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Pertti Saariluoma, Editor in Chief

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From the Editor in Chief

FROM TECHNOLOGY TO THE HUMAN USER

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When thinking of users, it is possible to look at them from a variety of perspectives. One essential way of considering users within the human–technology environment involves technical concepts. In this manner, we define what users should be able to do with a particular technical system. As such, there are tasks to accomplish and goals to reach by means of some technology, and therefore specific operations must be carried out in order to reach those goals or fulfill those tasks. For example, if someone wishes to buy boots from an eShop, it is necessary to get onto the Internet, find the eShop, find the boots, load them into a virtual shopping cart, and follow the process to check out. Savvy online shoppers can do this quite effortlessly.

This example provides a perspective on human–technology that can be called technical. This view simply defines what it is that people need to do technically to successfully accomplish whatever it is that they want to do. Within this perspective, people are considered a subsystem of a particular technical system—actually, one of several subsystems that work together to accomplish an intended goal. And, like all of the subsystems, the human element needs to be seriously considered in planning how the technology will work, thus making it a necessary component of human–technology interaction. This represents a traditional perspective on the role of humans in the design of technology: If the interaction does not operate smoothly, no one will be able to reach the goal with that particular technology, and so the technology is useless. Therefore, a focus on the technical aspects of design is emphasized.

However, recent developments in technology design, and in particular design for online services, have raised the discussion about extending or rethinking the traditional view on human–technology interaction. People cannot—and should not—be viewed only as extensions of machines, or as simply one more element in a complex technological system. Thus, significant and fundamental changes are required in the theory language that provides an alternative to the technology-based analysis.

First, research has demonstrated clearly the reality that people cannot possibly do everything. The human mind is simply not capable of every potential process, and so machines can assist in many areas. However, even though the human can, generally speaking, succeed at a wide variety of functions, the success level of any given individual for any particular task is quite variable. For example, the interaction models that are commonly used are just too difficult

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for some people. As a result, some individuals find themselves excluded from the possibilities offered by certain technologies because they do not know how to access them to reach their desired goals. In some cases, it might be as simple as not knowing which buttons to push. In other cases, the individual is unaware of the potential offered by a particular technology system to help him/her achieve a goal or receive a service, or is misinformed about or unwilling to invest the time needed to understand the process. These and similar situations result in the challenge of the "under user": By ignorance, inability, or choice, these people do not access available technologies to achieve their goals or to manage their everyday processes. So within the technology design process, merely thinking through goals, tasks, and operations, and the subsystems to accomplish them, does not help with the final use environment. Ultimately, for adequate technology use, designers and engineers need to penetrate the psychological reasons for under use.

Yet, as noted above, the solution is not a matter of simply providing the user the capability to access the technology. Fundamentally, it is a matter of whether the people really *want* to use these new technologies and services, and this want draws on their preferences and likings. People need to like the technology or service (Norman, 2004). Because underlying emotional rationales affect people's decisions regarding their behavior—in this case, the use of a particular technology—the concepts and processes of traditional technical usability are not practical in solving the under use challenge.

Thus, while the technological perspective on human–technology interaction is necessary, it is not sufficient. The designer or engineer certainly must contemplate the various technological problems and how the various subsystems interact, but this approach overlooks the multitude of human dimensions within the human–technology interaction that have direct impact on the creation and usability of the technical dimensions. What is essential in solving this use and usability challenge is a more advanced and human-oriented approach to human–technology interaction and technology design. Quite simply, it means human–technology interaction begins with the conceiving, analyzing, and designing of technology through the lens of human research.

Fortunately, this new way of thinking about the human role in human–technology interaction is becoming more common. One typical example of the human-based interaction analysis idea is that of worth-based design (Cockton, 2004). In this approach to product design, the primary emphasis rests on the impact of interaction outcomes. ICT design decisions are based on the intended or desirable practical value for the user, from the user's perspective. In this case, *worth* does not refer to a moral value, but rather to the additional value the technology brings to the users who know about and want to use it. Cockton's approach illustrates the new thinking on interaction, and draws on a deeper-than-intuitive understanding of the human psyche as the essential element in human–technology interaction. Yet there is much to do in integrating this thinking within the technological design sector.

The key point in human-focused human–technology design is actually quite simple: Technology should exist not for itself, but rather for improving elements of human life. Therefore, the correct perspective toward technology and human–technology interaction would not be that humans are simply one more subsystem within a complex environment, but that human beings are diverse, multiskilled, multiexperienced, multimotivated creatures who can and do make explicit choices in the process of living. For technologies to serve their purpose in the vast opportunities of human life, they must be conceived, designed, and implemented based on the scientific analysis of human living and being.

This current issue of *Human Technology: An Interdisciplinary Journal of Humans in ICT Environments* draws together papers from researchers who have explored the human component of human–technology interaction. Whether the research focused on the purpose for and use of technology, or a rethinking of how one approaches studies on the human–technology interaction, these papers represent the essential perspective of the multidimensional human being in the use of technology or technology research.

User-centered, iterative technology research is the basis of the paper by **Jaime Sánchez**, whose research group designed and tested a variety of games designed to educate legally blind children in a Chilean school. Significant in this research is that every technical element of the software programs was researched and based on the students' mental model of stimuli processing, which is quite distinct from sighted children. Through iterative design and with ongoing feedback and input from the blind users, the researchers were able to map sounds and tactile feedback, which facilitated game designs to assist the blind students in achieving skills in mathematics, problem-solving, and object location and maneuvering within a virtual environment. Evaluative testing demonstrated that educational software for legally blind children designed for their particular ways of understanding the world around them can facilitate specific learning goals.

The increase in technology-supported activities raises the concern about how people view and rely on agent support while completing challenging tasks. **Shenghua Liu, Sacha Helfenstein** and **Ari Wahlstedt** explore some social-psychological aspects of agent communication with the user, with the goal of learning how algorithmically intelligent agents can also be more socially skillful in communicating with the user. Such research involves understanding the elements of trust, persuasion, and likability. Their results indicate in that human–agent interaction can be both productive and enjoyable with more communicatively skilled agents, but that the interaction must always confirm that the human remains autonomous during the task.

Ezejiofo Patrick Udeh investigated how various elements of two well-established initial acceptance models, the technology acceptance model and the diffusion of innovation theory, affect current and future use of free wireless fidelity hot spots. Issues such as relative advantage, ease of use, trust in technological systems, personal motivations toward innovation, and facilitating conditions can impact not only a user's openness to implementing a technology but also long-term use intentions. This study clearly supports the emphasis on the human psychological dispositions toward technology use as foundational in plans to enhance or expand free Wi-Fi access.

While it is easy to understand that social and human needs affect what technologies are conceived and developed, **Raul Pertierra** emphasizes in his paper how technology and its uses shape and are shaped by the cultural practices of, in this case, the Philippines. Cultural traditions and practices influence how a technology is absorbed into and used in daily life, reflecting and embodying issues related to social interaction, religion and beliefs regarding death and the supernatural, popular culture, and politics, to name a few. In this paper, the focus is on mobile phone use, yet clearly demonstrates that while a technology may be the same throughout the world, the social and communicative implications of that same technology can be quite diverse.

Turning from application to research, the paper by **John Karn, Joseph J. Ninan**, and **Marian Gheorghe** explores the human elements within the technology design process. Specifically, these authors followed seven project teams and their clients to observe and investigate whether agile methodologies for technology development, such as extreme programming, really do facilitate enhanced communication, decreased gaps in expectation, and improve client satisfaction during the design process. They conclude that, as with most human interaction, results will vary, depending on the communicative skill and interactive attitudes of the individuals involved.

Finally, **Antti Salov**aara underscores an emphasis on human creativity and adaptability in his discussion of technology design and the process of user appropriation. He explores a variety of approaches and research perspectives regarding how and why technologies are appropriated into alternative uses, but suggests that the social sciences approach, particularly ecological psychology and a focus on cognitive processes, can advance the discussion and understanding of the various human elements at play in not only the actual appropriation of technologies, but in creating and designing technologies to facilitate users in applying whole or partial elements of technology systems into processes not initially envisioned by the designers.

Taken as a whole, this issue of *Human Technology* provides clear demonstration of the advocated human-centered approach toward technology design, application, and research as it applies to the human role in human–technology interaction. The findings and discussions advance our understanding of the multifaceted and complex role humans play in technological advances created for the benefit of society.

REFERENCES

Cockton G. (2004). From quality in use to value in the world. In proceedings of the *Conference on Human Factors in Computing Systems* (pp. 1287–1290). Vienna, Austria: ACM. Available at http://doi.acm.org/10.1145/985921.986045

Norman, D. (2004). *Emotional design: Why we love (or hate) everyday things*. New York: Basic Books.

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USER-CENTERED TECHNOLOGIES FOR BLIND CHILDREN

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Abstract: *The purpose of this paper is to review, summarize, and illustrate research work involving four audio-based games created within a user-centered design methodology through successive usability tasks and evaluations. These games were designed by considering the mental model of blind children and their styles of interaction to perceive and process data and information. The goal of these games was to enhance the cognitive development of spatial structures, memory, haptic perception, mathematical skills, navigation and orientation, and problem solving of blind children. Findings indicate significant improvements in learning and cognition from using audio-based tools specially tailored for the blind. That is, technologies for blind children, carefully tailored through user-centered design approaches, can make a significant contribution to cognitive development of these children. This paper contributes new insight into the design and implementation of audio-based virtual environments to facilitate learning and cognition in blind children.*

Keywords: *blind children, user-centered design, audio-based interfaces, learning and cognition.*

INTRODUCTION

The increasing pace of technological growth and development has been difficult to follow for the average citizen. This situation is more critical for people with disabilities, since many of them do not have easy access to new technologies. The possibilities for them to access information and to work with technological devices are highly restricted, preventing them from becoming more active in a globalized world.

Although sighted users have many different mental models[1], similarities exist among people from the same culture and with similar experiences. Moreover, digital natives[2] and digital immigrants[3] have varying intuitive mental models that determine the pace at which they can access information and develop a diverse array of strategies, but they do not have any major difficulties in the long run.

Children with visual disabilities have entirely different ways to structure, order, and perceive the world, assuming a singular mental model quite distinct from sighted children. This

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is a major issue affecting access to digital technologies based on graphical user interfaces: Children with nonvisual mental models have to cope with devices designed for children with visual mental models. In this paper, the term *blind* refers to children who are either totally blind or have some residual vision (known collectively as legally blind).

Some research initiatives have incorporated screen readers and text-to-speech technology into diverse computing environments for people with visual disabilities, but these are not sufficient because the core applications are designed for a user with a rather different mental model (Pitt & Edwards, 1996; Weber, Kochaneck, Stephanidis, & Homatas, 1993). Virtual environments with three-dimensional (3D) sound[4] have been developed to help legally blind users construct a mental representation of a virtual environment and to develop cognitive abilities (Mereu & Kazman, 1996). Loomis, Lippa, Klatzky, and Golledge's (2002) field study sought to understand the spatial updating of locations specified by 3D sound and spatial language. Savidis, Stepanidis, Korte, Crispien, and Felbaum (1996) incorporated a direct manipulation system for hierarchical navigation in nonvisual interaction. Schneider and Strothotte (2000) studied the constructive exploration of spatial navigation by blind users. Kurniawan, Sporka, Nemec, and Slavik (2004) designed and fully evaluated a spatial audio system for blind children. The work of Morley, Petrie, O'Neill & McNally (1998) presented blind users with the task of developing navigational strategies in order to represent complex spatial structures that pose cognitive difficulties to these users. This system was developed for use with various output devices, such as a concept keyboard, tablets, haptic interfaces (Lange, 1999), and joysticks with force feedback (Ressler & Antonishek, 2001).

In response to the issue of developing user-centered technology for blind children, diverse interface designs have been implemented for users with visual disabilities that allow them to utilize the technology more fully. One initiative in this line of research is centered on sound-based interfaces used to enhance cognition in blind children. This researcher's group has been using 3D sound to convey information and knowledge by exploiting users' auditory senses to cope with their loss of vision. Systematic usability evaluations have been performed during the development of the interface in order to inform the design of user-centered interfaces. Specifically, the research group has identified key interface issues used to map the blind users' mental models, needs, and ways of thinking (Sánchez, Baloian, Hassler, & Hoppe, 2003; Sánchez & Lumbreras, 1999; Sánchez & Sáenz, 2006a, 2006b, 2006c).

Spatial, sound-based virtual environments have been oriented toward assisting the cognitive development of children with visual disabilities through the development of tempo-spatial structures, short-term and abstract memory, haptic perception, problem solving, mathematics learning skills, and orientation and mobilization skills. Relevant data from these studies are helping to map the role that spatial sound can play in the cognitive development of blind children. Researchers are progressively accepting the hypothesis that computer-delivered spatial sound has a critical impact on the cognitive development of blind children (Baldis, 2001; Cernuzzi, Paniagua, & Chenú, 2004; Lahav & Mioduser, 2004; McCrindle & Symons, 2000; Sánchez & Flores, 2004, 2005; Sánchez, Flores, & Sáenz, 2005; Sánchez & Sáenz, 2005; Winberg & Helltrom, 2000).

Interfaces without visual cues for blind children have been critical for exploring the auditory means for enhanced cognition. In such research, digital applications for sighted children have not been embedded with audio, nor have screen readers been used in applications intended for blind children. As a result, through continuous testing in usability practices, researchers have been able

to define the particular mental models that blind users employ to perceive their real surroundings. Such research allows designers to improve embedded interface tools that help blind users to map their own virtual surroundings and access opportunities to become more fully integrated into their societies that are relying more regularly on technological access.

The purpose of this paper is to review, summarize, and illustrate the work on four audio-based games designed to assist blind children in mapping[5] their virtual environments and to improve their cognitive development. The development process of this research employed a user-centered design methodology through successive usability tasks and evaluations.

RELATED WORK

Hardware for Blind Children

One of the most traditional techniques blind people use for transferring and storing information comes from the creation of tactile-explored characters. Louis Braille created a system based on dots arranged in two columns of three points each and forming a cell that represents an alphabetic character. Paper or plastic sheets printed with these characters constitute permanent reading sources for visually impaired people, such as traditional books for sighted people. Today, Braille cells have been developed technically as a set of elements electrically configured in such a way that, when organized in lines, constitute a Braille line. When this line is used with a computer terminal and with appropriate software and interfaces, it is capable of reproducing a line of conventional text in Braille. The user reads the line by moving his or her finger over these Braille cells as if it were a printed line. Once read, a new set of characters takes the place of the previous one and the process continues in this way until a given text is completed. The use of bidimensional mechanisms, such as using Braille lines and haptic devices, is also seen as a viable alternative to help improve the social integration and inclusion of sight-impaired people (Ramstein, 1996).

Virtual reality systems often lack significant tactile stimulation. Currently, interaction is used primarily through visual cues. Likewise, no standard mechanisms exist that prohibit or help users avoid virtual collisions with objects in the digital world (since there is no sensation of contact). Recent literature proposes some possible alternatives to solving this problem by using haptic interfaces (Tan, 2000). Haptics relates to the sense of touch. It is applied in the digital environment by combining the tactile abilities with virtual reality.

Some haptic devices are capable of providing feedback through interaction with muscles and tendons, and, in this way, a feeling of applying force over a certain object is provided. Moreover, some devices use tactile terminals to provide information about temperature, texture, and pressure. For example, PHANToM is a pointer device that provides force feedback in such a way that the user can feel the volume and force simulated inside the virtual environment with his or her hand (Yu & Brewster, 2002). This provides for greater feedback during the interaction with objects inside a certain application, from menus to entire virtual worlds. Among the many diverse uses of this device is the design of regular and irregular geometrical figures, represented in order to allow blind users to identify shapes, reliefs, and textures. The PHANToM also allows for the modeling of a virtual environment with corridors, streets, rooms, buildings, and so forth, through which the user can navigate, assisted by the same device.

In a similar vein, the use of force feedback joysticks in software interaction introduces a new field of action for blind people. Such devices produce a decreased need for audio stimuli, which lowers the acoustic contamination. Force feedback joysticks are devices with a high potential for use, as they provide a sufficient number of buttons, button arrangements, sizes, and the like, to facilitate software interaction (Sánchez et al., 2003). The increased tactility provided through these joysticks and other haptic interfaces, coordinated with audio assistance, represents an important complement for user interaction and immersion in the virtual world.

Finally, tablets are devices used in conjunction with a pen and operate in a way similar to a mouse. They are very helpful in aiding interfaces for users with visual disabilities (Van den Doel et al., 2004). It is very easy to design objects and guide the interaction by locating spaces represented on screen areas of the tablet. The use process is similar to that of a mouse, but the tablet includes a grille with reliefs on it that permit the blind user to locate and select certain screen areas.

Software for Blind Children

Even though mental models are different for each human being, there are several similarities between people with similar lifestyles, cultures, experiences, training background, and knowledge. Digital immigrants and digital natives have intuitive mental models for accessing information via technologies without major problems. On the contrary, however, the way users with visual impairments shape, order, and perceive the world is completely different from sighted users, and thus they approach the virtual and real environment through an entirely different mental model. This is, without a doubt, the most critical challenge that blind users face when using technologies with interfaces that have not been designed and planned specifically for them. It is not enough to simply give them accessibility to information technology: They cannot interact with games in the same manner as their sighted peers. Such access must be designed from the beginning for users with visual impairments.

Tactile input/output hardware is not the only way to provide blind people with the information from codified texts in the computer's memory. Voice synthesizing software, known as text-to-speech (TTS), allows for the interpretation of written information through hearing it spoken aloud. There are many applications known as screen readers that allow users to navigate through a visual screen and to have access to software based on text mode and graphical interfaces that are supported by the operating system's message system. The main concern with this type of support is the proper design of the dialog between the sight-impaired user and the computer, because when the usability is not appropriately created, it may become useless (Pitt & Edwards, 1996).

Simply adding TTS to the software is not sufficient to achieve an adequate management of tools, due primarily to the distinctiveness between the blind and sighted users' mental models. As a consequence, some interface designs and developments for users with visual disabilities adopt a rather different paradigm in order to orient these special users to the management of technology, which would imply important achievements for blind users in the management of computer and mobile devices.

Audio-based virtual environments have helped to improve learning and cognition in blind children. They have assisted the development of tempo-spatial skills (Sánchez & Lumbreras, 1999), haptic perception, and abstract memory (Sánchez et al., 2003). The

development and practice of short-term memory skills has also been attained during interactions with virtual environments (Sánchez & Flores, 2004).

Based on this research, a game based on the board game Memory was designed (Sánchez & Flores, 2004). By considering the specific needs of blind children and their level of psychological development, educational topics were also included in order to go beyond entertainment and sociability and to delve more deeply into their learning. The cognitive emphasis of this software was on boosting short-term and long-term memory. Another software program helped blind children to identify and differentiate sound-enhancing orientation, navigation, and mobility skills in their everyday life (Sánchez and Sáenz, 2006a).

In this paper, the research emphasizes the results obtained after use of the four games specially designed for legally blind children: *AudioMath*, *The Farm of Theo & Seth*, *AudioVida*, and *AudioChile*. These games include both audio (for the totally blind) and visual (for those with residual vision) interfaces that were adapted to the specific needs and characteristics of the blind children.

THE METHODOLOGY OF THE STUDIES

For more than a decade now, researchers have developed software and games for blind users under the criterion that interfaces are appropriate for—that is, tailored—to the needs and interests of the user's mental model. In designing and developing software for blind people, researchers have established a methodology and instruments for usability and cognitive evaluation of software. These methods provide relevant data that can be used to redesign virtual environments and produce pertinent user-oriented interfaces. In this paper, four games are presented that were especially designed and implemented for children with visual disabilities and targeted to enhance specific cognitive skills (see Figure 1).

Participants

A total sample of 67 learners who were attending the Santa Lucia School in Santiago, Chile, was selected, although not all learners tested the games. All learners were classified as legally blind and most of them also had learning disabilities, such as varying degrees of intellectual development. Special education teachers and usability experts also participated in each study as facilitators. Usability experts were software engineers with human-computer interaction research and practice experience that fully evaluated the interfaces to map and tailor correctly the game use to blind children.

As displayed in Table 1, 37 of the 67 students evaluated the usability of the games, and 30 participated in the cognitive evaluation. The usability evaluation involved children who did not participated in the cognitive evaluation. The idea was that the children who interacted with the game for the cognitive evaluation did not have any previous experience with the software that could contaminate the studies. The usability evaluation did not consider a control group; all 37 children interacted with and used the games.

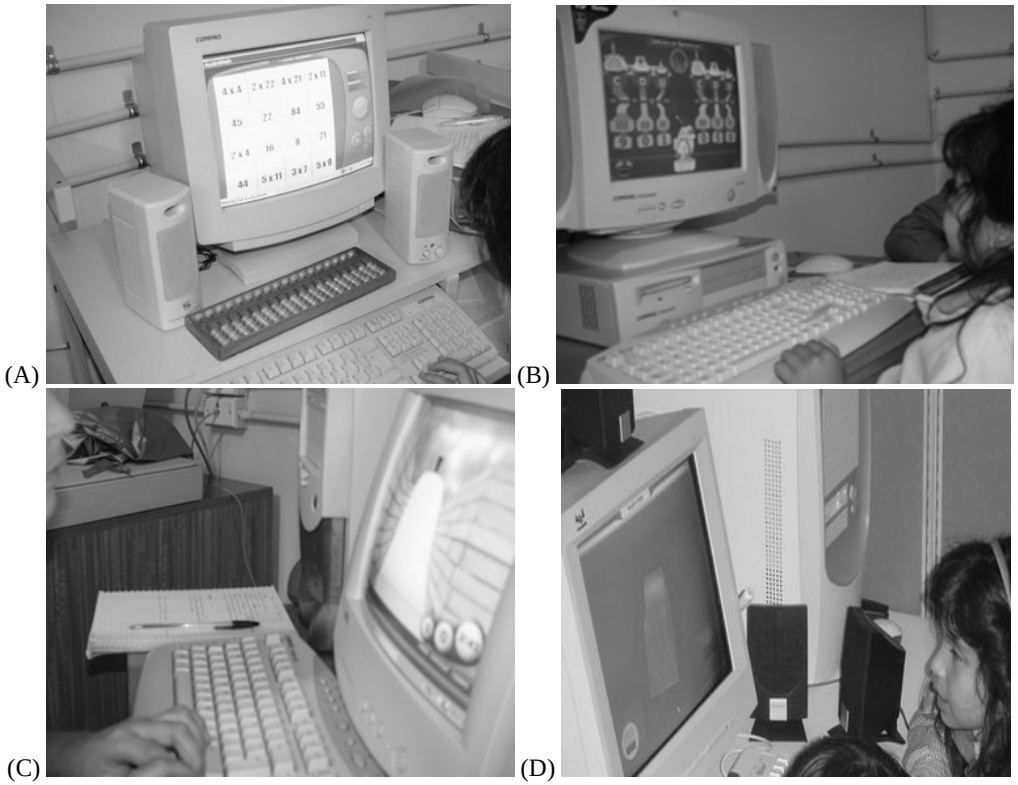


Figure 1. A user interacting with different software: (A) *AudioMath*, (B) *The Farm of Theo & Seth*, (C) *AudioVida* and (D) *AudioChile*. For the games shown in A, B and C, the setting is stereo sound. In the case of *AudioChile*, the actual setting for 3D sound interaction is also shown in D.

Table 1. Participants in the Usability and Cognitive Evaluations of the Four Games.

	Participants				
	AudioMath	***The Farm of Theo & Seth***	***AudioVida***	***AudioChile***	**TOTAL**
Usability Evaluation	19	9	3	6	**37**
Cognitive Evaluation	10	6	9	5	**30**
	29	**15**	**12**	**11**	**67**

It is important to note that all of the studies were conducted in Spanish with native speakers of Spanish using Spanish-language programs. The information has been translated for the purpose of this paper.

Usability Evaluation

For the usability of *AudioMath*, the sample consisted of 19 children, 9 boys and 10 girls, aged 6–15 years. Children had diverse intellectual development, such as normal, slow normal, borderline, below normal, and mentally deficient.

The usability evaluation of *The Farm of Theo & Seth* was implemented with a sample consisting of 9 children aged 8 years old. Four of them were blind (2 girls and 2 boys) and five had residual vision (4 girls and 1 boy).

For the usability evaluation of the game *AudioVida,* researchers selected a sample of three blind children, aged 10–15 years. One of them was blind from birth and the other two acquired blindness during childhood.

The sample for the usability evaluation of *AudioChile* consisted of 6 children with visual disabilities, 4 boys and 2 girls, aged 10–15 years. Three children had low vision and the other three had total blindness. Two of them were blind from birth, one child acquired blindness during childhood, two had good residual vision, and one had poor functional residual vision.

Cognitive Evaluation

The cognitive evaluation of *AudioMath* was implemented with 10 children, aged 8–15 years, 5 girls and 5 boys. The evaluation of *The Farm of Theo & Seth* was implemented with 6 children, aged 7–8 years, 3 girls and 3 boys. The sample for the evaluation of *AudioVida* consisted of 9 children with visual disabilities, 7 boys and 2 girls, aged 10–15 years. Five children had low vision (three had good residual vision, and two had poor functional residual vision) and four were totally blind (two of them were blind from birth, two acquired blindness during childhood). The sample for the evaluation of *AudioChile* sample consisted of 5 children with visual disabilities, 3 girls and 2 boys, aged 8–12 years. Four of them had total blindness and one had low vision.

Research Stages

Special care has been put into the software design for blind children because an effective outcome cannot be created from the mindset of a designer who simply closes his/her eyes: The designer must understand the blind children's behavior and way of thinking and reasoning. Therefore, the methodology used for these studies was user-centered design for blind children, meaning that we started from the needs and interests of blind children and then designed audio-based software accordingly. Blind children participated in the studies, interacting with and evaluating the usability and cognitive impact of *AudioMath*, *The Farm of Theo & Seth, AudioVida,* and *AudioChile* as they were being developed. The intervention is explained here, specifying the major stages in the methodology, followed by the games used, the system requirements, the evaluation instruments, the cognitive tasks employed, and experimentation procedure.

The following methodological stages were established in order to evaluate the usability and cognitive impact of game-based virtual environments for blind children (see also Figure 2).

1. *Analysis.* In this stage, the cognitive skills to be improved were considered as a baseline component of the software, and were defined through software features and interaction modes. In addition, the corresponding technologies were defined following an analysis of the current technologies and the solutions they provide. Evaluation instruments were also analyzed and selected. The usability and cognitive effectiveness of current research was evaluated by using already validated instruments. Cognitive tests varied according to the cognitive skill studied.

They ranged from general domain skills (problem solving) to specific domain skills (mathematics). The instruments used are fully explained in the Instruments subsection below.

2. *Design.* In this stage, storyboards, scripts, frameworks and other aspects of the software were defined, along with key interface usability issues. Usability evaluation involved the evaluation of software interfaces. The cognitive evaluation involved cognitive tasks implemented during interaction with the game and comprised concrete, hands-on activities that students performed and which involved solving problems similar to those encountered when playing the virtual game. There were fixed goals and procedures for these tasks in order to be able to later replicate the experience several times with different learners.

Figure 2. Research processes model. The research process starts with the analysis stage, then continues with design, implementation, and validation. The usability and cognitive aspects are considered in all research.

The idea was to combine gaming with cognitive tasks—completed by using concrete work materials—in order to form an integrated whole in the learning process of the blind children. This process helped to improve the perception and abstract representation of software elements, story personages, places, and scenarios. Blind children can understand more easily and thoroughly when working and learning with concrete materials first, and then interacting with the software (Roth, Petrucci, & Pun, 2000).

3. *Implementation.* During this stage, the software development was based on user-centered design, which makes the users and their opinions, interests, needs, thoughts, emotions, and behaviors key factors in the software's success. The same children that participated in Stage 2 also evaluated each iteration of the same program. The rapid prototyping model (Boehm, 1988) for software engineering was used.

4. *Validation.* The end users' usability evaluation was crucial in evaluating the blind user's understanding, affordances[6], visibility[7], mapping, and mental modeling of the software. The results obtained in the usability experience were later used for redesigning the software by tailoring it to the specific needs and mental models of blind children.

Based on the work of Shneiderman (1992), the researchers followed seven phases in each session of usability evaluation with end users:

a. *Introduction to the virtual environment.* The purpose of the testing and how to use input devices to interact with the applications were explained to the user. Facilitators (experienced special education teachers who specialize in working with visually impaired children) mediated the orientation process when the children were using the input devices;

b. *Software interaction.* Children navigated throughout the virtual environment and, according to their needs, they were encouraged to ask the facilitators for help in order to improve their orientation within the software.

c. *Anecdotal record.* Relevant data and observations of the child's interaction with the software were registered onto observation sheets by facilitators;

d. *Usability evaluation.* The facilitators asked the user questions from prepared questionnaires regarding issues such as icon usability and understandability during the software interaction, as well as an end-user questionnaire. These questionnaires are fully explained in the Instruments subsection below. On certain occasions, the children had to solve concrete tasks;

e. *Session record.* Each session was photographed and videotaped to register the child's behavior during the interaction;

f. *Protocol reports of the session.* All data from the child's interaction were archived for later analysis and revision. From these data we obtained comments, feedback, and suggestions in order to improve software navigation and interaction;

g. *Software design and redesign.* Each usability test ended with suggestions and comments from the children for redesign, change, and improvement. According to the comments and observations received from the session, the software was redesigned and new functions were added.

Following usability testing, a separate group of the blind users fully interacted with the software and solved problems using concrete cognitive tasks, thus learning cognitive skills as a consequence of interacting and using the software. They used real-world tasks and the virtual environment to assist in their learning and cognition. Cognitive evaluation is important in order to determine the impact that the use of the software has on learning and the development of cognitive skills, as demonstrated through cognitive tasks. The evaluation is based on the application of both qualitative and quantitative evaluation measures. These data, collected by different instruments, are described in the Instruments subsection below.

Game-Based Virtual Environments

AudioMath

This game (Sánchez & Flores, 2005; Sánchez et al., 2005) was modeled with mathematical content, and allows for the practice of audio memory by legally blind children, and for the practice of visual memory by children with residual vision. The tasks embedded in the game include the exercise of audio/oral, visual/oral, audio/image, and visual/image memory. By opening pairs of tokens on a board with several levels of difficulty, the child has to find the corresponding pair of tokens that agree with the current mathematical content presented. The

game emphasizes the establishment of correspondence and equivalence relationships, the development of memory, and the distinguishing of tempo-spatial notions (see Figure 3).

AudioMath was designed to go beyond merely enhancing general domain skills, such as memory and tempo-spatial notions, by integrating mathematical content. The researchers embedded the game with mathematical concepts like position value, sequences, additive decomposition, multiplication, and division.

The Farm of Theo & Seth

This farm-themed game (Sánchez & Sáenz, 2005) presents the objective of learning mathematical concepts, such as position value, sequences, additive decomposition, addition, subtraction, and cardinality. This game includes motivating and engaging activities for learning through different levels of complexity, and stimulates the relationship between entertainment and learning, thus motivating children to interact with the game (see Figure 4).

(A) 

(B) 

Figure 3. Screenshots of the graphic user interface (GUI) of *AudioMath*. GUIs are used by users with residual vision. (A) The user starts a new game by selecting the entrance interface: keyboard, joystick or tablet. (B) The game interface: On the left side there is a grid with paired cards and corresponding mathematics exercises; on the right side is the control menu.

(A) 

(B) 

Figure 4. Screenshots of the graphic interface of *The Farm of Theo & Seth*. (A) The main game interface puts the user into the context. (B) The Operations Henhouse requires the user to complete addition and subtraction exercises.

The game is separated into various learning areas in which the child can learn numbers and solve basic operations and problems. This spatial farm metaphor provides two major virtual environments: the numbers kitchen and the operations henhouse. The kitchen has two subenvironments: serving the food and interaction with kitchen utensils. Serving the food covers ordinal numbers (through the creation of a "numbers soup") and the kitchen utensils involves cardinal numbers (the position of utensils in numerical order, and information about preceding and succeeding numbers). The operations henhouse is a virtual space where children learn how to add and subtract. It also includes a help option to familiarize children with the keyboard.

AudioVida

This game, introduced in Sánchez & Sáenz (2006c), is targeted toward assisting with the development of problem solving skills. *AudioVida* emphasizes the implementation of different routes for displacement in a complex virtual environment, based on audio stimulation to facilitate reaching a specific destination and locating a particular object. To achieve this goal, the learner must analyze and interpret the virtual space by applying notions of spatiality and temporality. This favors the child's ability to recognize different possibilities for displacement, to exercise audio discrimination through the navigation of the virtual environment, to make a mental representation of the virtual space while moving, and to elaborate strategies used to navigate the environment through shortcuts (see Figure 5).

The user navigates the labyrinth assisted by audio orientation. The learner's immersion in the virtual environment is induced through spatial sound effects that indicate their position and provide references about walls, doors, elements with which they can interact, and intersections within the labyrinth. Children are informed about contextual changes through volume and the positional variations of the sound sources. When contexts are changing, learners receive an audio signal that defines the direction and closeness of the various game components, motivating learners to "walk through" the virtual labyrinth as they would do it physically.

AudioChile

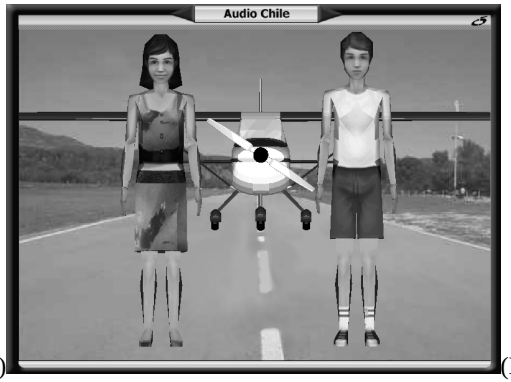
This game attempts to analyze the development of problem-solving strategies (Sánchez & Sáenz, 2006a). The goal is for children to develop strategies for problem identification and planning, to execute those strategies for subsequent verification, and to develop a capacity for verification, reflection, and the generalization of their strategies for use in solving other problems in a given virtual hyperstory (see Figure 6).

Once immersed in the game's 3D world, the user can adopt a main character that could be a girl or boy. *AudioChile* takes place in three different regions of Chile: Chiloé, Valparaíso, and Chuquicamata. Information relevant to each zone is provided by searchable clues that allow children to visit and learn about aspects of Chilean geography and cultural traditions. The clues are specified by the different personages within the game, so if the user does not talk with these personages, he/she will never find the clues. To be able to virtually travel between the different zones, children must attain certain objectives that will help them in future tasks. Navigation in the virtual world is delimited by labyrinths that allow for

(A) 

(B) 

Figure 5. Screenshots of the graphic interface of *AudioVida*. (A) The main menu of the game shows that a new game will start. (B) The user navigates game labyrinths and encounters different elements that result in winning or losing a game, depending on the decisions made.

(A) 

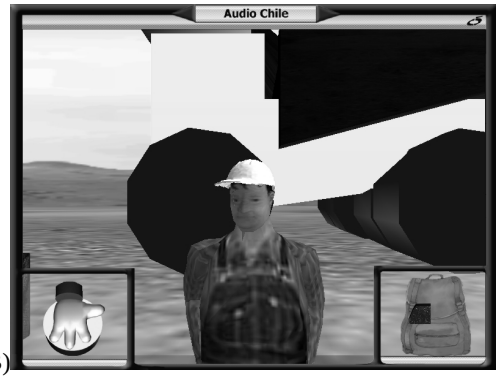
(B) 

Figure 6. Screenshots of the graphic interface of *AudioChile.* (A) Once the user has chosen to start a new game, an avatar from the virtual world is selected. (B) The user interacts with virtual persons in the game.

the character's mobility and freedom within certain parameters. Interaction occurs through avatar behaviors, such as taking, giving, opening, pushing, pulling, looking, speaking, using, traveling, and checking the backpack, as well as movements and turns. These actions are performed via the force feedback joystick and the keyboard.

All activities performed in the game, such as accessing the menu and actions taken during the story itself, have audio feedback (e.g., stereo sounds) so that the user can understand what is happening within the story. In navigating the virtual world, *AudioChile* uses 3D sound to provide a better sense of spatiality and immersion in the game.

System Requirements

All of these games were developed for a PC platform with the following system requirements: PC with the equivalent of a 1 GHz processor or higher, Microsoft Windows XP SP2, 128MB of RAM (256MB recommended), 32 MB DirectX 8 compatible video card required, sound card, 4 speakers or headphones required for audio (depending on the game) and keyboard.

AudioMath, *The Farm of Theo & Seth*, and *AudioChile* were developed using a Macromedia Director 8.5 framework, with Lingo language. In particular, *AudioMath* and *AudioChile* were developed with a library of routines for external joystick control, Xtra RavJoystick. *AudioVida* was developed with C++ language and an OpenGL library.

Instruments

Table 2 shows the use of the different evaluation instruments in the various methodology stages of each game's production.

Table 2. Evaluation Instruments Used for Each Methodological Stage.

Methodology Stage	Instruments	
	Usability	**Cognition**
Design	▪ Icon usability questionnaire ▪ Heuristic evaluation questionnaire ▪ Understandability questionnaire	
Implementation	End-user questionnaire	
Validation	End-user questionnaire	Cognitive Tests

Usability Evaluation

The main instruments used for the usability evaluation were icon usability, heuristic usability, understandability, and end-user questionnaires.

1. *Icon Usability Questionnaire.* This instrument was used for early evaluations of the interface. An icon evaluation questionnaire was taken during the usability sessions to evaluate the images and audio feedback by including an observation instrument with two parts: (a) a set of questions to identify the images of persons and objects in the game (for children with residual vision), as well as a section to record observations during the interaction, and (b) a set of questions to identify input/output sounds and any related associations made by the blind children. It also contained observations recorded during the interaction.

2. *Heuristic Evaluation Questionnaire.* The heuristic evaluation was based on systematic inspections of the interface made by two usability experts per each game. Researchers used heuristic evaluation questionnaires (Sánchez, 2000), designed using Shneiderman's (1992) "golden rules" and Nielsen's (1993, 1994) usability heuristics. The resulting test consisted of 12 heuristics, embracing a total of 25 items. These items were presented as a series of statements about which usability engineer experts had to indicate their appreciation using a 5-point Likert-type scale, ranging from *strongly agree* to *strongly disagree*. The 12 heuristics considered were: visibility of system status; the match between the system and the real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; assistance for children to recognize, diagnose, and recover from errors; help and documentation; content design; and media use.

3. *Understandability Questionnaire*. The problem-solving understandability questionnaire was applied during the interaction and consisted of 10 open-ended questions. The instrument was used to evaluate the understandability of the problems and tasks posed to the children, and of the related interface elements, such as instructions, sounds, visual and audio cues, voice, navigation issues, and strategies to find hidden cues.

4. *End-user questionnaire*. This instrument (Sánchez, 2003) was applied at the end of the usability sessions. It was basically a game acceptance test and consisted of 18 closed-ended questions based on a 5-point Likert-type scale, ranging from *strongly agree* to *strongly disagree*. Each of the answers was matched to a scoring scale from 5 to 1 respectively. The results can be grouped within five categories: (a) game satisfaction, (b) game control, (c) game usage, (d) quality of the game sound effects, and (e) game image and color quality.

Cognitive Evaluation

To evaluate the impact of virtual environments on blind children's cognition, researchers used a set of cognitive tests validated and adapted to the children's cognitive level and to the degree of their blindness. The Precalculus Test (Milicic & Schmidt, 2003) and Mathematics Knowledge Test of Benton & Luria, adapted for children with special needs by Chadwick & Fuentes (1980), were used to evaluate the impact of *AudioMath* and *The Farm of Theo & Seth* on the learning and practice of mathematical concepts. The purpose of the Precalculus Test is to measure the development of the mathematical skills of first-grade learners. The Mathematics Knowledge Test measures the capacity to understand oral and written numbers; the skills to make oral and written calculations; the skills to count numeric series and graphic elements; and mathematical reasoning skills. In the case of *AudioVida* and *AudioChile*, a part of the WISC-R (Wechsler Intelligence Scale for Children-Revised) test (Wechsler, 1981) was used. This test contains a subtest in two scales: manual and verbal. In particular, the verbal scale of comprehension was used because it did not need to be adapted for blind children. This scale determines the child's capacity to use practical judgments in the social situations of real life, referring to the child's common sense in real situations, and provides questions that can be asked in such situations. This is especially linked to the capacity of problem solving because the user has to be able to detect when and how to use his/her judgment and to ask questions to find a solution.

Cognitive Tasks

Once all the usability tests were completed, we evaluated the cognitive impact of each game. To do that, children who were not involved in the iterative usability interaction with the software were exposed to cognitive tasks during their interaction with the games. These tasks were designed and presented with concrete materials that represent structural and functional aspects of the virtual navigation, in order to develop and enhance different cognitive processes. Children understand some processes more fully when modeling and solving tasks with concrete materials during interaction with a virtual environment (Roth et al., 2000; Sánchez & Flores, 2004). Therefore, this methodology helps to improve the perception and abstract representation of interface elements. Audio-based virtual environments with accompanied cognitive tasks are crucial user-centered technologies for blind children.

For the cognitive tasks, researchers used concrete materials, and macro-type writing (traditionally in black ink for children with residual vision) and Braille (for children without vision) for the text portions. The idea was that children would transfer the tasks solved during virtual gaming to real-world tasks. For the games designed for mathematics learning, the researchers used the follow tasks (see Figure 7).

(A)  (B) 

Figure 7. A blind user solves cognitive tasks related to mathematical concepts. (A) The user solves tasks of *AudioMath* by playing a *Game of Slug.* (B) The user solves the tasks of *The Farm of Theo & Seth* by playing the *Lottery*.

1. *Roulette*. Learners spun the roulette to obtain a number and indicated the numbers coming before and after that number. Then the students exchanged questions with their peers about the numbers prior to and following other specific numbers. The idea was to motivate students to ask related questions and to prepare answers to correct their peers, if necessary.

2. *Game of Slugs*. Children participated in a race against time with four stops, each one with a mathematical exercise. Each child had to go through the four stops by solving the exercises. Once a child solved the four exercises, another student started the game

3. *The Lottery*. Learners played the lottery in which the teacher randomly chose a number from the raffle box that indicated a mathematical exercise (addition or subtraction) for all the children to answer simultaneously. Once the exercise was solved, it was written on the player's card. The winner was the child who first solved an entire line of exercises across his or her card or filled the whole card with solved exercises, depending on the version of the game. The game continued until all children had at least a chance to successfully fill a line of correct answers.

4. *The Store*. The classroom was transformed into a small supermarket where learners could spend a certain amount of money. Each student entered individually and was assisted by a teacher. Learners had to plan and choose what to buy, and made as many subtractions and additions as was necessary to make their shopping needs fit the monetary limitations.

In regard to assisting the users with analytic and problem-solving skills, the children had several problem-solving games to conduct. They developed their own activities to solve three cognitive tasks associated with the virtual games (see Figure 8):

Task 1. To identify and comprehend the use of skills to solve problems posed by the virtual environment;

Task 2. To plan and design a strategy to fulfill the goal of the game;

Task 3. To recognize the spaces navigated in the virtual environment through concrete mock-ups.

The children then had to apply the same strategy they used virtually to meet the final goal in the physical world. All of these cognitive tasks were considered in analyzing the strategies used to solve problems when children with visual disabilities interacted with *AudioVida* and *AudioChile.*

(A)  (B) 

Figure 8. A Blind user solving cognitive tasks related to problem solving. (A) The user undertakes a spatiality and temporality task after she interacted with *AudioVida*. (B) The child solves a problem in which she must represent in the concrete mock-up the spaces that she navigated in the virtual environment *AudioChile*.

Procedure

The four games used for the research are sound-based virtual environments that support the learning and cognition of legally blind children. *AudioMath* and *The Farm of Theo & Seth* are games that assist in the learning of basic mathematics concepts through the use of different metaphors and dissimilar learning methodologies. *AudioMath* uses stereo sound and the user has to move through a grid. *The Farm of Theo & Seth* uses stereo sound too, but the child can navigate freely and autonomously by interacting with different interfaces. *AudioVida* and *AudioChile* are virtual environments to support the development of problem-solving skills. They differ in the way of representing the contexts. *AudioVida* uses stereo sound and the movement is made through a rigid labyrinth, while *AudioChile* uses 3D sound and the child can move more freely. These four games were implemented and evaluated concurrently.

The usability testing was implemented in three stages during 5 months at the Santa Lucía School. The first stage, during the initial development of the games, consisted of pretesting the various modules and prototypes with the participants, assisted by the facilitators. The objective was to obtain initial feedback about the sounds and images of the games, with the information used to form the design of the interfaces in the beginning of the implementation phase. To obtain more detailed information, researchers used the icon evaluation questionnaire.

The second stage was implemented after researchers processed the data from the initial testing and redesigned and improved the prototypes. Researchers used the heuristic evaluation and problem-solving understandability questionnaires to evaluate these more advanced prototypes.

In the third stage the researchers applied the end-user questionnaire to the same children at two different times following their interaction with each game. After each questionnaire was administered, researchers analyzed the data from both the open- and closed-ended questions and made decisions concerning the interface design/redesign. Both tests served to improve the usability of the game.

Interacting with the games and solving the cognitive tasks were the main emphasis of the overall studies. During these steps, the children were observed and assisted by two special education teachers, who filled in check lists and recorded the behaviors that they observed. The teachers also administered the usability evaluation tests and observed the children. Also the children were video recorded and photographed for a later evaluation.

Finally, upon completion the usability studies, the second group of children were administered cognitive tests during two 1-hour sessions per week, over a 3-month period. They followed the steps of the pretest by taking the cognitive test and then interacting with the virtual games. The cognitive tasks of the Roulette, Game of Slugs, Lottery and Store were then applied of *AudioMath* and *The Farm of Theo & Seth*, and separate problem-solving cognitive tasks were applied to *AudioVida* and *AudioChile*, where the children solved real-world tasks. Finally, the children were posttested by taking the cognitive test.

RESULTS

Usability

The development process of the four games for blind children resulted in relevant data that has implications beyond this paper. The implications of these results should be considered and used when other learning games are created, designed, and developed for blind end users.

From the understandability questionnaire, applied to all games, researchers primarily learned that sounds must always convey information to the blind user. The audio elements should not be used as simple interface ornaments, as they are in some software for sighted people. Further, it is important to maintain normalized sounds. They must be coherent with what is being represented.

The icon usability tests provided researchers with essential knowledge about the design of the graphical interface for children with residual vision. From the *AudioChile* evaluation, we found that a simplistic set of icon buttons is not adequate for these children; rather the design should be clear and direct, representing the associated functionality more exactly by considering the appropriate affordances. Moreover, to keep confusion to a minimum, it is important to provide clear instructions to children before and during the game interaction and that a guide should be present to facilitate complete understanding of the required task. As the user gains experience with the game, these instructions may be reduced. The visually impaired and, most importantly, totally blind children need a diversity of cues and instructions to make for a better orientation because their navigation through the virtual environment should be as much like their real environment as possible.

From the end-user questionnaire of the four games, researchers found that the motivation of both residual vision and totally blind children for using audio-based virtual environments was triggered by their acceptance of sounds and acoustics. Interacting with some of the virtual environments described above allowed the learners to differentiate and identify

environmental sounds that helped them to navigate and orient themselves spatially in the virtual world. In the case of *AudioChile*, this interaction also contributed to improving their laterality and spatial concepts of up, down, left and right. When children recognized and accepted the sounds that were embedded in the virtual environments, they attained better control and navigability of the game. Moreover, the audio communication was fundamental for blind children to feel motivated to use and interact with sound-based game environments. Blind children needed clear and significant sound stimuli.

From *AudioChile*, the visibility[7] of the menus used in software applications for blind children was directly associated with their ability to navigate the games infinitely, thus creating a circular style of navigation. While sighted children expect to see all of the functions of the menu on their screens, the graphical interfaces for children with residual vision do not necessary need to provide all of the audio functions of the menu. Instead, it is enough to present the current item and allow the user to rotate through the other options, when necessary.

Furthermore, although many graphical interface elements are recognizable and used frequently by sighted children, there is no guarantee that the same results would apply to children with residual vision. The same applies to audio cues: Different sounds were tested and accepted by children throughout the series of studies summarized in this paper, generating a library of recognizable cues for blind children. Moreover, the classic ways of representing and performing actions in software is through the menus, which are organized in a certain hierarchy that allows for the visibility of the menu and direct access with a pointer, resulting in a multisensory interaction. However, when a blind user interacts with the menus through the keyboard (with or without the total visibility of the actions) he or she accesses only one action at a time. Therefore, the priority should not be the visibility but rather the ease of the user's navigation through the different options in the menu. For this reason the menus must be circular, allowing the blind user to select better the way he or she wishes to navigate.

The use of high contrast colors in the visuals of the four games was fundamental for children with residual vision, who will always try to use their vision for aiding the interaction within game-based virtual environments. The use of graphical screens allows for a higher degree of integration when sharing their experiences with sighted children. The majority of the characters and objects created in these games were identified by the children with residual vision, in some cases without the exact details but with enough clarity to recognize the context.

Figure 9 shows the results of the first and last usability tests. These are the average results obtained from all four of the games. For each of the statements the score goes from 1 point (*very low*) to 10 points (*very high*). Findings indicate that the interfaces developed are highly usable, especially in their acceptance, design, and use of audio and associated actions. The average score in the analyzed dimensions of the four games was 5.8 points in the first usability test and was improved to 7.4 points in the second usability test.

From the usability evaluation of *AudioMath* and *AudioChile*, the researchers found that the use of force feedback joysticks was an excellent aid for interaction. These devices allowed for information to be provided in conjunction with the audio, avoiding the excessive presence of sounds that could saturate and even confuse the user.

When a keyboard is used as an input interface in games, the keys that are easily recognizable for blind children, such as Enter, Space, Tab, and the directional arrows, should be utilized. Further, all QWERTY keyboards should have marks on the F and J keys that can be used as a reference for identifying and using the keys around them.

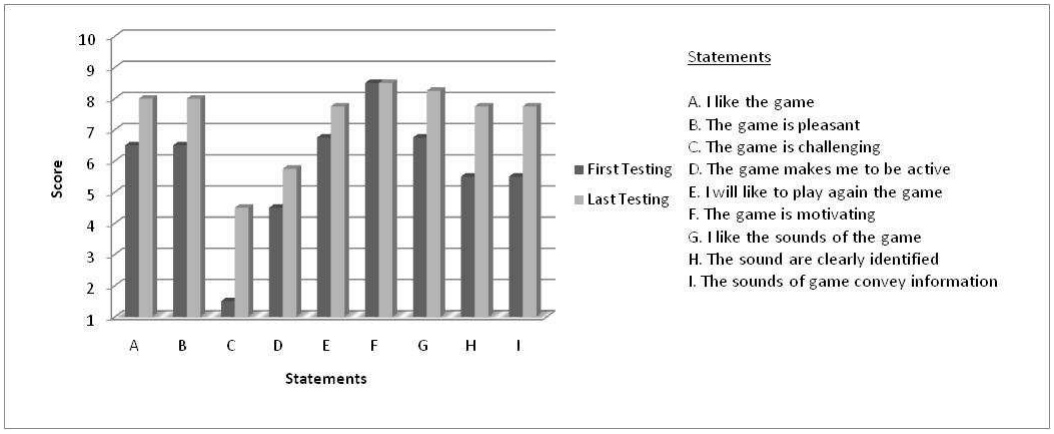


Figure 9. Combined mean scores of usability testing results for the four games for blind children: *AudioMath*, *The Farm of Theo & Seth*, *AudioVida* and *AudioChile.*

Cognition

From the application of the cognitive tests and tasks, researchers gathered data concerning the actual support that each game provided for the specifically targeted cognitive skills. From the analysis of *AudioMath* and *The Farm of Theo & Seth*, learners demonstrated that they can become quite agile in mental calculation when performing basic operations such as addition, subtraction, multiplication, and division. There also have been substantial gains in the learning of the abstract mathematical concepts involved in such operations (Sánchez & Flores, 2005; Sánchez et al., 2005). The children who worked with the mathematical games and associated cognitive tasks increased their knowledge of basic concepts remarkably. They also increased their ability to solve basic mathematics operations.

The mean score obtained in the pretest for *AudioMath* was 40.5 points and, after interacting with the game, the children demonstrated important gains, obtaining a posttest mean score of 74.3 points (see Table 3 and Figure 10). For *The Farm of Theo & Seth*, there was also an important pretest/posttest gain. In the pretest, children obtained 74 points; in the posttest children obtained 90.2 points.

Table 3. Pretest/Posttest Mean Scores in Mathematics Achievement after Playing *AudioMath* and *The Farm of Theo and Seth*.

SOFTWARE		PRETEST	POSTTEST
Audiomath	Mean	40.4900	74.2800
	N	10	10
	Std. Deviation	13.7259	12.2848
Theo and Seth	Mean	74.000	90.1667
	N	6	6
	Std. Deviation	23.5966	24.2439
Total	Mean	53.0563	80.2375
	N	16	16
	Std. Deviation	24.0701	18.6968

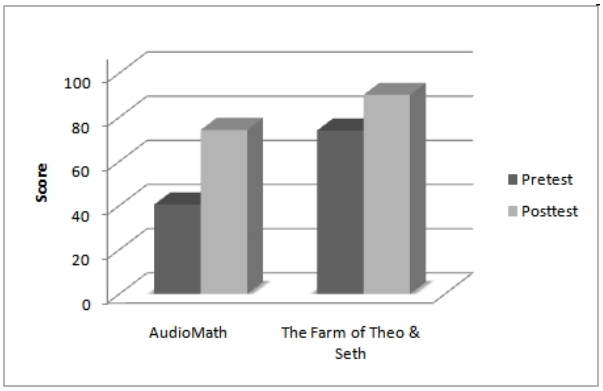


Figure 10. Children's achievement in mathematical skills following interaction with the virtual games *AudioMath* and *The Farm of Theo & Seth*.

By comparing *AudioMath* and *The Farm of Theo & Seth*, it can be seen in Table 3 that *AudioMath* children obtained lower pretest scores, but showed a higher pretest/posttest gains than *The Farm of Theo & Seth* children (34 points). *The Farm of Theo and Seth* children obtained a higher pretest and posttest performance scores than *AudioMath* children but a lower pretest/postest gains (16 points). It is important to notice that the games were applied to different aged user groups. The ages of the *AudioMath* children were from 8 to 15 years, while those for *The Farm of Theo and Seth* were between 7 and 8 years.

To analyze the statistical significance of pretest–posttest gains in *AudioMath*, the paired samples *t*-test was used. Significant pretest–posttest differences (t = -5.6; $p < 0.05$) were found between the groups, so it is possible to think that the game is the key factor for the increase in the scores (see Table 4).

For the game *The Farm of Theo and Seth*, pretest–posttest differences (t = -3.5; $p < 0.05$) were also significant. In this case we can also consider that the game was the main factor in explaining the differences in the scores (Table 5).

The analysis of *AudioVida* focused on verifying the children's skills in identifying the shortest paths from a fixed starting point to a certain goal. For this, a task was developed that consisted of locating one object inside the maze through several routes, and then indicating which one was the shortest path. Graphs, such as the one in Figure 11, were constructed using the information analyzed in these tests, showing that the more frequently the children utilized the game, the better they were able to accomplish the goal of identifying the most efficient route, thus decreasing radically the distance employed to attain the same objective.

In this case, the virtual environment and issues that the children faced in the problem-solving game allowed for the generation of adequate experiences for them to identify successfully the problematic situations, resolve them, and evaluate their actions. This was supported by the application of standardized tests to evaluate these types of skills. The results obtained from the evaluation of the impact of *AudioVida* on blind children have shown that these children can anticipate problems, plan, and apply different problem-solving strategies, explain the strategy proposed in the game and used to solve the problems, and transfer strategies to other contexts.

From the same analysis, researchers found that, once children explored the virtual environments, they were able to represent these environments through the use of concrete

Table 4. Paired Samples Test of *AudioMath.*

	Paired Differences					*t*	*df*	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 PRETEST-POSTTEST	-33.7900	19.0141	6.1280	-47.919	-20.1881	-5.620	9	.000

Table 5. Paired Samples Test of *The Farm of Theo & Seth.*

	Paired Differences					*t*	*df*	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 PRETEST-POSTTEST	-16.1667	11.4266	4.6649	-28.1581	-4.1752	-3.466	5	.018

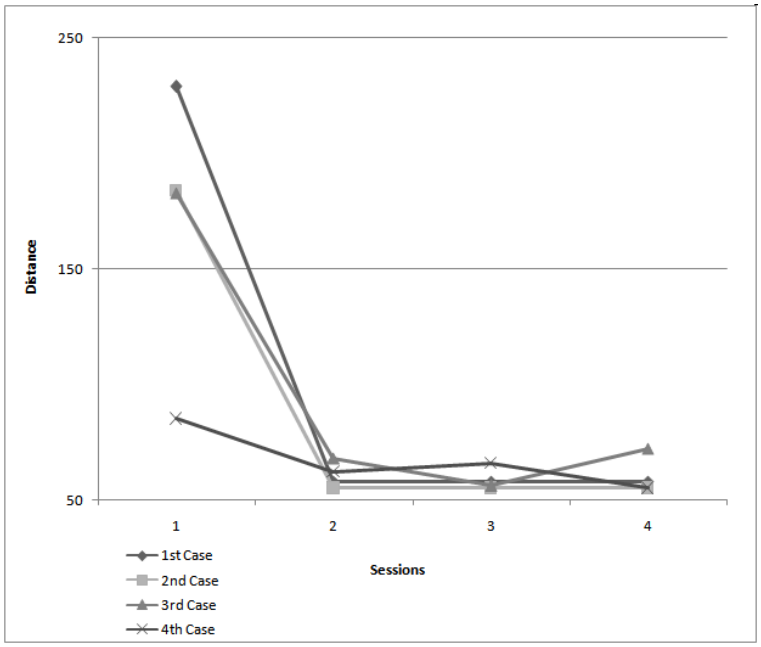


Figure 11. Learners' performances during interaction with *AudioVida.*

materials, showing exceptional skills for spatial and abstract memory. Due to the fact that they memorized the number of turns and the sequences necessary to obtain a representation of the explored route, the real-world reconstruction of the virtual map was directly related to the number of turns the user had to make, as well as to the number of times it took him or her to explore the labyrinth. When the user explored more than four times a certain route with no more than four turns, the resulting reconstruction was very faithful to the virtual environment. It is important to understand the degree of complexity of a space that a user can explore without getting lost.

The analysis of the impact of interacting with *AudioChile* on problem-solving data shows a different scene. As displayed in Table 6 and Figure 12, prestest/posttest mean scores show slight gains (from 6.2 points to 7.6 points). This was a small gain and a statistically nonsignificant difference between scores (t = -1.9; p = 0.13) was found between the groups. The game was not key factor in increasing significantly the scores even though there was a slight difference in the pretest/posttest mean scores (see Table 7).

Even though there was no statistically significant difference between the scores, learners were observed to have developed problem-solving skills after interacting with *AudioVida* and *AudioChile* (see Figure 12; see also Sánchez & Sáenz, 2006a,c). The different virtual environments and issues that the children had to face in the problem-solving games allowed for the generation of adequate experiences for them to identify successfully the problematic situations, resolve them, and evaluate their actions.

Table 6. Pretest/Postest Problem-Solving Mean Scores of *AudioChile*.

		Mean	Sample	Standard Deviation	Standard Error Mean
Pair 1	PRETEST	6.2000	5	4.0866	1.8276
	POSTTEST	7.6000	5	2.9665	1.3266

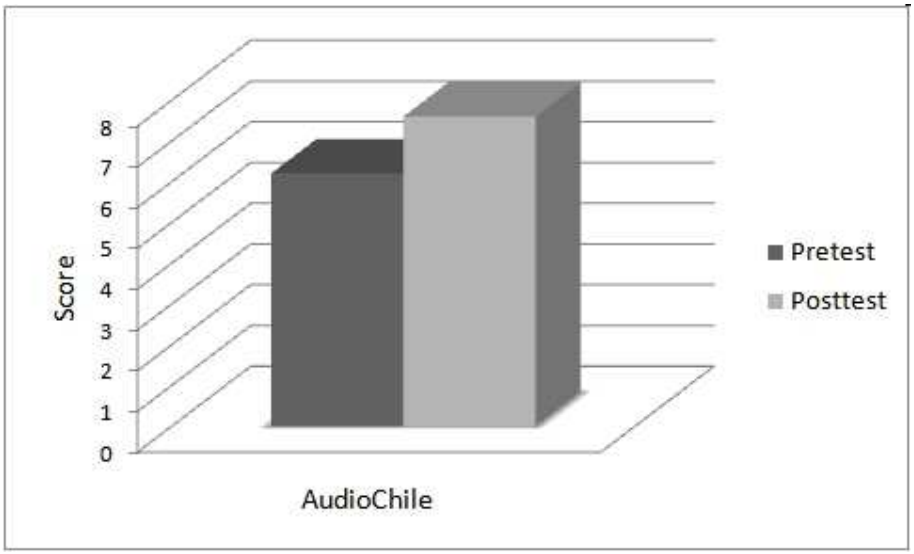


Figure 12. Pretest/postest problem-solving mean scores of *AudioChile*.

Table 7. Paired Samples Test for Problem-Solving Results of *AudioChile*.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 PRETEST-POSTTEST	-1.4000	1.6733	.7483	-3.4777	.6777	-1.871	4	.135

DISCUSSION

The purpose of this report was to review, summarize, and illustrate the work of four audio-based games created through a user-centered design methodology of successive usability tasks and evaluations. Frequent usability testing was crucial to be able to map the end users and their understanding of the game-based applications. Learners liked, accepted, used, and were very motivated by the games. After designing and redesigning the 3D sound interfaces, the children were able to map and navigate comfortably throughout the virtual environments.

The main axis of the researchers' line of research was the development of audio-based interfaces to increase blind children's learning and cognition, in which audio was used to convey information and knowledge. The research studies' analyses identified key interface issues necessary to map blind children's mental models, needs, and ways of interacting. It is very important to be aware of such matters when designing games for blind children because these considerations can determine the success or failure of a software project.

These findings confirm the idea that it is not enough to simply add audio to an existing application or to use screen reader tools to assist blind children in their interactions with technology. The mental model of blind users is unlike that of sighted people in that their styles of interaction to perceive and process stimuli and information are quite different. The challenge then is to create custom-made games for these children, such as the ones presented in this paper.

These studies demonstrate that the sense of hearing is a capable substitute for vision in its capacity for perceiving information and in the quantity and nature of the information that can be perceived. This reality should be considered for software design purposes when the children are sight-impaired. In the development of these interfaces, it is relevant to implement numerous usability evaluation methods to identify the interfaces' proximity to the blind children's needs, interactive modes, and mapping of mental models. It is also necessary to consider the methodology, instruments for evaluation, and the cognitive tasks used to design and implement usable interfaces for blind children.

Generally, the tools introduced in this report have allowed blind children to differentiate and identify ambient sounds that help them to orient themselves in various spaces, and to navigate and interact with objects and entities in virtual worlds. They have also contributed to improving cognitive laterality and spatial concepts, such as up, down, left, and right. Spatial sound has always been an important interface component in the research on game-based virtual environments. However, it is a critical aspect in the blind children's cognition that widens the scope for the use of other senses for learning and cognition. Thus through an ample variety of audio stimuli, children can stay alert and be motivated during their interaction with the game. Perhaps most importantly, audio can help them to actively construct knowledge. Spatial sound is especially required for newly blind children, who urgently need to minimize the deficiencies in accessibility that separates them from the cognitive experiences of sighted children.

Cognitive tasks accompanying the audio-based games were very helpful for children with visual disabilities who participated in the cognitive evaluation because the tasks improved the children's active tactile experience. Researchers observed that when children enjoyed using the concrete materials, and when the experiences were based on real life, the interest in learning and exploring increased. This is fundamental for children with visual disabilities because, with the total or partial loss of vision, the ability to understand through tactility allows them to construct meaningful learning experiences. For this reason, software

designed for the sight impaired should be accompanied by related cognitive tasks so that the learning achieved virtually can be constructed tangibly and effectively. Such a process permits the knowledge to be transferred to different settings and experiences. Finally, these studies have demonstrated that sight-impaired children can learn with a decrease in verbalism, which is the typical teaching behavior for children with visual disabilities.

As a result, significant improvements were achieved in learning and cognition by using audio-based games that were specially tailored as a medium for interaction through user-centered technology for blind children. These findings indicate that user-centered software for blind children can help to support and develop their intellectual capabilities, thus helping to close the gap between sighted and blind children.

ENDNOTES

1. Mental model: Users' individual thinking and reasoning about themselves, others, the surrounding world, and the interacting objects.
2. Digital native: A user who has been surrounded by technologies since birth, and thus is capable of using them naturally and transparently.
3. Digital immigrant: A user who has learned to use and adapt to technology.
4. Three-dimensional (3D) Sound: Sound that comes from all directions surrounding the user, allowing the person to determine the distance and location of the sound.
5. Mapping: The natural relation between the control of an interface and its functions.
6. Affordances: Properties that determine how objects should be used.
7. Visibility: Major parts of an interface should be easily identifiable.

REFERENCES

Baldis, J. (2001). Effects of spatial audio on memory, comprehension, and preference during desktop conferences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI 2001; pp. 166–173). New York: ACM Press.

Boehm, B. (1988). A spiral model of software development and enhancement. *Computer*, *21*, 61–72.

Cernuzzi, L., Paniagua, J., & Chenú, R. (2004). Club de Othello: Un desafío para niños con discapacidad visual [The Othello´s Club: A challenge for children with visual disabilities]. In *Actas del III Congreso Iberoamericano IBERDISCAP 2004: Tecnología de Apoyo para la Discapacidad* (IBERDISCAP 2004; pp. 27–32). San José, Costa Rica: Editorial EUNED.

Chadwick, M., & Fuentes, M. (1980). *Evaluation of mathematics knowledge: Adaptation of Benton-Luria test.* Santiago, Chile: Publieducares.

Kurniawan, S., Sporka, A., Nemec, W., & Slavik, P. (2004). Design and users evaluation of a spatial audio system for blind users. In P. Sharkey, R. McCrindle, & D. Brown (Eds.), *Proceedings of the 5th International Conference on Disability, Virtual Reality and Associated Technologies* (ICDVRAT 2004; pp. 175–182). Reading, UK: University of Reading.

Lahav, O., & Mioduser, D. (2004). Blind persons' acquisition of spatial cognitive mapping and orientation skills supported by virtual environment. In P. Sharkey, R. McCrindle, & D. Brown (Eds.), *Proceedings of the 5th International Conference on Disability, Virtual Reality and Associated Technologies* (ICDVRAT 2004; pp.131–138). Reading, UK: University of Reading.

Lange, M. (1999, March). *Tactile graphics: As easy as that*. Presentation at the Center on Disabilities Technology and Persons with Disabilities Conference, Los Angeles, CA, USA.

Loomis, J., Lippa, Y., Klatzky, R., & Golledge, R. (2002). Spatial updating of locations specified by 3-D sound and spatial language. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*, 335–345.

McCrindle, R., & Symons, D. (2000). Audio space invaders. In P. Sharkey, A. Cesarani, L. Pugnetti, & A. Rizzo (Eds.), *Proceedings of the 3rd International Conference on Disability, Virtual Reality and Associated Technologies* (ICDVRAT 2000; pp. 59–65). Reading, UK: University of Reading.

Mereu, S., & Kazman, R. (1996). Audio enhanced 3D interfaces for visually impaired users. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI 1996; pp. 72–78). Vancouver, BC, Canada: ACM Press.

Milicic, N., & Schmidt, S. (2003). *Manual of precalculus test* (2nd ed.). Santiago, Chile: Editorial Universitaria.

Morley, S., Petrie, H., O'Neill, A., & McNally, P. (1998). Auditory navigation in hyperspace: Design and evaluation of a non-visual hypermedia system for blind users. In *Proceedings of the Third International ACM Conference on Assistive Technologies* (ASSETS 1998; pp. 100–107). Marina del Rey, CA, USA: ACM Press.

Nielsen, J. (1993). *Usability engineering*. New York: Academic Press Professional.

Nielsen, J. (1994). Heuristic evaluation. In J. Nielsen & R. L. Mack (Eds.), *Usability inspection methods* (pp. 25–62). New York: John Wiley & Sons.

Pitt, I., & Edwards, A. (1996). Improving the usability of speech-based interfaces for blind users. In *Proceedings of Second International ACM Conference on Assistive Technologies* (ASSETS 1996; pp. 124–133). Vancouver, BC, Canada: ACM Press.

Ramstein, C. (1996). Combining haptic and Braille technologies, design issues and pilot study. In *Proceedings of the Second International ACM Conference on Assistive Technologies* (ASSETS 1996; pp. 37–44). Vancouver, BC, Canada: ACM Press.

Ressler, S., & Antonishek, B. (2001). Integrating active tangible devices with a synthetic environment for collaborative engineering. In *Proceedings of the Sixth International Conference on 3D Web Technology* (Web3D 2001; pp. 93–100). Paderborn, Germany: ACM Press.

Roth, P., Petrucci, L. S., & Pun, T. (2000). From dots to shapes: An auditory haptic game platform for teaching geometry to blind pupils. In *Proceedings of the 7th International Conference on Computers Helping People with Special Needs* (ICCHP 2000; pp. 603–610). Karlsruhe, Wein: Österreichische Computer Gesellschaft.

Sánchez, J. (2000). Usability and cognitive impact of the interaction with 3D virtual interactive acoustic environments by blind children. In P. Sharkey, A. Cesarani, L. Pugnetti, & A. Rizzo (Eds.), *Proceedings of the 3rd International Conference on Disability, Virtual Reality and Associated Technologies* (ICDVRAT 2000; pp. 67–73). Reading, UK: University of Reading.

Sánchez, J. (2003). *Cuestionarios de Usabilidad de Software para Usuario Final y Facilitador* [End-user and facilitator questionnaires for software usability]. Unpublished manuscript, University of Chile, Santiago.

Sánchez, J., Baloian, N., Hassler, T., & Hoppe, U. (2003). AudioBattleShip: Blind learners collaboration through sound. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI 2003; pp. 798–799). Fort Lauderdale, FL, USA: ACM Press.

Sánchez, J., & Flores, H. (2004). Memory enhancement through audio. In *Proceedings of the Sixth International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS 2004; pp. 24–31). Atlanta, GA, USA: ACM Press.

Sánchez, J., & Flores, H. (2005). AudioMath: Blind children learning mathematics through audio. *International Journal on Disability and Human Development, 4*, 311–316.

Sánchez, J., Flores, H., & Sáenz, M. (2005). Blind children developing mathematics skills through audio. In *Proceedings of ITI 2nd International Digital Media Conference* (DIGIMEDIA 2005; pp. 155–166). Cairo, Egypt: Information Technology Institute.

Sánchez, J., & Lumbreras, M. (1999). Virtual environment interaction through 3D audio by blind children. *Journal of CyberPsychology and Behavior*, *2*, 101–111.

Sánchez, J., & Sáenz, M. (2005). Developing mathematics skills through audio interfaces. In *Proceedings of 11th International Conference on Human-Computer Interaction* (HCI 2005; pp. 1–10). Las Vegas, Nevada, USA: Lawrence Erlbaum Associates, Inc.

Sánchez, J., & Sáenz, M. (2006a). 3D sound interactive environments for blind children problem solving skills. *Behaviour & Information Technology*, *25*, 367–378.

Sánchez, J., & Sáenz, M. (2006b). Assisting the mobilization through subway networks by users with visual disabilities. In P. Sharkey, T. Brooks, & S. Cobb (Eds.), *Proceedings of the Sixth International Conference on Disability, Virtual Reality and Associated Technologies* (ICDVRAT 2006; pp. 183–190). Reading, UK: University of Reading.

Sánchez, J., & Sáenz, M. (2006c). Interactive virtual worlds for learners with visual disabilities problem solving. In A. Ferreira, A. Frizera, & T. Freire (Eds.), *Proceedings of the IV IBERDISCAP Congress: Assisted Aids for Disability* (*IBERDISCAP* 2006; pp. CO-47–CO-52). Vitória, Brazil: Universidade Federal do Espirito Santo.

Savidis A., Stepanidis C., Korte, A., Crispien, K., & Felbaum, K. (1996). A generic direct-manipulation for hierarchical navigation in non-visual interaction. In *Proceedings of the Second ACM Conference on Assistive Technologies* (ASSETS 1996; pp. 117–123), Vancouver, BC, Canada: ACM Press.

Schneider, J., & Strothotte, T. (2000). Constructive exploration of spatial information by blind users. In *Proceedings of the Fourth ACM Conference on Assistive Technologies* (ASSETS 2000; pp. 188–192). Arlington, VA, USA: ACM Press.

Shneiderman, B. (1992). *Designing the user interface: strategies for effective human-computer interaction* (2nd ed.; pp. 129–133) Reading, MA, USA: Addison-Wesley.

Tan, H. (2000). Haptic interfaces. *Communications of the ACM, 43*, 40–41.

Van den Doel, K., Smilek, D., Bodnar, A., Chita, C., Corbett, R., Nekrasovski, D., & McGrenere, J. (2004). Geometric shape detection with soundview. In *Proceedings of Tenth Meeting of the International Conference on Auditory Display* (ICAD 2004; pp. 1–8). Sydney, Australia: International Community for Auditory Display.

Weber, G., Kochanek, D., Stephanidis, C., & Homatas, G. (1993). Access by blind people to interaction objects in MSWindows. In E. Jacobsson (Ed.), *Proceedings of the 2nd European Conference on the Advancement of Rehabilitation Technology* (ECART-2; pp. 1–3). Stockholm, Sweden: Swedish Institute for the Handicapped.

Wechsler, D. (1981). *WISC-R español, escala de inteligencia revisada para el nivel escolar* [WISC-R Spanish intelligence scale for children-revised]. Ciudad de México, México: Editorial El Manual Moderno, S.A. de C.V.

Winberg, F., & Helltrom, S. (2000). The quest for auditory manipulation: The sonified towers of Hanoi. In P. Sharkey, A. Cesarani, L. Pugnetti, & A. Rizzo (Eds.), *Proceedings of the 3rd International Conference on Disability, Virtual Reality and Associated Technologies* (ICDVRAT 2000; pp. 75–81). Reading, UK: University of Reading.

Yu, W., & Brewster, S. (2002). Multimodal virtual reality versus printed medium in visualization for blind people. In *Proceedings of the ACM Conference on Assistive Technologies* (ASSETS 2002; pp. 57–64). Edinburgh, Scotland: ACM Press.

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SOCIAL PSYCHOLOGY OF PERSUASION APPLIED TO HUMAN–AGENT INTERACTION

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Abstract: *This paper discusses and evaluates the application of a social psychologically enriched, user-centered approach to agent architecture design. The major aim is to facilitate human–agent interaction (HAI) by making agents not only algorithmically more intelligent but also socially more skillful in communicating with the user. A decision-making model and communicative argumentation strategies have been incorporated into the agent architecture. In the presented content resource management experiments, enhancement of human task performance is demonstrated for users that are supported by a persuasive agent. This superior performance seems to be rooted in a more trusting collaborative relationship between the user and the agent, rather than in the appropriateness of the agent's decision-making suggestions alone. In particular, the second experiment demonstrated that interface interaction design should follow the principles of task-orientation and implicitness. Making the influence of the agent too salient can trigger counterintentional effects, such as users' discomfort and psychological reactance.*

Keywords: *human-agent interaction, user-centered design, decision making, persuasion.*

INTRODUCTION

Wide employment of agents in human–computer interaction (HCI) design has proven to be an effective way to construct robust yet flexible software architecture, in which information communication between the user and the technical system is mediated by many kinds of agents. The new interaction paradigm, evolved from traditional HCI, can be called human–agent interaction (HAI). In HAI, users are provided with a novel social collaborator during their tasks: the software agent (Wooldridge & Jennings, 1995). Obviously, this new interaction element opens a series of design considerations. At its core, HAI invites a more consequent evaluation and application of social psychological concepts to guide the agent's behaviors during interaction.

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Hence, a key question is what we can learn from social interaction research in the human context in order to design user-friendly, adaptive, and effective HAI (e.g., Nass & Moon 2000; Reeves & Nass, 1996). This exploitation of social psychological concepts in interaction design is a logical extension of the user psychological approach to human–technology research (Moran, 1981; Oulasvirta & Saariluoma, 2004)—a paradigm approach that is especially effective in projects where the product or technology is new or where the audience characteristics and habits are not yet well defined (Goschnick & Sterling, 2002; Murray, Schell, & Willis, 1997). Thus, it is ideal for contemporary HAI research pursuing psychologically-based, integral agent architectures (Pasquier, Rahwan, Dignum, & Sonenberg, 2006; Rahwan, 2005). In this vein, it is essential to evaluate core issues such as interpersonal communication, influence, persuasion, and decision making in interaction (e.g., Cialdini, 1984; Eagly & Chaiken, 1984; McGuire, 1969, 1985; Petty & Cacioppo, 1981; Sewell, 1989; Zimbardo & Leippe, 1991).

For instance, one may argue that the way by which agents interact with people should be considerate and comfortable. This applies naturally to the presentation or communication of information to the user in general. Another criterion is to design for effective, that is, influential agent support of user deeds. Because one of agent's crucial roles is that it can enhance or substitute human user decision making when encountering points of judgment during system tasks, the exertion of persuasive influence is quite central. Therefore, communication skills, including argumentative rhetoric, dialogue strategies, and verbal proficiency, are highly relevant for the agent to effectively argue for its decisions, and to achieve the user's trust.

The present research concerned agent communication skills and the influence of such in the buildup and sustainment of a trusting collaborative relationship between the user and the agent. The core interest was the agent's ability to effectively persuade users during decision-making tasks in system interaction (e.g., Fogg, 2003; Parise, Kiesler, Sproull, & Waters, 1999; Stiff & Mongeau, 2002; Stock, Guerini, & Zancanaro, 2006). Persuasive design is an important complement to the traditional usability concept because it specifically addresses socioemotional dimensions of interaction. One problem with the traditional usability perspective is that it presupposes user need or motivation to utilize a tool. However, with the mushrooming of technological solutions, and ever-increasing functionalities built into them, it becomes of growing importance not just to allow users to do in a simple and effective manner what they essentially want to do, but to go above and beyond that, to influence their desire and inclination regarding what they want to do or use.

Agents, as sophisticated extensions to the interaction interface, are of core concern in this context. Agents are conceptualized as supports to user tasks in various ways, but often their use is based on a freedom-of-choice model. As a result, legitimate concerns are not so much whether users can in principal profit from agent use or in what way agent support is beneficial but, rather, whether users are willing to make use of the agent and how this is expressed in human–agent collaborative decision making. Hence, HAI is a suitable and interesting subject in persuasive interaction design research, especially in the context of the spreading relevance of agent technology in industrial applications (e.g., Luck, McBurney, Shehory, & Willmot, 2005; Wooldridge & Jennings, 1995).

Previous research has, for instance, investigated the potential of recommendation agents for electronic shopping to influence the human decision making by shaping user preferences (Häubl & Murray, 2001). Other research projects, such as those pertaining to the RPD-

enabled (recognition-primed decision) agent, focus on supporting decision-making teams by anticipating information relevant to their decisions based on a shared mental model (Fan & Yen, 2004). The results indicate that human teams, when supported by agents, can perform better in highly time-sensitive situations. Pasquier et al. (2006) developed an argumentation framework for an agent that is best suited to persuade other agents in a particular situation with a given standpoint. Social psychological insight is hereby applied to help in the exploration of belief/decision formation within a single agent and "social" interaction among many agents (Rahwan, 2005), yet not agent–user interaction. Finally, Katagiri, Takahashi, and Takeuchi (2001) reported on two preliminary experimental studies focusing on the nature and the effectiveness of social persuasion in HCI environments. In these types of studies, social factors, such as affiliation, authority and conformity, have been taken into account in interface agent design. Nguyen, Masthoff, and Edwards' (2007) experiment also suggests that dialog-based systems with the visual appearance of a conversational agent are preferred over systems that use text only. The former are perceived to be more personal and caring, less boring, and, to some extent, easier to follow. However, in spite of these valuable efforts, more research on the issues of collaboration and persuasion in HAI is needed.

CONCEPTUALIZING A PERSUASIVE AGENT IN A DECISION-MAKING TASK ENVIRONMENT

The major paradigm for the distribution of interaction roles between users and machines is that humans make decisions while machines carry out automated processes and routines. However, with user task complexities increasing and technology becoming more sophisticated, machines progressively enter the domain of decision making. Agents are the premier example for this latter development, geared at supporting user decision making on different authority levels, from merely offering useful information, to serving in advisory functions (e.g., decision support systems), to making decision in place of the user.

In the type of suggestive agent architectures explored here, users should maintain the dominant role during interaction; that is, the agent leaves the final decision to the user but tries to persuade the user to accept its decision. As noted above, this also means that HAI confronts users with a new type of decision, in addition to the ones concerning the actual use task: whether and how to utilize the agent and its suggestions during interaction. Whereas agent development traditionally focused on the technical elements, such as highly sensitive and thorough algorithms, somewhat less effort has gone into understanding how users can be convinced to utilize an agent's suggestions and support offers. Logically, however, the latter must precede the former concern. And thus, we need to be concerned regarding how to make agents not only algorithmically intelligent, but also socioemotionally so.

Ultimately, agent participation in system interaction tasks should award users with processing capacity and accuracy benefits. However, gaining people's trust and will to collaborate are vital requirements for smooth and effective HAI. It is expected that people may doubt or feel reluctant to accept an agent's decision or the information the agent provides, especially when they are not convinced and cannot validate the trustworthiness of the agent. On the other hand, due to the limited information-processing capacity of the human working memory, users may also feel tempted to overrely on agent recommendations in order to reduce

the cognitive load of decision making (Häubl & Murray, 2001). This tendency may backfire on well-functioning HAI within the context of system disturbances or other disagreements between user and agent assessments. In any case, acceptance or refutation of a given agent's standpoint may critically depend on the availability and form of presentation of the information.

Generally, we believe that the way agents influence people's thinking and behavior must exploit evidence from human–human interaction skills. This belief is based on the fact that people regard HAI as having similar social dynamics as human–human interaction (Katagiri et al., 2001; Nass & Moon, 2000; Reeves & Nass, 1996). Consequently, HAI design needs to consider the social dimension and significance of such interface agent traits as appearance, voice, and communication style (e.g., Guadagno, Blascovich, Bailenson, & Mccall, 2007; Hargie, 1997).

Architecturally, the present design of a persuasive agent was based on the BDI (beliefs, desires and intentions) agent model (Rao & Georgeff, 1992), which calls upon mental notions to encapsulate the hidden complexity of the inner functioning of an individual agent, and was further developed into a Procedure Reasoning System (PRS) by Ingrand, Georgeff, and Rao (1992). Although the cognitive BDI agent and its PRS applications have been well studied within the recent decade (Brazier, Jonker & Treur, 2002; Georgeff, Pell, Pollack, Tambe, & Wooldridge, 1998; Huhns & Singh 1998; Ingrand, Chatila, Alami, & Robert, 1996; Maes, 1994), current HAI research still continues in the design of the social BDI agent that has the ability to model human behaviors (Guzzoni, Cheyer, & Baur, 2007; Lokuge & Alahakoon, 2005; Pasquier et al., 2006; Peebles & Cox, 2006). In a broad sense, our research aims to enhance the agent's ability by incorporating social communication skills into the BDI agent decision model structure (see Figure 1). In this structure, the plan library holds the rules that ultimately govern decision making based on input and in accord with its beliefs and goals components, while the intentions component formulates the agent's decisions. Here, the architecture is essentially improved by

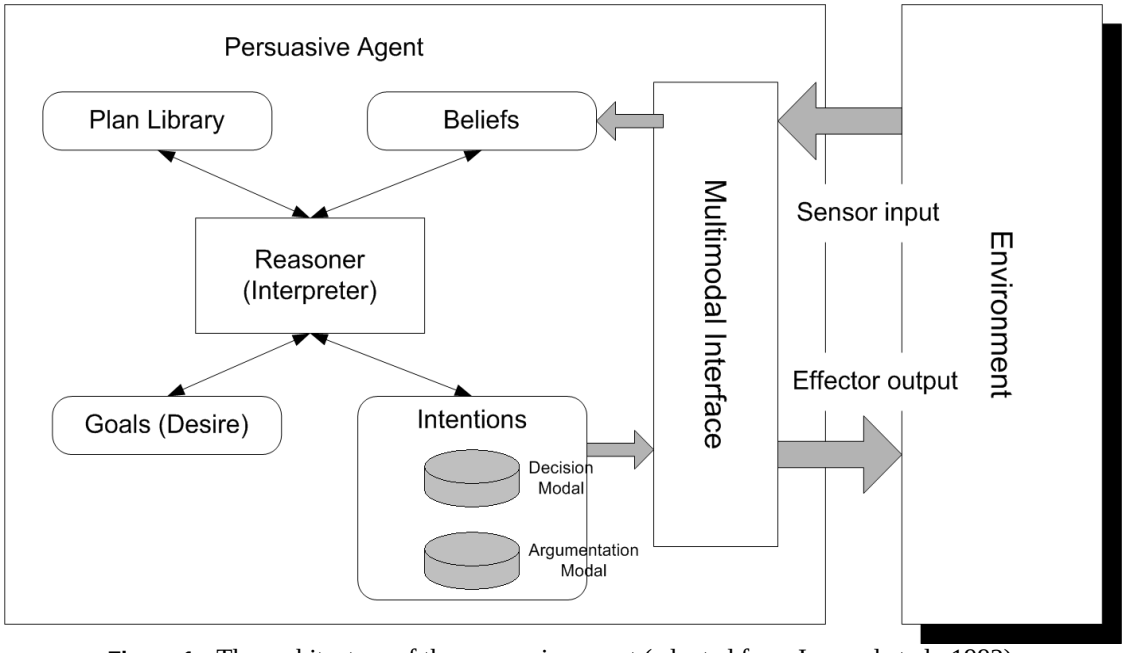

Figure 1. The architecture of the persuasive agent (adapted from Ingrand et al., 1992).

adding a decision model and an argumentation model to the intentions component so that the agent can argue for its decisions in a persuasive manner.

In operationalizing the decision and argumentation model outputs, we relied on various insights gained from original social psychology research. Considering that HAI is situated in the wider context of a user's task-oriented interaction with a system, time and processing resources are two obvious constraints to persuasion. This argues for the use of the heuristic model of persuasion (Chaiken, 1980) and Petty and Ciacoppo's (1981) "central versus peripheral framework." According to these theories, people's compliance with appeals often follow simple decision-making rules that are based on little-evaluated (contextual) persuasive cues, such as the likability of the message source, the connotations of expertise, or social (e.g., majority) reference. Other design-relevant findings concerning social collaboration are the positive correlation of people's willingness to cooperate with the frequency and richness of communication: For example, a visible collaboration partner is preferred over an invisible one (e.g., Deutsch, 1958; Wichman, 1972). In addition, friendliness, social liking, and request justification, among many others, have clearly shown to positively affect cooperation motives (e.g., Cialdini, 1984; Langer, 1978; Swingle & Gillis, 1968).

In contemplating such findings, we propose a design model for a persuasive agent that comprises five communication skill-relevant dimensions: agreeableness, anthropomorphism, informativity, persuasiveness, and adaptivity. They are explained more fully here.

1. *Agreeableness.* The agent should be agreeable, which is in line with most conventional criteria in interface design, requiring a friendly appearance and eloquent communication style. As an effect, users should feel willing and comfortable in interacting with the interface agent.
2. *Anthropomorphism.* Agents with human traits may be more attractive to users than machine-like ones. The anthropomorphic representation allows for a rich set of easily identifiable behavioral cues for social interaction (Hargie, 1997; King & Ohya, 1996; Takama, Dohi, & Ishizuka, 1998). Especially at initial exposure to the agent, these representations may make the agent seem more intelligent, capable of a higher level of agency, and more trustworthy.
3. *Informativity*. The agent's advice or decisions should be useful (necessary and sufficient) to the user and justified. Thus, when there is need for more information, the agent should provide more assistance. It is also valuable to accompany suggestions with some explanation or rationale. However, exhaustive information should be avoided since it can cause people to become impatient or overloaded.
4. *Persuasiveness.* Although all dimensions of communication skills affect the agent's persuasiveness, this dimension is concerned with more specific elements inducing social influence. Foremost, these include persuasive cues pertaining to the influence schemes of request justification, reciprocation, commitment and consistency, social proof, liking, authority, and scarcity (Cialdini, 1984). Persuasive behaviors should nevertheless be subtle enough so that people will not feel that they are being directed and apparent enough that people can understand it.
5. *Adaptivity*. Collaborative style and skill are usually not predefinable in absolute terms but must evolve and adapt to the HAI setting, especially the style and preferences of the user. Therefore, all of the above-mentioned dimensions outlining

the communication skills of the agent must be modifiable to take into account user goals and actions.

In order to apply this model to interface agent interaction design, and test the effect of agent communication skills on user persuasion, user–agent collaboration, and task performance, we constructed two experimental scenarios. Within such, we varied different HAI parameters according to the communication skill-relevant dimensions presented above.

EXPERIMENTATION

Investigating psychological dimensions of HCI is always tricky, especially when they pertain to socioemotional issues. A key challenge concerns the apt calibration of the task nature (e.g., difficulty) and setting in order to relate the elicited user actions and reactions in reliable ways to the experimentally chosen variations in stimuli, and not to peripheral (artifactual) or even external influences.

Our research primarily focused on the HAI element of persuasion. This emphasis on user motive and intention, rather than mere necessity and sophistication of implemented agent support, demands a task setting that favors the aspect of user preference over that of task operation requirements. For instance, it is a rather intuitive result that people would rely on agent support for a very complex task, where agent information processing capacities are evidently superior. However, when users notice (or have) almost no alternative to system or agent reliance, the value of persuasive design is obviously greatly undermined.

The real challenge is to persuade users in the context of relatively uncomplicated task requirements, because then users are given a true choice between working autonomously or collaboratively. On the other hand, it is worth noting that seemingly easy, repetitive tasks may pose their own performance challenges, due to impending lack of concentration or users' underestimation of the task demands.

The task chosen for the current study was easy enough (in terms of reasoning demands) to make the choice realistic, yet sufficiently challenging (in terms of operational demands, such as speed) in order to substantially afford the allocating of the user's attention to either the agent's suggestions or autonomous performance. This dilemma in deciding whether and how to employ the agent opens up an ideal influence space for persuasive agent design measures.

Experiment 1

Participants in our experiment needed to manage materials in a learning content management system (LCMS), with and without the help of various communicatively skillful interface agents. In order to make the task more natural, we also simulated agent performance failures.

Our general expectation was that users would benefit from agent assistance and, beyond this, that a persuasive agent design will be superior in its enhancement of HAI collaboration and task performances compared to a nonpersuasive agent design. Specifically, we assumed a communicatively skillful agent design to promote trusting HAI, which potentially jeopardizes user performance when the agent does not perform at optimal level, yet would enable quick collaboration restoration after such disruptions.

Method

Participants. The experiments were conducted in English by competent non-native speakers of English. We employed three experimental groups (H: no agent support, HAI: nonpersuasive agent support; and HA2: persuasive agent support), each containing 10 volunteer participants with university education backgrounds. There were 19 males and 11 females, aged 21 to 35, balanced across the experimental groups.

Materials. The task scenario was described to the participants as follows: A resource manager (i.e., human user) maintains a LCMS database that holds a number of local content files that frequently need to be updated. The user's task is to evaluate incoming files, that is, updates to existing files, and decide whether the current local copy should be replaced by the update or not (i.e., confirm or not confirm the update).

A new update announcement was received every 10 seconds, 72 in total. Each update was visible in a list for 30 seconds, after which it expired. During these 30 seconds, the participant needed to evaluate the incoming update, by comparing its attributes to those of the related local copy, and reach a confirmation decision. The unique relation of an incoming update to a file in the local database was expressed by a common ID. Further, the files had four attributes: *date* (the publication date, e.g., 13/06/2007), *size* (the file size, e.g., 1200 units), *rating* (i.e., the recommendation rank of this update, from 1 as the lowest to 5), and *cost* (the total cost of managing the file, e.g., 400 units). The ideal update for confirmation had four positive attribute values: It was newer, smaller, higher ranked, and cheaper than the local copy of the corresponding file. A clearly undesirable update had four negative attribute values; it was older, bigger, lower ranked, and more expensive. As a rule of thumb, participants were instructed to confirm an update when there were more positive attribute values than negative ones, compared to the local copy. Otherwise it was wise to not confirm the update.

The interface of the experimental group receiving the persuasive agent is depicted in Figure 2, using a female avatar (Elina) to symbolize the agent. No avatar was used in the nonpersuasive agent condition. The general interface further contained a table displaying the active incoming updates, interaction buttons and, in the agent-supported conditions, there was a text field containing the agent's messages. All user actions were performed with a mouse.

For each update, the two main operations participants could do were to confirm the update, by clicking the CONFIRM button, or to not confirm the update, by clicking NOT CONFIRM. In the agent-supported conditions, participants could also click the DO AS AGENT SAYS button to adopt the agent's suggestion. The psychological aim of this button was to attract and underscore the momentum of direct user-agent collaboration.

Design. Participants were naive to the purpose of the experiment, as well as to which experimental group they belonged. We employed a design with agent-support conditions as a between-subject factor (i.e., H, HA1, HA2) and three distinct task phases as within-subject factor applied to HA1and HA2. As illustrated in Figure 3, group H performed all 72 update decision tasks under unchanged conditions. In HA1and HA2, however, three task phases were differentiated: Phase 1, updates 1-24 (normal agent support), Phase 2, updates 25-48 (disrupted agent support, including misleading suggestions), and Phase 3, updates 49-72 (normal agent support). From the point of view of collaborative and trusting HAI, we may denote Phase 1 as

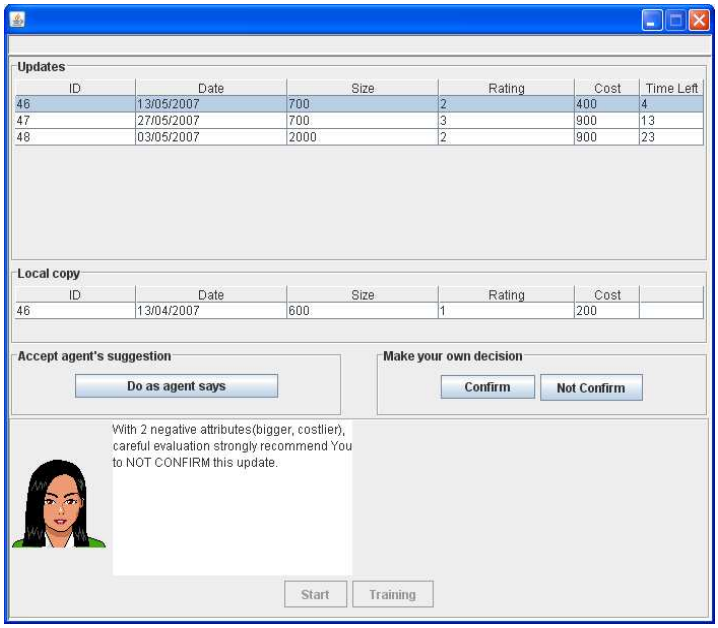

Figure 2. Interface in group HA2 (persuasive agent) for Experiment 1.

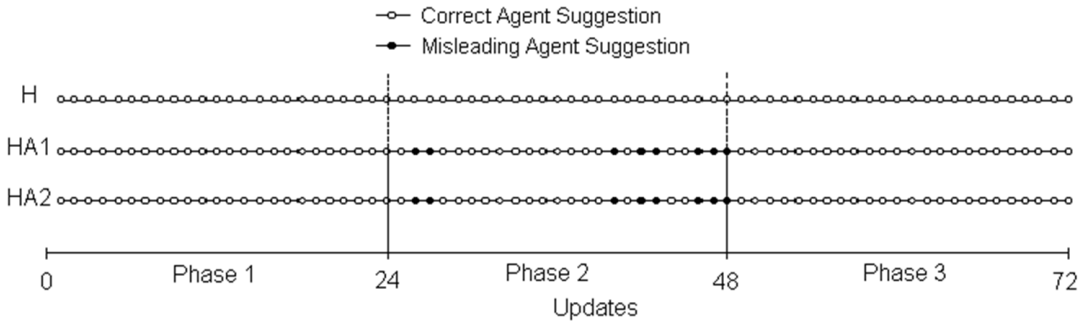

Figure 3. Experimental design: 3 experimental groups H (no agent), HA1 (nonpersuasive agent), and HA2 (persuasive agent), across experimental Phases 1-3.

the *collaboration and trust build-up* phase, Phase 2 as the *collaboration and trust disruption* phase, and Phase 3 as the *collaboration and trust restoration* phase.

In order to implement distinct agent behavior, the phases in HA1and HA2 differed with regard to the rules the agent used in deriving its decisions. We defined two main rules: R0 (i.e., confirm the update when there are more positive attribute values than negative ones, otherwise not confirm) and R1 (i.e., confirm the update when a selected attribute compares positively to the local copy). In Phases 1 and 3, the agent always made decision by using default R0, and its suggestions can thus be considered as correct throughout. In Phase 2, the agent made decision by using the adaptive R1. This meant that the agent's suggestion were at times incorrect and therefore misleading (e.g., one attribute was positive, but the three others were negative). Which of the four attributes the agent selected depended on the most frequently

featured positive update attribute in the confirmatory decisions the participant made during Phase 1. For example, if the users had made 10 confirmatory decisions and 7 of these updates featured a newer date, which was more than for any other attribute, then the date attribute was selected to express R1. The rational behind this R1 design was to keep agent failures as credible and suggestive as possible.

In sum, the experimental task for group H was straightforward and did not include any agent support. Agents in HA1 and HA2 had the same adaptive decision-making algorithm but differed in the communicatively skillful presentation of arguments used to persuade users. Compared to the pragmatic agent in HA1 the agent in HA2 was more human-like and more eloquent in "promoting" its intentions to participants. Communication skills varied in line with four of the five dimensions presented earlier (see Table 1), the exception being adaptivity, to maintain equality between the agent-supported persuasion groups in this dimension. .

In HA2 the agent presented its suggestions by elaborating reasons in logical argumentation statements, set forth in a persuasive, friendly, personalized, and convincing way. Elina (the agent) also introduced herself before the task started, with the intention to obtain a sympathetic impression. Persuasive cues, like "certain," "most safe," "ideal choice," "should," "best," and expert reference, were used to make the statement more impactful. We sought to keep the argumentative message structure consistent throughout the experiment because of its effect on increasing the processing speed and thereby enhancing persuasiveness.

Feedback was implemented as the final element in the communication skill and persuasion factor. In HA1, a brief verbal feedback was given only when participants instantiated their decision by clicking CONFIRM or NOT CONFIRM. The feedback simply restated the user's decision. The agent in HA2 reacted specifically when the participant clicked the DO AS AGENT SAYS button by saying, "Good. Well done!" but did not give feedback when participants made their decision by clicking CONFIRM or NOT CONFIRM. The intention of this was to further promote direct compliance with the agent through a kind of positive, reciprocal reinforcement.

Procedure: Experimentation was implemented on a PC in a quiet laboratory. Participants first received written instructions of the task and the decision rules. The actual test session lasted 12 minutes, after which the posttest questionnaire was completed and participants were debriefed. The questionnaire items inquired about general reactions to the experiment, such as task complexity and time pressure, as well as four main aspects of their HAI experience (agent-supported conditions only): agreeableness, anthropomorphism, persuasiveness, and usefulness. Finally, HA2 participants also answered questions concerning the agent's appearance.

Table 1. Agent's Social Communication Skills in the Two Experimental Groups.

Dimension of Communication Skills	Agent in Group	
	HA1: Non-persuasive	HA2: Persuasive
Agreeableness	neutral	friendly, supportive feedback
Anthropomorphism	no appearance, robotic	human face, personalized (Elina)
Informativity	low (suggestion-only)	high (decision justification)
Persuasiveness	no (suggestion-only)	high (persuasive cues, facial cues)
Adaptivity	minimal	minimal

Results

Definition of performance parameters: For each update, users either clicked a button or missed out on it. Recorded click actions translated into a user instantiated decision action (DA), which could be either correct (CDA), that is, corresponding to the update evaluation rule, or incorrect (IDA), that is, not corresponding to the update evaluation rule. The performance of the participants could now be expressed by the degree of correctness of their decision making and the speed by which they instantiated their decisions. For *decision-making correctness*, we calculated the ratio RCDA = CDA/DA. The click action latency for each update served as the measure of the decision-making speed.

The complete descriptive statistical data of each group in each phase is depicted in the Appendix. It shows that, overall, participants averaged 56.8 CDAs (i.e., RCDA at over 80%, while on average 1-2 updates expired without participant action) and spent 11.2 seconds per update before instantiating a decision.

In order to test for statistically relevant effects, we applied a variance analysis of group decision-making correctness and speed averages. We did so first for Phase 1 only. Because Phases 2 and 3 introduced clearly distinct conditions in HA1 and HA2, when compared to H, a comparison of the total performance across all three groups was not reasonable. The variance analysis for average decision-making correctness supported significant group differences, $F(2,19) = 13.63$, $p < 0.01$[1]. Post-hoc, Bonferroni-corrected tests confirmed a superiority only when HA2 is compared to H, $t(14) = 4.51$, $p < .01$. This means that having an agent making correct suggestions is substantially more effective only when the agent communicates its suggestions in a skillful, persuasive manner (cf. Figure 4).

A variance analysis of decision-making speed group averages also hinted at the situation that agent support necessitated slightly longer interaction times, Welch's statistic $F(2,14.52) = 6.01$, $p < .05$[1]. However, no differences were found between the two agent groups (cf. Figure 4). This means the superior performance of the persuasive-agent-supported group (HA2) did not necessary come at the cost of a longer interaction time, when compared to HA1. Note, however, that heterogeneity in variances may overestimate the significance of group differences and therefore agent use may not at all be more time consuming.

Next, we prepared the analysis of agent communication skill effects in the context of the distinct task conditions over the three experimental phases. Because group H performed all 72 update decision tasks under unchanged conditions (see Figure 3), we can use these participants' performances as a base line during the first, second, and third set of 24 updates. For instance, the explanation of possible performance differences over the three phases in the light of a change in the collaborative nature of HAI necessitates the consideration of other sources for variability, such as learning or fatigue effects, or effects of variation in update difficulty. A repeated measure analysis revealed no significant differences in decision-making correctness or speed over the three phases, $F(2,18) = 2.69$, $p = .10$ and $F(2,18) = .99$, $p = .39$, respectively (see Figure 4). Merely looking at the trend, we found a noteworthy increase in correct decision actions after the first 24 updates, to a level that was maintained until the end of the experiment. Concerning the decision-making speed, we noticed an improvement for the second 24 updates, and, probably a fatigue-induced decline towards the end of the experiment (see Figure 4).

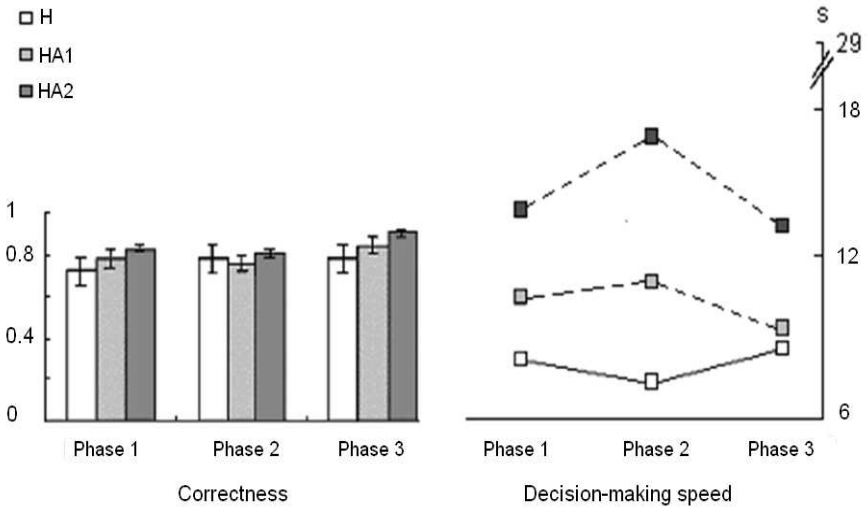

Figure 4. The experimental groups' (H: no agent; HA1: nonpersuasive agent; HA2: persuasive agent) mean ratio of correct decision actions (RCDA) and average speed of decision actions (TDA) across experimental Phases 1-3.

We then contrasted participants in the agent-supported groups (HA = HA1∪ HA2) to those receiving no agent support (H). Due to eight[2] misleading suggestions included in Phase 2 of the HA groups, we expected their performance to suffer somewhat in regard to both correctness and speed of decision making. Recovery from the collaboration disruption of Phase 2 would only occur in the final part of the experiment (i.e., Phase 3). As Figures 4 and 5 illustrate, this is exactly what we found. In Phase 2, the HA groups' mean ratio of correct decision actions dropped to the same level as observed for group H (see Figure 5). Remarkably, however, correctness did *not drop below* the level of H in Phase 2 despite the fact that, for participants in HA1and HA2, every third update was associated with a misleading (i.e., inapt) suggestion from the agent. This could mean that the agent support had helped these participants to develop greater decision-making proficiency during the first phase. Correctness of decision making by the HA groups recovered and improved in the third phase of the experiment. Associated with the drop in decision-making correctness during Phase 2, we noted a visible increase in interaction time (Figure 5) for the HA groups, which regressed in Phase 3. Statistically, we found a significant interaction between the phases and the factor of agent-support, however, only for correctness, $F(2,42) = 3.57$, $p < .05$[1], but not for speed of decision making, $F(2,46) = 2.13$, $p = .13$[1].

The reason for the lack of statistical proof for the phase effect on decision-making speed between H and HA groups may be due to the special collaborative relationship in HA2, which brings us to the comparison of the two agent groups. Indeed, we found a statistically significant greater time cost for decision making in HA2 as compared to HA1, but only in Phase 2, $t(2) = 1.81$, $p < .05$ (one-tailed). In contrast, HA2 experienced in absolute terms the

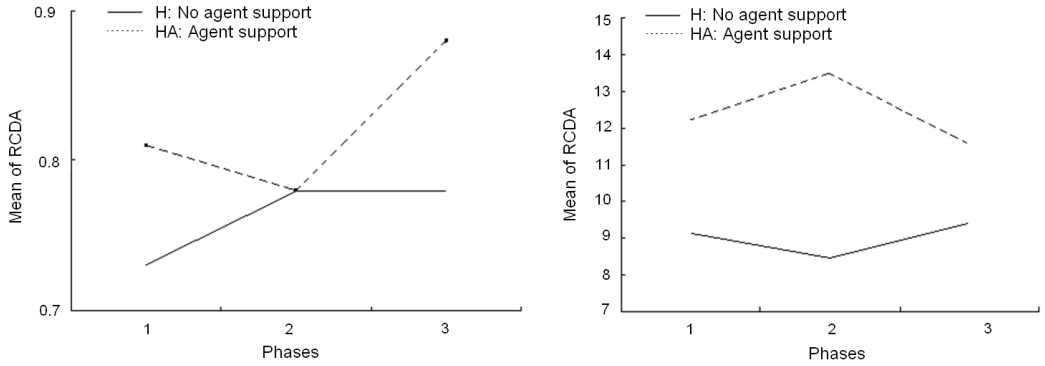

Figure 5. The comparison of correctness and time cost between the group with agent support and the group without agent support.

greatest performance improvement during the trust restoration Phase 3, that is, the greatest increase in decision-making correctness and speed (see Figure 4).

Comparing the total performances in HA1 and HA2, we found an expected overall superiority of the persuasive agent-supported users, $t(22) = 1.75$, $p < .05$, but no significantly greater time cost, $t(22) = 1.32$, $p = .10$ (both one-tailed). This decision-making correctness advantage is, in absolute terms, most substantial during Phase 3, that is, after the critical disruption of collaborative HAI and, thus, when trust restoration is most relevant, $t(18) = 1.42$, $p = .09$. Indeed, absolute mean differences in the ratio of correct decision actions grew steadily with each phase. This is a clear sign that collaborative HA1 with a persuasive agent is built up gradually, and not halted even by a disruption in the reliability of agent suggestions.

Next, we explored the posttest questionnaire results to attain an enriched picture of the participants' performances and their experiences. The majority of participants agreed that the decision-making demands in the experiment were at an appropriate (slightly easy) level. Interestingly, the participants in HA2, when compared to H and HA1, appeared to have found it easier and more unhurried to make the decisions, and noted agent support as most appropriate. This was despite the fact that the information complexity was clearly highest in HA2.

The answers of the agent-supported groups concerning the agent's agreeableness were overall strongly in favor of comfort, but friendliness also was widely attributed. There was no evident group difference here (HA1 vs. HA2), which may be caused by the circumstance that neither agent was particularly *un*friendly. Regarding anthropomorphism, the majority of the participants in the agent-supported groups[3] felt additional human-like features were undesirable. Nevertheless, participants in HA2 indicated that the appearance of Elina was comfortable and did not affect their decisions or how much they trusted the agent's advice. Agent-supported participants in general acknowledged the agent's persuasive traits, although many believed that the agent was not always right about the updates. However, a clear majority did not believe that the agent persuaded them to make wrong decisions. No difference between groups was evident. Participants in HA2 responded substantially more frequently to having used the agent's suggestions in order to assess their own decision making. Finally, the agent's usefulness was considered as good. Ninety percent agreed that the agent's advice was easy to understand and reading the suggestions was not a waste of time.

Finally, taking a glimpse at the click action logs, we noticed an unexpected result according to which participants in HA1 clicked the DO AS AGENT SAYS button more often than those in HA2. By checking the recorded experimental data, we found this was mainly caused by one participant in HA1 who used the DO AS AGENT SAYS button most of the time during the task. HA2 participants, however, were more likely to click the DO AS AGENT SAYS button when the agent provided a misleading suggestion, and thus seemed to be more strongly persuaded and to exhibit more blind trust. This strong collaboration was especially evident in Phase 2, where HA2 participants achieved considerably worse performance results by clicking the DO AS AGENT SAYS button, as compared to HA1 participants (see Appendix).

Discussion

The results of Experiment 1 substantiated the claim that people's performance, when supported by an agent, could be improved and, importantly, that an agent with persuasive communication skills could be superior to a communicatively less skillful agent. Accordingly, we conclude that the effectiveness of agent support could be achieved best when the agent communicates its suggestions in a skillful, persuasive manner.

Apart from this, we observed that the participants' task learning curve generally benefited from agent support. This helped participants develop a greater decision-making proficiency during the initial phase of the experiment, which made them partly immune to the disruptions in agent support introduced in Phase 2. As an effect of this, the agent-supported task performance did not decline below the level of the group without agent support, despite the fact that the agent provided misleading suggestions, on average, in every third update during that phase.

As a clear display of the deeper collaborative relationship between the user and the agent in HA2, we interpret that these participants were most sensitive and thus more negatively affected by the disruption in HAI collaboration and trust during Phase 2. We explain this in terms of heuristic processing's cognitive downside, such as error vulnerability and negligence (see, e.g., Shiffrin & Schneider, 1977), as well as cognitive dissonance (Festinger, 1957) induced by a persuasive agent making misleading suggestions. On the other hand, the subsequent trust restoration during Phase 3 was most impressive for participants who had a persuasive agent (the difference between HA1 and HA2 here was most substantial), which means that, although dissonance may be greatest for participants in HA2 in the context of the agent making flawed suggestions, trust and effective HAI is thereafter also most quickly restored.

Finally, the positive collaboration with the persuasive agent was also reflected in user experience. Although participants working with the persuasive agent received the largest amount of information, in principle demanding more interaction time, they experienced least task time pressure, and found the information given by the agent most appropriate.

Further examination of these issues was warranted. Two questions that especially demanded further clarification were the ones concerning the function of the interaction buttons used (i.e., CONFIRM, NOT CONFIRM, DO AS AGENT SAYS) and the proper level of task difficulty.

Experiment 2

The second experiment was designed to further substantiate and complement our findings from Experiment 1. Three issues were addressed. First, we wanted to shed more light on the

effects of the different interaction buttons in the interface design. Second, we wanted to isolate the impact of the message style (persuasive vs. nonpersuasive) by alternating randomly between them within a single user. And, third, we decided to increase task complexity, in order to raise the value of the agent support.

To recapitulate, participants in the first experiment were provided with different, yet partially redundant, interaction options: (a) They could instantiate their decision concerning the update confirmation by pressing either the CONFIRM or the NOT CONFIRM button; or (b) In the case of agreement with the agent's suggestion, they could instantiate their decision as a confirmation of the agent's decision by using the DO AS AGENT SAYS button. We termed the button functionality in the former interface interaction design as *task-oriented*, the latter as *agent-oriented*.

The DO AS AGENT SAYS button, as is our belief, underscores the collaborative element of HAI specifically because it can be used only in instances of decision convergence and compliance. It also allows executing the task in a blind manner, by making one's own performance completely dependent on the agent. On the other hand, if the participant derives his or her own assessment of the update, the use of the special button necessitates a conscious comparison and concluded agreement between the personal decision and that of the agent. Further, informal comments of users after completion of Experiment 1 indicated that the DO AS AGENT SAYS button may also trigger discomfort, mainly because it forces the participants to read the agent's message, which in a subtle way undermines their autonomy. This means that although the DO AS AGENT SAYS button can free a user's cognitive resources in the case of (fully) trusting human–agent interaction, it can also increase cognitive complexity and instigate discomfort in users' interaction experiences.

Therefore, we believe that an agent-oriented interface interaction design potentially triggers counterbeneficial effects, such as user discomfort and psychological reactance, and thereby resistance against agent's suggestions. This could easily be tested by designing an agent that performs at 100% correctness level. Hereby, greater reactance and, thus, a higher disagreement rate would logically result in a lower task performance.

A side effect of using randomized persuasive and nonpersuasive messages within a single interaction design (see the Design subsection) would, in our opinion, be a weakened buildup of the collaborative relationship between the user and the agent. This could possibly undermine the positive effects of persuasive agent communication upon decision-making correctness. We therefore caution that research on collaborative HAI is not easily reducible to single interaction instances. Concerning intra-individual variances in decision-making speed, we believed that the longer, persuasive agent messages would tend to increase necessary interaction time. In spite of this all, we hoped to secure some positive effects of persuasive messages upon performance.

Finally, increasing the task's information load would, in our opinion, display little influence on the core social psychological effects of persuasion. On the one hand, it may accentuate the utility of the agent, while on the other hand lower the overall performance level due to time pressure.

Method

Participants. We recruited 24 voluntary participants with university education backgrounds. The age range was from 20 to 32, and there were overall 14 males and 10 females, balanced across experimental groups.

Design. We used a mixed design with two experimental groups, featuring the critical interface interaction design differences (agent-oriented vs. task-oriented button design) as a between-subject factor and two types of messages accompanying the updates (persuasive and nonpersuasive) as a randomly applied within-subject factor. Randomization was used in order to avoid confounding the agent–message types with particular updates. As dependent variables, we included decision-making correctness and speed, as well as questionnaire-based indicators of HAI experience.

Materials and Procedure

The materials and procedure were largely identical to the first experiment. However, we made obvious modifications to the interface design and adjusted the task demands. As in Experiment 1, this experiment was conducted in English with competent users of English as a second language.

We used the same agent interface as in Experiment 1, but without the agent avatar, and only two interaction buttons. In the agent-oriented interface interaction design, the buttons featured were AGREE WITH AGENT and DISAGREE WITH AGENT. In the task-oriented interface interaction design the buttons stated CONFIRM and NOT CONFIRM this update.

The agent's message contents were directly adapted from the HA1 condition in Experiment 1 for nonpersuasive messages, and from the HA2 condition for persuasive messages. The number of updates was reduced to 50, while the attributes rose from 4 to 7. This clearly increased the task complexity and raised the value of agent support. The added update attributes were *scalability* (i.e., the ease of updating from the old version to the new version), *security* (i.e., the level to which the update is safe against unauthorized use), and *maintainability* (i.e., the quality of being easily maintained). The value range of these attributes was 1 (*lowest*) to 5 (*highest*).

In the posttest questionnaire, we focused on participants' assessment of the agent's performance (e.g., "The agent was probably always correct"), their appreciation of the agent's support (e.g., "The agent distracted me from the task"), their evaluation of the agent's influence on their own performance (e.g., "The agent's messages strongly guided my decision making"), their comfort with the agent's assistance (e.g., "Having an agent helping during decision making was comfortable"), and the task difficulty (e.g., "There were too many [update] attributes to consider"). Participants were given the opportunity to provide additional comments and remarks at the end of the questionnaire.

Results

Of the 50 updates, participants instantiated, on average, 44.6 decision actions (DA), of which 32.3 were correct (CDA). Thus, average decision-making correctness dropped to 72.75%, when compared to Experiment 1. Participants averaged 17.2 seconds per update, with every tenth (but for some participants, as much as every second) update expiring before a decision was instantiated. Both results reflected well the increased task demands.

Mixed design variance analyses confirmed that the agent-oriented group performed, overall, inferior to the task-oriented group in terms of decision-making correctness, $F(1,20) = 3.15$; $p < .05$ (one-tailed). This group difference was, in absolute terms, most pronounced for updates with persuasive agent messages. In fact, although this was a statistically

nonsignificant interaction effect, there were strong indications that participants in the agent-oriented interface condition suffered from persuasive agent messages, as compared to non-persuasive ones, while this relation was contrary in the task-oriented condition (see Figure 6). Message persuasiveness showed no main effect on decision-making correctness.

Concerning task speed for all updates, we found a strong overall tendency for persuasive messages to increase task time, $F(1,22) = 4.11$, $p = .06$. This seemed easily explainable based on the lengthier message texts involved, and affected both groups in a comparable manner (i.e., no group or interaction effect was found).

However, from a psychological perspective, it was interesting to look at the correct and incorrect decision-making outcomes separately, since only the latter would trigger cognitive dissonance due to the implication that the user had to disagree with the agent's suggestion. As apparent from Figure 6 (right side), time-cost increase for persuasive messages was limited to and strongest for participants in the agent-oriented interface interaction design, who had to *explicitly disagree* with the agent's suggestion. During correct decision making, persuasive messages, although richer in syntax, actually decreased interaction costs ($F(1,22) = 9.62$, $p < .01$), here in comparable manner for both groups.

Finally, looking at the posttest questionnaire results, we found that the task, as intended, was judged overall as challenging, yet not too difficult. Participants did not indicate that they sensed the flawless functioning of the agent, which supported the natural validity of the experiment. Two thirds said that they could keep up their concentration until the end. We further found that the majority of participants experienced the agent's assistance as helpful and rather comfortable, and thus not annoying or distracting, or strongly seductive as such.

Concerning group differences, and consistent with our expectations, we found nevertheless a significantly lower level of interaction comfort in the group with agent-oriented interface interaction design, $U = 29.58$, $Z = 2.71$, $p < .05$. No other significant findings emerged.

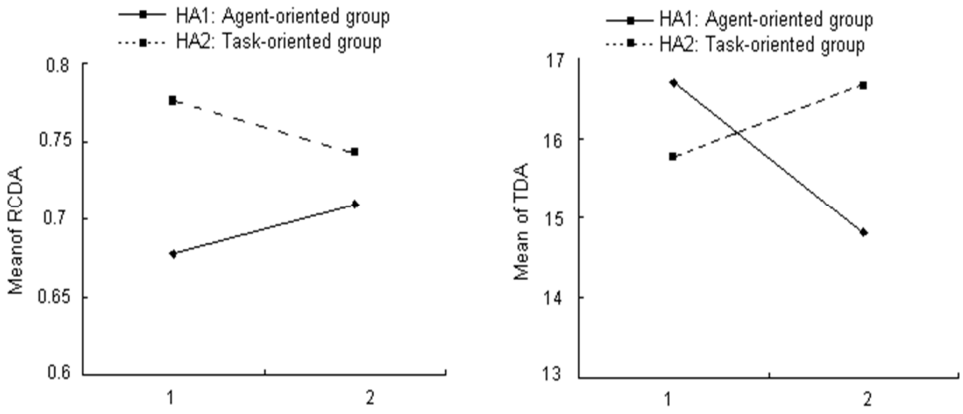

Figure 6. The comparison of correctness and time cost for incorrect decision making between the agent-oriented and task-oriented groups for different agent message types (1: persuasive; 2: nonpersuasive).

Discussion

Both the number of updates handled and the decision-making correctness diminished in the second experiment, as compared to the first, which reflected the increased complexity of the task (i.e., nearly double the number of update attributes to consider). The agent's message type (persuasive vs. nonpersuasive), which alternated randomly for each participant during the test session, did not seem to affect user decision-making correctness. This would confirm our view that the positive performance effects of HAI collaboration depends on the relatively slow process of trust buildup based on consistent persuasive agent behaviors. Persuasiveness is not visibly effective when message types vary arbitrarily.

However, although both experimental groups received the same updates and agent messages, participants in the agent-oriented interface interaction design chose more frequently to disagree with the agent, resulting in inferior task performance. This was very interesting, considering that this group had the opportunity to click simply the AGREE WITH AGENT button every single time in order to score a 100% correct result. We interpret this finding in terms of psychological reactance, that is, the natural human reluctance to accept external authority and the need to retain a sufficient level of autonomy during decision making (cf. Brehm's theory of psychological reactance, 1966). The finding was also in line with these participants' more critical evaluation of HAI comfort.

Further, the results suggested that reactance is especially fueled by persuasive agent messages, and thereby also triggering interaction time costs. Rejecting the agent's decision by clicking the DISAGREE WITH AGENT button, of course, raised the salience of the contradictory action and may have been experienced as psychologically more distressing. The length of the persuasive messages had no negative effect on decision-making speed when the user's decision conformed to that of the agent. Indeed, we found here that persuasive messaging actually increased interaction speed.

The findings give rise to an important HAI-design criterion, according to which the nature of collaboration with agents should be subtle rather than explicit or overly salient. We should avoid situations in which users experience the agent as a central actor, and thereby retain a human-centric feel to the interaction.

GENERAL DISCUSSION AND CONCLUSIONS

The presented empirical facts substantiated our claim that HAI could be enhanced through the use of elements of persuasive agent design, for example, persuasive message cues familiar from research on social influence. The results overall demonstrated that a communicatively more skillful agent can boost user task performance without the legacy of slower interaction time. The most appropriate interpretation of these effects hinted at an augmentation of users' trust and collaborative attitude regarding the employment of the agent. The findings of Experiments 1 and 2 suggested that absolute performance superiority induced by the persuasive agent grew steadily from update to update and phase to phase, and that beneficial task performance effects were not tied to single persuasive messages alone. This means, as in social reality, collaboration buildup is not instant, but evolves gradually. Hence, it is a

persuasive agent using consistent, social psychologically sophisticated communicative cues, not the persuasive messages per se, which achieves the best effects.

The findings also revealed two valuable constraints or downsides to persuasive agent design. The first pertains to agent inaccuracies and system failures or disruptions, which are always a real threat in HCI settings. In such circumstances, trusting HAI may, as was shown, have negative performance implications. Nevertheless, the findings of Experiment 1 also showed that such disruptions, even if the agent's suggestions are outright false, do not need to be catastrophic. Indeed, positive collaboration can be restored well by a persuasive agent.

The second challenge concerns establishing a social psychologically apt level of persuasive influence. Experiment 2 in particular suggests that the interaction design should refrain from making the persuasive nature and collaborative demands too salient or agent-centered. Human users want to retain a healthy degree of autonomy; influence exertion easily can go overboard and trigger user discomfort and reactance.

In sum, the effectiveness of HAI is often questioned on the level of trust that people would grant to agents. This means that research on agent design should focus not only on the agent's algorithmic sophistication in solving a problem, but also on its ability to communicate in an apt manner with human users. The present work explicates an improvement to the conventional BDI agent structure by incorporating two important models into the intentions component (see Figure 1): decision making and argumentation. The decision-making model helps the agent formulate its intention according to the input from the environment and the reasoner's actions. The argumentation model handles the presentation of the intention to the user, applying social psychologically based communication skills in order to make the agent's arguments more persuasive. This kind of persuasive agent design, if applied with consideration, is user-task effective and best suited for building trusting, long-term HAI relationships.

We challenge future research to generate more insight into these issues. In particular, we encourage extension of our work by attending to matters such as user personality effects, including user-versus-agent-avatar gender interaction.

ENDNOTES

1. Outliers, defined as observations departing more than 1.5 inter-quartile ranges from the first and third quartiles, were excluded from analysis.

2. In groups HA1 and HA2, the agent also provided misleading suggestions, depending on the decision rule extracted from participant's prior decisions. Interestingly, we found that all participants followed without exception the date rule, meaning that the date attribute featured most frequently as a positive attribute in those updates the user confirmed. It also meant that all participants received the same number (8) of misleading suggestions for the identical updates during Phase 2 (see Figure 3). This conformity was despite that other update attributes (i.e., size, rating, and cost) were more likely to be featured in the confirmatory updates. We explain this in terms of a primacy effect (Asch, 1946): Because the date attribute was displayed as the first (furthest left) attribute in the interface, it might have been the first to be compared between the file's local copy and its update.

3. In the posttest questionnaire, only the agent-supported group participants were asked about the appearance of an agent. HA2 participants were asked about the human appearance of the agent in their testing, while HA1 participants were asked what they would have thought about an agent with human appearance.

REFERENCES

Asch, S. E. (1946). Forming impressions of personality. *Journal of Abnormal and Social Psychology, 41*, 258–290.

Brazier, M. F., Jonker, M. C., & Treur, J. (2002). Dynamics and control in component-based agent models. *International Journal* of Intelligent *Systems***,** *17*, 1007–1047.

Brehm, J. W. (1966). *A theory of psychological reactance.* New York: Academic Press.

Cialdini, R. (1984). *Influence: The new psychology of modern persuasion*. New York: Quill Publishing.

Chaiken, S. (1980). Heuristic versus systematic information processing and the use of source versus message cues in persuasion. *Journal of Personality and Social Psychology, 39*, 752–766.

Deutsch, M. (1958). Trust and suspicion. *Conflict Resolution, 2*, 265–279.

Eagly, A. H., & Chaiken, S. (1984). Cognitive theories of persuasion. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 17; pp. 268–361). New York: Academic Press.

Fan, X., & Yen, J. (2004). Modeling and simulating human teamwork behaviors: Using intelligent agents. *Journal of Physics of Life Reviews, 1*, 173–201.

Festinger, L. (1957). *A theory of cognitive dissonance*. Evanston, IL, USA: Row, Peterson & Company.

Fogg, B. J. (2003). Prominence-interpretation theory: Explaining how people assess credibility online. In *Proceedings of CHI'03*: *Extended Abstracts on Human Factors in Computing Systems* (pp. 722–723). Ft. Lauderdale, Florida, USA: ACM.

Georgeff, P. M., Pell, B., Pollack, E. M., Tambe, M., & Wooldridge, M. (1998). The belief-desire-intention model of agency. In J. Muller, M. P. Singh, & A. S. Rao (Eds.), *Proceedings of the 5th International Workshop on Intelligent Agents V: Agent Theories, Architectures, and Languages* (pp. 1–10). Heidelberg, Germany: Springer-Verlag.

Goschnick, S., & Sterling, L. (2002). Psychology-based agent architecture for whole-of-user interface to the Web. Retrieved October 10, 2008, from http://www.solidsoftware.com.au/Information/Paper/Hf2002/Poster-SteveGoschnick.pdf

Guadagno, R., Blascovich, J., Bailenson, N. J., & Mccall C. (2007). Virtual humans and persuasion: The effects of agency and behavioral realism. *Media Psychology*, *10*, 1–22.

Guzzoni, D., Cheyer, A., & Baur, C. (2007). Modeling human-agent interaction with active ontologies. In N. Yorke-Smith (Chair), proceedings from the *Interaction Challenges for Intelligent Assistants*, Spring Symposium (Series Technical Reports, 1; pp. 52–59). Menlo Park, CA: AAAI Press. (Also available at http://infoscience.epfl.ch/record/102324)

Hargie, O. (1997). Communication as skilled performance. In O. Hargie (Ed.), *The handbook of communication skills* (2nd ed., pp. 10–11). London: Routledge.

Häubl, G., & Murray, K. (2001). Recommending or persuading? The impact of a shopping agent's algorithm on user behavior. In M. Wellman & Y. Shoham (Eds.), *Proceedings of the ACM conference on Electronic Commerce* (pp. 163–170). New York: Association for Computing Machinery.

Huhns, N. M., & Singh, P. M. (1998). Cognitive agents. *IEEE Internet Computing, 2*(6), 87–89.

Ingrand, F., Chatila, R., Alami, R., & Robert, F. (1996). PRS: A high level supervision and control language for autonomous mobile robots. In *Proceedings of the Thirteenth IEEE International Conference on Robotics and Automation* (pp. 43–49). Minneapolis, Minnesota, USA: IEEE.

Ingrand, F., Georgeff, M., & Rao, A. S. (1992). An architecture for real-time reasoning and system control. *IEEE Expert, 7*(6), 33–44.

Katagiri, Y., Takahashi, T., & Takeuchi, Y. (2001). Social persuasion in human–agent interaction. In *The Second International Joint Conference on Artificial Intelligence Workshop on Knowledge and Reasoning in Practical Dialogue Systems* (pp. 64–69). Menlo Park, CA: AAAI Press.

King. W. & Ohya, J. (1996). The representation of agents: Anthropomorphism, agency, and intelligence. In R. Bilger, S. Guest, & M. J. Tauber (Eds.), *Human Factors in Computing Systems*: *CHI'96 Electronic Conference Proceedings* (pp. 289–290). Vancouver, British Columbia, Canada: ACM.

Langer, E. (1978). Rethinking the role of thought in social interaction. In J. Harvey, W. Ickes, & R. Kidd (Eds.), *New directions in attribution research* (Vol. 2; 35–58). Potomac, MD, USA: Lawrence Erlbaum Associates.

Lokuge, P., & Alahakoon, D. (2005). Reinforcement learning in neuro BDI agents for achieving agent's intentions in vessel berthing applications. In *Proceedings of the 19th International Conference on Advanced Information Networking and Applications* (pp. 681–686), Los Alamitos, CA, USA: IEEE Computer Society.

Luck, M., McBurney, P., Shehory, O., & Willmott, S. (2005). *Agent technology: Computing as interaction; A roadmap for agent based computing*. Retrieved October. 10, 2008, from http://www.agentlink.org/roadmap/al3rm.pdf

Maes, P. (1994). Agents that reduce work and information overload. *ACM Communications, 37*(7), 30–40.

McGuire, W. J. (1969). The nature of attitudes and attitude change. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* (Vol. 3; 2nd ed., 136–314). Reading, MA, USA: Addison-Wesley.

McGuire, W. J. (1985). Attitudes and attitude change. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* (Vol. 2; 3rd ed., 233–346). New York: Random House.

Moran, T. P. (1981). An applied psychology of the user. *ACM Computing Surveys, 13*, 1–11.

Murray, J., Schell, D., & Willis, C. (1997). User centered design in action: Developing an intelligent agent application. In *Proceedings of the 15th Annual International Conference on Computer Documentation* (pp. 181–188). Salt Lake City, UT, USA: The ACM Press.

Nass, C., & Moon, Y. (2000). Machines and mindlessness: Social responses to computers. *Journal of Social Issues, 56*(1), 81–103.

Oulasvirta, A., & Saariluoma, P. (2004). Long-term working memory and interrupting messages in human-computer interaction. *Behaviour and Information Technology, 23*, 53–64.

Nguyen, H., Masthoff, J., & Edwards, P. (2007). Persuasive effects of embodied conversational agent teams. In J. Jacko (Ed.), *Proceedings of the 12th International Conference on Human-Computer Interaction* (pp. 176–185). Beijing, China: Springer-Verlag.

Parise, S., Kiesler, S., Sproull, L., & Waters, K. (1999). Cooperating with life-like interface agents. *Computers in Human Behavior, 15*, 123–142.

Pasquier, P., Rahwan, I., Dignum, F., & Sonenberg, L. (2006). Argumentation and persuasion in the cognitive coherence theory. In P. Dunne & T. Bench-Capon (Eds.), *Proceedings of the 1st International Conference on Computational Models of Argument* (COMMA; pp. 223–234), Liverpool, UK: IOS Press.

Peebles, D. J., & Cox, A. L. (2006). Modelling interactive behaviour with a rational cognitive architecture. In P. Zaphiris & S. Kurniawan (Eds.), *Human computer interaction research in Web design and evaluation* (pp. 290–306). London: Idea Group Inc.

Petty, R. E., & Cacioppo, T. J. (1981). *Attitudes and persuasion: Classic and contemporary approaches*. Dubuque, IA, USA: Brown.

Rahwan, I. (2005). Guest editorial: Argumentation in multi-agent systems. *Autonomous Agents and Multi-Agent Systems, 11*, 115–125.

Rao, A. S., & Georgeff, M. P. (1992). An abstract architecture for rational agents. In C. Rich, W. Swartout, & B. Nebel (Eds.), *Proceedings of Knowledge Representation and Reasoning* (pp. 439–449). San Mateo, CA, USA: Morgan Kaufmann Publishers Inc.

Reeves, B., & Nass, C. (1996). *The media equation*. Cambridge, UK: Cambridge University Press.

Sewell, W. H. (1989). Some reflections on the golden age of interdisciplinary social psychology. *Annual Review of Sociology, 15*, 1–16.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review, 84*, 127–190.

Stiff, J. B., & Mongeau, P. A. (2002). *Persuasive communication* (2nd ed.). New York: The Guilford Press.

Stock O., Guerini M., & Zancanaro, M. (2006). Interface design and persuasive intelligent user interfaces. In S. Bagnara & G. C. Smith (Eds.), *The foundations of interaction design* (pp. 193–210). Hillsdale, NJ, USA: Lawrence Erlbaum Publishing Co.

Swingle, P. G., & Gillis, J. S. (1968). Effects of emotional relationship between protagonists in the prisoner's dilemma. *Journal of Personality and Social Psychology, 21*, 121–137.

Takama, Y., Dohi, H., & Ishizuka, M. (1998). A visual anthropomorphic agent with learning capability of cooperative answering strategy through speech dialog. In the proceedings of the *Third Asian Pacific Computer and Human Interaction* conference (pp. 260–265). Washington, DC, USA: IEEE

Wichman, H. (1972). Effects of isolation and communication on cooperation in a two-person game. In L. S. Wrightsman, J. O'Connor, & N. J. Baker (Eds.), *Cooperation and competition: Readings on mixed-motive games* (pp. 197–206). Belmont, CA, USA: Brooks/Cole Publishing Company.

Wooldridge, M., & Jennings, N. R. (1995). Intelligent agents: Theory and practice. *Knowledge Engineering Review, 10*, 115–152.

Zimbardo, P., & Leippe, M. (1991). *The psychology of attitude change and social influence*. New York: McGraw-Hill.

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EXPLORING USER ACCEPTANCE OF FREE WIRELESS FIDELITY PUBLIC HOT SPOTS: AN EMPIRICAL STUDY

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Abstract: *Research regarding commercial and free wireless fidelity (Wi-Fi) public hot spots acceptance and adoption is sketchy. Therefore, it has become imperative to understand the critical factors that affect their acceptance. The focus of this study is free Wi-Fi public hot spot users, with the objective to better understand their user acceptance. In doing so, this study integrated two well-established initial acceptance models, specifically, the technology acceptance model and the diffusion of innovation theory. This study was conducted using an on-line survey that collected data from 129 users. It uses the Partial Least Square (PLS) technique to examine the relationship between variables. The results indicate that each critical factor has direct or indirect positive effects on current use and/or future use intention, which confirmed the majority of the proposed hypotheses. Relative advantage emerged as the only construct with a direct positive effect on both current use and future use intentions.*

Keywords: *technology acceptance model, diffusion of innovation, free Wi-Fi, public hot spots, partial least square, wireless fidelity.*

INTRODUCTION

Researchers suggest that advanced information technology and telecommunications infrastructures are requirements for active participation in today's global information economy (Cairncross, 2001; Kelly, 1998). One of the most important components in accelerating such active participation is high-speed broadband technology. The U. S. Technology Administration & Office of Technology Policy (2002) noted that most experts predict broadband access will enable the creation of new applications and services that will transform economies and significantly impact the competitiveness of the businesses of the future.

More importantly, wireless Internet access has entered the mainstream of the United States and other industrialized countries. As a result, broadband access to the Internet has increased and become more available to the general population. A wireless network uses radio waves as its carrier to establish broadband network connections to the Internet for users within a coverage area.

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Wireless communication allows consumers and businesses to transcend time and place, thus increasing accessibility and expanding both social and business networks (Palen, 2002). Wireless communication also promises to provide convenience, localization, and personalization of services (Clarke, 2001). One of the driving forces behind wireless technology growth was the creation of the working group of Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard of 1997, called wireless fidelity and popularly known as Wi-Fi (Bianchi, 2000).

Devices such as laptop computers and personal digital assistants (PDAs) enabled with Wi-Fi can send information to and receive it from the Internet anywhere within the range of an access point. Omni directional Wi-Fi access points are currently capable of transmitting signals up to 300 feet at up to 54 megabits per second.

Because a broadband Internet connection is seen as a facilitator for electronic commerce, eGovernment, eLearning, telemedicine, telecommuting, and overall economic prosperity, organizations and governments have supported its deployment and development by promoting the establishment of free public "hot spots" for citizen use, while businesses have created commercial public hot spots for subscription fees. For example, the early free Wi-Fi public hot spots were championed by technology enthusiasts, such as, among others, Anthony Townsend—professor of geographic information systems at New York University and co-founder and advisory board member of NYCwireless, a non-profit organization that promotes community broadband initiatives using an unlicensed wireless spectrum—who pioneered the early deployment of free Wi-Fi public hot spots in Bryant Park, Manhattan in 2002. In May 2003, the Alliance for Downtown New York City launched the Lower Manhattan Wireless Network, a collection of free wireless public hotspots in seven large and widely used locations throughout Lower Manhattan. In recent years, other players have joined in the deployment of free Wi-Fi public hot spots, hoping to reduce the digital divide and spur economic activities.

Research regarding both commercial and free Wi-Fi Internet access acceptance is sketchy; therefore, it has become imperative to understand the critical factors that affect the user acceptance of Wi-Fi public hot spots. The focus of this study is on free Wi-Fi public hot spot users, with the objective to better understand factors influencing their current use and future use intentions. In doing so, this study draws upon several well-established acceptance models, specifically the technology acceptance model (TAM; Davis, 1989), rooted in the theory of reasoned action (TRA; Ajzen & Fishbein, 1980), and the diffusion of innovation theory (DIT; Rogers, 1983, 1995, 2003).

The results of this study will extend the current knowledge of technology acceptance, and Wi-Fi in particular. The research outcome is useful to (a) academics, in extending, integrating, and refining the TAM and DIT; and (b) government and non-profit organizations, for better assessing the benefits of free Wi-Fi public hot spot investment.

For clear communication of the research findings, this paper will first present a review of the current technology acceptance literature, followed by a discussion of the theoretical framework for the study. The paper then describes the methodology and data analysis results. It concludes with a discussion of the findings, conclusions, contributions to theory and practice, limitations, and future research.

LITERATURE REVIEW

Adoption research typically attempts to describe and explain the adoption decision of individual end-users by integrating various individual and social theories of decision making. Innovation research postulates that many different outcomes are of interest in technology acceptance, including the initial decision to use the system and the continued or sustained use of the innovation (Rogers, 1995). Furthermore, as individuals gather and synthesize information, the information processing results in the formation of perceptions about the target innovation (Agarwal & Prasad, 1997). Based on these perceptions, a decision is made to adopt or reject the innovation; if this decision favors adoption; overt behavior change is manifested in the use of the innovation (Wee, 2003). The initial use of an innovation, however, may not always be sufficient to fully derive the benefits desired from the system. Users sometimes need to institutionalize the innovation as part of regular use, a usage referred to as confirmation or continued use (Rogers, 2003). Thus, this study will not only examine the factors influencing the initial use, but also will further understanding of the determinants of future use intentions.

The two theoretical models providing the underlying framework for this research—the TAM, based on the TRA, and the DIT—are explored in greater detail in the next two subsections. I will look at the TAM and DIT separately, and then how they relate to each other in regard to this study.

Technology Acceptance Model (TAM)

The most widely accepted model used to understand end-user adoption and acceptance of information technology is the TAM (Davis 1989; Davis, Bagozzi, & Warshaw, 1989) and its extension, referred to as TAM2 (Venkatesh & Davis, 2000). Many studies have successfully applied TAM, its extension, and other theories to explain end-user acceptance of various information and communications technology systems and applications (Ajzen, 1991; Moore & Benbasat, 1991; Mathieson, 1991; Taylor & Todd, 1995b).

Based on the TRA notion that a person's behavioral intention depends on the person's attitude towards the behavior and subjective norms, TAM theorizes that an individual's behavioral intention to use a system is determined by two factors: perceived usefulness and perceived ease of use. Both perceived usefulness and perceived ease of use directly affect a person's attitude towards the target system and indirectly affect actual system use (Davis, 1993). While TRA was designed to explain virtually any human behavior, the goal of TAM was to specifically provide an explanation for information systems acceptance. TAM also provides an explanation of the determinants of computer acceptance that is general and capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while simultaneously being theoretically justified (Davis et al., 1989).

The Szajna (1994) study found that the perceived usefulness (PU) and ease of use (EU) instruments demonstrate reasonably good predictive validity. Legris, Ingham, and Collerette (2003) concluded that TAM has proven to be a useful theoretical model for understanding and explaining user behavior. TAM has also been tested frequently in empirical research and the tools used with the model have proven to be of quality and to yield statistically reliable results (Legris et al., 2003).

A number of studies have successfully utilized TAM to study the acceptance of Internet-related technologies. Such technologies include e-mail (Gefen & Straub, 1997), the World Wide Web (Agarwal & Prasad, 1997; Fenech, 1998; Moon & Kim, 2001), microcomputers (Igbaria,Guimaraes, & Davis, 1995), the computer resource center (Taylor & Todd, 1995a), voice mail (Straub, Limayem, & Karahanna, 1995), telemedicine (Chau & Hu, 2001; Hu, Chau, Sheng, & Tam, 1999), a digital library (Hong, Thong, Wong, & Tam, 2002), and on-line shopping (Gefen, Karahanna, & Straub, 2003).

The Diffusion of Innovations (DIT)

This theory has been used to understand adoption behavior related to innovation (Rogers, 2003). DIT provides a theoretical framework for analyzing the characteristics of adopters and understanding their behavior over time in relation to innovations (Rogers, 1995). Diffusion has been defined as the process by which (a) an innovation (b) is communicated through certain channels (c) over time (d) among the members of a social system (Rogers, 1983, 1995, 2003). Innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted more rapidly than other innovations (Rogers, 2003). This model has been used frequently in research to predict information technology innovation and systems acceptance.

TAM and DIT Studies

Moore and Benbasat (1991) adapted the characteristics of innovations presented in Rogers (1983) and refined a set of constructs that could be used to study individual technology acceptance and adoption. In developing the instrument to measure an individual's perceptions concerning the attributes of an innovation, they pointed out the many parallels between the TAM and the DIT. As such, Moore and Benbasat asserted that the TAM's constructs, PU and EU, are essentially the same as the constructs of relative advantage and less complexity in DIT, reflecting the dominant measurement paradigm in ICT research, and hence the integration of both in this study.

Numerous studies had incorporated the TAM and DIT. Apart from Moore and Benbasat (1991), for example, Agarwal and Prasad (1997) examined the relationship between the innovation characteristics of the World Wide Web via perceived Web voluntariness and acceptance behavior. They tested individual perceptions about the characteristics of the target technology as explanatory and predictive variables for acceptance behavior. The two outcomes examined were initial use of an innovation and intention to continue such use in the future. The research model's variables accounted for 48% of the variance in current usage.

Lu, Yu, Liu, and Yao (2003a) developed a technology acceptance model for wireless Internet mobile devices (WIMD), a conceptual framework to explain the factors influencing user acceptance of WIMD. TAM for wireless Internet proposes that the key constructs affecting the medium are individual differences, technology complexity, facilitating conditions, social influences, and the wireless trust environment (Lu et al., 2003a).

Rogers (1995) used innovativeness, operationalized as time of adoption, to derive adopter categories. However, Agarwal and Prasad (1998), in reviewing prior work that has examined Rogers' notion of innovativeness, presented evidence suggesting that Rogers'

definition of a theoretical construct in operational terms suffers from methodological limitations. The shortcomings include its measurement as an ex post descriptor of behavior, thereby precluding its use as a predictor, and a lack of metrics to assess the reliability and validity of the construct. They developed and validated a construct labeled personal innovativeness in the domain of IT (PIIT), which was conceptually defined as the willingness of an individual to try out any new information technology. Their research suggested that the PIIT moderates the relationship between individuals' perceptions about technologies and their intention to use them (Agarwal & Prasad, 1998).

Chen, Gillenson, and Sherrell (2002) applied TAM and DIT to achieve an extended perspective of consumer behavior within the virtual store context, and found that these two classical theories remain valid in explaining and predicting user behavior in the business-to-consumer eCommerce context. Chen et al.'s (2002) study suggests that TAM and DIT reconfirm each other's findings, which raises the validity and reliability of these theories.

Critiques of TAM and DIT have suggested that both models do have strong limitations. Following an analysis of 22 published papers from 1980 to 2001, Legris et al. (2003) concluded that TAM was a useful model; however, they suggested integrating it into broader model. Also, critiques found DIT not predictive enough, and an overly simplified representation of a complex reality (Rogers, 2003)

Despite the criticisms, Venkatesh, Morris, Davis, and Davis (2003) integrated the elements of TAM, DIT, and six other prominent acceptance models to formulate the unified theory of acceptance and use of technology (UTAUT). The UTAUT model sets out to integrate the fragmented theory and research on individual acceptance of information technology into a unified theoretical model found to outperform each of the individual models (Venkatesh et al., 2003).

RESEARCH MODEL

The primary goal of this study is to better understand users' acceptance of free Wi-Fi public hot spots. Acceptance in this case includes the initial use and future use intentions. It is evident from the literature that a number of factors influence the acceptance of this innovation. According to the integration of TAM and DIT, the factors include, but are not limited to, the following: relative advantage (RA), ease of use (EU), facilitating conditions (FC), wireless trust (WT), and personal innovativeness in the domain of information technology (PI). These factors most likely will influence free Wi-Fi acceptance, that is, current use (CU) and future use intention (FU). Finally, this literature review has progressed to establish relevant theoretical foundation and conceptual framework necessary for hypothesis development and to operationalize the proposed study.

Hypotheses Development

The hypotheses, developed from theory-based constructs, explored the critical factors that affect acceptance of Wi-Fi in free public hotspots. In all cases, the theoretical framework of this research is based on the TAM and the DIT, as previously discussed. The five critical factors from TAM and DIT that affect the acceptance of free Wi-Fi public hot spots are shown in Figure 1.

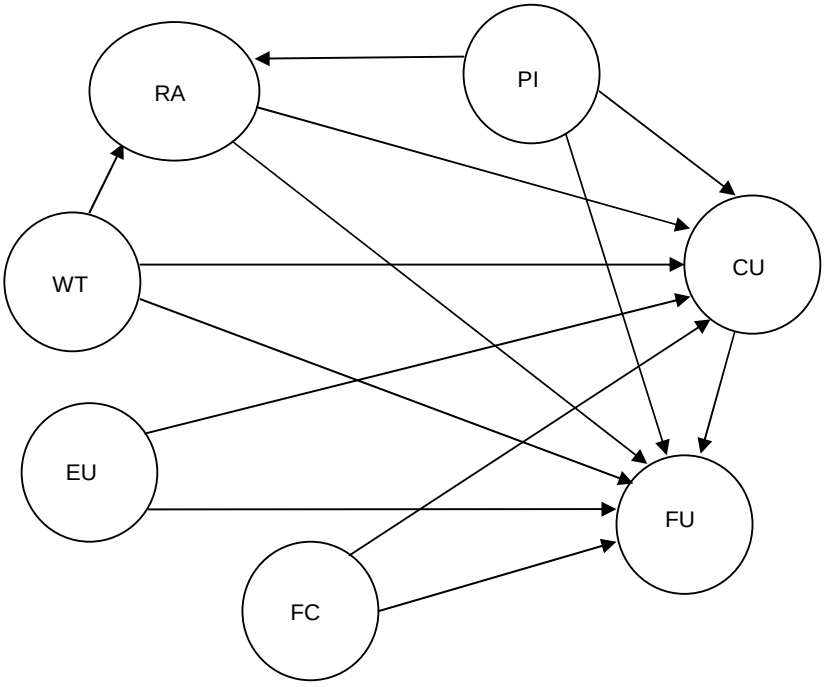

Figure 1. Research Model and Hypotheses: Relationship of Critical Factors and Wi-Fi Acceptance (current use/future use intention). Note: RA = Relative Advantage; PI = Personal Innovation in the Domain of Information Technology; CU = Current Usage; FU = Future Use Intent; FC = Facilitating Conditions; EU = Ease of Use; and WT = Wireless Trust.

Relative Advantage (RA)

RA describes the degree to which an innovation is perceived as better than that which it supersedes (Rogers, 1983; 1995). Moore and Benbasat (1991) adapted RA from the DIT (Rogers, 1983) to study individual technology adoption. They reiterated that the relative advantage construct is similar to the notion of PU in TAM (see also Davis, 1989; Plouffe, Hulland, & Vandenbosch, 2001; Venkatesh et al., 2003). Venkatesh and Davis (2000) defined PU as the degree to which an individual believes that using a particular system would enhance his or her job performance. Davis (1993) argues that PU is the most influential determinant of system usage.

Moreover, empirical studies support the importance of RA in predicting adoption behavior (Adams, Nelson, Todd, 1992; Agarwal & Prasad, 1997; Davis, 1993; Moore & Benbasat, 1991; Tornatzky & Klein, 1982). Therefore, the first two hypotheses postulate that users will name RA as direct and immediate positive effects as a determinant in their acceptance (in CU and FU) of Wi-Fi service in free public hot spots.

H1: RA of free Wi-Fi has a direct and positive effect on the CU of free Wi-Fi public hot spots.

H2: RA of free Wi-Fi has a direct and positive effect on the FU of free Wi-Fi public hot spots.

Ease of Use (EU)

Venkatesh et al. (2003) defined perceived EU as the degree to which an individual believes that the use of a particular system would be free of physical and mental effort. Systems that are perceived to be easier to use and less complex have a high likelihood of being accepted and used by potential users (Agarwal & Prasad, 1997). EU is opposite in definition to Rogers' (1983) notion of complexity, which is the degree to which an innovation is difficult to understand and use. Moore and Benbasat (1991) adapted EU and defined it as the degree to which a potential adopter views usage of the target system to be relatively free of effort. Venkatesh et al. (2003) found similarity in Davis' (1989) perceived EU and Moore and Benbasat's (1991) EU definition.

In any emerging information technology, perceived EU is an important determinant of users' intention of acceptance and usage behavior (Venkatesh & Davis, 2000). Therefore, EU will be examined as a determinant of free Wi-Fi acceptance in CU and FU situations.

H3: EU has a direct and positive effect on the CU of free Wi-Fi public hot spots.

H4: EU has a direct and positive effect on the FU of free Wi-Fi public hot spots.

Facilitating Conditions (FC)

FC are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system (Venkatesh et al., 2003). Moreover, FC encompass environmental factors that make it easy or remove barriers to perform a desired behavior (Thompson, Higgins, & Howell, 1991). Thus, FC were described as factors in the environment that encourage or discourage a behavior (Triandis, 1979). According to Lu et al., (2003a), in the context of workplace technology use, FC are believed to include the availability of training and the provision of support.

FC are confirmed as an important factor affecting Internet and WWW usage (Cheung, Chang, & Lai, 2000). Other empirical results indicate that FC do have a direct influence on usage beyond that explained by behavior intention alone (see, e.g., Cheung et al., 2000; Taylor & Todd, 1995b; Thompson et al., 1991; Venkatesh et al., 2003). Therefore, FC will be examined as a determinant of free Wi-Fi acceptance (CU and FU).

H5: FC have a direct and positive effect on the CU of free Wi-Fi public hot spots.

H6: FC have a direct and positive effect on the FU of free Wi-Fi public hot spots.

Wireless Trust (WT)

WT can be defined as the extent of a user's belief that privacy protection, security assurance, and system reliability are achieved within a wireless technology (Lu, Yu, Liu & Yao, 2004). Lu et al., (2003a) argued that trust is a complex social phenomenon that reflects technological, behavioral, social, and psychological, as well as organizational aspects, of interactions among various human and non-human agents. Trust is someone's assurance that he or she may predict the actions of the third party, may rely upon those actions, and that those actions will follow a predictable pattern in the future, especially under risky circumstances and when no explicit guaranty is provided (Jones, 2002). Consumer trust was found to be important in on-line commerce, and a widely accepted antecedent (Gefen et al., 2003). McKnight, Cummings, and Chervany (1998) defined institutional-

based trust as an individual's perceptions of safety and security within the institutional environment, in this case wireless technology, and the structural characteristics of the Internet.

According to a survey conducted by the Boston Consulting Group (Goldman, 2001), nearly 75% of U.S. consumers are concerned about security and privacy in the wireless environment. For example, computer hackers with appropriate software can steal the personal information of users (Brewin, 2002). Compared to wired Internet, wireless access to the Internet is exposed to a greater danger of security breaches (Lu et al., 2003a). The open nature of the Internet as a communication and transaction infrastructure and its global reach has made trust a crucial element of transactions, such as eCommerce (Hoffman, Novak, & Peralta, 1999).

Lu, Yu, Liu, & Yao (2003b) proposed WT as one of the determinants affecting acceptance of wireless Internet for mobile devices. WT has three key elements: security, privacy, and system reliability (Lu et al., 2004). Reports of privacy and security concerns in using the wireless Internet have been on the rise (Desai, Richards, & Desai, 2003; Phillips, 2002). Privacy concerns often arise with new information technologies, such as the wireless technology that supports enhanced capabilities for collection, storage, use, and communication of personal information (Culnan, 1993; Milberg, Burke, Smith, & Kallman, 1995; Webster, 1998). In addition to security and privacy, overall system reliability also contributes to user perceived trustworthiness. In fact, system reliability serves as the basis for system trust (Lu et al., 2004).

Because trust is a complex psychological construct, it is not easy to define its antecedents. The use of the TAM infused with the trust element is perceived to be adequate and efficient to assess users' trust levels and acceptance in virtual on-line shopping and wireless environment (Gefen et al., 2003; Lu et al., 2003a; 2003b; 2004; Mcknight, Choudhury, & Kacmar, 2002; McKnight et al., 1998). Dahlberg, Mallat, and Öörni (2003) proposed the applications of the trust-enhanced TAM to investigate user acceptance of mobile payment solutions.

It is impossible to implement business applications in a public wireless environment without first setting up a trustworthy on-line environment (Lu et al., 2003a). Therefore, all communications and transactions require an element of trust; especially those conducted in the uncertain environment of wireless technology (Lee, 1998), Therefore, WT closely relates to the RA and the CU and FU acceptance of free Wi-Fi, as I propose:

H7: WT has a direct and positive effect on the RA of free Wi-Fi public hot spots.

H8: WT has a direct and positive effect on the CU of free Wi-Fi public hot spots.

H9: WT has a direct and positive effect on the FU of free Wi-Fi public hot spots.

Personal Innovativeness in the Domain of Information Technology (PI)

PI epitomizes the risk-taking propensity that is higher in certain individuals than in others (Lu et al, 2003a). In DIT research, highly innovative individuals have been recognized as active information seekers of new ideas who are able to cope with high level of uncertainty and, at the same time, develop more positive intentions towards acceptance (Rogers, 1983, 1995, 2003).

Agarwal and Prasad (1998) defined PI as an individual trait that reflects the willingness of a person to try any new information technology. It is assumed that individuals with higher-level innovativeness are more likely to adopt an innovation. The PI construct, developed and validated, is conceptually defined as the willingness of an individual to try out any new information technology (Agarwal & Prasad, 1998).

Prior research demonstrates that individual characteristics play an important role in people's decisions to adopt or reject innovation (Lu et al., 2003b; Rogers, 1983, 1995, 2003; Tornatzky, Fleischer, & Chakrabarti, 1990). For example, Hung, Ku, and Chung (2003) confirmed that PI directly affects an individual's attitude towards the use of wireless application protocol services. Karahanna, Ahuja, Srite, and Galvin (2002) concluded that PI is one of the factors that influence a person's perceived RA of using group support systems. Lee, Kim, and Chung (2002) hypothesized and empirically supported that PI has a positive direct impact on the degree of PU of mobile Internet services.

Wi-Fi is an important information technology innovation. Potential adopters and users have the opportunity to use it of their own volition, and among them are innovators and early adopters. Therefore, it is appropriate to include PI as one individual variable in the current study to test its impact under new circumstances. Thus, PI closely relates to the RA and the acceptance of Wi-Fi, as I propose:

H10: PI has a direct and positive effect on the RA of free Wi-Fi public hot spots.

H11: PI has a direct and positive effect on the CU of free Wi-Fi public hot spots.

H12: PI has a direct and positive effect on the FU of free Wi-Fi public hot spots.

Current Usage (CU)

Innovation research postulates that many different outcomes are of interest in technology adoption, including the initial decision to use the system and the continued or sustained use of the innovation (Rogers, 1995). Initial use does not necessarily indicate that user will continue to use the target system. Furthermore, as individuals gather and synthesize information, the information processing results in the formation of perceptions about the target innovation (Agarwal & Prasad, 1997). Based on these perceptions, a decision is made to adopt or reject the innovation. If this decision favors adoption, overt behavioral change, as manifested in the use of the innovation, results (Wee, 2003). Therefore, current use for this study is defined as the successful use of free Wi-Fi public hot spot at least once.

The initial use of innovation is the CU, although it may not always be sufficient to fully derive the benefits desired from the system or lead to continued use. Past research acknowledged the necessity to control the potential influence of inertia resulting from existing use on FU (Agarwal & Prasad, 1997). Consequently, this model suggests that CU may influence the FU; hence, I propose:

H13: CU has a direct and positive effect on the FU of free Wi-Fi public hot spots.

Future Use Intention (FU)

CU and FU are the key dependent variables in information technology research and many studies have examined empirically their determinants (Agarwal & Prasad, 1997; Davis, 1989, 1993; Mathieson, 1991; Moore & Benbasat, 1991). The assumption was that widespread use of Wi-Fi had not occurred. Therefore, this study examined the decision to engage in the outcomes: Current system usage, a measure of a successful Wi-Fi use, and FU, which reflects the likelihood that the Wi-Fi usage would be institutionalized in the future (Agarwal & Prasad, 1997). This study would explore further whether the same perceptions relevant for CU also affect FU.

METHODS AND RESULTS

The research employed cross-sectional quantitative survey research as the methodological and measurement path to this study. New York City, with Wi-Fi public hotspots available throughout Manhattan, and the John F. Kennedy (JFK) and LaGuardia airports, presented the opportunity to find Wi-Fi users in the numbers needed to make the research meaningful.

A purposive sampling method was employed to identity users of Wi-Fi hot spots and to distinguish between commercial and free users. Sampling occurred in high traffic public Wi-Fi hot spot locations in Manhattan, and JFK and LaGuardia airports areas. Leaflets announcing the study were conspicuously displayed at public hotspots throughout New York City. Respondents either picked up the leaflet or were approached in person. They were asked to visit a Web site to complete a short on-line questionnaire. No discriminatory criteria (age, sex, device used) affected the decision to approach potential respondents.

A 26-item instrument was developed for the survey. The combined 8-item measures of RA (5) and EU (3) were based on the work of Agarwal and Prasad (1997), which is an adaptation of instruments previously created by Moore and Benbasat (1991) to measure the perceptions of adopting an information technology innovation. RA scored a Cronbach's alpha scale for reliability of 0.90 in studies by Agarwal and Prasad (1997), and Moore and Benbasat (1991), while EU was 0.80 and 0.84 respectively (Agarwal & Prasad, 1997). The 4-item scale of FC was based on the UTAUT model by Venkatesh et al. (2003). The questions were slightly modified to fit the context of Wi-Fi hotspots. The internal consistency reliability of Venkatesh's et al.'s (2003) original questionnaire was 0.87. The instrument to measure the level of WT (5) of users of Wi-Fi was adapted from the conceptual and definition of WT by Lu et al. (2004). The questions were revised to reflect the nature of Wi-Fi. The Cronbach's alpha internal consistency reliability for Wi-Fi was 0.84 (Lu et al., 2004). The questions measuring the degree of PI (4) were taken from the research of Agarwal and Prasad (1998), with a composite reliability for PI of 0.91 (Larsen & Sorebo, 2005).

The 5-item measures of CU (3) and FU (2) were also based on Agarwal and Prasad (1997), as adapted from Davis (1993). Self-reported measures are reasonable indicators of relative system use, and since this study is not longitudinal, a FU scale will assess the likelihood of continued usage (Agarwal & Prasad, 1997; Davis, 1993). CU and FU resulted in a Cronbach's alpha scale reliability of 0.92 and 0.81, respectively (Agarwal & Prasad, 1997).

The instrument employed a 5-point Likert scale to elicit respondents' responses to statements regarding "Wireless Fidelity Public Hotspots Service" (Elmore & Beggs, 1975). The respondents scored the statements from 1 (*strongly disagree*) to 5 (*strongly agree*). Data were collected during a period from December 2005 through September 2006. In total, 181 responses were collected. Of the 181, 52 responses were removed because the respondents did not complete the entire survey and/or they failed to indicate the particular Wi-Fi hot spot they used most often, thus making it impossible to classify them as free Wi-Fi public hot spots users. Consequently, the usable sample was reduced to 129 responses.

Descriptive Data Analysis

Of the respondents, 60% were males, 40% females. The overwhelming majority (69%) of respondents were under the age of 39 years. Only 1% were over 65 years of age. Fifty-three

percent identified themselves as professionals, while 16% were self-employed and 30% were students. Forty percent of the respondents had obtained a graduate degree (master's or higher) while 27% completed undergraduate degree. Only 4% did not attend college. Even though the study did not determine the nationalities or residence location of the respondents, the education level of Wi-Fi users surveyed is much higher than that would be found in the general U.S. population. According to 2006 U.S. census data, 25% of Manhattan residents, aged 25 and older, hold graduate degree; nationwide the number is 9.4 percent (Census Bureau, 2006).

Thirty-six percent of respondents had an annual income of above $60,000, while 33% had incomes between $30,000 and $59,999. The mean annual income of the New York metropolitan statistical area averaged $47,200 in 2005, as reported in the Metropolitan Area Occupational Employment and Wage Estimates (Bureau of Labor Statistics, 2005).

Regarding respondents' technology skill level, 48% classified themselves as experts, while 38% were high intermediate. Sixty percent have used Wi-Fi on or before 2003, and the same percentage use Wi-Fi from 1 to 5 hours a week. Laptops were by far the most frequently used device for accessing Wi-Fi (80%), and 59% used Wi-Fi in hotels, library, park, and/or schools. Given the current status of Wi-Fi use in the US (see McIntyre, 2007), the reported demographics of the respondents indicate a representative sample of Wi-Fi public hot spots users.

Partial Least Square

The data analysis of this study included the use of the Sequential Equation Modeling (SEM), specifically Partial Least Square (PLS) and SPSS analysis packages (Chin 1998b). Due to the exploratory nature of this study and its sample size, the partial Least Square (PLS) versions—Visual PLS – LVPLS version 1.04, and Chin's PLS-GRAPH 3.0 Build-1126 software—were used to estimate the model (Chin, 2003; Fu, 2006a). The minimum sample size requirement for PLS is determined by finding the larger of two possibilities: (a) a construct with the largest number of indicators, or (b) a dependent construct with the highest number of independent construct impacting it (Chin, 1998b; Gefen, Straub, & Boudreau, 2000). The minimum sample size should be at least 10 times the larger number of these possibilities (Chin 1998b). The RA and WT constructs had the largest number of indicators (five); the 129 survey respondents exceed the minimum of 50 respondents required to establish statistical validity and reliability. Analysis with PLS comprised two actions: the assessment of the measurement model, and the assessment of the structural models (Bagozzi, 1982; Fornell, 1982; Fornell & Bookstein, 1982).

The Measurement Model

The measurement model defines how each set of indicators (items) relates to its respective construct. The model comprised six latent independent variables and three latent dependent variables with 26 indicators (items). All of the items were related to constructs in reflective mode because they were viewed as effects (not causes) of the latent variables (Bollen & Lennox, 1991).

PLS is a predictive technique that handles many independent variables, even when the variables display multicollinearity (Chin, 1998b, Gefen et al., 2000). To assure that the manifest variables (items) measure the unobservable latent variables (construct), the measurement model was evaluated by examining the individual item reliabilities, reviewing

the internal consistency or convergent validity of the measures, and assessing discriminant validity (Barclay, Higgins, & Thompson, 1995).

Individual Item Reliability

In assessing the individual item reliability, the loading of each indicator on its respective construct was examined (see Chin, 1998b). Hair, Anderson, and Tatham (1987) recommend retaining indicators with a factor loading of at least 0.50 and consider them significant. In the initial run, three indicators—FC3, FC4, and WT5—loaded lower, and were subsequently dropped (see Hulland, 1999). Another run displayed acceptable factor loadings.

Internal Consistency

Internal consistency, also referred to as composite reliability or convergent validity, indicates the reliability of each block of items used to measure a specific construct. Composite reliability is considered a closer measure of internal consistency of reliability than Cronbach's alpha (Fornell & Larker, 1981). Nunnally's (1978) guideline of 0.70 for assessing reliability coefficients was used for evaluating the composite reliability of each measure block of manifest variables. A composite reliability score of 0.70 or higher is considered to be acceptable (Barclay et al., 1995). The data indicate the composite reliability and Cronbach's alpha in the free Wi-Fi model were found to be higher than the acceptable level.

Discriminant Validity

As previously stated, discriminant validity reflects the degree to which each construct is unique. To establish discriminant validity, the average variance extracted (AVE) was assessed for each construct. AVE is a measure of the average variance shared between a construct and its manifest variables (Fornell & Larker, 1981). The AVE should be greater than or equal to 0.50 for satisfactory convergent validity for a construct (Chin, 1998a; Fornell & Larker, 1981). Secondly, the AVE for a construct should be greater than the squared correlations of the construct and other constructs in the models (Chin & Newsted, 1999). These data indicate that the AVEs in the model were found to be higher than the acceptable levels.

Another measure of discriminant validity is that the square root of the AVE for a given construct should be greater than the variance between that construct and other constructs (Chin, 1998b). The final requirement of discriminant validity is that no indicator should load more highly on another construct than the construct it intends to measure (Barclay et al., 1995). An examination of the square root of the AVEs and cross-loading matrix data show that constructs and items exceeded the acceptable level.

Based on the measurement model, several observations were made. Each item loaded more highly on its own construct than on any other. Constructs' reliabilities exceeded the thresholds of > 0.70, ranging from 0.84 to 0.95. The AVEs exceeded the threshold of 0.50, ranging from 0.57 to 0.90. The scores of the constructs compared well with those measured in previous studies. Therefore, the constructs provide ample evidence of sufficient internal consistency and convergent validity of the reflective construct scales, and their items, as shown in Tables 1 and 2.

Table 1. Reliability Analysis and Average Variance Extracted.

Constructs	Composite Reliability	Cronbach Alpha	AVE
RA	0.92	0.89	0.70
EU	0.87	0.77	0.68
FC	0.91	0.82	0.84
WT	0.92	0.89	0.74
PI	0.84	0.73	0.57
CU	0.86	0.75	0.67
FU	0.95	0.90	0.90

Note: RA = Relative Advantage; EU = Ease of Use; FC = Facilitating Conditions; WT = Wireless Trust; PI = Personal Innovation in the Domain of Information Technology; CU = Current Usage; FU = Future Use Intent.

Table 2. Correlations of Latent Variables (Free Wi-Fi).

	RA	EU	FC	WT	PI	CU	FU
RA	0.840*						
EU	0.546	0.828*					
FC	0.249	0.456	0.917*				
WT	0.234	0.253	-0.222	0.863*			
PI	0.389	0.352	0.398	0.129	0.854*		
CU	0.390	0.445	0.442	0.104	0.328	0.867*	
FU	0.595	0.402	0.190	0.281	0.460	0.558	0.951*

*Square Root of AVE
Note: RA = Relative Advantage; EU = Ease of Use; FC = Facilitating Conditions; WT = Wireless Trust; PI = Personal Innovation in the Domain of Information Technology; CU = Current Usage; FU = Future Use Intent.

The Structural Model

The structural model estimates the relationship among the latent constructs. The assessment of the structural model is basically examining the path coefficients and R^2. PLS path coefficients are similar to standardized beta coefficients in ordinary regression. Larger values of R^2 indicate a higher percentage of variance of dependent variable that is explained by respective independent variables (Barclay et al., 1995). In essence, the path coefficient (standard coefficient, known as beta) indicates the relative strength of statistical relationships, while the R^2 is the relevant statistic that explains the predictive capability of the model (Fornell & Larker, 1981).

The PLS makes no distributional assumptions, therefore, a nonparametric test must be used to determine the significance of the model parameters. Moreover, the traditional overall goodness-of-fit measures used by SEM (e.g., LISREL) would be neither appropriate nor meaningful in this model (see Chin, 1998b; Hulland, 1999).

To examine the stability of the estimates, or the significance (*t* statistics) of the path coefficients, a nonparametric resampling method, such as bootstrapping or jackknifing techniques (Chin, 2003), were used to further confirm the predictive ability of the hypothesized paths (Chin 1998b; Gefen et al., 2000). In this study, the hypotheses were tested by running a bootstrapping procedure with the resampling set at 200, as recommended by Chin (1998b), to determine path coefficients and to assess their significance with *t* values.

The PLS Graph and VPLS software calculated the R^2 score for each endogenous variable (CU, FU, & RA), and the path coefficient score for each structural path between constructs. The models demonstrated high predictive power with R^2 for FU at 0.544, which indicates the explanation of 54% of the variance of future use intention. The models also demonstrated predictive power of R^2 for CU at 0.311, which indicates the explanation of 31% of the variance of the CU. Furthermore, the R^2 for RA is 0.186, as shown in Figure 2 and Table 3.

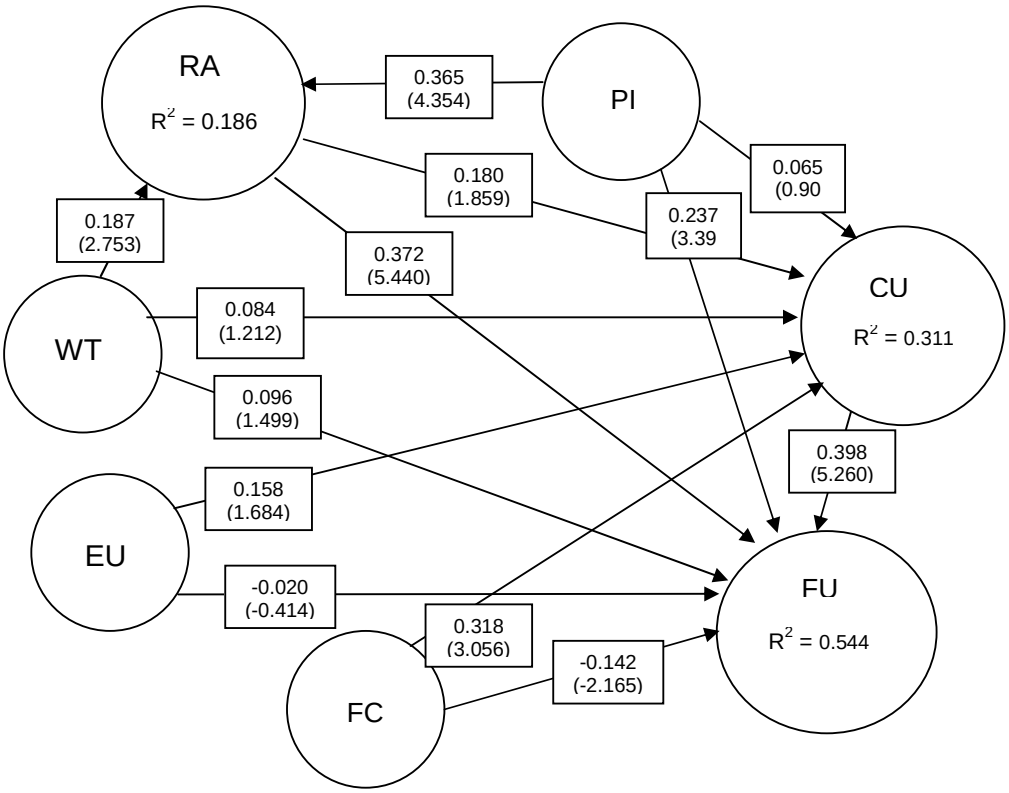

Figure 2. Free Wi-Fi public hotspots acceptance model with beta, t-statistics, and R^2
Note: RA = Relative Advantage; PI = Personal Innovation in the Domain of Information Technology; CU = Current Usage; FU = Future Use Intent; FC = Facilitating Conditions; EU = Ease of Use; and WT = Wireless Trust.

Table 3. Variance Explained/R-squared.

	Free Wi-Fi Acceptance Model
Future Use Intention (FU)	0.544
Current Use (CU)	0.311
Relative Advantage (RA)	0.186

The Effect Sizes

To further confirm the results, recall that the R^2 provides the same information about variance explained as in ordinary regression. The larger values of R^2 indicate a higher percentage of variance explained by the contributing latent variables. According to Chin (1998a), the predictive power of each latent variable can be assessed by estimating the effect size. Effect size of an independent latent variable on dependent variable is calculated to determine the magnitude of effect.

To calculate effect size in this study, each path from the exogenous (independent) construct contributing to the endogenous (dependent) construct was in turn eliminated individually, and the resulting R^2 was used to calculate the effect size (see Chin, 1998a). As recommended by Cohen (1988), the effect size value of 0.02, 0.15, and 0.35 are viewed as small, medium or large effect on the structural level. The results indicate at least a small effect exist for all validated hypotheses. Table 4 presents summary results of the interrelationships of the variables.

Table 4. Free Wi-Fi Acceptance Model Hypotheses Summary of Results.

Hypotheses	Path	Beta	t-stat	Validation
H1	RA>CU	0 .180	1.86*	Supported
H2	RA>FU	0.372	5.76***	Supported
H3	EU>CU	0.158	1.68*	Supported
H4	EU>FU	-0.020	-0.41	Not supported
H5	FC>CU	0 .316	3.05**	Supported
H6	FC>FU	-0.142	-2.16	Not supported
H7	WT>RA	0.187	2.75**	Supported
H8	WT>CU	0.084	1.21	Not supported
H9	WT>FU	0 .096	1.50	Not supported
H10	PI>RA	0.365	4.35***	Supported
H11	PI>CU	0.065	0.91	Not supported
H12	PI>FU	0.237	3.40**	Supported
H13	CU>FU	0.398	5.26***	Supported

Note: * p =.05, ** p = 01, *** p = .001
Note: RA = Relative Advantage; EU = Ease of Use; FC = Facilitating Conditions;
WT = Wireless Trust; PI = Personal Innovation in the Domain of Information Technology;
CU = Current Usage; FU = Future Use Intent.

DISCUSSION OF THE FINDINGS

The purpose of this study was to understand the critical factors affecting user acceptance of free Wi-Fi public hot spots. Eight of the 13 hypotheses proposed by the model were supported.

The RA construct was represented by five questions that reflected different dimensions of the benefits of Wi-Fi. The data support RA positive effect on CU and FU, which validates H1 and H2, statistically significant at <.05 and .001, respectively. This implies that users of free Wi-Fi public hot spots consider the benefits in their decision-making process. The validation supports much of prior research on the role of RA on CU and FU (see Agarwal & Prasad, 1997). Perhaps the actualization of the benefits that initially led users to try Wi-Fi and the derived benefits and satisfaction propelled the continued use, which is acceptance.

According to the research study data, EU has a significant influence on CU, which validates H3, statistically significant at 0.05 levels. This implies that users considered the difficulty or simplicity of the use of Wi-Fi during their decision-making process. Moreover, EU has been observed to be a significant predictor of user acceptance in a wider variety of prior research studies (see, e.g., Davis 1989; Mathieson, 1991). However, contrary to prior expectation, the results indicate that EU has no statistically significant influence on FU; thus, H4 is not supported.

There is a plausible explanation for the appearance of EU as a significant factor on CU but nonsignificant influence on FU. As stated previously, the majority of free Wi-Fi users in this study are self-proclaimed experts or high intermediates in technology skills. This suggests that users are experienced in technology use. They may consider EU as a given in new products and, as such, may not necessarily consider it in their decision to continue use of Wi-Fi beyond the initial use. Moreover, most manufacturers now include Wi-Fi chip in new laptops at no extra cost, making connection in the hotspots effortless.

In regard to FC, the research results indicate a direct and positive effect on CU, which validates H5, statistically significant at <0.001. The FC construct is represented by two questions (FC1, FC2) that reflect factors in the environment that encourage behavior, including the availability of technological resources for and knowledge about Wi-Fi usage. The results indicate that users of Wi-Fi found the technological resources, technical infrastructure, and knowledge are available and favorable to the CU of Wi-Fi. However, the results indicate that the FC construct did not demonstrate significant direct effects on FU. Thus, H6 is not supported. FC proved to have a negative and slightly significant impact on FU. The nonsupport for H6 is one of the particularly unexpected findings of this study. The direction of the hypothesized relationship was reversed, meaning that with increased availability of technological resources and knowledge ofWi-Fi, there was a decrease in FU. One possible explanation is that the majority of free Wi-Fi users in this study are relatively young (under 39), highly educated, and possessing high income and vast technology use experience. It is reasonable to infer that FC may not be as important for these users as compared to others with less experience and resources.

Regarding the WT relationship to RA, the study data show a very significant direct and positive effect, which validates hypothesis H7, statistically significant at 0.0001 levels. However, contrary to expectation, the results do not support the WT effect on CU and FU; thus, H8 and H9 were not supported. The WT construct was tested by four questions that reflect transmission security and privacy protection. In the Lu et al. (2004) study, WT had an

indirect positive but moderate effect on intention to accept through RA. Since the free Wi-Fi users in this study were of vast technology use experience, highly educated with a high income it is possible that they are well aware of the nonsecured environment of free Wi-Fi. As a result, they probably narrowed their online activities to transactions of limited risks, which might have suppressed their concerns for transmission security and privacy protection. Thus, while the free Wi-Fi users in this study were concerned about transmission security and privacy protection, such concerns seem to be factored in through RA, which highlights the benefits of the use free Wi-Fi public hot spots.

According to the results, the PI construct demonstrated significant direct and positive effects on RA, which validates hypothesis H10, significant at 0.001 levels. These findings suggest that highly innovative and more technologically experienced free Wi-Fi users perceive the benefits of the technology more than the less innovative users. However, contrary to expectation, the results found that PI has no significant influence on CU; H11 was not supported. The lack of support suggests that free Wi-Fi users do not directly accept a technology solely on its individual innovativeness. However, there are plausible explanations. While there are only a few studies (see, e.g., Lee, Kim & Chung, 2002) that found PI as a direct and positive effect on CU, the majority of prior studies found PI exerts an indirect influence on CU through other constructs, such as usefulness, RA, and EU (Agarwal and Prasad, 1998).

Furthermore, in regard to the relationship of the PI construct on FU, the results also show very significant direct and positive effects, which validate hypothesis H12, statistically significant at 0.0001 levels. The findings suggest that the highly educated and innovative free Wi-Fi users do frequently explore the new technology by experimenting with it as they become proficient and master the various uses. The experience in technology increases mastery of use, which subsequently leads to a positive influence on continued use of Wi-Fi. According to Rogers (2003), it has been recognized that highly innovative individuals are active information seekers of new ideas who are able to cope with high level of uncertainty and, at the same time, develop more positive intentions towards acceptance (Rogers, 1983, 1995, 2003).

Lastly, the results demonstrated very significant positive relationship between CU and FU, which validates H13, statistically significant at 0.001. According to Agarwal and Prasad (1997), the initial use of innovation may not always be sufficient to fully derive the benefits desired from the system. Users sometimes need to institutionalize the innovation as part of regular use; this type of usage is referred to as *confirmation.* Initial use, which is a form of participation in the implementation process, can also potentially serve as a means of developing favorable perceptions for continued use (Barki & Hartwick, 1989). The actual use, in most cases, is a prerequisite for FU. These findings are not unexpected because intentions are often formed on the basis of past behavior (Triandis, 1979).

CONCLUSIONS

This study was developed to better understand the critical factors that affect the acceptance of free Wi-Fi public hot spots. Like many other technologies, the practical implementation of Wi-Fi preceded its theoretical research.

The results indicate that each critical factor, except WT, has direct and positive effects on CU and/or FU, which confirmed majority of the proposed hypotheses. Although not all the

hypotheses were confirmed, the results showed strong support for the inclusion of these variables in the model. Thus, this research study partially fills a void in free Wi-Fi hot spots acceptance and, based on the results, a number of theoretical and practical implications are suggested that may be of interest to persons involved in the development, deployment, and study of free Wi-Fi public hot spots.

This research specifically examines the integration of TAM and DIT, known to be among the most influential theories in predicting technology acceptance and innovation diffusion. The research findings add to the cumulative knowledge on technology acceptance prediction because it clarifies the critical factors influencing Wi-Fi acceptance at free public hot spots.

Specifically, the theoretical contribution of this study is the demonstration of the importance of each of the critical factors (constructs) on the acceptance of free Wi-Fi public hot spots. The results demonstrated that the acceptance of free Wi-Fi in the public hot spots is subject to the direct or indirect influences of RA, EU, FC, WT, and PI, and the affect of CU on FU. Each construct taken alone can provide insight into user perception that contributes to Wi-Fi acceptance.

Furthermore, free Wi-Fi acceptance is being influenced by RA, EU, and FC with direct and positive influence on CU, while RA, PI, and CU have positive influence on FU. Interestingly, RA is the only construct found to have direct and positive influence on both CU and FU. WT and PI demonstrated direct and positive effect on RA, and thus indirect positive effect on CU. Overall, the research model demonstrates high explanatory power in the CU and FU of free Wi-Fi in the current research setting.

In addition to the theoretical contributions, the study has important practical considerations to contribute. RA reflected different dimensions of Wi-Fi benefits. Consequently, the evaluation of these benefits is particularly influential in the initial use and ultimate acceptance of Wi-Fi. Moreover the significance of the RA in this study also has managerial implications on how organizations and governments can expand the usage of Wi-Fi public hotspots. Operators will need to highlight the tangible benefits of Wi-Fi to potential users to convince them to try it. When users try Wi-Fi and the promised benefit matches the actual experience, there will be a tendency for continued use. In addition, operators will need to demonstrate the EU of Wi-Fi to attract new users. These demonstrations must incorporate a clear demonstration of the tangible benefits of using the Wi-Fi.

The findings suggest that the momentum generated by current Wi-Fi use in free public hotspots can be relied upon to prompt continued FU. Consequently, the favorable experience of current users of Wi-Fi is instrumental in predicting FU. Therefore, operators of public Wi-Fi hotspots must ensure a pleasant experience by meeting the benefit expectation of the initial users, with hope of retaining them as permanent users.

This study was implemented in a wide variety of locations within New York City. While it is believed to comprise a solid cross section of potential use locations, there is no evidence that the New York City user or any specific location is (or is not) representative of the rest of the United States, or any other country. Thus, these findings may not apply to the full spectrum of Wi-Fi public hot spots users at all times and in all locations. This is an exploratory study of a relatively new technology. The constructs, items, and on-line survey techniques were used uniquely for this study. Furthermore, this study suffers from certain limitations that must be taken into consideration while interpreting the results. Due to self-selection of respondents, it is impossible to conclude that a random sample was obtained. The

sample size, though valid for the techniques and methods used in the analysis, could be improved further. The sample size prevented the performance of confirmatory factor analysis on items included in the perceptual scales.

The characteristics of respondents were very different than is found in the general U.S. population. For example, the overwhelming majority of this study's users held college degrees and indicated a much higher annual income as compared to the general population. Also, they reported years of experience using technology. Such differences therefore limit the applicability of the research findings to ongoing efforts to reverse what is often called "the digital divide" (where Wi-Fi is sometimes positioned as a means of equipping people who cannot afford a monthly contract fee with an Internet service provider). Despite the above limitations, it is believed that this study does provide valuable and relevant information that may be of interest to both researchers and practitioners.

Several avenues for future research are available. In this research study, the focus was on a specific new technology, wireless fidelity in the context of examining the critical factors that influence its acceptance in the free Wi-Fi public hot spots. Future research could build upon this study through a replication across different samples, different locations, and a range of new technologies.

In addition, this is a cross-sectional research study design, which provided insight into the predictors of Wi-Fi acceptance in free public hotspots on the assumption that Wi-Fi is still in infancy and has not been widely accepted and used. Additionally, a longitudinal research design could be used with multiple samples over an extended period to provide more information to correlate or extend the findings of this study. Moreover, as we begin to understand the acceptance of Wi-Fi in the free settings with quantitative research, a qualitative research study could be very useful in providing an in-depth investigation and understanding of other issues surrounding Wi-Fi acceptance.

In summary, the overall objective of this research study was to better understand the acceptance of free Wi-Fi public hot spots users. This objective was achieved by adapting a theoretical framework of several well-established initial acceptance models that helped identify and define a set of critical factors deemed to positively influence acceptance of Wi-Fi. Moreover, the analysis employed the partial least square approach to test the constructs' relationship. Overall, the results support some of the widely held beliefs about technology acceptance while lending no support for others.

REFERENCES

Adams, D., Nelson, R., & Todd, P. (1992). Perceived usefulness, ease of use, and usage of information technology: A replication. *MIS Quarterly*, *16*, 227–247.

Agarwal, R., & Prasad, J. (1997). The role of innovation characteristics and perceived voluntariness in the acceptance of information technologies. *Decision Sciences*, *28*, 557–582.

Agarwal, R., & Prasad, J. (1998). A conceptual and operational definition of personal innovativeness in the domain of information technology. *Information Systems Research*, *9*, 204–215.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*, 179–211.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ, USA: Prentice Hall.

Baggozi, R. P. (1982). Causal modeling: A general method for developing and testing theories in consumer research. In K. B. Monroe (Ed.), *Advances in consumer research* (pp. 195–202). Ann Arbor, MI, USA: Association for Consumer Research.

Barclay, D., Higgins, C., & Thompson, R. (1995). The partial least square approach to causal modeling: Personal computer adoption and use as illustration. *Technology Studies, 2*, 284–324.

Barki, H., & Hartwick, J. (1989). Rethinking the concept of user involvement. *MIS Quarterly, 13*, 53–63.

Bollen, K., & Lennox R. (1991). Conventional wisdom on measurement: A structural equation perspective. *Psychological Bulletin, 110*(2), 305–314.

Brewin, D. (2002, July 15). Watch out for wireless rogues: Employees are bringing unsecured wireless LAN access points through the back door. Here's how to fight back. *Computerworld*. Retrieved December 25, 2003, from http://www.computerworld.com/mobiletopics/mobile /story/0,10801,72664,00.html

Bureau of Labor Statistics, U. S. Department of Labor. (2005). May 2007 metropolitan and nonmetropolitan area occupational employment and wage estimates: New York—Northern New Jersey-Long-Island, NY-NJ-PA. Retrieved May 10, 2007, http://www.bls.gov/oes/current/oes_35620.htm#b00-0000

Cairncross, F. (2001). *Death of distance: How the communications revolution is changing our lives*. Boston: Harvard Business School Publishing.

Census Bureau, U. S. Department of Commerce. (2006). Current population survey, 2006 annual social and economic (ASEC) supplement. Retrieved May 10, 2007, from http://www.census.gov/apsd/techdoc/cps/cpsmar06.pdf

Chau, P. Y. K., & Hu, P. J. H. (2001). Information technology acceptance by individual professionals: A model comparison approach. *Decision Sciences, 32*, 699–719.

Chen, L., Gillenson, M., & Sherrell, D. (2002). Enticing online consumers: An extended technology acceptance perspective. *Information &Management, 39*, 705–719.

Cheung, W., Chang, M., & Lai, V. (2000). Prediction of Internet and World Wide Web usage at work: A test of an extended Triandis model. *Decision Support Systems, 30*, 83–100.

Chin, W. (1998a). Issues and opinion on structural equation modeling. *MIS Quarterly, 22*, 7–16.

Chin, W. (1998b). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), *Modern methods for business research* (pp. 295 – 336). Mahwah, NJ, USA: Lawrence Erlbaum Associates.

Chin, W. W., Marcolin, B. L., & Newsted, P. N. (2003). A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an electronic-mail emotion/adoption study. *Information Systems Research, 14*, 189–217.

Chin, W., & Newsted, P. (1999). Structural equation modeling analysis with small sample using partial least square. In R. H. Hoyle (Ed.), *Statistical strategies for small sample research* (pp. 307–341). London: Sage Publications.

Clarke, I. (2001). Emerging propositions for m-commerce. *Journal of Business Strategies, 18*, 133–148.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ, USA: Lawrence Erlbaum Associates.

Culnan, M. (1993). How did you get my name? An exploratory investigation of consumer attitudes towards secondary information use. *MIS Quarterly, 17*, 341–363.

Dahlberg, T., Mallat, N., & Öörni, A. (2003, May). *Trust enhanced technology acceptance model: Consumer acceptance of mobile payment solutions*. Paper presented at the Mobility Roundtable, Stockholm, Sweden.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319–340.

Davis, F. D. (1993). User acceptance of information technology: System characteristics, user perceptions and behavioral impacts. *International Journal of Man-Machine Studies, 38*, 475–487.

Davis, F., Bagozzi, R., & Warshaw, P. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*, 982–1002.

Desai, M. S., Richards, T. C., & Desai, K .J. (2003). E-commerce policies and customer privacy, *Information Management & Computer Security*, *11*, 19–27.

Elmore, P. E., & Beggs, D. L. (1975). Salience of concepts and commitment to extreme judgments in response pattern of teachers. *Education*, *95*, 325–334.

Fenech, T. (1998). Using perceived ease of use and perceived usefulness to predict acceptance of the World Wide Web. *Computer Networks and ISDN Systems*, *30*, 629.

Fornell, C. (1982). *A second generation of multivariate Analysis: Vol. 1. Methods*. New York: Praeger.

Fornell, C., & Bookstein, F. (1982). Two structural models: LISREL and PLS applied to consumer exit-voice theory. *Journal of Marketing Research*, *19*, 440–452.

Fornell, C., & Larker, D. (1981). Evaluating structural equation models with unobservable variables and measurement errors. *Journal of Marketing Research*, *18*, 39–50.

Fu, J. R. (2006a). VisualPLS – Partial Least Square (PLS) Regression – An Enhanced GUI for Lvpls (PLS 1.8 PC) Version 1.04. National Kaohsiung University of Applied Sciences, Taiwan, ROC. Retrieved May 10, 2007, from http://www2.kuas.edu.tw/prof/fred/vpls/index.html

Gefen, D., Karahanna, E., & Straub, D. (2003). Trust and TAM in online shopping: An integrated model. *MIS Quarterly*, *27*, 51–90.

Gefen, D., & Straub, D. (1997). Gender difference in the perception and use of e-mail: An extension to the technology acceptance model. *MIS Quarterly*, *21*, 389–400.

Gefen, D., Straub, D., & Boudreau, M. (2000). Structural equation modeling and regression: Guidelines for research practice. *Communications of the Association of Information Systems*, *4*, 1–80.

Goldman, C. (2001). Banking on security. *Wireless Review*, *18*, 22–24.

Hair, J., Anderson, R., & Tatham, R. (1987). *Multivariate data analysis*. New York: Macmillan Publishing.

Hoffman, D., Novak, T., & Peralta, M. (1999). Building consumer trust online. *Communications of the ACM*, *42*, 80–85.

Hong, W., Thong, J., Wong, W., & Tam, K. (2002). Determinants of user acceptance of digital libraries: An empirical examination of individual difference and system characteristics. *Journal of Management Information Systems*, *18*, 97–124.

Hu, P. J., Chau, P. Y. K., Sheng, O. L., & Tam, K. Y. (1999). Examining the technology acceptance model using physician acceptance of telemedicine. *Journal of Management Information Systems*, *16*, 91–112.

Hulland, J. (1999). Use of partial least square (PLS) in strategic management research: A review of four recent studies. *Strategic Management Journal*, *20*, 195–204.

Hung, S. Y., Ku, C. Y., & Chang, C. M. (2003). Critical factors of WAP services adoption: An empirical study. *Electronic Commerce Research and Applications*, *2*, 42–60.

Igbaria, M., Guimaraes, T., & Davis G. (1995). Testing the determinants of microcomputer usage via structural equation model. *Journal of Management Information Systems*, *11*, 87–114.

Jones, A. (2002). On the concept of trust. *Decision Support Systems*, *33*, 225–232.

Karahanna, E., Ahuja, M., Srite, M., & Galvin, J. (2002). Individual differences and relative advantage: The case of GSS. *Decision Support System*, *32*, 327–341.

Kelly, K. (1998). *New rules for the new economy*. New York: Penguin Books.

Larsen, T., & Sorebo, O. (2005). Impact of personal innovativeness on the use of the Internet among employees at work. *Journal of Organizational and End User Computing*, *17*, 43–63.

Lee, H. (1998). Do electronic marketplaces lower the prices of goods? *Communications of ACM*, *41*, 73–80.

Lee, W. J., Kim, T. U., & Chung, J. Y. (2002, July). *User acceptance of the mobile Internet*. Paper presented at the First International Conference on Mobile Business [Mobiforum], Athens, Greece.

Legris, P., Ingham, J., & Collerette P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management*, *40*, 191–204.

Lu, J., Yu, C., Liu, C., & Yao, J. (2003a). Technology acceptance model for wireless Internet. *Internet Research: Electronic Networking Application and Policy*, *13*, 206–222.

Lu, J., Yu, C., Liu, C., & Yao, J. (2003b). Exploring factors associated with wireless Internet via mobile technology acceptance in Mainland China. *Communications of the Information Management Association*, *3*, 101–120.

Lu, J., Yu, C., Liu, C., & Yao, J. (2004). Wireless trust: Conceptual and operational definition. *International Journal of Mobile Communications*, *2*, 38–50.

Mathieson, K. (1991). Predicting user intentions: Comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research*, *2*, 173–191.

McIntyre, T. (2007). Poll reveals one third of US citizens access Wi-Fi: So what? Retrieved July 10, 2007, from http://tech.blorge.com/Structure:%20/2007/02/26/poll-reveals-one-third-of-us-citizens-access-wifi/

McKnight, D., Choudhury, V., & Kacmar, C. (2002). Developing and validating trust measures for e-commerce: An integrated typology. *Information Systems Research*, *3*, 334–359.

McKnight, D., Cummings, L., & Chervany, N. (1998). Initial trust formation in new organizational relationships. *Academy of Management Review*, *23*, 473–490.

Milberg, S., Burke, S., Smith, H., & Kallman, E. (1995). Values, personal information privacy, and regulatory approaches. *Communications of the ACM*, *38*(12), 65–84.

Moon, J. M., & Kim, Y. G. (2001). Extending the TAM for a World Wide Web context. *Information and Management*, *28*, 217–230.

Moore, G., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting new information technology innovation. *Information Systems Research*, *2*, 192–222.

Nunnally, J. (1978). *Psychometric theory*. New York: McGraw-Hill.

Palen, L. (2002). Mobile telephony in a connected life. *Communication of the ACM*, *43*(6), 73–82.

Phillips, J. (2002). Welcome to the new wireless culture. *Information Management Journal*, *36*, 64–68.

Plouffe, C., Hulland, J., & Vandenbosch, M. (2001). Research report: Richness versus parsimony in modeling technology adoption decision: Understanding merchant adoption of a smart card-based payment system. *Information Systems Research*, *12*, 208–222.

Rogers, E. M. (1983). *Diffusion of innovations* (3rd ed.). New York: Free Press.

Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York: Free Press.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

Straub, D., Limayem, M., & Karahanna, E. (1995). Measuring system usage: Implications for IS theory testing. *Management Science*, *41*, 1328–1342.

Szajna, B. (1994). Software evaluation and choice: Predictive validation of the technology acceptance instrument. *MIS Quarterly*, *18*, 319–324.

Taylor, S., & Todd, P. (1995a). Assessing IT usage: The role of prior experience. *MIS Quarterly*, *19*, 561–571.

Taylor, S., & Todd, P. (1995b). Understanding information technology usage: A test of competing model. *Information Systems Research*, *6*, 144–176.

Technology Administration & Office of Technology Policy, U. S. Department of Commerce. (2002, September 23). Understanding broadband demand: A review of critical issues. Retrieved December 12, 2007, from http://www.broadband.gr/content/modules/downloads/UNDERSTANDING_BROADBAND_DEMAND.pdf

Thompson, R., Higgins, C., & Howell, J. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quaterly*, *15*, 125–143.

Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). *The processes of technological innovation*. Lexington, MA, USA: Lexington Books.

Tornatzky, L., & Klein, K. (1982). Innovation characteristics and innovation adoption-implementation: A meta-analysis of findings. *IEEE Transactions on Engineering Management*, *29*, 28–45.

Triandis, H. (1979). Values, attitudes, and interpersonal behavior. In H. E. Howe (Ed.), *Nebraska Symposium on Motivation: Vol. 27. Beliefs, Attitudes and Values* (pp. 192–259). Lincoln, NE, USA: University of Nebraska Press.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*, 186–204.

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*, 425–478.

Webster, J. (1998). Desktop videoconferencing: Experiences of complete users, wary users, and non-users. *MIS Quarterly*, *22*, 257–286.

Wee, T. (2003). Factors affecting new product adoption in the consumer electronics industry. *Singapore Management Review, 25*, 51–71.

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APPENDIX

RESEARCH INSTRUMEMNT

Relative Advantage (RA)

RA1: Using the "Wireless Fidelity Public Hotspots" makes it easier to do my work.

RA2: Using the "Wireless Fidelity Public Hotspots" helps me to accomplish my tasks more quickly.

RA3: Using the "Wireless Fidelity Public Hotspots" improves the quality of the work I do.

RA4: Using the "Wireless Fidelity Public Hotspots" gives me greater control over my work.

RA5: Using the "Wireless Fidelity Public Hotspots" enhances my work effectiveness.

Ease of Use (EU)

EU1: Learning to use the "Wireless Fidelity Public Hotspots" is easy for me.

EU2: I find it easy to get the "Wireless Fidelity Public Hotspots" to do what I want it to do.

EU3: My interaction with the "Wireless Fidelity Public Hotspots" is clear and understandable.

Facilitating Conditions (FC)

FC1: I have the technological resources necessary to use the "Wireless Fidelity Public Hotspots."

FC2: I have the knowledge necessary to use the "Wireless Fidelity Public Hotspots."

FC3*: The "Wireless Fidelity Public Hotspots" are often not compatible with other wireless equipment I use.

FC4*: I would know whom to contact if I had problem with the "Wireless Fidelity Public Hotspots."

Wireless Trust (WT)

WT1: When using "Wireless Fidelity Public Hotspots," I am sure that I will be notified if personal information is collected for commercial use.

WT2: When using "Wireless Fidelity Public Hotspots," I am sure I will be allowed to access the data collected from me.

WT3: When using "Wireless Fidelity Public Hotspots," I am sure that I have a choice to op-in and/or opt-out on the sharing of my personal information with third parties.

WT4: When using "Wireless Fidelity Public Hotspots," I am sure that adequate procedures exist to protect my personal information.

WT5*: "Wireless Fidelity Public Hotspots" are reliable all the time.

Personal Innovativeness in the Domain of IT (PI)

PI1: I like to work with new information/communication technologies.

PI2: If I heard about new information/communication technology, such as Wi-Fi, I would look for ways to experiment with it.

PI3: In general, I am hesitant to try out new information technologies. (Reversed)

PI4: Among my peers, I am usually the first to try out new information/ communication technologies.

Current Usage (CU)

CU1: I use the "Wireless Fidelity Public Hotspots" at least once per week.

CU2: I use the "Wireless Fidelity Public Hotspots" whenever I am in a location where it is available.

CU3: I use the "Wireless Fidelity Public Hotspots at least three times per week.

Future Use Intention (FU)

FU1: I intend to increase my use of the "Wireless Fidelity Public Hotspots" in the future for personal and entertainment purposes.

FU2: I intend to increase my use of the "Wireless Fidelity Public Hotspots" in the future for my work purposes.

*dropped for low loading during the analysis

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THE NEW MEDIA AND HETEROTOPIC TECHNOLOGIES IN THE PHILIPPINES

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Abstract: *Information overload is perhaps the most common frustration of our age. It strikes everyone: young and old, educated and uneducated, rich and poor, first world and third world. Human communication has taken on the qualities of the supernatural. Indeed it has surpassed it! Zeus could only rely on Mercury's speed to convey his commands; presently electronic messages zip around the globe and the universe at the speed of light. No wonder that new communication technologies often evoke notions of the supernatural. This paper deals with some of the unexpected effects of the new communication technologies, in particular for mobile phones. While the mobile has become the icon of connectedness, it also serves as the index of our disconnectedness with mundanity. This apparent contradiction generates inevitable anxieties often linked to the supernatural or the otherworldly.*

Keywords: *mobiles, heterotopia, posthuman subjects, supernatural communication.*

INTRODUCTION

Information overload is perhaps the most common frustration of our age. It strikes everyone: young and old, educated and uneducated, rich and poor, first world and third world. It manifests itself in diverse forms: philosophically as postmodernism, theologically as fundamentalism, economically as overproduction, politically as the rise of globalism. As a wit put it, "Never before in human history …have so many been surrounded by so much that they can't follow" (Iyer, 2000, p. 28). No wonder that the "War on Terror," however misapplied, aptly describes what everyone—Muslim, Christian, Jew, conservative, non-conformist, migrant, woman, gay—feels. In Iyer's terms, we have become *nowherians*, only at home elsewhere. What has brought about this condition?

Human communication has taken on the qualities of the supernatural. Indeed it has surpassed it! Zeus could only rely on Mercury's speed to convey his commands (Katz & Aakhus, 2002). Presently electronic messages zip around the globe and the universe at the speed of light. No wonder that new communication technologies often evoke the wonder of the supernatural.

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This paper deals with some of the heterotopic effects of the new communication technologies, in particular for mobile phones. While the mobile has become the icon of connectedness, it also serves as the index of our disconnectedness with mundanity. The collapse of the social and its replacement by the network requires different communicative strategies. Sometimes these strategies involve the recently passed away. It is these transgressions that generate heterotopias or incommensurable experiences.

THE RISE OF CULTURAL DEMOCRACIES

H. G. Wells' novel (*The Time Machine*, 1895) provided the first fictional account of space/time disjunction, at a time when great social transformations were being experienced in Europe. For Wells, the age of technology would dismantle all the social subtleties generated by tradition, resulting in a world of "respectable mechanics" (Cochrane, 1966, p. 11). Electricity was seen as the great leveler and threatened a major social transformation. Thomas Hardy describes a crowd in the British Museum in the 1880s:

> They pass with flippant comments the illuminated manuscripts – the labour of years – and stand under Ramases the Great, joking. Democratic government may be justice to man but it will probably merge in the proletarian, and when these people become our masters, it will lead to more of this contempt and possibly be the utter ruin of art and literature. (cited in Carey, 1992, p. 24)

A similar view is expressed by T.S. Eliot:

> There is no doubt that in our headlong rush to educate everybody, we are lowering our standards … destroying our ancient edifices to make ready the ground upon which the barbarian nomads of the future will encamp in their mechanized caravans. (cited in Carey, 1992, p. 15)

Except for overcrowded parking lots, the consequences have not been so dire but it has resulted in the domination of the public sphere by popular culture, hitherto the preserve of the elite. The explosion of the electronic media has indeed produced a social revolution of tastes, values, and ideologies. No wonder people are proclaiming the end of history, of politics, and even the corporeal. Or, are they simply confusing this with the democratization of the sphere of culture?

We seem to be on the cusp of a new age! Astonishing claims are being made by social theorists. According to Barlow (1995, p. 36),

> With the development of the Internet, and with the increasing pervasiveness of communications between networked computers, we are in the middle of the most transforming technological event since the capture of fire. I used to think that it was just the biggest thing since Gutenberg, but now I think you have to go back further.

The invention of movable type printing by Gutenberg in the 15th century was the impetus for modernity, with its reflective and abstract textuality (Pertierra, 1997). The text inserted the abstract, with its qualities of detachment from the immediately concrete, into the routines of everyday life. Reading became a major practice, leading to an inner reflectivity as well as connecting these reflectivities into broad audiences whose members were unknown to one

another. This resulted in a community of strangers. It was virtual communities such as these that allowed the construction of a national imaginary, whose members shared strong attachments to common sentiments even as they remained unknown to one another (Anderson, 1983). But these virtual communities consisted of passive members, unable to communicate with each other directly. Most modern mass media has retained this passivity, whose members mainly share practices of consumption. While consumption can be seen as a form of appropriation (Miller, 1997), its generative structures largely remain inaccessible. The attempts to make these communities of consumption more participative or interactive—such as talk shows, readers' columns, and discussion groups—have not been entirely successful. The technology needed to connect large numbers of interlocutors simultaneously did not exist before the age of computers. The World Wide Web connected computers into a network of communication whose participants have increased in geometric proportions. People now routinely participate in global networks, enjoying a simultaneous present or in real time.

The Internet makes it possible to return to a more intimate orality on a global scale, with its chat groups and informal networks. The limits of community are confounded when the local, diasporal, and global intersect. Their members are both de-spatialized and re-territorialized: They are nowhere and everywhere. These new intersections produce distinct hybridities embodied in transformed subjectivities. The self is able to take new identities, thus transcending corporeal limitations. The human and its avatar become indistinguishable. Real and virtual identities interact in the cyberworld, whose members include humans, cyborgs, and even the dead.

Barlow makes an even bigger claim. He equates the Internet with the domestication of fire, the very beginning of human culture and the start of our domination of nature. The control of fire gave humans a truly transforming technology, resulting in basic anatomical and sociocultural changes (Goubsblom, 1992). Human evolution took on a distinctive path thereafter. The control of fire was followed by the domestication of plants and livestock. Thus began the human project of controlling and dominating nature. Some claim the end of nature, since this domination is now complete. As Saunders (1989, p. 222) argues, "In the modern world, where we work, sleep or take our leisure depends more in the created spaces we have manufactured—the factory, the semi-detached house, the seaside resort—than on the natural or inherent characteristics of different locations."

Following Barlow, one assumes that the electronic revolution will transform the human either into the post-human or, at least, the cyborg. Organically modified crops now include human, baboon, and tomato genes in weird combinations. Cyberspace and virtual reality are new ontologies, often subverting the former space–time continuum. The global merges with the local into the glocal, disrupting identities based on territoriality, such as the nation-state. Homogenous and territorialized cultures are rapidly hybridized, while diasporas are localized. The ephemeral and transitory become tropes of our time, transforming social solidities into highly malleable (liquid) states (Bauman, 2005).

The routine incorporation of dacron, steel, and electronic devices (e.g., cochlear implant, pacemaker, silicon breasts, aluminum joints, artificial hearts, and synthetic lenses) into the human body transforms it from an organic unity into a techno-formation. The seamless merging of human and machine generates problems for an earlier understanding of culture as distinct from and opposed to nature. In the cyborg, the dialectic between culture and nature is fully established and transcended. Culture not only informs but also constitutes nature, which

in its turn disinforms culture. Brute facticity and human purposiveness merge into the human–machine. The post-human subject combines the corporeal intimacy of a tool with the effectiveness of a machine. For these reasons, social theorists (e.g., Kirby, 1997) are presaging the end of the corporeal and the birth of the post-corporeal or the replacement of the human by the post-human. H. G. Wells' (1895) fears may have been exceeded: We are becoming a nation not of mechanics but of machines. Society has been transformed into a technoformation where culture has been reduced to data.

Perhaps this is the source of our unease: the fear of being displaced and outmoded by machines. Others make equally astonishing claims: "We're going to be Gods, we might as well get good at it" or "In another thousand years, we'll be machines or gods" (Gray, 2002, p. 9). These claims may be a bit premature for the Philippines, with its low rate of Internet (12%) and mobile phone penetration (60%), even if these usages are growing quickly (Pertierra, 2006). Nevertheless, new forms of technoscience have enormous potentials for social and cultural change. A leading electronic journal advertised its orientation as follows:

> The Leonardo Electronic Almanac (ISSN No: 1071-4391) is inviting papers that address the complex relationship between technology and difference. Technology is often conceived as an ability to "create", "innovate", "make"; all that which differentiates: 'man' from 'nature'; human from animal. It is seen as a path to 'God(s)' and 'community', sociality, spirituality, and consciousness.
>
> Cultural differences are enacted in differentiations of "technologically advanced" from "technologically backward" cultural traditions, often evidenced in statistics on use and proliferation of such technologies.…
>
> In the past few decades, however, a new optimism has been propagated of a technology that is said to operate as a de-differentiating force: it builds bridges, it unites, it globalizes (for better or for worse), it brings us closer. It goes beyond "old" differences: ethnic, sexual, cultural, animal, towards "new" differences between human and (intelligent) machine, human and post-human, human and transgenic or artificial species.

Admittedly, evidence of these future transformations had been building for sometime. Hughes (1979, p. 35) argues that,

> There are certain periods in history in which a number of advanced thinkers, usually working independently of one another, have proposed views on human conduct so different from those commonly accepted at the time–and yet so manifestedly interrelated that together they seem to constitute an intellectual revolution. The decade of the 1890s was one of such periods.

Quoting Parsons, he comments,

> A revolution of such magnitude in the prevailing empirical interpretations of human conduct is hardly to be found occurring within the short space of a generation, unless one goes back to about the 16th century. What is to account for it? (Hughes, 1979, p. 33)

Romain (1987) uses 1900 as the turning point for the end of the old European order and the beginning of the new one. This new age included a perplexing variety of events, such as the wedding of Archduchess Maria Immaculata to Prince Ruprecht of Wurttemberg, the Paris-Lyons motor race, the outbreak of bubonic plague in Glasgow, the death of Nietzche, the publication of Freud's *The Interpretation of Dreams*, the meeting of the International

Congress of Spiritualists, the use of statistics for public policy, and the 8th issue of Durkheim's journal *L'Annee Sociologique*. These events had been preceded by the laying of the transatlantic cable in 1870, as well as the introduction of standard time zones (O'Malley, 1990). Together they welded a hitherto diachronic world into a synchronic one. This synchronicity now includes visual, aural, and textual communication. Before long, one expects this to include tactile contact.

ETHERIC MESSAGES

Thomas Watson, Alexander Graham Bell's assistant, described how he was fascinated by the power of the telephone:

> I used to spend hours at night in the laboratory listening to the many strange noises in the telephone and speculating as to their cause. One of the most common sounds was a snap, followed by a grating sound that lasted two or three seconds before it faded into silence, and another was like the chirping of a bird. My theory at this time was that the currents causing these sounds came from explosions on the sun or that they were signals from another planet. (cited in Heumann, 1998, p. 3)

Michael Heumann (1998, p. 1) writes,

> There is, no doubt, a link between the telephone's otherworldly sounds and the voices and noises (Watson) heard during Spiritualist séances. That he approaches both the spiritualist and the scientific mediums with the same careful scrutiny suggests not merely the seriousness with which he held both subjects but also a willingness to see in the telephone the same supernatural forces that are conceivably at work during a séance. Sound, in Watson's case, is the medium through which science and superstition are able to converge.

Moving from the telephone to the phonograph, Heumann continues,

> Just as the phonograph presents a new conception of communication based upon replication and reproduction, so it also questions the authenticity and authority of the human voice as maker and definer of meaning. The ambivalence generated by such disconcerting consequences is raised in the December 22, 1877 article in *Scientific American*, which … emphasizes the phonograph's humanity as if to "deliberately magicalize the apparatus as if it were animated by a little human inside it," with a full knowledge of social customs, an eager concern over others well-being, and a calm and graceful demeanor.… (1998, p. 8)
>
> Just as the phonograph has the potential to transcend death and heighten democratization (making music available to all citizens), it also alters the reality of a sound so that even "the illusion of real presence" cannot be certified without first checking with the phonographic recording. This is a point Theodore Adorno and Walter Benjamin, among others, make in the 1930s; however, by then, the focus had shifted away from the effacement of reality to fascism's manipulation of that "illusion" by technologic means. This results in a newly conceived "reality" that is wholly subsumed within the "virtual" realm of technology. (1998, p. 12)

ANTINOMIAN TECHNOLOGIES

Technologies of displacement, whether spatial, temporal, or communicative, inevitably produce neurasthenia. The telephone, just like the steam locomotive before it, disrupted accepted routines and raised fears about their consequences. No wonder that new technologies evoke antinomian and even eschatological fears. The disengagement of time from space has led to the transgression of hitherto impenetrable boundaries. The divisions between life and death, nature and culture, male and female, human and machine have to be renegotiated. The hopes and fears initially accompanying the implementation of a new technology not only tell us much about how such novel technologies are embedded in existing practices but also about how such a novel technology comes to be culturally constructed in a particular context, time, and place.

While popular fiction and the cinema have often expressed the anxieties caused by novel technologies, this concern is also found in more realist, albeit non-Western, accounts. There have been reports in Nigeria that people die after receiving certain mysterious calls. Jane-Francis Agbu (2004) recounts the case of a woman who claimed to have received a call that almost led to her death. The phone flashed the name of a relative but without the number:

> On the first day the phone rang, I picked it up and shouted hello, hello but did not get any reply. I was hearing strange noises in the background. The call came again at the weekend, when I picked it up, I lost control completely. I don't know who is behind this and I don't want any problems. (Agbu, 2004, p. 5)

A similar incident was reported in Lagos that same year. A young man received a call from a number 0172021127. Suddenly he shouted "Blood of Jesus, Blood of Jesus," before he collapsed. Fortunately sympathizers were able to revive him. A company in Lagos warned its employees about these killer numbers and posted them on its notice board:

> Please beware of these strange GSM numbers: 0801113999, 08033123999, 08032113999 and 08025111999. In short any number that ends with 333, 666, 999. They are killing! This is nothing but reality, you are warned. (Agbu, 2004, p. 7)

TECHNOLOGY AND SOCIETY

The relationship between technology and society has always been problematic. On the one hand, all technology is a product of its contextual culture but, on the other, technology threatens to bring about societal change, often in unpredictable ways. While technology does not itself determine sociocultural change, it opens up new conditions of possibility hitherto unavailable (Katz & Aakhus, 2002). These new conditions of possibility, using a Weberian metaphor, act as rail switches enabling social change to proceed along new ways. According to Weber (1930/1976), changes in the inner-world brought about by the Protestant ethic ultimately created the conditions for modern capitalism. This change in attitude was the product of the wide accessibility of the Bible, made possible by mechanical printing (Eisenstein, 1979). This technological revolution ushered in a new spirit of inquiry enabling a renewed spiritual awakening, as well as its eventual replacement by natural science. What

started out as a new form of reflectivity made possible by the text (Ricoeur, 1971) resulted in intersubjective and objective structures known as modernity.

The global condition exacerbates this tension between society and technology since technology can now rapidly spread to cultures far removed from its origins. While this paper deals with the idiosyncratic use of mobile phones in the Philippines, we could as easily have stressed the commonalities of their uses found throughout the world. While technology always responds to its cultural environment, it may also reflect transcultural and universal features. Technologies may express the zeitgeist and hence may be described as *apparatgeist* (Katz & Aakhus, 2002). Such claims may be made of mobile phones, not only because of their rapid spread globally but also because of their common enabling effects. They not only reflect the times, but also usher corresponding changes.

Similar to its introduction in the West, the first steam locomotive initially unsettled the tranquility of the Philippine countryside but quickly established itself as integral to commerce and everyday life (Gonzalez, 1979). The railway line from Manila to Dagupan was inaugurated in 1892 amidst a great celebration that included a Te Deum Mass. The event was seen as a great triumph of both the State and the Church. The telegraph, the motorcar, and other inventions were quickly introduced in the Philippines, reflecting as well as exacerbating the rapid changes of late modernity. Colonialism and imperialism imposed alien forms of the life in distant lands and a global economy brought everything into flux everywhere. No wonder that the present condition is ontologically insecure (Giddens, 1990) or, as some have described the contemporary world, having a surplus of meaning but a lack of sense (Markus, 1997). We need anchoring structures in such shifting conditions, and perhaps the success of the mobile phone is due to its ability to meet this need.

In a parallel but opposite direction, modern technologies such as mobile phones bring about changes in the inner-world of their users (Pertierra, Ugarte, Pingol, Hernandez, & Dacanay, 2002) that have significant social and cultural consequences. Mobile phones encourage a more privatized and personalized orientation to the world. They enable a discursive intimacy hitherto difficult, if not impossible, in traditional societies such as the Philippines. Moreover, private orientations may quickly coalesce into collective actions through the rapid transmission of information. These collectivities, or smart mobs (Rheingold, 2002), easily mobilized, are capable of the microcoordination of their hitherto unconnected participants. Some claim that this microcoordination brought about the downfall of Philippine President Joseph Estrada in 2001, an event known as EDSA 2. This political event has also been referred to as a *coup d'text*. Others credited EDSA 2's success as an act of God or, more precisely, as the intercession of the Virgin Mary, in whose honor a statue was established at EDSA (the street associated with the downfall of President Marcos in 1986) where this 2001 event took place.

Perhaps the two most common explanations for EDSA 2 (seemingly a repetition of EDSA 1986) are that it was caused by mobile phones with their SMS messages or that it was a miracle brought about by the concern of the Virgin Mary for the well being of Filipinos. This conflation of technology with eschatology confirms the close links between culture and religion in the Philippines. It also indicates that new technology can easily fit into traditional schemes. In this case, one might even suggest that texting took on the efficacy of prayers.

RELIGION AND THE COMMUNICATION REVOLUTION

Following such global changes, it is no surprise that worldviews and other orientations of the *habitus* were significantly affected. But most of these changes arose out of earlier structures and often kept their traditional form, if not their substance. The new technologies affected traditional religions, causing them to evolve into new and exotic forms. The spread of cargo cults worldwide, bizarre and futuristic groups, such as the Peoples Temple of Jonestown and Scientology, as well as the use of media like television, the Internet, and SMS to spread the faith, have become routine aspects of contemporary life.

While many of these new religious movements are a response to the material changes brought about by modernity, they also express new ways of relating to the mundane world. Heidegger (1977) has argued that technology not only affects the world outside our existence but also enters into our being-in-the-world in new ways. We are thus "in the world" differently, opening up new possibilities of being and becoming. Technology is not just a set of techniques but *techne*, a way of dealing with others in the world. New technologies allow us to relate to ourselves and to others in new ways. Technology is not only mechanical materiality or a body of techniques that stands in an exterior relationship to human subjectivity. Technology is also techne, the application of knowledge that connects us intersubjectively to the material and the supernatural worlds. It enables new ways of being in the world (including the afterworld), thereby revealing to us our human possibilities. As a recent conference on mobile phones concluded, "the machine becomes us" (Katz, 2003). The passive voice transfers agency from humans to machines.

Historically, the spread of religion has always been closely linked to the growth and proliferation of new technologies. The Gutenberg press marked both the entrance of a new age as well as the revival of an old religion. Literacy has since then been a primary condition for conversion. More recently, radio and television have become important channels for experiencing as well as for spreading the faith. These media mimic, even if in a mediated way, direct presence. While the contribution of technological innovations to economic change is widely known and accepted, how new technologies impact on the experience of the sacred and the supernatural in Asia is poorly understood. The relationship linking society, technology and experiences of the supernatural in Asia involve complex structures. The Bali bombings and the fears of Al Qaeda in the Philippines are among the most dramatic examples of these complex structures. But preceding them, bands of Western televangelists flooded the global airways with messages of superiority and warnings about Armageddon. By combining capitalist resources with new media skills, no one was beyond the reach of these global preachers. Religious conversion became another aspect of the competitive struggle for global domination. However, despite their underlying agonistic possibilities, expressions of the supernatural in this age of technological domination are mostly nonviolent but often surprising.

Texting God

The Catholic Church in the Philippines has not been slow in using mobile technology to spread its message. Apart from providing religious lessons via texting ("catextism"), several text services provide an array of prayers, devotions, and services. There is even a service known as Text God. The texter receives biblical quotations appropriate for the day or

occasion. Religious messages with suitable images are regularly shared by most Filipinos. Apart from personal greetings, religious sayings are undoubtedly the most popular SMS texts. Filipinos have also formed religious text brigades, bombarding God with SMS requests for protection. Some claimed that this is the reason the Philippines was spared the tragedy of the 2004 Indonesian tsunami.

Fr. Robert is one of my major informants regarding the use of the mobile and the Internet for his congregation. In an interview, he admitted his dependence on the new media. Asked if he had any unusual experiences with cell phones, Fr. Robert replied that he has occasionally received missent messages from people interested in becoming his friend. Whenever he sensed that such overtures may lead to inappropriate textual exchanges he ended it. He pointed out that he has a normally busy schedule and a rich texting environment involving family and friends. There is no need or interest in embarking in other texting exchanges.

But it is another matter when it comes to religious texting. Fr. Robert admits to receiving many religious texts from family and friends. These he readily sends to other people, including acquaintances. These messages are often inspirational and serve as ideal vehicles for fulfilling his congregation's spiritual mission. This includes not only evangelical ends but also broader social concerns, such as justice, education, and peace.

Fr. Robert admitted to sometimes feeling personally helpless and paralyzed when facing difficult tasks. The ability to communicate easily and instantly with friends, family, and colleagues on a range of matters greatly relieved his sense of powerlessness. The new media increased his sense of communality and hence of greater solidarity with meaningful others.

In a study of religious texting, Roman (2005) confirmed the centrality of religious texts for a wide range of informants, even if this texting also involved more secular and less salubrious practices. God, sex, and politics are inextricably entwined in Philippine life and attempts to separate them are futile. This conflation is based on the also inseparable domains of natural/supernatural and its correlate, the living/dead.

In a recent study of the role of science in Philippine culture, Pertierra (2003) discovered that even eminent scientists consider the supernatural and natural worlds to coexist. Understanding the latter is often assisted by belief in the former. A science professor claims,

> I have discussed this with my students in my science class. Most of them believe in miracles, but they also want to know the scientific reason behind miracles. And yet knowing the scientific reason does not make these events any less of a miracle. One student actually told me that life itself is a miracle. (Pertierra, 2003, p. 100)

This view of students is shared by a mathematician:

> There is nothing wrong in believing in miracles. Many people believe strongly in miracles. It does not mean that just because they have a scientific orientation, everything will be explained systematically. There are such things as love, miracles, karma, and lust. They are part of life but you cannot explain them scientifically. (Pertierra, 2003, p. 99)

Modernity has defused much (but not all) of the tension between the sacred and the profane by consigning the former into private belief and the latter into public fact. The boundaries between private beliefs and public facts are not fixed, but rather are always shifting and contested. Deciding where the boundaries exactly lie is as much a practical (political) as it is a cognitive (rational) decision. It is also somewhat historical (Foucault,

1990). These boundaries have not only shifted significantly as a result of the new technology but have become exceedingly porous.

Supernatural Connections

In the northern Philippines, as in most parts of Asia, the souls of the recently deceased are believed to hover near their earthly dwelling for a period of days or weeks. During this time, communications between the dead and their living kin are frequent. Messages from the dead are conveyed in a number of ways, from the strange chirping of birds, the presence of an unusual number of insects, such as fireflies, or conversations between a medium and the deceased. Soon after a death, a close relative goes into trance (*naluganan*; Pertierra, 1988) and asks the dead person's soul what they need for the journey into the afterlife. Previously, such communications were easily managed. But now since many villagers now work overseas, special arrangements have to be made. The mobile phone is a handy technology in such circumstances. The medium, often a relative who may be abroad, having been informed about the situation, goes into a trance. In the village, the mobile phone is placed on a favorite item of the deceased. After the trance, the medium conveys the necessary information to their kin in the village via the mobile phone.

If the early telephone and phonograph encouraged notions of the "ghost in the machine," the mobile phone is an obvious device for contacting the supernatural. The personal nature of mobile phones conflates its owner with the communication process. Mobile numbers become extensions of their owners, including the deceased. The link between technology and supernatural forces has a long Western literary genealogy and taken up recently in cinema. These representations in popular culture reflect many fears involving the new communication technologies. They threaten the hitherto impassable barrier between the natural and the supernatural or the living and the dead. In a society such as the Philippines, where the supernatural is often experienced as part of everyday life, it is no wonder that accounts of communicative exchanges involving the supernatural are becoming increasingly common.

Texts from the Grave

Jaime Licauco is a well known commentator on supernatural matters. Recently, he wrote about the case of a texting exchange between a man and his dead girlfriend.

> Two weeks ago, Carmina, who became my girlfriend through text messaging, died. After her death, she started sending me text messages. During her wake, she continued to text me, telling me how much she loved me. In one of our conversations, she told me she was not dead. After her burial, I thought she would stop sending text messages. I was wrong. She would usually send me text messages around 11 in the evening or at midnight. Her cousin is now using her SIM card, per Carmina's request. I asked her cousin to turn off the phone but Carmina was still able to get through to me. It's funny that she found herself in different places, like her home or a resort. I want to ask: Should I continue talking to her? Please enlighten me on this strange event. Thank you. **(**Licauco**,** 2006, p. C4)

Licauco advised the young man to inform his dead girlfriend that he still loved her but that she should accept her new condition and move on. This example is a logical extension of extended communication, from corporeal to noncorporeal absence. It is not clear if the two ever

met; perhaps the whole relationship was conducted via texting, in which case, the example simply refers to a cyber relationship, independent of the corporeal. Similar cases of supernatural communication via mobile phones have been reported in Indonesia (Barendregt, 2005).

On 26 February, 2004, a passenger ferry bound for Bacolod departed from Manila. Barely an hour away, the ship caught fire and sunk with the loss of 116 passengers and crew. A member of the investigating committee wrote the following account about the incident:

> Two families whose relatives perished in the incident reported having received text messages of a disturbing nature. One was living in the United States when she got a call that her sister was trapped in the ship's comfort room. At the time of the alleged call, the ship had been burning continuously for the past 24 hours and was submerged on its side in Mariveles, Bataan.

The second story also reported a similar situation where the caller was trapped in the comfort room of Deck A. The relatives in Mindanao got the call sometime after the ship had caught fire and had sunk (Ferdinand Flores, personal communication, October 24, 2006).

Ramon Tulfo (2006, p. A18), a well-known journalist, reported a conversation he had with his manicurist:

> I was at Bruno's Tuesday for my haircut. Domencil was doing my nails. She said she was surprised Nazareno didn't show up for his appointment. He always came on time for his appointments, she added. When I told her that Nazareno couldn't come as he had died the previous day, Monday, Oct. 30, she was dumbfounded. "Don't kid me because I got two missed calls from him a while ago" Domencil said. She then showed me two missed calls on her cell phone from General Nazareno….The "missed calls" that Domencil received on Tuesday was a way of telling her that he couldn't make it to his appointment.

While the incidents described above could well have been emergency calls made by the trapped victims, their relatives believed that the callers were dead and that they were informing relatives of their situation. Tulfo and Domencil also accepted that the missed calls were sent by Nazareno after his death. In a popular TV show (*The Boy Abunda Show*, 2005), members of the audience were asked to relate strange experiences with their cell phones. Several participants volunteered information that they had received texts or calls from dead relatives. These calls came immediately after the callers' death or some time after. The purpose of the calls was to inform or warn relatives about the death of close kin. Traditional culture has provisions for such communicative exchanges, which the mobile phone readily accommodates.

MOBILES AND POPULAR CULTURE

While the new mass communication technologies did not cause the cultural havoc that European intellectuals such as Hardy, Eliot, and H. G. Wells had predicted, they have nevertheless changed the cultural landscape significantly. Ratings, rather than aesthetic standards, have become the main index for success. But not all media are equally undiscriminating. The print media is still highly specialized, and radio and cinema retain their sophisticated followers, but television mainly addresses a mass audience. The Internet breaks all these conventions and boundaries with its ability to provide highly specialized and esoteric sites, pornographic invitations, government propaganda, advertising scams, terrorist appeals, mass entertainment, personal messages, and business transactions. Since the basis of

communication is a digital code, there is no guaranty that one's interlocutor is a human subject since software programs can as easily respond to many queries. An example is George[1], a talking Internet robot who speaks 40 languages and can talk simultaneously with 2000 people (*Philippine Daily Inquirer,* September 18, 2006). George is an improvement on an earlier device described by the *Scientific American* in 1877:

> It is already possible by ingenious optical contrivances to throw stereoscopic photographs of people on screens in full view of an audience. Add the talking phonograph to counterfeit their voices, and it would be difficult to carry the illusion of real presence much further. (cited in Heumann, 1998, p. 3)

Modern communication media arrived in the Philippines surprisingly early. In 1876 the first telegraph line was established and extended to Hong Kong in 1881. The telephone arrived in 1890 and prompted Jose Rizal (the foremost Philippine national hero) to write a short play depicting its capacity for unmediated information. In 1897, imported films were being shown; a few decades later Filipino films were being locally produced. In 1922, the first radio stations began broadcasting, and in the early 1950s television started. It was this latter technological arrival that, according to Randolf David (2004), finally created a national mass audience. David credits television as creating a national audience with populist tastes and political ambitions. The print media, radio and film also contributed in generating a national audience.

David (2004) argued that the *masa* (poor people's) vote, as expressed in the support of President Estrada in 1997, is a new phenomenon in Philippine political life. Prior to this, the *masa* was divided by local and hierarchic loyalties, supporting ward leaders or powerful patrons. In other words, the *masa* were localized and only influential within local bailiwicks. According to David, this important transformation from local personal loyalties to a national, and hence de-localized, perspective was the product of the mass media, in particular television. Naturally, this important change in personal orientation must have also been accompanied by appropriate changes in the material conditions of life of the *masa*. Nevertheless, the important role claimed for television in a media-saturated society like the Philippines is an interesting suggestion and merits serious attention.

Media as Presentation of Everyday Life

Philippine society has become media saturated, where popularity contests determine everything from reality shows to presidential elections. Both are seen by most Filipinos as media-constructs. While the print media provides serious analyses of contemporary events, TV and radio remain the favored media for the *masa*. Television not only provides escapist entertainment for its national audience, but also interprets national and global events in a language accessible to most Filipinos. Discussions of current events, including investigative programs, are popular and regular aspects of everyday life. Combining entertainment and information, often not distinguishing between the two, television brought the outside world into the home more effectively than earlier media, such as the theatre, cinema, or radio. EDSA has been called the first electronic revolution since its success depended crucially on the control of the news media (Brisbin, 1988). Images of soldiers taking over television stations and crowds massing in front of tanks were watched globally. The same emphasis on media images characterized EDSA 2 (Pertierra et al., 2002), with its detailed cover of the

rallies and scores of people marching towards the presidential palace. EDSA 3 (President Estrada supporters who tried to have him re-instated) received much less television coverage and its participants were portrayed as paid Estrada hacks and loyalists. Years earlier (1983), during the dark days of authoritarian rule, the funeral procession of Benigno Aquino (an eminent politician killed upon his return at Manila airport), despite attracting large crowds, received minimal mention in the mainstream media, except for the Catholic radio station Veritas. These examples show that media portrayals of mass actions are crucial but not always determinant of success. The media is itself embedded within political interests and its role is neither impartial nor autonomous. When the Philippine media approve of demonstrations, they refer to them as the actions of civil society, but when they disapprove, demonstrations are dismissed as Leftist agitations or irresponsible acts of the *masa*.

The New Media

While the Internet is only accessible to a small number of Filipinos (12%), cell phones have taken the country by storm, exceeding the wildest predictions. Presently about 70% of Filipinos own or have direct and easy access to cell phones. There are about 55 million cell phone subscribers in a population of 88 million. No other technology has been accepted with such enthusiasm. It took television nearly 50 years to reach the penetration rate that cell phones achieved within 5 years (Lallana, 2004). Moreover, cell phones are not only mobile, allowing perpetual contact, but are also highly interactive. They connect to virtually all existing electronic services. They also connect hitherto unconnected aspects of the inner-self and its relations with alter: The normal spatio-temporal contexts of talk are lacking in cyberspace. Interactions between interlocutors are not the result of a prior agreement of a given situation but may be pursued independently. Thus, they facilitate the development of new discursive fields, resulting, for example, in intimate exchanges. The traditional constraints of speech in oral communities are transcended, allowing even strangers to be included within this new network of intimacy. This results in new forms of urbanity.

SMS has generated new modes of writing, combining numbers, letters and new expressions, such as “c u 2nyt” (see you tonight) or “got l8 tnx” (got late thanks). It has also enriched the vocabulary of interaction with words such as *lobat* (low battery), *nolod* (no load), eyeball (face to face meeting), *miscal* (missed call), *textmate*, and acronyms like NASL (name, age, sex, location) and SOP (sex over phone). It has also spawned a new literary genre—*textula*—a traditional verse form using SMS. Filipinos have also followed foreign trends, such as movie making, using their mobiles. These practices have transformed ordinary people into producers of media. In a recent survey of the most important inventions, the readers of The *Philippine Star* (October 8, 2006) nominated the cell phone ahead of all the others, including the computer and electricity.

All previous media have had to adjust to the cell phone. TV and radio shows are now routinely assessed by their audience via cell phones. TV has also become a connecting node for mobile phones, with several channels displaying text (SMS) messages on their screens that allow texters to contact one another. While the earlier communicative technologies (e.g., print, radio, television, and cinema) were mainly disseminative, the cell phone empowers its user to express and share opinions, perspectives, and strategies. The social, cultural, and political implications of these new local, national, and global interactions may transform the

Philippines from a conservative, elitist, and poor society to a more open, egalitarian, and dynamic one. But, a word of caution is needed: The transformative potentials of earlier technologies were quickly controlled by conservative power holders to ensure their dominance. Existing cell phone services are mainly geared to the entertainment sector, encouraging private consumption rather than public commitment. But, there are also signs that this technology may upset traditional hierarchies by subverting old verities and leveling access to the public sphere. Spreading gossip, rumor, and scandal, as well as the capacity to mobilize and network, are greatly enhanced by this technology. They convert aimless crowds into smart mobs or individual protesters into organized demonstrations (Rheingold, 2002).

The mobilizing potential of cell phones was shown in EDSA 2 and 3, but their effects have been greatly exaggerated (Pertierra et al., 2002). Their greatest use still seems to favor private rather than public networks. This is because Filipinos have very low levels of trust and are unlikely to accept information from unknown sources. Politicians have to be careful in exploiting the cell phone's use, knowing the Filipinos' irreverent sense of humor.

But what the mobile phone seems to encourage is a greater sense of individualism. This individualism is expressed in the establishment of novel relations with strangers. Whereas the stranger is assiduously avoided in traditional societies, the cell phone opens the possibility of cultivating virtual relationships. These virtual relationships can be transformed into more conventional ones should the circumstance arise, or they may remain virtual as a choice. Virtuality may allow forms of intimacy normally disapproved. Mobile phones and the Internet have resulted in an explosion of virtual relationships in the Philippines, many of them explicitly sexual in nature. This virtuality takes on particular saliencies in an urban context, where hitherto unknown interlocutors can arrange to meet. As others have noted (Kopomaa, 2000), the mobile phone allows you to put the city in your pocket.

CONCLUSION

This paper has raised several points. It began by noting the excess of meaning in the contemporary world and our easy access to it. This excess often leads to a lack of sense. We are overwhelmed by the availability of information. This informational saturation of the public sphere has also led to its pauperization. Leading intellectuals pour scorn on this shallowness of meaning and predict that a democracy of tastes will result in the end of manners and civilization. While modernity has withstood this challenge, much of popular culture certainly undermines the earlier primacy of elitist genres, simply through the extent of its circulation.

The Internet and the mobile communication technologies compound an already overloaded public sphere, causing its boundaries to disappear and new antinomies to take their place. This is the age of heterotopias, where things are not what they seem. This knowledge revolution is seen by some as a radical rupture from the past and as leading to our transformation into machines or gods. Human social evolution has important markers, of which the discoveries of fire, writing and, later, printing are among the most important. The industrial age ushered in fundamental changes in society and culture with unprecedented speed. These changes have been compounded by the new communication technologies. No wonder that chiliastic claims and millenarian hopes characterize modernity. Postmodernism, fundamentalism, consumerism, and globalization are expressions of the age. New fictions are necessary and traditional religion is put to novel

uses. Televangelists, terrorists, pornographers, politicians, and a host of others post their messages next to one another on the Web. This conglomeration, like Borges' imaginary *Chinese Encyclopedia* (Foucault, 1973, p. xv), stretches the limits of our comprehension, resulting in a state of hysterical bewilderment, if not terror.

Indeed, the new communication technologies often provoke the supernatural, initially in the West and more recently in Asia. The latter has imported these technologies while still adhering to earlier beliefs about the natural intercourse of spirits and humans. While in Europe these technologies sprouted from an attitude of secularism, in Asia their introduction reinforced many traditional beliefs. Hence mobiles and religion coexist happily in the Philippines. One may even describe mobiles as conveyors of spirituality. Religious texts, like prayers, are directed to their supernatural solicitors.

Moreover, new methods of communicating, such as texting, also give rise to new authenticities. Subjects are better able to express their innermost needs and to share them with others. Even the dead are allowed to participate in this new form of discursive communion. Just as the telephone enabled long-distance relationships, mobiles allow absent others to maintain a presence in their home communities. They also reveal aspects of inner reflectivity not normally possible within the confines of local society. While technology alters our relationship to the material world, it also reshapes (as Heidegger, 1977, argued) our relationship to ourselves and to others.

Finally, modern media has also generated new publics, of which the national is a major actor. In the past, only wealthy and educated Filipinos generated public opinion. The poor, or *masa*, could not express a public voice or exercise public action. Modern media has empowered the *masa*, converting their numbers into a formidable expression of public opinion. As a result, most of public life consists of performances aimed at obtaining the highest ratings. Political life is enacted on the stage, transforming politicians into performers and media stars. Conversely, media stars are transformed into politicians. Performativity has become the hallmark of public life. The democratization of tastes, values, and competencies made possible by modern media has had both emancipatory and conflictive consequences. Human and animal rights are now routinely defended in the media, soon to be followed by more controversial issues such as the rights of machines and objects. But these advances are also threatened by equally strident claims made by crusaders, jihadists, and the purveyors of purity and absolutism. The reputed Chinese curse—May you live in interesting times—has come home to roost.

ENDNOTE

1. George can be found at www.jabberwacky.com

REFERENCES

Abunda, B. (Host). (2005, May). *The Boy Abunda Show* [Television broadcast]. Quezon City, the Philippines: GMA Television Network

Agbu, J. (2004). From Koro to GSM: Killer calls scare in Nigeria; A psychological view. *CODESRIA Bulletin, 3 & 4*, 16–19.

Anderson, B. (1983). *Imagined communities.* London: Verso.

Barendregt, B. (2005, October). *Haunted and hacked*. Paper presented at the Mobile Communication and Asian Modernities Conference, Beijing, China.

Barlow, J. P. (1995). Is there a there in cyberspace? *Utne Reader*, *2*, 50–56.

Bauman, Z. (2005). *Liquid life*. Cambridge, UK: Polity Press.

Brisbin, D. (1988). Electronic revolution in the Philippines. *Journal of Popular Culture*, *22*, 49–63.

Carey, J. (1992). *The intellectuals and the masses*. London: Faber & Faber.

Cochrane, R. (1966). *Measures for progress*. Washington, DC: National Bureau of Standards, U.S. Department of Commerce.

David, R. (2004, February 8). Media. *Philippine Daily Inquirer* [Manila]**,** p. 11.

Eisenstein, E. (1979). *The printing press as an agent of change*. London: Cambridge University Press.

Foucault, M. (1973). *The order of things.* New York: Vintage Books.

Foucault, M. (1990). *The history of sexuality* (Vol. 1). London: Penguin.

Iyer, P. (2000). *The global soul: Jet lag, shopping malls and the search for home*. London: Bloomsbury.

Giddens, A. (1990). *The consequences of modernity.* Stanford, CA, USA: Stanford University Press.

Gonzalez, M. (1979). The De Manila a Dagupan. *Asian Studies, 17*, 18–36.

Goubsblom, J. (1992). The civilizing process and the domestication of fire. *Journal of World History*, *3*, 34–65.

Gray, C. (2002). *Cyborg citizen*. London: Routledge.

Heumann, M. (1998). *Ghost in the machine: Sound and technology in twentieth century literature.* Retrieved November 18, 2005, from www.hauntedink.com/ghost/

Heidegger, M. (1977). *Being and time* (J. Macquarrie & J. Robinson, Trans.). Washington, DC: SCM Press.

Hughes, T. (1979). The electrification of America: The system builders. *Technology & Culture, 1*(20), 124–161.

Katz, J. (2003) Do machines become us? In K. Nyri (Ed.), *Mobile communication* (pp. 23–45). Vienna, Austria: Passagen Verlag.

Katz, J., & Aakhus, M. (Eds.). (2002). *Perpetual contact: Mobile communication, private talk, public performance*. London: Cambridge University Press.

Kirby, V. (1997). *Telling flesh*. New York: Routledge.

Kopomaa, T. (2000). *The city in your pocket: Birth of the mobile information society*. Helsinki, Finland: Gaudemaus Press.

Lallana, E. (2004). *SMS in business and government in the Philippines*. Manila, the Philippines: Department of Science & Technology.

Licauco, J. (2006, January 3). Supernatural experiences. *Philippine Daily Inquirer* [Manila], p. C4.

Markus, G. (1997). Antinomien der kultur [Antinomies of culture]. *Lettre International,* Herbst, Germany.

Miller, D. (Ed.). (1997). *Material cultures.* London: UCL Press.

O'Malley, M. (1990). *Keeping watch*. New York: Penguin.

Pertierra, R. (1988). *Religion, politics and rationality in a Philippine municipality*. Quezon City, the Philippines: Ateneo de Manila University Press.

Pertierra, R. (1997). *Explorations in social theory and Philippine ethnography*. Quezon City, the Philippines: University of the Philippines Press.

Pertierra, R. (2003). *Science, technology, and everyday culture in the Philippines*. Quezon City, the Philippines: Institute of Philippine Culture, Ateneo de Manila University.

Pertierra, R. (2006). *Transforming technologies: Altered selves–Mobile phone and Internet use in the Philippines.* Manila, the Philippines: De la Salle University Press.

Pertierra, R., Ugarte, E., Pingol, A., Hernandez, J., & Dacanay, N. (2002). *Txt-ing selves: Cellphones and Philippine modernity*. Manila, the Philippines: De La Salle University Press.

Philippines Daily Inquirer [Manila]. (2006, September 18). The talking computer [editorial], p. 8.

The Philippine Star [Manila]. (2006, October 8). Cellphone revolution [editorial], p. 8.

Ricoeur, P. (1971). The model of the text: Meaningful action considered as a text. *Social Research, 38,* 329–362.

Roman, A. (2005). Texting God: SMS & religion in the Philippines. *Journal of the Asian Research Center for Religious and Social Communication, 3*(1), 1–18.

Romain, J. (1987). *The watershed of two eras* (A. Pomerans, Trans.). Middletown, CT, USA: Wesleyan University Press.

Rheingold, H. (2002). *Smart mobs.* Cambridge, MA, USA: Basic Books.

Saunders, P. (1989). Space, urbanism and the created environment. In D. Held & J. Thompson. (Eds.), *Social theory of modern societies: Anthony Giddens and his critics* (pp. 68–82). Sydney, Australia: Cambridge University Press.

Tulfo, R. (2006, November 2). Report it to Tulfo. *Philippine Daily Inquirer* [Manila], p. A-18.

Weber, M. (1976). *The protestant ethic and the spirit of capitalism* (T. Parsons, Trans.). London: Allen & Unwin. (Original work published in 1930)

Wells, H. G. (1895). *The time machine: An Invention.* London: Heinemann.

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TEAM–CLIENT RELATIONSHIPS AND EXTREME PROGRAMMING

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Abstract: *This paper describes a study that examined the relationship between software engineering teams who adhered to the extreme programming (XP) methodology and their project clients. The study involved observing teams working on projects for clients who had commissioned a piece of software to be used in the real world. Interviews were conducted during and at the end of the project to get client opinion on how the project had progressed. Of interest to the researchers were opinions on frequency of feedback, how the team captured requirements, whether or not the iterative approach of XP proved to be helpful, and the level of contextual and software engineering knowledge the client had at the start of the project. In theory, fidelity to XP should result in enhanced communication, reduce expectation gaps, and lead to greater client satisfaction. Our results suggest that this depends heavily on the communication skills of the team and of the client, the expectations of the client, and the nature of the project.*

Keywords: *XP, software clients, requirements analysis, communication, satisfaction.*

INTRODUCTION

This paper describes a qualitative study that aimed to observe the relationship between software engineering (SE) teams and the clients who had commissioned the software, how the interaction progressed over the course of the project, and whether the clients were satisfied with the final software product and the team. The teams in this study were supposed to adhere to the extreme programming (XP) methodology (Beck, 2000). Therefore a specific aim was to examine the claim that XP is a people-oriented methodology that should, in theory, lead to greater client satisfaction.

Viewed in the context of SE history, agile methodologies such as XP represent a fairly recent development. XP is the most well-known agile method and is said to be light on documentation,

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follows an iterative approach, is incremental, and claims to favor human communication and collaboration over clearly defined stages as mechanisms for developing software (Lycett, Macredie, Patel, & Paul, 2003). There are other agile methodologies in addition to XP, such as Dynamic Systems Development Method (Stapleton, 1995), and Scrum (Janoff & Rising, 2000).

The rationale behind the research described in this paper was the realization that more work was needed that focused specifically on the role of the client in XP projects. Increased client feedback, communication, and involvement in the development process, as stated by XP leads to greater transparency. This had led to concerns that the greater transparency of XP allows clients to have too much insight into how the team is working, which may lead to dissatisfaction on the client side because the client will see problems in software development as they are occurring (Murru, Deias, & Mugheddu, 2003). A recent survey (Ambler, 2007) found that clients were, on the whole, happy with the results of agile teams, and that there was a high success rate for agile projects. In terms of XP specifically, the studies that have been carried out tended to focus primarily on the role of the on-site customer (Koskela & Abrahamsson, 2004; Martin, Noble, & Biddle, 2003; Murru et al., 2003). The results of these studies suggest that the on-site customer is a problematic feature of XP and can be difficult to manage.

Other XP-related research looked at, among other things, the role of novice customers in XP projects and how a team can be lulled into a false sense of security when the customer seems to be very quiet and satisfied early in the project (Elssamadisy & Schalliol, 2002). This sense of security is shattered at a later stage of the project when the team is bombarded with complaints about failing to meet requirements. Another recent publication unequivocally called for more studies that focused on the social issues of the developer-customer relationship during XP development (Grisham & Perry, 2005) and stated that "Customer satisfaction and customer relationships tend to be a sorely unexplored and largely misunderstood aspect of software engineering" (p. 5).

Therefore this work aims to build on these earlier studies by focusing on the relationship between clients and XP teams over the course of seven entire projects. The research aimed to ascertain client opinions on several factors of XP methods, such as the frequency of feedback, whether teams kept them informed, whether they were happy with the communication that took place, the SE and contextual knowledge of themselves and the team, and whether or not they were happy with the overall project, particularly with how they interacted with the team and the final software system they received.

The remainder of the paper is laid out as follows: The next section describes XP in greater detail and the research environment, followed by the methodological procedure, the results, discussion, and then the limitations of the study. Finally there is a conclusion that summarizes the key findings and suggests avenues for further research.

eXTREME PROGRAMMING

XP (Beck, 2000) is an agile methodology centered on 12 core development practices: planning game, small releases, metaphor, simple design, testing, refactoring, pair programming, collective ownership, continuous integration, 40-hour week, on-site customer, and coding standards. More information pertaining to these practices, drawn from Morris, 2001, is given in Table 1.

Table 1. XP Practices (Morris, 2001).

Practice	Description
On-site customer	The customer's job is to write and prioritize stories (tasks from a user's perspective that the software must perform), assist with acceptance testing, and be on hand to answer questions from the development team as they arise.
Metaphor	The project metaphor is, more or less, an informal architecture of the system. The metaphor describes the system in simple concepts. The concepts can be literal or figurative, depending on the clarity of the actual system.
Small Releases	Small releases are a key part of generating feedback and making a project resilient. An XP project is a series of iterations, each lasting 2 to 4 weeks. Each iteration starts with the Planning Game, an activity that determines the tasks for the current iteration, and ends with a "finished" product: All tests pass and the product is as functional as possible.
Planning Game	An iteration begins with the Planning Game, an informal process that sets the agenda for the iteration. The game starts with the customer defining requirements, or the "user stories." Technical members work with the customer to normalize these stories into manageable chunks and break them down into specific tasks, as well as introduce technical tasks needed to support the customer's requests (e.g., upgrading development software, automating builds, etc.).
Pair Programming	All programming on an XP team is done in pairs, two people at one machine. Each task from the Planning Game is owned by an individual. When the day starts, pairs form up, each person either pairing to help someone else, or requesting help on his/her own tasks. Pairs stay together until a logical break comes up. While paired, one takes a turn "driving" while the other actively participates verbally. As ideas flow between the two, the keyboard can be swapped off as often as necessary to get the best code on the screen. Pair assignments are fluid and change throughout the course of a day.
Collective Ownership	Collective ownership refers to the code. Collective ownership allows anyone on the team at any time to work with any piece of code. If a pair working with object A needs object B to change, that pair can go immediately make the change in object B to accommodate the needs of object A.
Testing	Testing is a crucial practice on an XP project. XP succeeds by making a project resilient. Resilience means accurate and frequent feedback; testing provides this. In XP, there are two categories of tests: unit tests and acceptance tests. A unit test is a piece of code that exercises one aspect of a piece of production code. Acceptance tests are distinguished from unit tests in a couple of ways. First, they should test the system end-to-end. Second, the customer is involved in creating the acceptance tests.
Refactoring	Refactoring is the process of improving the design of code without changing the functionality. The code should be clean and readable. Any duplication should be consolidated. Refactorings should be done on an ongoing basis throughout development of the code. As soon as structural improvements make themselves known, they should be done.

Simple Design	To help ensure frequent feedback, it is important that the application's design be kept simple and kept to providing business value. While there will always be tasks that are primarily technical and necessary to support providing business value, these tasks should be kept as simple as possible.
Continuous Integration	Mixing the latest code from each programmer together can be a difficult process, especially if this task is not done often. To stay resilient, newly written code that passes all tests locally must then be integrated with the latest code base by the programs and then ensure all the tests still pass. If not, fixes must be made right away until all tests again pass.
Coding Standard	Having a coding standard for a project is a commonly accepted practice in most projects regardless of methodology. This practice is equally important within an XP team, especially in light of Collective Ownership and Refactoring practices.
40-Hour Week	XP promotes a well-rested team. Its founders do not believe in the sweatshop mentality. Tired workers make mistakes and start desiring a new job.

XP stresses a highly incremental and iterative development process, starting with a simple design that aims to meet an initial set of requirements defined at the start of the first iteration. This design should evolve as the project progresses. XP is aimed at small- to medium-sized teams. The physical environment is also very important, as it should facilitate communication between team members and allow them to coordinate their activities.

THE RESEARCH ENVIRONMENT AND SUBJECTS

The context for this study is the Software Engineering Observatory at the University of Sheffield. The Department of Computer Science's Verification and Testing (VT) research group run this research facility. The observatory was designed specifically to aid those working in the field of empirical software engineering by allowing researchers to observe, question, and interview students taking part in industrial SE projects. Several projects take place within the observatory. These range from a Software Hut project that is taken by second year bachelor's students to the Genesys and Maxi, which are Master of Science (MSc)-level projects.

The research subjects were second- and fourth-year bachelor's and MSc students. The bachelor's students tended to be domestic students and, unless they were mature students returning from industry, lacked any significant SE project experience. The fourth-year students had completed all of their prior higher education at the University of Sheffield and had already completed one group project, thereby having gained invaluable experience. The MSc students tended to be predominantly from overseas (mostly from Asian countries, with particularly large contingents from India and China, and to a lesser extent the Arab world and Greece) and had not completed any of their previous education at the University of Sheffield.

The academics responsible for running the group projects act as managers and meet teams on a weekly basis. The managers have a great deal of experience in managing student projects with real industrial clients and in some cases managing external software projects. The Sheffield students take pride in the fact that they are producing software that will be used by a real-world client. This has led over the years to many satisfied customers, who have been impressed with the students' professionalism and also the final software system produced.

METHODOLOGICAL PROCEDURE

In order to gather data for this study, researchers observed meetings between SE teams and their project clients. We also conducted interviews with representatives of each team, engaged in informal discussions with clients before and after meetings, and conducted formal interviews with clients at the conclusion of the project.

The research was explained to all of the students and clients at the start of a particular project. The students were also reassured that the observations and interviews had no bearing on their final mark and that there would be no instances of students being reported to project management by the researchers. The teams were typically made up of 4 to 6 students. When the students agreed to take part, they were instructed to inform researchers of any client meetings that were to take place, whether on campus or at the client's business premises.

During the client meetings, a researcher would sit in the corner of the room to take field notes. Afterwards the clients would be asked how they felt the project was progressing and clarification was sought if some aspects of the observations were unclear. This continued for the duration of the project, in the case of Software Hut for one semester (4 months), and, in the case of Genesys, for the academic year (8 months).

In terms of interviews, this research adopted a semistructured interview process for the software developers, with the data recorded by hand. This was achieved through a mixture of open-ended questions and specific questions to get not only information perceived to be important by the interviewer, but also unseen information. Before each interview, the interviewee received a brief description of the aims of the research. The goals were made clear and, in particular, the interviewee was informed how this study would help in understanding the XP methodology and the factors that contribute to it, and thus the importance of their answers. The client interviews were more formal in structure, with preplanned questions generated by the research team. This was primarily because of time constraints and the need to gather specific information. When need arose, clarifications were sought on the replies given by the clients. The use of a scribe was employed during these interviews to maintain the even pace of the interview period and to ensure that no important data were missed.

This triangulation of the data through various collection techniques was beneficial because it provided multiple perspectives on an issue, and supplied more information on emerging concepts. The data collection focused on the environment, the culture of the organization in which the developers were working, the history of systems development within the organization (Genesys and Software Hut), managerial expectations and commitment to the development teams, training, and finally individual and team experiences with XP.

The data collection, coding, and analysis proceeded iteratively: The early stages of the research were more open ended, while later stages were directed more toward emerging concepts. This prompted the creation of more structured interview protocols as the project progressed.

RESULTS

This section describes both the positive and negative results found during this research period. There was a wide variety of projects, including an e-commerce system for an outdoor sports business, a text-based system informing customers of offers for tickets to football matches,

special deals for high street stores, and for certain night spots within Sheffield; a Web site for children suffering from cystic fibrosis to help them adhere to a healthy diet; and a system for managing exam results in the Department of Electronic Engineering at the University of Sheffield. For each project, a table illustrates the positive and negative perceptions regarding each team's use of XP and how this influenced the relationship with the project client. For the purposes of anonymity, each team member is referred to by a code (i.e., 4F, 2A, etc., with the number representing a specific team and the letter reflecting the team member).

Project 1

The client for this particular project had a good idea of what he wanted at the outset, and claimed to have a good level of SE knowledge. This assessment was not shared by the team, who strongly disagreed with the notion that the client had a good level of SE knowledge. During the project's lifespan, there were several problems between the team and client, which reached a critical point when the disenchanted client threatened to walk out halfway through the project. Table 2 provides an overview of the project.

Table 2. Overview of Project 1.

Team Size	Team Characteristics	Client Type	XP Mentoring	Project Type and Duration	Main Languages Used
6	A mixture of 4th year and MSc students. Two were experienced with the XP methodology and very strong technically.	Single client with prior project experience.	Training period for 2 weeks before the start of the project.	New mobile communi-cations 8 months	PHP

> "*I have been thinking if this is worth the hassle. I may even walk out, as we are not getting anywhere*." (Project 1 client)

Although the client claimed to have a very clear understanding of what he wanted, this understanding was not conveyed to the team, who felt the client spoke in vague and unrealistic terms. In addition the client had a blunt way of expressing himself and sometimes wished to take a more hands-on role. The team also experienced problems trying to document the requirements while attempting to adhere to XP. An attempt was made to understand the scope of the project by whiteboarding at the beginning. Additional requirements modeling may have been useful at this stage, in addition to the story-cards. A story-card represents a brief description of a specific user requirement; each implemented function in an XP iteration represents a story-card.

An alleged confidentiality breach also seriously damaged team–client relations. After these events, the team attitudes towards the client went from distrust and apathy to downright hostility and anger. It would be unfair to blame the team alone for this. The client, with his bellicose and heavy-handed attitude, was certainly not without fault, as the quotes below illustrate.

> "*Someone in this team is a liar. They have disclosed sensitive information about this project to a third party. No one has had the guts to own up. Whoever did it should be purged from the organization*." (Project 1 client, on an alleged confidentiality breach)
>
> "*He* [the client] *is a liar. He has lied about many things throughout the project. Now he is making these unfounded allegations*." (1F, Project 1 team member)

One reason why the client was so intransigent for periods of the project was that he had a preference for detailed documentation to be done upfront, which is at odds with the XP approach. There was much debate about this issue, which carried on into the latter stages of the project. It was suggested by one team member that the team should use a formal document to supplement the XP story-cards, to provide the extra documentation. The team went along with this idea but encountered more problems when the client modified the requirements document. This forced the team to complain that the client's version of the document had no structure.

> *"I feel that my requirements document is more comprehensive and does a better job of capturing the essence of the project."* (Project 1 client, on the decision to introduce additional requirements documentation)

Further problems were evident when the client expressed the desire to modify the structure of the database. The team did not trust him to make these changes. However, the client felt it was his right to modify parts of the project and expressed anger when these wishes were not granted. Having meetings and listening to ideas from the client was another source of turmoil in part because of the problems, such as the confidentiality breach, but also due to the perception from certain team members that the client was being unreasonable with his demands and accusations. The fact that this team was following XP created confusion for the client, who was clearly unaccustomed to the agile way of working. In some ways this served to prejudice the team against documentation and modeling. This contributed to the antagonism between team and client. The outcomes of Project 1 are provided in Table 3.

Table 3. Positives, XP Experience, Negatives, and the Outcome for Project 1.

Positives	Team experience with XP	Client Negatives	Outcome
▪ Story-cards and whiteboard modeling used effectively early in the project. ▪ Regular contact with client.	▪ Pair programming done consistently only by two members of the team. ▪ Persistent confusion about the exact role of documentation in an XP project. ▪ Test-first not adhered to. ▪ Did not discuss changes with client.	▪ Voiced a strong opinion that the XP approach was not sufficient to capture the requirements for this particular project. ▪ Urged team to produce a detailed requirements document in addition to story-cards. ▪ Made unilateral decisions to alter requirements documentation. ▪ Expressed dissatisfaction with the process.	Incomplete system

Project 2

The client for this project, the characteristics of which are provided in Table 4, had a clear idea of what the project objective required at the start. The requirements were clear, but the

client lacked SE knowledge. This led to complaints by the team that the project was too complex and the client was being unrealistic in his goals. In some of the earlier meetings, the client took on a largely passive role and allowed the team members to drive the meeting, only occasionally interjecting with comments about technical aspects of the task at hand. Because the team members all came from a traditional SE background, they found it difficult to adhere to the tenets of XP with its emphasis on fluidity. For example, one team member did not want to make changes to any story-cards, which made it difficult to adapt to changing requirements. The reason for the aforementioned difficulties was because the member in question was used to completing requirements documentation and then moving on. The iterative approach to XP and modification of story-cards was a new way of working. Story-cards are supposed to be updated on a regular basis to represent the requirements from the most recent iteration.

Table 4. Overview of Project 2.

Team Size	Team Characteristics	Client Type	XP Mentoring	Project Type and Duration	Main Languages Used
5	Second-year bachelor's students, but two members had extensive knowledge of different programming languages and of working on tight deadlines.	Single client with prior project experience.	Training period for 1 week before the start of the project. Further help available on demand.	New Web-based database 4 months	PHP, various scripting languages

Personal work preferences made it difficult to do pair programming; the team never got used to this method and worked by running from one machine to the next. Several members expressed a preference for working at home, often during twilight hours. This can be seen from the following quotes:

> *"This situation is far from ideal. There is too much noise in this lab. How can we get any work done?"* (2A, Project 2 team member)
>
> "*I prefer to work at home, rather than here."* (2B, Project 2 team member)
>
> "*I like to stay at home and shut myself off from the world."* (2D, Project 2 team member)

One problem that condemned XP from the start in the eyes of this team was the admission that they all enjoyed Discovery (Simons, 1999). Discovery is a documentation centric methodology with defined phases and is similar to the Waterfall method in that it is a linear methodology that goes through the phases of analysis, design, coding and testing. Members of this team found the Discovery module of their studies very interesting, and would have liked to use it in this project. There was some debate about abandoning XP and switching to Discovery, which led to the response from 2B that the team was not really following XP, as can be seen from the quote below. This shows that the team experienced problems remaining faithful to the XP methodology.

"*We should stop being so worried about following XP practices. We are essentially following an unholy amalgamation of methodologies*." (2B, Project 2 team member)

None of this helped the team to foster a genial relationship with the client, since the process they were following was not clear, but nor did it lead to a breakdown. The argument from 2B that was expressed during interviews and discussions with researchers went along the lines of the team not doing XP correctly and that they should make it look as if they are using XP in meetings with the project managers. The outcomes for Project 2 are provided in Table 5.

Table 5. Positives, XP Experience, Negatives, and the Outcome for Project 2.

Positives	Team experience with XP	Client Negatives	Outcome
▪ No conflict with the client. ▪ Regular contact with client. ▪ Professional public image presented during discussions with client and project manager.	▪ Pair programming not done due to personal working habits. ▪ Test-first seen as counterintuitive. ▪ Admissions that team were not concerned about adhering to XP practices. ▪ Product-driven, as opposed to process-driven, team.	▪ Failed to understand that project was very ambitious, given the timescale and experience of the developers. ▪ Indifferent to the work produced until the later stages of the project. The client was satisfied with sitting back and letting the team get on with the development work.	▪ The system was incomplete, a skeleton system was created that provided the basics but lacked all of the core requirements.

Project 3

Some work had already been done by developers from the client's business prior to the commencement of this project: A Web site already existed in a skeleton form. There were some positives to take out of this XP project, which is introduced in Table 6. The team did present iterations of the software, and the client noted that the working models presented by the team were useful. The level of understanding between the team and the client was improved by intense whiteboard modeling and sketching in the early stages of the project. This also helped with the subsequent production of story-cards relating to specific requirements. The client was happy that the team had a good understanding of the requirements and that there was a working model up and running early in the project.

However, there were also problems to take into account. The client experienced problems conveying the requirements to the team, hence the need for intensive whiteboard modeling. When the client was interviewed at the end of the project, he offered his opinion on why this was the case.

Table 6. Overview of Project 3.

Team Size	Team Characteristics	Client Type	XP Mentoring	Project Type and Duration	Main Languages Used
5	Bachelor's students. Two members were mature students and had prior experience of working as programmers, but lacked any XP experience. Work roles were clearly defined; one member produced documentation.	Single client with prior project experience.	Training period for 1 week before the start of the project. Further help available on demand.	Online database and content management system for a research project 4 months	PHP, CMS, CSS

> "*The environment made it difficult to communicate: A dedicated meeting room should have been used. There was too much background noise in the main lab and this contributed to the mutual lack of understanding in some of the early meetings."* (Project 3 client)

The client had a very rudimentary knowledge of SE, and felt that the team took too much for granted in this regard. The team had trouble pitching ideas at the client's level of SE understanding.

> *"They took too much for granted with regards to my technical knowledge. No one asked if I understood certain points. I couldn't get them to pitch things in laymen's terms.*" (Project 3 client)

XP stresses regular and informative feedback between the team and client. In this project, the feedback was infrequent and incomplete. This was not entirely the team's fault; the client also canceled several meetings. This client was informed before the start of the project, as are all clients, about the importance of attending meetings and of providing regular feedback. In this particular case, serious problems of a personal nature prevented the client from attending several meetings; therefore the project managers could not apply much pressure. Nonetheless the client had nagging doubts that the team was not showing enough initiative.

> *"I was available at other times, and they could have called. I was happy for them to have my number.*" (Project 3 client)

To their credit, the team was open about what they could and could not do, given the time scale and the level of technical complexity involved in meeting some of the requirements. It took a while for the team to convince the client of the validity of the argument that concentrating on the core requirements was the best way forward. This honesty was appreciated towards the end of the project. Because XP promotes communication and respect, this was a minor drawback. On the positive side there was little conflict between team and client and useful discussions took place. Table 7 presents the outcomes of the project.

Table 7. Positives, XP Experience, Negatives, and the Outcome of Project 3.

Positives	Team experience with XP	Client Negatives	Outcome
▪ Whiteboard modeling and sketches helped team to gain early understanding of requirements. ▪ Client impressed with iterations. ▪ Honesty was appreciated.	▪ Heavy emphasis on refactoring and cleaning up code. ▪ Adapted well to the idea of turning out different iterations of the software. ▪ Used story-cards, coupled with whiteboard modeling, to capture the requirements. ▪ Difficult to enforce pair programming and test-first due to working habits of two members of the team.	▪ Complaints about the noise and environment. ▪ Hinted that the team could have contacted him more often.	▪ Successful, as core and additional requirements were satisfied.

Project 4

This particular project, indicated in Table 8, differed in that the team did not have access to the main clients who had commissioned the software, but instead communicated with an ambassador who acted as a bridge between the two parties. All of the clients were from the same organization.

Table 8. Overview of Project 4.

Team Size	Team Characteristics	Client Type	XP Mentoring	Project Type and Duration	Main Languages Used
5	A mixture of 4th year and MSc students. Half the team had XP experience.	Multiple clients; clients' ambassador had prior project experience.	Training period for two weeks before the start of the project.	Maintenance project 8 months	PHP

The ambassador was chosen to represent his organization primarily because he had a higher level of SE knowledge than the primary clients. One positive outcome from this process was that the level of SE knowledge by the clients' representative had increased by the end of the project. During meetings with the team, the ambassador would probe and ask many questions if he did not understand a certain point. This helped to clarify matters for both parties. On a positive note, the team encouraged the ambassador to ask questions. The ambassador reciprocated this attitude and urged the team to ask as many questions as necessary.

The requirements were said to be concrete from the start of the project and the project involved replicating existing systems. For the client, the project was also a learning experience, as the quote below illustrates.

> "*I have come out of this with a greater understanding of the whole SE process, and how developers go about their tasks.*" (Project 4 client ambassador)

The team's professional approach was also impressive. It was clear that they had prepared well for meetings: No time was wasted and they asked several pertinent questions during each meeting. The client acknowledged this professional approach, and was also impressed by three more things: the team's high level of technical competence, the genuine team effort that was not dominated by one or two prominent individuals, and the helpful interim releases. The client saw that the various revisions gave a clear picture of how things were progressing. However, not everything was straightforward, particularly a voiced concern about the lack of feedback during certain periods towards the latter stages of the project.

> "*I had no indication that you were stalling. It is almost as if I have been kept in the dark.*" (Project 4 client ambassador, to team after hearing about problems)
>
> "*The problems are due to other commitments. This project is still at the forefront of my thinking.*" (4D, Project 4 team member)

Despite the openness of both the team and ambassador, problems were still uncovered with the process of gathering the requirements for the software. This highlights the importance of initial requirements envisioning, since this would, in theory, result in the client having a better understanding of the way in which the software will be developed, as well as the project's needs and possible constraints. The lack of understanding with regards to the constraints led to problems that delayed the final release of the software. Although the project had overrun by a month, in the end, the outcome was positive, as Table 9 and the quote below indicate.

Table 9. Positives, XP Experience, Negatives and the Outcome of Project 4.

Positives	Team experience with XP	Client Negatives	Outcome
▪ Professional approach from team. ▪ A team effort. ▪ High level of technical competence. ▪ No serious problems caused by not meeting primary clients directly. ▪ Sufficiently knowledgeable ambassador acted as an effective bridge between team and primary clients. ▪ Ambassador suitably satisfied with delivered product.	▪ Pair programming used throughout by all of the team. ▪ Successful adaptation of test-first. ▪ Refactoring of code. ▪ Effective whiteboarding and use of story-cards. ▪ Effective communication and respect between team members. ▪ Effective XP adaptation.	▪ Complaints about being kept in the dark for a period. ▪ Criticized the team for not shadowing the existing process.	▪ The client was happy on the completion of the project. There was recognition that significant progress had been made.

"*All in all I am happy with the progress that has been made. The software is not quite there, some tweaks are needed, but significant progress has been made.*" (Project 4 client ambassador)

Project 5

This project, presented in Table 10, got off to a promising start but, by the end of the project, there was an acrimonious split between the team and client. The client felt he was clear with his requirements from the beginning, and that he had provided very detailed and relevant documentation about a specific hierarchy of products. Additionally, the client felt that he was open with regard to meeting and allowing the team to contact him.

Table 10. Overview of Project 5.

Team Size	Team Characteristics	Client Type	XP Mentoring	Project Type and Duration	Main Languages Used
6	MSc and 4th year members. Two excellent developers. Three members of the team had prior XP experience.	Single client with prior project experience.	Training period for 2 weeks before the start of the project.	New project 8 months	PHP, various scripting languages

"*The main requirements were clear, but not the nitty-gritty details. The idea of iterative development is good in theory.*" (Project 5 client)

As previously stated, this project got off to a promising start. However, as time passed, the client noted that the team had seriously underestimated the complexity of the project. Worse still was the observation and claim by the client that the team's body language gave the impression that they did understand what was going on, and they acted as if they understood, but did not. In retrospect, the client felt the team did not probe enough in the early stages, and allowed one or two members to do all of the talking.

"*The team did not understand the requirements, and they underestimated the complexity of the project. They gave the impression that they understood, but as the time passed, it was clear that they didn't.*" (Project 5 client)

Additional concern was expressed about the professionalism of the team during meetings. The client said they should have had a clear agenda, a scribe, and a chairperson for each meeting, and that the venue could have been better. The client complained on several occasions about background noise and an uncomfortable environment.

A more serious problem was that the team was forced to start all over halfway through the project. According to the client, this was because they underestimated the initial complexity of the project and they failed to convey their concerns to him. The team argued that the problem was due to the client trying to bring additional requirements in and aiming for increasingly complex features. The implementation of such features would have been very time consuming. This highlighted the need for more requirements envisioning and

scoping when producing story-cards in the early stages of the project. Due to this, there was some degree of slippage, requirements were missed as time passed, and the team claimed this was due to changing requirements. The client disagreed.

> *"The reason we are not moving forward is because he* [the client] *keeps trying to change the requirements or add new ones. He is trying to ride roughshod over the contract."* (5B, Project 5 team member)
>
> "*You are panicking, and the meltdown has nothing to do with changing requirements. The problem is you underestimated the initial requirements.*" (Project 5 client)

This breakdown in communication resulted in irreparable damage to the team–client relationship. The team felt that it would have been wiser to focus on either an eCommerce or stock control system, and that it was unwise to pursue both aims simultaneously during the same project. The client challenged this point.

> *"It would make more sense to focus on one aspect of the project. Trying to incorporate the stock control system is unrealistic."* (5B, Project 5 team member)
>
> "*The discussion has been focused on the Web site. You have neglected the stock control system, which was always part of the project.*" (Project 5 client)

Upon completion of the project, the client expressed the opinion that it would have been more useful if the team had produced a detailed requirements and design document. This may have been too extreme and may not have been necessary had the team effectively modeled the requirements early on and paid more attention to the scope of the project. Another point made was that a specialist analyst would have come in useful and there should have been a detailed specification. This is akin to the traditional approach in which systems analysts determine and document detailed user requirements before developers get to work on coding.

Another reason for the client's anger was that he felt he did not have enough time to explore the look and feel of the system during the project process. Furthermore, he did not get the chance to suggest any changes that could have been made. This was another source of conflict.

> "*Not having a chance to play with the system and explore the look and feel in enough detail has soured the whole experience for me*." (Project 5 client)
>
> "*This is not true. The contract explicitly stated that that any changes after a specific period—30 days before the end of the project—would not be accommodated*." (5B, Project 5 team member)
>
> "*I have not been given a fair chance to review the system.*" (Project 5 client)

The client was unhappy at the end of the project, expressing his dissatisfaction with the quote below. It also is reflected in the project outcomes, as indicated in Table 11.

> "*This project has been a bittersweet experience. So much promise and things were going well for a period. I am not happy with the final system: Important functionality is missing.*" (Project 5 client)

Table 11. Positives, XP Experience, Negatives, and the Outcome of Project 5.

Positives	Team experience with XP	Client Negatives	Outcome
▪ Regular meetings with client. ▪ High level of technical competence shown by main spokesman for this team.	▪ Adapted well to the idea of iterations as specified by XP. ▪ Pair programming was done effectively and pairs were rotated at regular intervals. ▪ Test-first adhered to. ▪ Code was refactored at regular periods. ▪ High degree of respect and communication among team members. ▪ Lack of modeling early on led to misunderstandings later in the project.	▪ Bitter arguments towards the end of the project. ▪ Felt that not enough scoping took place early in the project. ▪ Over time, the client suspected the team had underestimated the complexity of the project. ▪ The client felt that the contract did not fairly represent his requirements.	▪ Team and client were in conflict at the end of the project. ▪ Differing opinions over whether or not core requirements were met. ▪ Incomplete system, in the client's opinion.

Project 6

The client for this project, the overview of which is presented in Table 12, had a greater level of SE knowledge than any of the others, and came from a very technical background. The client also believed that the requirements for this project were clear from the beginning. However, the team working on this project had to continue on what had been done by another team the previous year. This took a lot of time, and, for the first few months of the project, the team was seeking to understand what the previous team had done because the code from the previous year was poorly commented, full of bugs, and the project lacked documentation. As a result of these problems, the team was unable to address the client's requirements immediately. The following quotes shed some light on this particular set of problems.

> "*Do you understand what we are trying to achieve with this system*?" (Project 6 client)
>
> "*As there is no documentation, I am confused about what the system does.*" (6D, Project 6 team member)

Table 12. Overview of Project 6.

Team Size	Team Characteristics	Client Type	XP Mentoring	Project Type and Duration	Main Languages Used
4	One fourth-year student and three MScs. All strong technically, with prior experience.	Single client; prior project experience.	Training for 2 weeks before the start of the project.	Maintenance project 8 months	Java

There was a sense of frustration in the first few months of the project because the client felt there were problems transferring knowledge, and that only one or two people on the team, at most, had any understanding of what was required for the current project. Interestingly the team felt that the client was being unfair by expecting them to start working on the latest version of the system without gaining an adequate understanding of what had preceded it. On the client side, there was a feeling that the team was going round in circles without understanding what to do.

> "*Well the system should generate reports.*" (6D, Project 6 team member)
>
> "*They were there last year. As yet you haven't created anything*!" (Project 6 client)
>
> "*We have attempted to clean up the UI* [user interface] *and make it friendlier.*" (6D, Project 6 team member)

The knowledge transfer problem was exacerbated by the claim from the client that there was only periodic contact during the early stages of the project. The team disagreed with this perspective by stating that they arranged meetings when they had something to present. Because so much time was spent trying to make sense of the old code, the team argued that there was precious little in the first few months to show the client that he had not already seen. Both sides seemed to be irritated during this period.

> *"There are a lot of bugs in the first version of the software. The rules were totally wrong.*" (6D, Project 6 team member)
>
> "*So have you actually written anything*?" (Project 6 client)
>
> "*No, just reworked existing code.*" (6D, Project 6 team member)
>
> "*The comments and the code are very poorly structured.*" (6D, Project 6 team member)

Things picked up in the second half of the project and the team made good progress towards meeting the client's requirements. However, there were still problems. Towards the end of the project, the client remarked that he did not think the (new) code was well structured, and voiced doubts about the validity of the XP approach.

> *"XP seems to involve team members looking over each other's shoulders. It doesn't seem to be terribly structured to me. Due to the absence of a detailed requirements specification document, the use of iterations is the only option.*" (Project 6 client, on the implementation of an XP process)

A common theme in several projects, as was here, was a desire for documents. This was confusing for the teams involved, since the XP rhetoric motivates teams to provide instead evidence of working functions by way of presenting work done on each iteration. Interestingly, both the team and client remarked that detailed documentation from the previous year would have been helpful in this particular project.

> *"Are you enjoying the project? I understand that it is difficult to take on someone else's system.*" (Project 6 client)
>
> "*I wouldn't say we were enjoying it. We were not given any documentation.*" (6D, Project 6 team member)

One possible way of alleviating this need for documentation in an XP project is by completing an initial envisioning, which will generate high-level models. This would allow stakeholders to communicate their overall desires, to set direction, and to see that the team understands what needs to be built. Two agile practitioners with a wealth of project experience have produced what has been described as a seminal book describing how software developers following agile methodologies should approach modeling and documentation (Ambler & Jeffries, 2002). A relevant argument for this research is that modeling and documentation are important aspects of any software project, including XP projects. Without the high-level models generated during the initial requirements envisioning phase, clients may be tempted ask for detailed documentation without realizing that there is a middle ground.

Ultimately, the client acknowledged that the team had worked hard throughout the project, even though he was not totally satisfied with the final product. Nevertheless, the outcome of the project provided a starting point, a basic database, and a tool for manipulating data. By the end, as the outcomes listed in Table 13 indicate, the client had a realistic view of the project and was not too surprised by the outcome.

> *"This project was par for the course as far as software failures are concerned; there are no great surprises."* (Project 6 client regarding project outcome)

Table 13. Positives, XP Experience, Negatives, and Outcome of Project 6.

Positives	Team experience with XP	Client Negatives	Outcome
▪ Very strong team technically. ▪ All members worked hard throughout the project. ▪ Client appreciated their effort and said they conducted themselves in a professional manner.	▪ Initial difficulties when attempting to understand previous work. ▪ Not enough focus on story-cards and modeling early in the project. ▪ Adapted well to the idea of iterations as specified by XP. ▪ Pair programming was done effectively and pairs were rotated at regular intervals. ▪ Test-first adhered to. ▪ Code was refactored at regular periods. ▪ High degree of respect and communication among team members.	▪ Frustration expressed due to perceived slow progress and, at times, the lack of meaningful contact. ▪ Awareness that at times the team were not enjoying the project. ▪ Unsatisfied with the final product but conceded it was a good starting point. ▪ Noted that although all members worked hard, not all were forthcoming during meetings.	▪ Another iteration needed, more tweaks to fix. ▪ Client was realistic, was aware that such problems are likely to occur during SE projects. ▪ Par for the course for projects to overrun.

Project 7

A booklet dealing with personal medical issues concerning children triggered the idea behind this project: The clients of this project, characterizations of which are presented in Table 14, agreed that a Web site could be created based on the booklet. The clients were based in different UK cities and had no knowledge of SE. Overall, the client based in Sheffield expressed a positive opinion about the project, since initially they started with concepts as opposed to firm ideas. He and the other clients found the iterative approach and interim releases to be very helpful, particularly since the scope of the requirements changed from the start of the project and the iterations put the concepts into focus. The interim releases provided a realistic picture of what was possible, as well as allowing the clients to see the progress being made.

> "*The iterative approach was helpful. As time went by it became clear that more could be done with the software. As a result, it was possible to change the scope of the requirements without creating too many problems.*" (Project 7 main client)

Table 14. Overview of Project 7.

Team Size	Team Characteristics	Client Type	XP Mentoring	Project Type and Duration	Main Languages Used
6	Six members in the team, split between 4th year and MSc students.	Multiple clients; no prior project experience.	Training period for 2 weeks before the start of the project.	New project 8 months	PHP, Flash, scripting languages

Another positive was that the clients were surprised at the professionalism of the team, and how many people turned up for meetings. If a specific time was agreed upon to deliver a part of the project, the team kept their side of the bargain. This was another aspect of the team's praiseworthy behavior. Finally, the team managed to pitch concepts at a level the clients could understand and refrained from bombarding them with technical jargon.

The Sheffield-based client admitted that he was ignorant of SE and that, in the future, he would put more work into preparing for meetings and learn more about the development project. The lack of SE knowledge was not a major problem for the team, who were happy to explain how to develop ideas in layman's terms. They also explained if something was infeasible given the technical complexity, time scale, and copyright issues (when using images), and so on.

> "*Timelines were set, which all parties agreed to. I could understand what the team was trying to convey.*" (Project 7 main client)

> "*It was important to make it clear that there were certain restrictions on having sounds and animations on the Web site. In particular, it would have cost the client thousands of pounds for the bandwidth if large numbers of people started to download videos from his site.*" (7C, Project 7 team member)

The team gave no false assurances that things could be done that were not possible. This did not mean that the team was inflexible, since the scope of the project did change. The original idea was to have a site with a lot of animations and games to be used by younger children. This option and the idea behind the project changed into a more educational tool for a broader age range. Honesty proved to be the best policy in this project, and the clients were happy with what was done. This may not have been the case, however, if the clients were too dogmatic or outlandish with unreasonable requirements.

This project is interesting because, on the whole, the clients were satisfied with how things had developed. However, the team was unsatisfied with the frequency of feedback from the client side. What this shows is that clients in an XP project also have a responsibility to maintain contact with their development teams. However, it must be added that, as the outcomes in Table 15 indicate, upon completion of the project, the infrequent contact with the client(s) did not cause as many problems as first feared. The successful outcome suggests that the frequency of contact and feedback was deemed to be sufficient from the client side.

> "*We need more interaction with all of the clients. The meetings are useful, but more feedback is needed.*" (7C, Project 7 team member)
>
> "*At times it seems as if the client is not bothered about the project. We need more face-to-face meetings to hammer things out.*" (7C, Project 7 team member)
>
> "*I am delighted with what has been done, and impressed with the team's performance.*" (Project 7 main client)

Table 15. Positives, XP Experience, Negatives and the Outcome for Project 7.

Positives	Team experience with XP	Client Negatives	Outcome
▪ Not the strongest team technically, but enthusiastic and hard working. ▪ Clients were impressed with the openness and professional approach of the team. ▪ Led well by one very technically gifted member.	▪ No test-first due to time constraints and the technology employed. ▪ Pair programming only adhered to by one pair. ▪ Iterations worked well. ▪ Effective use of story-cards and whiteboarding to capture requirements before and after initial meetings.	▪ None expressed by the clients.	▪ Clients were delighted with what had been done, upon completion of the project. ▪ Positive impression of the team and the methodology used.

SUMMARY OF RESULTS

This research aimed to investigate the nature of the relationship between project clients and SE teams attempting to adhere to the XP methodology. To this end, there are both positives and negatives to take from the results. Table 16 illustrates the positive and negative aspects of the relationship between clients and teams in these observed XP projects.

Table 16. Summary of Results.

General Positives	XP Positives	XP Negatives
▪ Professionalism of teams. ▪ Praise for high level of technical competency. ▪ Most teams pitched ideas and comments at an understandable level for a layman.	▪ Emphasis on keeping in contact with clients kept communication breakdowns to a minimum. ▪ Pair programming, when used, was beneficial and increased team understanding of the project, which led to greater input from all members during client meetings. ▪ The greater focus on testing meant that the software was relatively bug free. ▪ Several clients commented that they find the idea of iterations to be very helpful since it helped them to see how the system was progressing. ▪ The need for excessive documentation was alleviated by effective whiteboarding and probing done in the early stages in some of the teams. ▪ Story-cards, coupled with the whiteboarding, captured the requirements.	▪ Story-cards lacked sufficient details. ▪ Insistence on detailed requirements document by some clients. ▪ An "unholy amalgamation of methodologies" at times, as opposed to XP. ▪ Time wasted at the beginning of projects due to lack of scoping. ▪ Confusing feedback from some clients that the teams had not followed requirements. ▪ Test-first seen to be counter-intuitive by several developers. ▪ Glitches unfixed at the end of some of the projects, due to lack of testing within allotted time period. ▪ Lack of prior documentation for maintenance projects caused problems. ▪ Pair programming not fully functional: incompatible pairs and incompatible working hours.

Overall the results show that greater client involvement in a project may well be a double-edged sword. In some cases, a client may feel pressured to exert more authority over the development process and start to take unilateral decisions. There is also a greater risk of open conflict breaking out, especially if a client feels the team is not putting enough effort in or is attempting to throw up a smoke-screen to hide the reality of the situation (whether or not this perception reflects the reality of the team). Ultimately, what this research has shown is that, even with XP and its supposedly greater emphasis on human factors and communication, there are still serious problems with expectations and satisfaction on the part of clients within the produced system.

LIMITATIONS

There are a number of limitations of this study that need to be discussed in light of the results obtained. Firstly, it must be kept in mind that the team subjects were students, not professional practitioners. As always when this is the case, one must be careful about generalizing from

students to practitioners. In defense of our work, however, it must be added that the students were working on projects for real-world clients who actually needed a piece of software, and the students were working in an environment that is as close to an industrial software house as is possible in academia. This means the work carried out for this study is more valid than would have been the case if teams were working on projects defined by academics with researchers playing the role of a client. Another point worth mentioning is that team members were primarily master's students who had previously completed other group projects or, on some occasions, worked in industry before returning to higher education.

Another argument in defense of the use of students for this study relates to the authority of the client. As was previously reported, the clients were diverse in terms of SE project experience. The fact that the clients were working with students may have empowered them to make more decisions and to take on a more active role throughout the project. This could be contrasted with how clients may have conducted themselves in a project in which the development team was made up of seasoned professionals. In such a situation, clients may not be so forthright and direct due to fear of rejection or ridicule. Although we have no evidence that this was the case, it is nonetheless a plausible perspective. A client without any SE experience would be more open and authoritative with students, that is, those still learning the trade of SE, as opposed to seasoned professionals.

Secondly, the work aimed to explore team–client relationships when teams were following XP. It would be unfair to state that all of the teams were all adhering to a purest version of XP as described by Beck (2000).

A further threat is the relatively small sample size of seven teams, although this is an improvement on previous studies that have looked at clients in XP projects. Nonetheless, the sample size and the fact that all projects took place at the University of Sheffield still constitute a threat to the external validity of the study.

The final threat was the Hawthorne effect: Did the presence of researchers have any affect on the behavior of the research subjects, whether they were teams or clients? It cannot be said with 100% certainty that the researchers' presence did not induce socially acceptable behavior. However, the fact that heated discussions and arguments took place when the researchers were present suggests that research subjects were not overly concerned about acting in a socially acceptable manner. Additionally, the often blunt responses from the clients when they were interviewed and the fact that they had commissioned a piece of real-world software supports the notion that they had nothing to gain by behaving in a manner they thought would be more appropriate for the researchers benefit.

CONCLUSIONS AND FUTURE WORK

As stated earlier, XP is a popular agile development method that explicitly defines a role for a client working in close conjunction with the development team (Beck, 2000). So how does this research build on the existing literature? It adds to the knowledge base concerning human and social factors of XP by focusing specifically on how teams interact with clients and sheds light on an area that has been overlooked by other XP researchers in the main. This work is important because XP attempts to increase and improve client–development team communication, both in quality and quantity over traditional methods. In theory, this should

prevent serious breaches between teams and clients, as expectation gaps should not become too large. This theory needed to be tested in realistic situations.

However, this and other related research have shown that success in XP projects depends, to a large extent, on the quality of the communication between teams and clients. In reality it may also depend on how dogmatic the teams, clients, and managers are with regards to XP practices, and whether they are willing to tailor other practices to scale XP to meet the needs of the project teams. This particular study has attempted to fill the knowledge gaps on how clients communicate with teams and how they convey their requirements, the effect of their expectations, and if and when they change. Carrying out more work in this area will provide a greater insight into client needs in XP projects, and whether or not teams following XP actually meet those needs.

This work provided more evidence to suggest that the effective management of client needs and expectations is of crucial importance regardless of the methodology being followed. However, this takes on greater importance with XP, due to its transparency, emphasis on fluidity and rapid feedback, and the explicit call for the client to play an active role in the development process. While placing greater pressure on the team, XP also calls for the client to devote more time to the project.

More work is needed in this area to confirm the findings of this and earlier papers. Future studies of XP should aim to devote more attention to the role of the client. This may involve expanding the scope of current XP studies or carrying out research specific to the role of the client. In addition, future work should also focus on how the team found the experience of working with a specific client. This could involve conducting interviews with software developers and managers.

This line of research is important for SE as a whole, particularly since we are now living in an age of competing methodologies. Agile methodologies suggest that greater client involvement should lead to fewer expectation gaps and greater satisfaction; more work is needed to confirm whether or not this is actually the case. We hope that the work described in this paper will stimulate other researchers to look into issues such as client satisfaction and expectation gaps during XP development projects. Finally, once an XP knowledge base has been established, future work need not focus purely on XP but may incorporate other agile methodologies.

REFERENCES

Ambler, S. (2007). Survey says…agile has crossed the chasm: Examining the effectiveness of agile practices. Retrieved on June 11, 2008, from http://www.ddj.com/architect/200001986?pgno=1

Ambler, S., & Jeffries, R. (2002). *Agile modeling: Effective practices for extreme programming and the unified process*. Hoboken, NJ, USA: Wiley.

Beck, K. (2000). *Extreme programming explained: Embrace change*. Reading, MA, USA: Addison Wesley, Longman.

Elssamadisy, A., & Schalliol, G. (2002). Recognizing and responding to "bad smells" in extreme programming. In *Proceedings of the 24th Conference on Software Engineering* (pp. 617–622). Heidelberg, Germany: Springer.

Grisham, P. S., & Perry, D. E. (2005). Customer relationships and extreme programming. In *Proceedings of the 2005 Workshop on Human and Social Factors of Software Engineering* conference (pp. 1–6). Heidelberg, Germany: Springer.

Janoff, N., & Rising, L. (2000). The Scrum software development process for small teams. *IEEE Software, 17*, 26–32.

Koskela, J., & Abrahamsson, P. (2004). On-site customer in an XP project: Empirical results from a case study. In *Proceedings 11th Conference on Software Process Improvements* (Euro SPI 2004*;* pp. 1–11). Heidelberg, Germany: Springer.

Lycett, M., Macredie, R. D., Patel, C., & Paul, R. J. (2003). Migrating agile methods to standardized development practice. *IEEE Computer, 36*, 69–93.

Martin, A., Noble, J., & Biddle, R. (2003). Being Jane Malkovich: A look into the world of an XP customer. In *Proceedings of the 4th International Conference on eXtreme Programming and Agile Processes in Software Engineering* (XP 2003; pp. 234–243). Heidelberg, Germany: Springer

Morris, C. (2001). The case for XP. Retrieved July 20, 2008, from http://clabs.org/caseforxp.htm

Murru, O., Deias, R., & Mugheddu, G. (2003). Assessing XP at an European Internet company. *IEEE Software, 20*, 37–43.

Simons, A. J. H. (1999). The discovery method for object-oriented software engineering. Retrieved May 4, 2007, from http://www.dcs.shef.ac.uk/~ajhs/discovery/

Stapleton, J. (1995). *Dynamic systems development method*. Boston: Addison Wesley.

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INVENTING NEW USES FOR TOOLS: A COGNITIVE FOUNDATION FOR STUDIES ON APPROPRIATION

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Abstract: *Appropriation refers to the processes that take place when new uses are invented for tools and when these uses develop into practices and start spreading within a user community. Most research in human–computer interaction and computer-supported cooperative work to date has studied this phenomenon from a social sciences approach, thus focusing on the practice side of the phenomenon. This paper addresses appropriation from the other direction, drawing from ecological psychology and focusing on cognitive processes in context. Appropriation from this perspective is understood as an interpretation process in which the user perceives in a tool a new opportunity for action, thus acquiring a new mental usage schema that complements the existing uses. This approach highlights the need to study how schemata are put into use and how they evolve through new interpretations. Ensuing research questions are presented together with three strategies of applying the new approach in system design.*

Keywords: *appropriation, schema, artifact, tool, ecological psychology.*

INTRODUCTION

Appropriation—the invention of new purposes of use—as a phenomenon in human–computer interaction is gaining increasing interest, especially in computer-supported cooperative work (CSCW) research (e.g., Balka & Wagner, 2006; Bansler & Havn, 2006; Brown & Perry, 2000; Dourish, 2003; Huysman et al., 2003; Pargman & Wærn 2003; Petersen, Madsen, & Kjær, 2002; Salovaara, 2007). The reason for this is that, from the late 1980s until today, it has become increasingly clear that a system's use should be conceived more as a *projection* of its features instead of a direct *outcome* of the design (see, e.g., DeSanctis & Poole, 1994; Orlikowski, 1992). Design does not determine how and for what purposes a system will be used in real settings, but rather is a component in a more complex, evolving process in which unforeseen contextual features, social factors, creativity, and opportunism, as well as new user interpretations, also play a part. The result of such a process is a multitude of different uses for the same system, each use having a different history behind it. Put in another way, users often adapt their tools by transforming their use and even their configuration, thus making them suitable for ongoing practices in different environments.

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An often-used definition for appropriation comes from Dourish, who has captured the above-mentioned viewpoints in the following description:

> Appropriation is the way in which technologies are adopted, adapted and incorporated into working practice. This might involve customisation in the traditional sense (that is, the explicit reconfiguration of the technology in order to suit local needs), but it might also simply involve making use of the technology for purposes beyond those for which it was originally designed, or to serve new ends. (Dourish, 2003, p. 467)

It is clear that understanding appropriation is important for CSCW, human–technology research, and system design. By describing appropriation processes in different settings, it is possible to gain a better understanding of the nature of evolving patterns of use, the factors that support or suppress user innovation in everyday settings, the processes of user innovation, and the workarounds and strategies developed by users to overcome unanticipated problems. These findings can be turned into design implications, and they also sensitize designers to conceptualize their work in a new way. Through such awareness, design methodology can be improved to take into account better the variety and richness that can be found in many use practices.

Appropriation of technology has been mainly researched within CSCW by carrying out longitudinal follow-up case studies and applying theoretical frameworks to account for the observed activities. Examples of such applications of theories from other fields are the adaptive structuration theory (DeSanctis & Poole, 1994; Orlikowski, 1992, 1996; Pipek & Wulf, 2006; Tyre & Orlikowski, 1994; adapted from the structuration theory by Giddens, 1984), the sensemaking perspective (Bansler & Havn, 2006, originally presented by Weick, 1995), cultural-historical activity theory (Pargman & Wærn, 2003; Petersen et al., 2002), and ethnomethodology (Brown & Perry, 2000; Salovaara, 2007). The focus has been on deepening the understanding of human activity and supporting the design of more appropriable technologies. Appropriation research has also benefited from research on tailoring—how users adapt and modify systems to fit their work better (e.g., Pipek, 2005; Trigg & Bødker, 1994). Systems purposely built to support tailoring provide one way to achieve appropriable technologies. Allowing users to modify and adapt the systems gives them more freedom to find new uses for a system.

Technology appropriation is a widely used concept and has been given definitions in fields other than CSCW. Eglash (2004) has used it in social studies of technology to examine the politics of use and questions on the power to decide what a technology is used for. This has led him to study cases in which high-power designers (such as the architects of a building) and low-power user-consumers (such as graffiti artists) interpret the technology (in this case, a building) in different ways, rendering visible the dynamics of the proper use of technology. Eglash has conceptualized these dynamics as three appropriation categories that span a continuum from semantic reinterpretation to structural reinvention, leaving adaptation (as a change of use) in the middle. The presentation in this paper relates primarily to the middlemost category, but because the aim here is not to understand power relations, Eglash's categorization is not directly applicable to issues relevant to this paper.

Another sociological approach, the research on the consumption and domestication of consumer products (Silverstone, Hirsch, & Morley, 1992; Williams, Stewart, & Slack, 2005), also makes use of the term appropriation, using it to identify the steps of progressive

ownership in processes in which commodity products such as TV sets are bought from stores and gradually converted by their owners into objects that bear personal significance. The analysis of different uses is carried out under the concept of incorporation. Despite having a different name, it carries the same meaning as what is called appropriation in this paper. The purpose of analysis, however, deviates from that of CSCW and is more focused on consumption patterns than design.

A common topic raised across all these efforts has been an emphasis on how important it is to focus on the context-specificity of activities and practices: The setting for action is every time slightly different than before and that this affects the way in which different resources in the environment—digital and physical tools, other people, and so on.—are perceived, interpreted, and acted upon. This leads us to ask how users actually might interpret the possible uses of an artifact. Understanding interpretation has therefore a central role in understanding appropriation and artifact use in general.

Interpretations of artifacts are naturally affected heavily by the user's ongoing activities and goals, but also by experiences from previous situations of use and socially learned pieces of knowledge from other users. Often there are multiple interpretations of the same artifact, each having a different relevance from one situation to another. If we assume that all the situations bear some meaning for the user, we end up with the conclusion that there cannot be a single correct interpretation of an artifact.

In some cases, however, there is a demand for communicating only a single possible interpretation. It may be feared that a new use directly or indirectly has negative effects on users, other people, or society in general. This aspect is especially important in occupational health and safety-critical systems (e.g., Kjellen, 2000). However, in spite of this, the purpose of this paper is not to find ways to hinder people from inventing uses that someone could consider deviant or harmful. The aim is to remain neutral on such value attributions and instead focus purely on understanding how users come up with *any* new uses. By emphasizing the appropriating users' viewpoint, the focus is admittedly more on the "sunny" side of appropriation than on misuses and misappropriations. However, by adopting the user's viewpoint, unwanted appropriations can also be better understood and, if wished, the subsequent systems engineering and design efforts can then attempt to hinder such misappropriations from taking place. Work towards this direction is currently being carried out in computer security (Dhillon, 1999) and organizational e-mail misuse prevention (Attaran, 2000; Duane & Finnegan, 2004).

Whenever preventing users from appropriating is not an issue, the task for an appropriation-friendly designer is thus transformed. Instead of communicating only a single possible use as clearly as possible, the designer concentrates on making the device usable and useful for many different situations and users.

Approaching appropriation from the point of view of interpretation connects us with two lines of research that are especially relevant to the topic at hand. They represent two quite different fields of research: critical approaches drawing from the humanities and arts on one hand, and cognitive science on the other. Within the former field, it has been seen as important to engage the user in reflecting on the meanings of artifacts. For instance, Gaver, Beaver, and Benford (2003) advocate design that deliberately incorporates ambiguity in the presentation of information, the artifact's purpose of use, and its relationship with the surrounding social context. Such a design strategy provokes and engages users to question

easy and seemingly obvious interpretations in favor of personally more meaningful ones. They claim that using such systems can provide users with experiences of delight and intrigue. Similarly, by presenting a series of design case studies, Höök (2006) suggests ways to open the interpretation space of digital systems. For instance, a communication tool may provide a space for expressing different moods with colored backgrounds, whose meanings the users are free to negotiate on their own.

Sengers and Gaver (2006) take this perspective to a conclusion particularly relevant to the purposes of this paper. They present an idea of multiple interpretations, stating that the designer's idea of a tool's usage is not always the correct one, and therefore the correct design strategy would be to help users in creating their own interpretations of how an artifact can be used. Furthermore, designers should remember that the users' interpretations can even be in conflict with each other. The designer should let the user exercise freedom to choose what is best.

Whereas the approach arising from the arts has received attention in the human–computer interaction (HCI) research community, the cognitive approach has not been taken up to an equal extent. The purpose of this paper is to establish grounds for this line of research. Psychological studies of interpretation processes and their relations to actual usage are valuable in providing more systematically gained insight into how different interpretations are constructed in different settings. They can also complement the research on appropriation that has been carried out in CSCW and sociology by studying the ways in which an individual's interpretations contribute to the negotiations about suitable usages in collaborative settings.

APPROPRIATION FROM THE PERSPECTIVE OF COGNITIVE SCIENCE

Appropriation has the particular character of being hardly predictable, even to the extent that it is more likely to occur in anomalistic situations (Tyre & Orlikowski, 1994). It is also difficult to predict what elements in the context happen to contribute to the appropriation process. Appropriation processes therefore have a particular real-life flavor that is difficult to replicate in a laboratory. Cognitively oriented research on appropriation must meet this hindrance and be prepared to study a phenomenon despite this challenge. The requirement is, of course, not particular to cognitive science, as it holds for other theoretical approaches to appropriation as well. The difference to the approaches listed above comes from the emphasis on models and predictions in cognitive studies. Theory-building can be started with descriptive studies, but the final aim is to end up with something that can be subjected to empirical critique more directly.

Ericsson and Hastie (1994) have addressed ways to proceed towards ecological validity in research on thinking and problem solving. Their discussion is also suitable for the purposes of this paper. Ericsson and Hastie point out that psychologists have had particular problems in finding out how to take into account test subjects' previous experiences in analyzing experiment results. If a person is experienced in the tasks that she has to carry out, then her ways of solving the tasks are incomparable to the results of other participants. This problem has led to a research tradition that has advocated artificial problems or precise problem domains (such as chess) in which the test subjects are on the same level in terms of experience, either as experts or complete novices. This approach has sometimes led to studies

whose ecological validity other researchers have questioned (e.g., Lave, 1988). Ericsson and Hastie (1994) propose two strategies to improve the situation. One is to identify the relevant cognitive processes on such a fundamental level that they are always present in the cognitive tasks of interest, and therefore also in the artificial problems. If such processes can be found, they can be studied in controlled settings with better precision than in the real world. The other strategy is to go into the field and attempt to identify phenomena that could be replicated in a laboratory without losing the necessary characteristics of the phenomenon.

When studying appropriation, it likewise must be remembered that there are users with different skill levels and experiences. The approach presented below will tackle this by using the Ericsson and Hastie strategy as a guideline. In relation to the approaches mentioned above, the purpose is to provide a complementary perspective that has the potential to produce understanding that previously has not been excavated.

Appropriation as Development of Usage Schemata

This paper uses the theories in ecological psychology as its scientific background. Ecological psychology originated in the 1970s, when many psychologists found themselves dissatisfied with the ecological validity of the cognitive psychology of the time. Naturally, the quest for ecological validity was not invented then but dates further back in history to works by James, Brunswik, and the Gestalt psychologists such as Koffka, Köhler and Wertheimer (Heft, 2001). Later, ecological psychology was influential in the movement towards studies on embodied cognition, which seeks to overcome the problematic demarcation between mind and body in psychological research.

The interest in the processes of interpretation in this paper is the connecting link to ecological psychology. For the purposes of this paper, interpretation refers to the user's sense-making of an artifact's purpose of use. One way to approach the nature of an interpretation process is to think how a user perceives the resources for action that are necessary in the achievement of a goal. A resource can be close to an affordance (Gibson, 1979), such as a physical property that affords certain manipulations, but can also be something more elaborate, such as a new sequence of actions in a program to work on information.

Many activities are dependent on the skillful use of available resources, and it is important to study how they are perceived in the first place. The perception of resources develops through learning, that is, through experiences gathered by being in interaction with an environment and using different artifacts. Because skillful perception is dependent upon learning, the existence of resources is not independent of the perceiver. Resources are "there," available for action, only if the person has, for instance, seen them previously in effect, heard about them, tried similar resources before, or reflected about a need for such a resource in the past. Alternatively, learning can take place in a moment of interaction in which a user faces an immediate need to achieve something and starts to search for something that would serve the need. Resources are therefore personal, and each person may perceive the resources of an artifact in a different way.

If appropriation is interpreted as a process of perceiving resources facilitated through previous and immediate experiences, one way to conceptualize this is to see appropriation as a cycle of perception and action, in which both parts may change the other. Neisser (1976) has presented this idea as a perceptual cycle in which the concept of a schema directs the perception and orients the actions in the world:

> A schema is that portion of the entire perceptual cycle which is internal to the perceiver, modifiable by experience, and somehow specific to what is being perceived. The schema accepts information as it becomes available at sensory surfaces and is changed by that information; it directs movements and exploratory activities that make more information available, by which it is further modified. (p. 54)

The perception–action cycle can also be visualized with a help of a schema concept, as shown in Figure 1. The figure shows Neisser's original perceptual cycle on the left and one adapted for describing appropriation on the right.

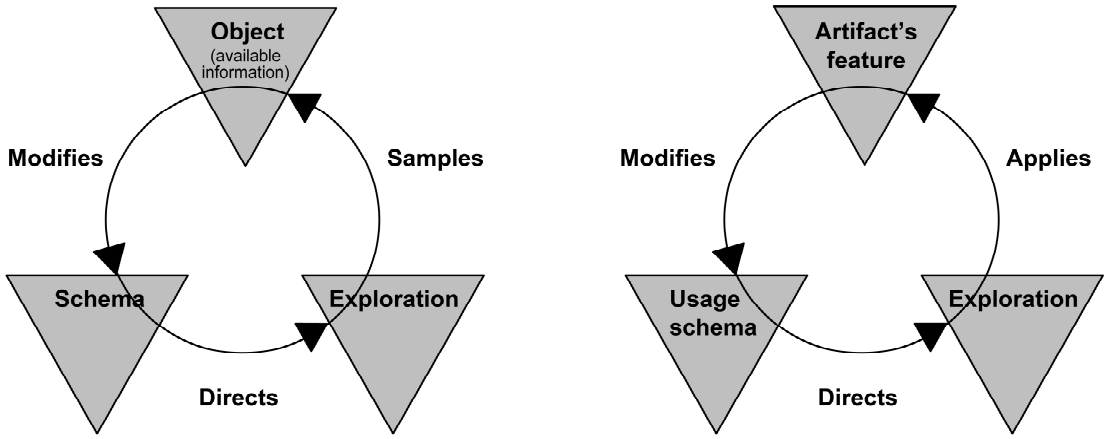

Figure 1. Neisser's perceptual cycle (1976, p. 21) and its adaptation for describing appropriation.

Comparison to Other Models

The model for appropriation presented in Figure 1 is different from certain other cyclical models used in HCI and CSCW. The task–artifact cycle (Carroll, Kellogg, & Rosson, 1991) presents a cycle of alternating stages of design and use that serves as an evolutionary model of the nature of technology development. When a user is carrying out a task with an artifact, new requirements for the artifact emerge, and when a new artifact is designed as a response to those requirements, it opens up possibilities for new tasks. Many of the typical user-centered design tasks, such as the creation of a design rationale and scenario-based design activities, can be mapped into the model (pp. 80–82). The task–artifact cycle is therefore a model about iterative product development, but does not address changes in use in cognitive terms.

The adaptation of Giddens' (1984) structuration theory—called adaptive structuration theory (Orlikowski, 1992; DeSanctis & Poole, 1994)—also contains a cyclical element. The original theory by Giddens introduces the concept "duality of structure," which is needed for building a bridge between macro-level theories on how social structure shapes action and micro-level theories on the continuous recreation of such structures (Giddens, 1984, pp. 25–28). Using this work as a starting point, developers of adaptive structuration theory have suggested that social structures are represented in artifacts' properties through the ways in

which they afford and constrain action and cooperation. Social practices develop to make use of these structures and in this way shape the social organization of the workplace (DeSanctis & Poole 1994; Orlikowski, 1992; see also Pipek & Wulf, 2006).

Finally, the action cycle by Norman (1988) models interaction with computers as a cycle, more specifically as seven stages. These stages are divided into goal formation and two "aspects" with three stages each. The aspect of execution contains stages for the formulation of intentions to act, the planning of a sequence of actions, and the execution of actions, while the aspect of evaluation consists of observation of the result and interpreting it and evaluating it to create new goals (p. 47). The model is close to the model presented here, but it is best suited for cases that resemble problem solving and in which learning during use is not a central element.

Of the models presented, none is targeted at describing appropriation through an individual's point of view, with an emphasis on cognitive processes. The closest of all three is the seven-stage action cycle, but it does not explicitly address the possibility of learning new cognitive representations through interaction.

Usage Schemata

While Neisser's (1976) model has not been applied in HCI as actively as the three others presented above, analyzing appropriation from its point of view has certain virtues. It provides a starting point for cognitive theory building that helps to direct research into novel aspects of appropriation, while at the same time also builds connections to the large body of research of higher cognitive processes (which are briefly discussed later in this paper). It also strives for ecological validity—an important requisite for HCI—that is concerned with everyday activities.

The usefulness of the new model can be exemplified by using it to analyze episodes that describe actual appropriations. Table 1 provides three such examples. They may seem quite eclectic and sketchy, but this is due to a lack of studies that would have documented appropriations systematically from the point of view presented in this paper. They can nonetheless highlight ways of using some of the model's features.

Looking at Table 1, certain qualitative differences in the nature of appropriations can be noted. The first two examples are workarounds in which an artifact is used as a replacement because a better solution is not available. In contrast, the third episode is an example in which a new technique for making music is born and nothing is replaced. Instead, a completely new kind of activity is invented. In addition, the first two appropriations result from problem solving, whereas the third takes place serendipitously, without intention.

However, more important than building classifications is to analyze the episodes in terms of the model's primary theoretical concepts: perception, schemata, exploration, and action. In the first two episodes, the perception of a new possible use is the result of making a match between the task requirements and the resources at hand in the environment. In both cases, the person is forced to engage in matchmaking because she does not have a usage schema for any of the surrounding artifacts that would directly solve the problem. Therefore the environment is explored in order to find something that would fit the requirements. The exploration is successful: The person is able to apply a feature or features of an artifact to the task at hand. This results in a new usage schema for the artifact.

Table 1. Three Episodes of Appropriation.

Episode 1: Using a panty liner to cope with a blister "I was in the city centre with a friend of mine, and we had been walking quite a lot. I was getting a bad blister on my heel because of my new shoes, and wondered what I could do to improve the situation. I had a plaster in my handbag, but it wouldn't have been thick and big enough. I needed something that would fit better in the shoe, something that would not come loose when walking, and I needed it at that moment. After thinking about this for just a short while I realized that a panty liner would be perfect; it would meet all the requirements listed. It also solved the problem." (Source: Personal communication with a female friend of the author)
Episode 2: Using an ethnographer's camera to replace a faulty video conferencing system An excerpt of field notes from an observation of setting up a video conference: <Unfortunately, the phone line is very poor and breaks up often. This brings on an interesting piece of behaviour – TN [student mentor] notices me [observer] and attempts to bring another, more compatible form of media into use> TN: I'm wondering if we have a tape recorder, or video and can send you … a copy of <looks at the ethnographer and the video recording equipment> … okay, you have a video <points at the ethnographer>, okay, yeah, <looks back at the team> we have a video of this, so maybe we can send you a video discussion later, so that you can watch it. (Source: Perry, Fruchter & Rosenberg,1999, p. 147)
Episode 3: The invention of the scratch sound (also called "needle drop" below) in hip hop music Interviewer: "So Grandmaster Flash says that you invented the needle drop; tell me how you discovered that?" Grand Theodore Wizard: "I was probably about 11 years old when I pretty much came up with the needle drop and 12 and half years old with scratch, the summer of 1975, which marks 30 years of the scratch this year. I was just basically in my room just practising and playing music a little bit too loud. My mother is the kind of person that doesn't argue or fight or fuss [;] she just start swinging[,] you know like Mike Tyson. I'm in the house trying to make the tape and back in those days you didn't have no tape decks or anything like that[;] its just take a big boom box and put it in front of the speaker and that's how we made our tapes. I was making a tape and she came in the room and banged on the door and I was like 'oh man…'[;] she looked at me and the look was like either turn your music down or turn the music off, so I had one record playing on my right hand side and I was holding the record on my left hand side and back then we didn't have no cross faders like the up and down fade, so I had all the up and down faders all the way up and whiles she was screaming at me in the doorway[,] I was rubbing the record back and forth and forth and back, so when she left the room I realised what I was doing and practiced it and perfected it and it became a scratch and the rest is history." (Source: interview of DJ Grand Wizard Theodore, ukhh.com Original UK HipHop 2005; see also Goldberg, 2004)

In the third episode a new usage schema (about a new way of manipulating the turntable) is also created, but the role of goal-directed exploration is much weaker. The exploration is actually directed at turning down the music, which is achieved by "rubbing the record back and forth." The perception of a new use comes only after that, as a result of exploration and interaction that has originally served a different purpose. After this realization, the perception results in a schema that will serve to direct future interactions and explorations with the device.

Some comments about the nature of the main theoretical concepts can be made based on these examples. First, as was already said above, the perception of a new use is strongly dependent on interpretation. Perception without interpretation would not be able to address the evaluation of the usefulness of the new usage, but would treat any random use as an appropriation. In addition, most new uses are also not directly perceivable by the senses but need more conceptual processing. For instance, the first two examples showed examples of planning and mental simulation before any actions were actually commenced.

Second, the artifact's features in the model can denote the whole artifact or just a part of it, as emphasized also by Sengers and Gaver (2006). In all three episodes in Table 1, the new schema was created for the whole artifact, but, for instance, many appropriations related to basic office programs address only certain features in a program. This shows clearly in cases when a piece of data is copy-pasted across programs in order to make all the necessary changes to it, each one with a different program:

> For example, a report may need some data in a particular form and style. The data might be collected by a number of searches in an internal database, and on the web and pasted into Excel so that all the results could be composed. A graph might be drawn in Excel, but require some tweaking that was done in Paint before pasting it into a Word document and passing it on to a colleague for help. (Twidale & Jones, 2005, p. 81)

Third, schemata resulting from appropriations are long-term mental representations, and therefore learning a new schema has a permanent effect on structuring a user's actions in the future. The schema can also direct later explorations of features in the environment and in this way contribute to new appropriations. As a result of new appropriations, multiple usage schemata will be created for the same artifact and its features over time. A new schema thus does not replace or override the existing usage schemata, but it will coexist alongside earlier ones.

The following sections will start to chart the connections of this approach with the existing domains of research in psychology and cognitive science. As a result, more specific research questions can be formulated and methods introduced to answer them.

Representations and Embodied Cognition

Schemata belong to a larger class of mental concepts called representations. In the literature to date on ecological psychology and embodied cognition, the nature of representations has been discussed actively (Brooks, 1991; Clancey, 1997; Clark, 1997; Lave, 1988; Reed, 1996; Varela, Thompson & Rosch, 1993; Winograd & Flores, 1986). Some researchers have stated that committing to the existence of representations is antithetical to the idea of embodied cognition (e.g., Brooks, 1991; Varela et al., 1993). To exaggerate the argument, a conflict arises if representations are interpreted as symbolic units, each containing pieces of information that a human mind would manipulate using abstract rule-like operations. This interpretation would lead to advocating the disembodied approach on cognition that assumes that external stimuli are encoded into a "language of thought" before they are cognitively processed.

In opposition to the disembodied view, this paper follows the conceptualization of Clark (1997). Without taking an explicit stance on how representations are manifested physically in the brain, Clark requires that representations (and thus also schemata) must be seen as action oriented (pp. 47–51 and 147–153) in that they "simultaneously describe aspects of the world

and prescribe possible actions, and are poised between pure control structures and passive representations of external reality" (p. 49). Such representations have a situation-specific nature. Thus, they help to structure human action in the world, but they need not be abstract symbolic models of that world.

Relationship to Other Higher Level Mental Representations

Other often-discussed higher level mental representations, in addition to schemata, include mental models and scripts. Mental models denote a whole category of representations that describe people's understanding of the world and its laws and dynamics (e.g., laws of gravity; see chapters in Gentner & Stevens, 1983), the understanding of grammar (Johnson-Laird, 1983), laws of human reasoning (Johnson-Laird, 1983), and the interpretation of narratives (Bower & Morrow, 1990). Closest to the interests of this paper is the research on world models when applied to the understanding of the inner workings of electronic devices. In the words of Carroll and Olson (1988), a mental model "is a rich and elaborate structure, reflecting the user's understanding of what the system contains, how it works, and why it works that way" (p. 51). When studying mental models in this way (see also Bibby & Payne, 1993, 1996; Kieras & Bovair, 1984; Norman, 1988; Payne, 2003), the focus differs from the interests of appropriation in that the emergence of an artifact's purpose of use is not the primary concern. Instead, researchers have investigated the processes of how users learn to operate a device in a uniform manner. Another research question has been how users' reasoning of how a device works differs from the device's actual operation. In these experiments, the interpretations of the device's purposes of use have not been allowed to vary because that would have compromised the comparability between test users.

The research on scripts, on the other hand, is mostly associated with the work by Schank and Abelson (Schank, 1982; Schank & Abelson, 1977) and subsequent work both in artificial intelligence and cognitive science. Schank and Abelson explain a script as a structure that "describes appropriate sequences of events in a particular context" (1977, p. 41), which often have default values for each item in the structure, unless the items have been instantiated with the contextually determined values. Scripts, while describing how to do certain things, have not been artifact centered. That research has not therefore produced findings on appropriation.

IMPLICATIONS FOR RESEARCH

Psychology is a field with an emphasis on explication and theory testing with systematic methods. To embark on this process, this section addresses research strategies and the ensuing research questions.

Research Strategies

Related to the commitment to the embodied nature of representations is a need to define the ecological approach to research. The level of the "ecologicality" of analysis is related to the importance given to the situatedness of representations. A radical approach would be to treat the representation in each situation as different, leading to a denial of any generalizability of

usage schemata. Fortunately, such a position need not be maintained because users are often found to show opportunistic uses of tools based on previously learned usages. Some transfer and learning across situations must therefore take place. With permission to make comparisons between cases to find larger patterns, two strategies can be described that preserve a suitable ecological validity.

The first is the already mentioned strategy of identifying phenomena in real life and converting them to studies in more controlled settings (Ericsson & Hastie, 1994). In research on appropriation, this strategy is mostly suitable for studying opportunistic and emergent behavior when the task is given to a user by the researcher. For instance, a particular study by Galantucci (2005) can be used as an inspiration. He conducted an experiment on the emergence of language in human–human communication. Subjects were asked to carry out a collaborative task through a system that forced them to construct a new language that could only be based on drawings on a sketchpad. This setup allowed researchers to analyze the variation and commonalities of different expression–object mappings that the subjects tended to develop during the course of interaction. Similar kinds of research designs could be devised, for instance, to study new forms of communication with digital media. The tasks administered must, of course, bear real-life relevance to test subjects.

Studies that follow the strategy devised by Ericsson and Hastie can uncover the ways in which users find new means for reaching a goal, but are poor in addressing how new goals of activity will emerge. Related to the examples given in Table 1, this strategy would work better for the two first episodes (the blister and recording device examples) than the third one (the music instrument example).

The other strategy—which has a better chance at succeeding in studying the emergence of new goals—is to start by identifying suitable action settings. Those with a clear asymmetric balance between the amount of an artifact's functionalities and the approximate number of appropriations are of particular interest. For example, a camera is an artifact that has a rather straightforward functionality (taking pictures), but it can be used in many settings. This creates an asymmetric 1–to–N mapping. A longitudinal study can produce data on how a user perceives new opportunities of action for the picture-taking functionality in different settings and how the interpretations of the camera therefore undergo changes and become more varied. Adobe Photoshop and certain script programming tools can be used as examples of the opposite N–to–1 mapping. In these cases, the tool offers many alternative avenues for reaching the same goal. Also in this case it is possible to start mapping the perceived functionalities of the artifact to the user's goals.

Studying N–to–N cases is not out of the question but, because the interrelationships can become complex in these cases (and even more so if they involve social processes), studying such appropriations is very challenging without a clearly defined theoretical framework. Currently no such framework exists since the existing ones (see the list of CSCW-based frameworks above) can only provide descriptive accounts of appropriation. However, studies in complex settings are useful in picking out interesting appropriation-related phenomena. For instance, Aoki and Woodruff (2005) have identified different face-saving strategies (e.g., white lies) that instant messaging users may develop to explain why their responses to others' messages are sometimes delayed. In many of these cases, the users appropriate the potential errors in the system as excuses for their nonresponsiveness. As will be mentioned more fully

below, phenomena such as face-saving can later be turned into more precise studies on cognitive appropriation processes.

Questions for Future Research

The primary question that motivates all cognitively oriented appropriation research is to find out what kind of cognitive process is taking place when usage schemata originate and change. This question is very similar to the question that has been posed for all the schema theories in general, and also has been seen as the primary weakness of the idea of schemata in general (for criticisms, see Dahlin, 2001; Eysenck & Keane, 2000, p. 256;). The problem is that, because schemata are observable only indirectly, any changes in action can be explained post hoc by stating that a schema change took place. Such claims prove very little theoretically. One reason for this is that Neisser's (1976) perceptual cycle model provides an account of the stages of the learning process but does not describe what happens at each stage. Upon facing this problem during the 1990s, research in psychology turned away from general schema concepts and chose to tackle the related issues on a more particular level, for example through concepts such as event coding (Hommel, Müsseler, Aschersleben & Prinz, 2001), perceptual symbol systems (Barsalou, 1999) and less representationally laden topics such as motor skills (Willingham, 1998) and connectionist models (Botvinick & Plaut, 2004). The studies of appropriation in HCI cannot yet make full use of these steps of progress, and there is a gap to be filled with new research findings. Cognitively oriented appropriation research also has the potential to inform general schema research, as well as to make progress in its own field. The following questions may provide useful starting points for fertile research.

First, one research track is to study the temporal characteristics in the changing interpretations of a tool. With enough of a temporal span and close data collection of actual use, supported with verbal reports or other probing methods, models of perception–interpretation–action relationships can be built (for an example of the method but a different theoretical framework, see Salovaara, 2007). A more structured approach is to use the artifact itself as a research tool. For instance, changes in its design (e.g., a different visualization of its functionalities) may contribute to different interpretation processes. Another approach is to find people who are in the process of acquiring a new technology, and carry out a follow-up study (e.g., Petersen et al., 2002). Longitudinal studies can help to identify both breakthrough moments (if such exist) and hindrances in appropriation. Whenever a more structured approach is possible, it provides the possibility to tie the cognitive processes more closely to the design features of the artifact itself.

Second, a class of questions arises from the comparisons of different schemata. What are the characteristics of such schemata that represent clever appropriations? The underlying construction processes of rich schemata can be investigated by studying those people who appropriate actively and whose usage schemata therefore are more varied than others'. Also, retrospective analyses of such users' usage histories may reveal important contributing factors.

Third, related to the previous point, comparisons can also be carried out between novice and expert users of technology to understand the differences between their usage schemata. Such findings have a good potential for surprise: On one hand, experts have encountered a larger variety of situations, and therefore the scope of applicability (and the number of appropriations) for the artifact should be larger. On the other hand, experts might have been

habituated to existing use patterns and cannot observe new opportunities (see, e.g., Wiley, 1998). It will be important to find out ways to avoid getting fixated on existing use patterns.

Fourth, the situation specificity of usage schemata should be studied to assess the possibility for transfer of learned usages to new task domains and contexts. The design of appropriable artifacts should strive to facilitate all kinds of transfer and especially train users to pay attention to new opportunities of use. Research would tell us how feasible such a goal is.

Finally, in the spirit of the strategy proposed by Ericsson and Hastie (1994), the existing appropriation research and mundane everyday situations also can suggest phenomena that could be studied in more controlled settings: the processes of reflection-in-action when carrying out interactive problem-solving tasks (Schön, 1983), the already mentioned uses of interactional ambiguity in digital communication systems (Aoki & Woodruff, 2005), and learning processes to maintain parallel communication through using multiple channels (e.g., voice chat and text chat) in multiplayer computer games (Chen, 2007).

IMPLICATIONS FOR SYSTEM DESIGN

While detailed studies on interpretation processes would certainly help in proposing design principles for designing more appropriable systems, the theoretical framework depicted above can already highlight some central aspects. A set of design implications is presented below. Although similar suggestions have been published in previous literature as well (for a condensed list of such guidelines, see Dix, 2007), they have not had a connection to the concepts in the cognitive research approach.

Visualization of an Artifact's Effectors

Being able to perceive what an artifact is able to do within its environment in each situation is a requisite without which a user cannot develop a rich set of different usage schemata. If the user can see how the artifact connects to its environment and how it can make changes to it (i.e., what are its "effectors"), she is better able to find new uses for it. In a simple case, the perception of effectors is based on artifact's physical affordances. However, digital artifacts are often more complex than that, and therefore more complex reasoning and interpretation is often needed. To aid in such processes, the artifact's connections to the digital information space need to be made easily perceivable or noticeable through interaction.

To achieve maximal appropriability, the user should be supported in finding mappings from the functionalities of the artifact to a large number of goals. To do this, the designer can either think of different uses of the artifact and then visualize them for the user, or abandon the strategy of predicting the user's tasks and just visualize the effectors in a maximally transparent way, so as to help the user perceive what lies behind the artifact's most apparent uses. The challenge in applying this approach as a general rule, however, is to avoid providing too much detail and too many functions through the interface (Twidale & Jones, 2005).

The mobile awareness system ContextContacts (Oulasvirta, Raento, & Tiitta, 2005) and its commercialized version Jaiku[1] are good examples of how these principles can be used. It replaces the contact book in the user's mobile phone with another directory that, in addition to showing names and numbers, displays contextual information about each other person who

also uses the system. Based on the GSM cell ID, neighboring Bluetooth devices, a log of recent interactions with the phone, contents in the user's mobile calendar and so on, the system is able to deliver information about other users' locations, nearby friends, time lapses since last use, phones' ringing profiles, and the activities that other users might be engaged in at this and the next moment. All the information is collected unobtrusively without prompting the users. By visualizing this information in the contact book—the most often used application in the phone in addition to the text message editor—users are enabled to make inferences about each other in ways not previously possible. This provides possibilities for many opportunistic, serendipitous interactions (Oulasvirta, Petit, Raento, & Tiitta, 2007).

Making the Artifact Ubiquitously Available

Related to the previous item, appropriation is also supported by affording the tool for interaction in multiple situations. This maximizes the user's contact time with the artifact and the probability of mapping it to new goals. The reason why this is beneficial is thus similar to what was said above: providing more opportunities for use contributes to the construction of new usage schemata.

Two ways of doing this are obvious. One can facilitate availability by making the artifact physically easy to carry (e.g., implementing a program in a mobile phone). A second, indirect way is to make the system accessible from many devices (such as providing an interface to the program from a dedicated software program, a mobile phone, or a Web application). E-mail is an example of a system accessible from many terminals, and this has contributed to special uses. For instance, a user may send an e-mail with an attachment to her own address in order to enable access to the attached document in a different location from another terminal.

A third method is more indirect and is related to the fact that often tools are not used in isolation but together with other tools. This means that only a part of an artifact may be relevant to a user. For instance, a certain feature may be needed only to serve as a supplement to another artifact, as the example of copy-pasting in the Twidale and Jones (2005) paper cited above. To make artifacts useful in these cases as well, their design should support carrying out incomplete task sequences by allowing easy entries and exits to and from the application. Artifacts should not force users through the primary functionalities in a tunnel-like manner that does not allow any deviations. Likewise, by-products and side effects of use might also prove useful in some situations.

In standard desktop applications, implementing full support for copy-pasting is a good way to achieve the third solution. This solution has not been fully propagated to other computing systems, however. For instance, it would be useful in mobile phones, when data needs to be copied between calendar events, phonebook entries, and the text message editor. Although solutions to this exist (e.g., a dedicated pen button in high-end Nokia phones), it is not supported in all applications, and its use is both unobvious and requires effort (e.g., the use of both hands).

Propagating Good Usages

Finally, whenever someone invents a good use, it is beneficial to let others know about the new use as well. This can happen by learning through example. Many studies (Bansler & Havn,

2006; Kellogg & Erickson, 2005; Mackay, 1988; MacLean, Carter, Lövstrand, & Moran, 1990; Nardi, 1993; Trigg & Bødker, 1994) have pointed out that, especially in workplace settings, many good usages are invented and distributed through certain knowledgeable people— in the literature called mediators, gardeners, translators, or tinkerers—who have started to teach others the appropriations that they have come up with or heard about.

The presence of mediators is beneficial, but learning from others is not always completely dependent on them. In some cases, users can be encouraged to verbalize their usages or develop names for certain ways of use and thus make them referenceable in discussions. This serves the purpose of converting the usage schema into an externalized form. Macros in office software serve this purpose, but adopting them from others may require programming skills, and sharing them is not always easy (for an example of a system with shareable macros, see MacLean et al., 1990). It is also common that people develop special vocabularies within sports and music to describe movements and techniques. Episode 3 in Table 1, for instance, mentions needle drops and scratches as particular techniques unique to DJ'ing. The invention of such concepts enables the members of the community to communicate about each other's appropriations. This also serves the purpose of externalizing usage schemata.

An alternative approach is to make the usage more visible to other users. This can be as simple as making more visible the interaction with the tool. For example, a digital camera owner might see another user taking a picture of a map on an information display and may learn the use of a camera for note-taking from that example. This would not be learned if the map was downloaded to a phone by sending a text message to a special mobile service and getting the map back as a result. Alternatively, in some cases, documents and other products created with a tool may allow other users to see the building blocks or steps that were needed in creating them. HTML pages are an example of this: Upon finding a well-designed Web page, it is possible for anyone to see what code has been used to create it. In a similar manner, although this is less common, new ways to manipulate images can be learned by looking at how layers have been used in programs such as Adobe Photoshop and GIMP. However, preserving the layer structure when distributing images is rare among designers because the file sizes for layered images can be very large. It is therefore more common that the uses of layers are discussed in Web forums and with colleagues, without sharing the actual files. The idea can, however, prove useful in other design contexts.

CONCLUSION

Cognitive psychology has often been the target of criticism in current HCI and CSCW literature because of its assumed disregard of the importance of the context of activity. This critique (e.g., Bannon & Bødker, 1991; Kaptelinin, 1997; Kuutti, 1997) is often directed towards the by now two-decade-old model-based information processing theories that were developed to understand desktop-based interaction (e.g., GOMS; Card, Moran, & Newell, 1983). The contemporary context of interaction with computers and computing infrastructures is very different from the situation back then, and therefore the psychological approaches are also being adapted. This has already happened in mobile HCI research (e.g., Oulasvirta, Tamminen, Roto, & Kuorelahti, 2005). In a similar vein, this paper has sketched a research approach for

studies on appropriation, drawing from ecological psychology, presenting research questions, and describing ways to improve artifacts to suit into everyday tasks better.

By doing this, the paper has attempted to show that appropriation can and should be studied cognitively. This new perspective differs from previous research by aiming at developing research questions that can lead to systematic empirical work and ultimately to models, hypotheses, and theories that can supplement the existing appropriation research with new ideas.

ENDNOTE

1. See www.jaiku.com for more information.

REFERENCES

Aoki, P. M., & Woodruff, A. (2005). Making space for stories: Ambiguity in the design of personal communication systems. In W. Kellogg, S. Zhai, G. van der Veer, & C. Gale (Eds.), *CHI'05: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 181–190). New York: ACM Press.

Attaran, M. (2000). Managing legal liability of the Net: A ten step guide for IT managers. *Information Management & Computer Society, 8*, 98–100.

Balka, E., & Wagner, I. (2006). Making things work: Dimensions of configurability as appropriation work. In P. Hinds & D. Martin (Eds.), *CSCW'06: Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work* (pp. 229–238). New York: ACM Press.

Bannon, L., & Bødker, S. (1991). Beyond the interface: Encountering artifacts in use. In J. M. Carroll (Ed.), *Designing interaction: Psychology at the human–computer interface* (pp. 227–253). Cambridge, UK: Cambridge University Press.

Bansler, J. P., & Havn, E. (2006). Sense-making in technology-use mediation: Adapting groupware technology in organizations. *Computer Supported Cooperative Work, 15*, 55–91.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*, 577–660.

Bibby, P. A., & Payne, S. J. (1993). Internationalization and the use specificity of device knowledge. *Human–Computer Interaction, 8*, 25–56.

Bibby, P. A., & Payne, S. J. (1996). Instruction and practice in learning to use a device. *Cognitive Science, 20*, 539–578.

Botvinick M., & Plaut, D. C. (2004). Doing without schema hierarchies: A recurrent connectionist approach to normal and impaired routine sequential action. *Psychological Review, 111*, 395–429.

Bower, G. H., & Morrow, D. G. (1990). Mental models in narrative comprehension. *Science, 247*, 44–48.

Brooks, R. A. (1991). Intelligence without representation. *Artificial Intelligence, 47*, 139–159.

Brown, B. A., & Perry, M. (2000). Why don't telephones have off switches? Understanding the use of everyday technologies. *Interacting with Computers, 12*, 623–634.

Card, S. K., Moran, T. P., & Newell, A. (1983). *The psychology of human–computer interaction.* Mahwah, NJ, USA: Lawrence Erlbaum.

Carroll, J. M., Kellogg W. A., & Rosson, M. B. (1991). The task-artifact cycle. In J. M. Carroll, (Ed.), *Designing interaction: Psychology at the human–computer interface* (pp. 17–38). Cambridge, UK: Cambridge University Press.

Carroll, J. M., & Olson, J. R. (1988). Mental models in human–computer interaction: Research issues about what the user of software knows. In M. Helander (Ed.), *The handbook of human–computer interaction* (pp. 45–65). Amsterdam: North-Holland.

Chen, M. (2007). *Communication, coordination, and camaraderie in World of Warcraft*. Retrieved June 10, 2008, from Mark Danger Chen's website, http://www.markdangerchen.net/pubs/chen_WoW_revised.pdf

Clancey, W. J. (1997). *Situated cognition*. New York: Cambridge University Press.

Clark, A. (1997). *Being there: Putting brain, body, and world together again*. Cambridge, MA, USA: MIT Press.

Dahlin, B. (2001). Critique of the schema concept. *Scandinavian Journal of Educational Research, 45*, 287–300.

DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity of advance technology use: Adaptive structuration theory. *Organization Science, 5*, 121–147.

Dhillon, G. (1999). Managing and controlling computer misuse. *Information Management & Computer Security, 7*, 171–175.

Dix, A. (2007). Designing for interaction. In D. Ramduny-Ellis & D. Rachovides (Eds.), *People and computers XXI…but not as we know it: Proceedings of the 21st British HCI Group Annual Conference* (Vol. 2). Retrieved June 10, 2008, from The British Computer Society, http://www.bcs.org/server.php?show=ConWebDoc.13347

Dourish, P. (2003). The appropriation of interactive technologies: Some lessons from placeless documents. *Computer Supported Cooperative Work, 12*, 465–490.

Duane, A., & Finnegan, P. (2004). Managing email usage: A cross case analysis of experiences with electronic monitoring and control. In M. Janssen, H. G. Sol, & R. W. Wagenaar (Eds.), *ICEC'04: Proceedings of the Sixth International Conference on Electronic Commerce* (pp. 229–238). New York: ACM Press.

Eglash, R. (2004). Appropriating technology: An introduction. In R. Eglash, J. L. Croissant, G. Di Chiro, & R. Fouché (Eds.), *Appropriating technology: Vernacular science and social power* (pp. vii–xxi). Minneapolis, MN, USA: University of Minnesota Press.

Ericsson, K. A., & Hastie, R. (1994). Contemporary approaches to the study of thinking and problem solving. In R. J. Sternberg (Ed.), *Thinking and problem solving* (pp. 37–79). San Diego, CA, USA: Academic Press.

Eysenck, M. W., & Keane, M. T. (2000). *Cognitive psychology: A student's handbook* (4th ed.). Hove, UK: Psychology Press.

Galantucci, B. (2005). An experimental study of the emergence of human communication systems. *Cognitive Science, 29*, 737–767.

Gaver, W. W., Beaver, J., & Benford, S. (2003) Ambiguity as a resource for design. In G. Cockton & P. Korhonen (Eds.), *CHI'03: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 233–240). New York: ACM Press.

Gentner, D., & Stevens, A. L. (Eds.). (1983). *Mental models*. Hillsdale, NJ, USA: Lawrence Erlbaum.

Gibson, J. J. (1979). *The ecological approach to visual perception*. New York: Houghton-Mifflin.

Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*. Cambridge, UK: Polity Press.

Goldberg, D. A. M. (2004). The scratch is hip-hop: Appropriating the phonographic medium. In R. Eglash, J. L. Croissant, G. Di Chiro, & R. Fouché (Eds.), *Appropriating technology: Vernacular science and social power* (pp. 107–144). Minneapolis, MN, USA: University of Minnesota Press.

Heft, H. (2001). *Ecological psychology in context: James Gibson, Roger Barker, and the Legacy of William James's radical empiricism*. Mahwah, NJ, USA: Lawrence Erlbaum.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24*, 849–937.

Höök, K. (2006). Designing familiar open surfaces. In A. Mørch, K. Morgan, T. Bratteteig, G. Ghosh, & D. Svanaes (Eds.), *NordiCHI'06: Proceedings of the 4th Nordic Conference on Human–Computer Interaction* (pp. 242–251). New York: ACM Press.

Huysman, M., Steinfield, C., Jang, C.-Y., David, K., Huis in 't Veld, M., Poot, J., & Mulder, I. (2003). Virtual teams and the appropriation of communication technology: Exploring the concept of media stickiness. *Computer Supported Cooperative Work, 12*, 411–436.

Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness.* Cambridge, UK: Cambridge University Press.

Kaptelinin, V. (1997). Activity theory: Implications for human–computer interaction. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human–computer interaction* (pp. 103–116). Cambridge, MA, USA: The MIT Press.

Kellogg W. A., & Erickson, T. (2005). Supporting appropriation work with social translucence, collective sensemaking, and social scaffolding. *International Reports on Socio-Informatics, 2*(2), 30–43. Retrieved June 10, 2008, from the International Institute for Socio-Informatics, http://www.iisi.de/fileadmin/IISI/upload/IRSI/IRSIv2i2.pdf

Kieras, D. E., & Bovair, S. (1984). The role of a mental model in learning to operate a device. *Cognitive Science, 8*, 255–273.

Kjellen, U. (2000). *Prevention of accidents through experience feedback.* London: Taylor & Francis.

Kuutti, K. (1997). Activity theory as a potential framework for human–computer interaction research. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human–computer interaction* (pp. 17–44). Cambridge, MA, USA: The MIT Press.

Lave, L. B. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge, UK: Cambridge University Press.

Mackay, W. E. (1988). More than just a communication system: Diversity in the use of electronic mail. In I. Greif (Ed.), *CSCW'88: Proceedings of the 1988 ACM Conference on Computer-supported Cooperative Work* (pp. 344–353). New York: ACM Press.

MacLean, A., Carter, K., Lövstrand, L., & Moran, T. (1990). User-tailorable systems: Pressing the issues with buttons. In J. C. Chew & J. Whiteside (Eds.), *CHI'90: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 175–182). New York: ACM Press.

Nardi, B. A. (1993). *A small matter of programming: Perspectives on end user computing.* Cambridge, MA, USA: The MIT Press.

Neisser, U. (1976). *Cognition and reality*: *Principles and implications of cognitive psychology*. San Francisco: W. H. Freeman and Company.

Norman, D. A. (1988). *The psychology of everyday things.* New York: Basic Books.

Orlikowski, W. J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science, 3*, 398–427.

Orlikowski, W. J. (1996). Improvising organizational transformation over time: A situated change perspective. *Information Systems Research, 7*, 63–92.

Oulasvirta, A., Petit, R., Raento, M., & Tiitta, S. (2007). Interpreting and acting on mobile awareness cues. *Human-Computer Interaction 22*(1&2), 97–135.

Oulasvirta, A., Raento, M., & Tiitta, S. (2005). ContextContacts: Re-designing smartphone's contact book to support mobile awareness and collaboration. In M. Tscheligi, R. Bernhaupt, & K. Mihalic (Eds.), *MobileHCI'05: Proceedings of the 7th International Conference on Human Computer Interaction with Mobile Devices and Services* (pp. 167–174). New York: ACM Press.

Oulasvirta, A., Tamminen, S., Roto, V., & Kuorelahti, J. (2005). Interaction in 4-second bursts: The fragmented nature of attentional resources in mobile HCI. In W. Kellogg, S. Zhai, G. van der Veer, & C. Gale (Eds.), *CHI'05: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 919–928). New York: ACM Press.

Pargman, T. C., & Wærn, Y. (2003). Appropriating the use of a Moo for collaborative writing. *Interacting with Computers, 15*, 759–781.

Payne, S. J. (2003). Users' mental models: The very ideas. In J. M. Carroll (Ed.), *HCI Models, theories and frameworks: Toward a multidisciplinary science* (pp. 135–156). San Francisco: Morgan Kaufmann.

Perry, M. J., Fruchter, R., & Rosenberg, D. (1999). Co-ordinating distributed knowledge: A study into the use of an organisational memory. *Cognition, Technology & Work 1*, 142–152.

Petersen, M. G., Madsen, K. H., & Kjær, A. (2002). Usability of everyday technology: Emerging and fading opportunities. *ACM Transactions on Computer–Human Interaction 9*, 74–105.

Pipek, V. (2005). *From tailoring to appropriation support: Negotiating groupware usage*. Doctoral dissertation, University of Oulu. Oulu, Finland: Acta Universitatis Ouluensis.

Pipek, V., & Wulf, V. (2006). Appropriation and re-appropriation of groupware: Theoretical and practical implications of a long-term case study. *International Reports on Socio-Informatics 3*(1). Retrieved June 10, 2008, from the International Institute for Socio-Informatics, http://www.iisi.de/fileadmin/IISI/upload/IRSI/IRSIv3i1.pdf

Reed, E. S. (1996). *Encountering the world: Toward an ecological psychology*. New York: Oxford University Press.

Salovaara, A. (2007). Appropriation of a MMS-based comic creator: From system functionalities to resources for action. In M. B. Rosson & D. Gilmore (Eds.), *CHI'07: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1117–1126). New York: ACM Press.

Schank, R. C. (1982). *Dynamic memory: A theory of reminding and learning in computers and people*. New York: Cambridge University Press.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals and understanding*. Hillsdale, NJ, USA: Lawrence Erlbaum.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Sengers, P., & Gaver, B. (2006). Staying open to interpretation: Engaging multiple meanings in design and evaluation. In J. M. Carroll, S. Bødker, & J. Coughlin (Eds.), *DIS'06: Proceedings of the 6th ACM Conference on Designing Interactive systems* (pp. 99–108). New York: ACM Press.

Silverstone, R., Hirsch, E., & Morley, D. (1992). Information and communication technologies and the moral economy of the household. In R. Silverstone & E. Hirsch (Eds), *Consuming technologies: Media and information in domestic spaces* (pp. 15–31). London: Routledge.

Trigg, R. H., & Bødker, S. (1994). From implementation to design: Tailoring and the emergence of systematization in CSCW. In J. B. Smith, F. D. Smith, & T. W. Malone (Eds.), *CSCW'94: Proceedings of the 1994 ACM Conference on Computer Supported Cooperative Work* (pp. 45–54). New York: ACM Press.

Twidale, M. B., & Jones, M. C. (2005). "Let them use emacs": The interaction of simplicity and appropriation. *International Reports on Socio-Informatics 2*(2), 78–84. Retrieved June 10, 2008, from the International Institute for Socio-Informatics, http://www.iisi.de/fileadmin/IISI/upload/IRSI/IRSIv2i2.pdf

Tyre, M. J., & Orlikowski, W. J. (1994). Windows of opportunity: Temporal patterns of technological adaptation in organizations. *Organization Science, 5*, 98–118.

ukhh.com Original UK HipHop. (2005). DJ Grand Wizard Theodore interview. Retrieved June 10, 2008, from http://www.ukhh.com/elements/turntablism/grandwizardtheodore/index.html

Varela, F. J., Thompson, E., & Rosch, R. (1993). *The embodied mind: Cognitive science and human experience*. Cambridge, MA, USA: The MIT Press.

Weick, K. (1995). *Sensemaking in organizations*. Thousand Oaks, CA, USA: Sage Publications.

Wiley, J. (1998). Expertise as mental set: The effects of domain knowledge in creative problem solving. *Memory & Cognition, 26*, 716–730.

Williams, R., Stewart, J., & Slack, R. (2005). *Social learning in technological innovation: Experimenting with information and communication technologies*. Cheltenham, UK: Edgar Elgar Publishing.

Willingham, D. B. (1998). A neuropsychological theory of motor skill learning. *Psychological Review, 105*, 558–584.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation for design*. Reading, MA, USA: Addison-Wesley.

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