be helpful to get feedback on all different types of functionalities, the number of scenario elements to be used in the evaluation, had to be reduced in order to avoid overloading participants in the study. Therefore, it was decided to test only the eight functionalities, most often addressed in existing scenario descriptions. The types of elements, integrated into the evaluation scenario, were based on the core functionalities listed in the following table.

Table 2: *Functionalities incorporated in the test scenario.*

Functionality	Percentage
1. Adaptation of Content to Single User	11,40%
2. Adaptation to Enhance Personal Well-Being	5,81%
3. Support of Personal Encounters	5,35%
4. Speech Input	4,65%
5. Ambient Displays	4,42%
6. Personal Reminder	3,95%
7. Asynchronous Communication	3,95%
8. Public Activity Histories	3,95%
Sum of Scenario Elements	**43,49%**

The set of scenario elements, chosen to develop the evaluation scenario, incorporated the functionalities of nearly half of all scenario elements, extracted from the various scenario descriptions (see Table 2). So, even if only the functionalities of eight sub-groups were tested, these functionalities seemed to be a good indication about applications and services, that will become part of smart office environments.

The evaluation scenario described an ordinary working day of two co-workers in a future office environment. All functionalities and situations, described within the scenario, were taken from existing scenario elements, extracted during the analysis. For each functionality, it was aimed to choose a scenario element, which is representative for the whole group of elements and provides an understandable description of the functionality itself. In order to make the evaluation scenario as realistic as possible, the main activities, described in the course of the scenario, are standard office activities, which should be familiar to most test persons.

Questionnaire

The scenario was presented to a target user population using a paper-based questionnaire. The participants were asked to assess their individual usage intention in two different social surroundings: a private work situation and a public work situation. To avoid any ambiguity in the assessment process, private and public work situations were explicitly described and potential consequences outlined. The following two definitions were used:

- *Private Work Situation*
  The complete interaction with the system as well as all input and output information is only available to the user himself. Others are not able to see or hear any activity related to the usage of a specific functionality.

- *Public Work Situation*
  The interaction with the system as well as input and output information could be potentially observed by colleagues, being present in the surrounding. This might lead to several consequences including privacy violations, if the provided information is of confidential nature or interruption of ongoing work activities and communication processes.

For each situation the participants were asked, whether they would use the presented functionality or not. The continuous feedback scales ranged from ‘never’ on one side to ‘always’ on the other side (see Figure 1).

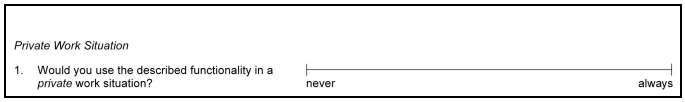

Figure 1: *Example question and rating scale.*

In order to evaluate the feedback provided by the participants, the continuous rating scales were transferred to 10-point scales later on in the evaluation. All rating scales used in the questionnaire were designed to be exactly 10cm long with the endpoints referring to the values of ‘0’ and ‘10’. For example, a rating of ‘0’ in the previous question means that the participant would never use the described functionality, while a rating of ‘10’ means, that she would always use it. For all other ratings, the distance to the left end of the scale was measured. The numeric value of this interval was then used as the level of agreement with the corresponding question. If a participant placed a ‘X’, for example, 4,7cm from the left end of the rating scale, this will be considered as a rating of 4,7 on a 10-point scale.

Participants

In the course of a cross-cultural user study (see Röcker, 2009), N=200 questionnaires were distributed to participants in Germany and the United States. For each country, N=100 questionnaires given out to participants with work experience in office environments. In total, N=161 persons returned their questionnaire, which resembles a return rate of 80,5%. Out of this group, N=96 came from Germany and N=65 from the United States. The overall population was nearly evenly distributed over male (49,1%) and female participants (50,9%), with slightly more males (52,1%) in Germany and slightly more female participants (55,4%) in the United States.

RESULTS

Usage Intention in Private Work Situations

Table 3 provides an overview over the usage intentions in private work situations. As explained above, the participants were asked to assess their intention to use a functionality on a scale ranging from never, represented by a ‘0’, to always, represented by a value of ‘10’.

In the overall group, the average intention to use a functionality is M=5,96. As shown in the table, the average usage intention of American participants (M=6,68) is considerable higher compared to German participants (M=5,47). The scenario elements describing personal reminder services (M=6,71; SD=2,55) and the adaptation to enhance personal well-being (M=7,21; SD=2,77) received the highest ratings of all elements. At the same time, speech input (M=5,04; SD=3,08) and services adapting content to a single user (M=5,37; SD=3,24) obtained the lowest ratings.

Table 3: *Usage intention in private work situations.*

Functionality		GER	USA	Overall
1. Adaptation of Content	Mean	5,11	5,75	5,37
	SD	3,35	3,04	3,24
2. Personal Well-Being	Mean	6,56	8,16	7,21
	SD	2,95	2,16	2,77
3. Personal Encounters	Mean	4,93	6,24	5,46
	SD	3,38	2,26	3,04
4. Speech Input	Mean	4,32	6,10	5,04
	SD	3,31	2,33	3,08
5. Ambient Displays	Mean	5,77	7,04	6,28
	SD	3,19	2,04	2,85
6. Personal Reminder	Mean	6,60	6,88	6,71
	SD	2,88	1,95	2,55
7. Asynchronous Communication	Mean	4,79	6,52	5,49
	SD	2,93	2,46	2,87
8. Public Activity Histories	Mean	5,69	6,73	6,11
	SD	3,12	2,32	2,86
Average Usage Intention	**Mean**	**5,47**	**6,68**	**5,96**

Table 4: *Usage intention in public work situations.*

Functionality		GER	USA	Overall
1. Adaptation of Content	Mean	4,33	3,82	4,12
	SD	3,25	3,05	3,17
2. Personal Well-Being	Mean	6,38	6,62	6,48
	SD	2,90	3,00	2,93
3. Personal Encounters	Mean	4,58	4,80	4,67
	SD	3,16	2,62	2,94
4. Speech Input	Mean	3,20	2,94	3,10
	SD	2,78	2,43	2,64
5. Ambient Displays	Mean	5,75	5,08	5,48
	SD	3,36	3,16	3,29
6. Personal Reminder	Mean	5,58	4,17	5,02
	SD	3,16	2,65	3,04
7. Asynchronous Communication	Mean	3,72	2,92	3,40
	SD	3,15	2,12	2,79
8. Public Activity Histories	Mean	4,31	3,88	4,14
	SD	3,09	2,93	3,03
Average Usage Intention	**Mean**	**4,73**	**4,28**	**4,55**

Usage Intention in Public Work Situations

An overview over the results regarding the usage intention in public work situations is presented in Table 4. The rating scale used in the questionnaire was the same as for the previous question.

An average rating of M=4,55 in the overall group indicates, that the participants would rather not use the described functionalities in public work situations. Nevertheless, some of the scenario elements received quite high ratings. Like in the previous situation, the adaptation of the physical surrounding was the preferred service of most participants. With a rating of M=6,48 (SD=2,93) such adaptation services got a considerable higher rating than ambient displays, the service with the second highest rating in the overall group (M=5,48; SD=3,29). With an average rating of M=5,02 (SD=3,04), personal reminders are the only other functionality, which received a rating higher than 5 in the overall group. The average ratings for all other functionalities are below 5. With average ratings of M=3,10 (SD=2,64) and M=3,40 (SD=2,79) in the overall group, speech input and asynchronous communication services, which ranged in the mid-field in private work situations, received the lowest ratings. This suggests that services, which require the usage of speech, either for input or output, are less accepted in public work situations. This can also be seen in the rating for personal reminder services. Although personal reminders are rated as the most useful functionality (see Table 3), they receive a comparably low rating with respect to the usage intention in public work situations (M=5,01; SD=3,04).

A detailed comparison of the usage intentions in private and public work situations is provided in the next section.

Influence of the Social Situation on the Usage Intention

As explained above, it was assumed that the social situation, in which a certain functionality is provided, has a significant impact on the participants' intention to use the functionality. The results gained in the study foster this assumption. Table 5 shows an overview over the influence of the social situation on the participants' intention to use a specific functionality.

Table 5: *Mean differences between private and public work situations.*

Functionality	GER	USA	Overall
1. Adaptation of Content	1,0579**	3,5785***	2,0819***
2. Personal Well-Being	1,3802**	2,8508***	1,9739***
3. Personal Encounters	0,1621	1,5462***	0,7244***
4. Speech Input	1,0198*	2,7365***	1,7000***
5. Ambient Displays	0,0208	1,9615***	0,8043***
6. Personal Reminder	1,1208***	3,1523***	1,9410***
7. Asynchronous Communication	0,2989	1,4385***	0,7619***
8. Public Activity Histories	0,7802*	1,9308***	1,2447***

* p≤0,05; ** p≤0,005; *** p≤0,001

In the American and overall group the social situation has a highly significant influence on the participants' usage intention. For all tested functionalities the differences between the usage intentions in private and public work situations are significant

on a 0,1%-level. The observed differences between the two social situations are less clear in the German sub-group. For all functionalities the mean differences between public and private situations are smaller than in the other two groups. For example, the average mean difference in the American group is MD=2,3994 compared to MD=0,7303 in the German group. As a consequence, only the differences for 5 out of 8 functionalities are statistically significant in the German sub-group. Nevertheless, the results statistically confirm, that the social situation has a significant impact on the decision of participants to use a specific functionality.

CONCLUSION

In general, potential end users seem to appreciate the illustrated functionalities in private work situations (M=5,96). Nevertheless, they are not overwhelmed by the possibilities Ambient Intelligence technologies offer, at least not in the office context. An overall mean value of M=4,55 in public work situations indicates, that the participants would rather not use the described functionalities in multi-user situations. Thus, the study was able to confirm the initial hypothesis, that the social situation significantly influences the participants' intention to use specific functionalities. The low willingness of participants to use the illustrated services in public work situation is likely to become a serious problem in future office environments, as the tendency to work in public and semi-public spaces is constantly increasing. Already today a change towards higher personal mobility is observable in most companies (see also Röcker, 2005; 2006). Even if employees are within the office building, they spend considerable time away from their own desk, working in meeting rooms, other offices or in the hallway (Lamming et al., 2000; Huang et al., 2004). According to estimations, white-collar workers spend between 25% and 70% of their daily working time in conferences or meetings with colleagues (Panko, 1992; Eldridge et al., 1994; Whittaker et al., 1994). Bellotti and Bly (1996) studied local mobility in a design company and observed an even higher level of personal mobility with people being away from their private workspace for around 90% of their time. Based on the current developments, it has to be assumed that future office environments will allow an even higher level of personal mobility than today's office concepts already do. Hence, the statistically confirmed impact of the social situation on the participants' decision to use the described functionalities should motivate designer to re-think their implementation strategies and develop services, that users are willing to use in public work spaces.

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