U-COMMERCE:

AN EXPERIMENTAL INVESTIGATION OF UBIQUITY AND UNIQUENESS

by

IRIS ANGELIKA JUNGLAS

(Under the direction of Richard T. Watson)

ABSTRACT

U-commerce extends traditional commerce (geographic, electronic, and mobile) to a world of ubiquitous networks and universal devices, a world in which users can access networks at any time from any place, using a range of devices to invoke unique and personalized services. As such, u-commerce presents a new perspective on time and space.

Specifically, four constructs are identified that form the fundamental dimensions of u-commerce: ubiquity, uniqueness, universality, and unison. Ubiquity allows users to access networks from anywhere at any time, and in turn, to be reachable at any place and any time. Uniqueness allows users to be uniquely identified—not only in terms of their identity and associated preferences, but also in terms of their geographical position. Universality means mobile devices are universally usable and are multifunctional. Unison covers the idea of integrated data across multiple applications so that users have a consistent view on their information—irrespective of the device used.

This dissertation undertakes an experimental investigation to examine how two of the four u-constructs, namely ubiquity and uniqueness, impact individual task performance, perceptions of usefulness and ease of use across differing levels of u-commerce technology and a variety of tasks. Four different treatment groups are created, each varying on combinations of high or low technology ubiquity and high or low technology uniqueness. Ubiquity is simulated by providing wireless technology (or not); uniqueness is simulated by providing location-based services (or not). A total of 117 senior level MIS students served as subjects for this study.

The major findings of the study are:

- Wireless technology was perceived to be very useful for location-dependent tasks.
- None of the technology treatments turned out to be superior in terms of perceptions of ease of use. However, in situations where technology severely lacks the ability to fit the task at hand, perceptions of ease of use decreased dramatically.
- Compared to measures taken prior to the experiment, perceptions of usefulness and ease of use are significantly higher during the experiment for every task set.
- Achieving high performance of non-location-dependent tasks was irrespective of the technology used.
- For location-dependent tasks, wireless technology in combination with location-based services led to major performance impacts.

INDEX WORDS: Electronic Business, Mobile Business, E-Commerce, M-Commerce, U-Commerce, Ubiquity, Uniqueness, Universality, Unison, Utilization, TAM, TTF, TIM

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CHAPTER 1 – INTRODUCTION

The Internet has introduced a significant wave of change. Our communication patterns have changed. We have become dependent on email. We interact with firms via Web sites. The next wave—introduced through wireless technology—is about to change our lives even more. The increase in transmission capacity of wireless devices lays the foundation for communication unrestricted by physical locations. We can surf the Internet decoupled from landline computers. In addition, we can do it any time, blurring the borderlines of business and private space. In the future, we will experience another wave of change—a world that provides the ultimate form of ubiquitous networks and universal devices, a world that presents an alternative view of space and time (Miller, 2002, Watson, et al., 2002).

Up to now, the majority of the attention has focused on Internet-based business (i.e., e-commerce). In contrast, GSM-based research (i.e., m-commerce) has been relatively neglected. There are a growing number of publications on m-commerce sometimes labeled as research. Most of this work would be better called market studies or benchmarks (e.g., (Durlacher, 1999), (Lehman Brothers, 2000), and others), highlighting different aspects such as the number of prospective consumers, the estimated market volume, usage behavior, etc. Many of the remaining publications are rather technically oriented (e.g., (WAP Forum, 2000), (ETSI, 2001), etc.).

Nevertheless, current literature agrees that mobile devices[1] can be viewed as a new form of an information system. People use them for acquiring information (such as news, weather, stocks, etc.), sending and receiving e-mail, and to do commercial transactions. Whereas most countries (including the U.S.) are using second generation mobile technology nowadays providing users with low transmission rates only, Japan—as the first country—has already introduced third generation mobile technologies at the end of 2001. Japanese users are able to surf the Internet and run multimedia applications at transmission rates of up to 2 Mbits per second, thus, getting a glimpse of an entirely new form of commerce—a form that goes over, above, and beyond traditional commerce, i.e., the "ultimate commerce" or simply "u-commerce." As such, we define u-commerce as "*the use of ubiquitous networks to support personalized and uninterrupted communications and transactions between a firm and its various stakeholders to provide a level of value over, above, and beyond traditional commerce*" (Watson, et al., 2002).

RESEARCH QUESTION

The genesis of a new concept always raises a sequence of questions that awaits answers by the discipline. Being the first to take the challenge to explore this new terra incognita, this dissertation tries to find answers to the most fundamental issues, such as *"What are the constructs that emerge in u-commerce?"* and *"How do these constructs fit*

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[1] The term "mobile device" is deliberately used in order to account for the fact that not only cellular phones belong into this category. A more detailed description can be found in following chapters.

into our traditional understanding of information systems?" and *"Under what task conditions does u-commerce technology impact perceptions of usefulness, ease of use, and performance?"*

The dissertation applies a set of four new constructs, so-called "*ultimate constructs*", or simply "*u-constructs*" (adopted from (Watson, 2000)). These u-constructs include *ubiquity*, *uniqueness*, *universality*, and *unison*. *Ubiquity* allows mobile users to access networks from anywhere at any time, and in turn, to be reachable at any place and any time. *Uniqueness* allows mobile users to be uniquely identified—not only in terms of their identity and associated preferences, but also in terms of their geographical position. *Universality* means mobile devices are universally usable. Currently, for instance, U.S. cell phones are unlikely to work in Europe because of different standards and network frequencies, and vice versa. *Unison* covers the idea of integrated data across multiple applications so that users have a consistent view on their information—irrespective of the device used.

All four constructs are conceptually extended in the dissertation, using (Watson, 2000, Watson, et al., 2002) as the foundation. Based on interviews conducted with IS practitioners, we found that two of the four constructs, namely ubiquity and uniqueness, are mostly prevalent and are thus assumed to have grater impact on individuals' lives. In order to examine ubiquity and uniqueness in more detail, an experimental setup is chosen. Since a "true" u-commerce environment providing both technology aspects did not exist at the point of the dissertation, it had to be artificially created. The experiment employed a total of 117 senior level MIS students providing them with differing levels of ubiquity and uniqueness for solving a variety of differing tasks while monitoring their performance and their perceptions of usefulness and ease of use.

IMPORTANCE OF THE RESEARCH

For IS scholars the u-constructs will force them to look ahead and revisit the fundamentals of IS. Revalidating major IS theories will be essential because these were developed during the era of mainframe or end-user PC where an information system was viewed as a processing unit that transformed data and instructions into reports while operating in an centralized fashion, used for organizational purposes only. With the emergence of networking capabilities and client-server architectures, however, centralization turned into decentralization, thus, abstracting from the geographical location of an information system. In addition, the Internet is able to blur away the boundaries between professional and private life by penetrating an information system into an individual's environment. Nowadays, 51 percent of all U.S. households own a computer, of which more than 80 percent have Internet access (NTIA and ESA, 2002). As a consequence, information system access is not restricted to working hours anymore, but can be used at any time.

For IS practitioners, the same considerations apply. As mobile penetration increases and applications become more sophisticated, the transformation of the mobile phone into a fully integrated data, communications and commerce tool seems inevitable. As such, the u-constructs not only provide a means to understand the potential of future "u-technologies" but also are able to serve as an instrument for identifying u-commerce needs and evaluating potential business benefits.

These trends give reason to believe that the u-constructs proposed in this dissertation make a valuable contribution to enhancing traditional IS models. In particular, two significant models, namely the Technology Acceptance model (TAM by (Davis, 1986), (Davis, et al., 1989)) and the Task-technology Fit model (TTF by (Goodhue and Thompson, 1995)), can be augmented in their explanatory and predictive power through incorporating the u-constructs.

OUTLINE OF THE DISSERTATION

The dissertation is divided into six chapters. Chapter 1 serves as an introduction to the study.

Chapter 2 summarizes the two research streams relevant for this study; the first one on e- and m-commerce, reflecting on two perspectives: technology and task; and the second one on traditional IS models. The chapter ends with merging all these streams into one conceptual model (TIM model) that forms the crux of the dissertation.

Chapter 3 introduces the research model and the research method used. The research design is presented.

Chapter 4 describes the operationalization of the constructs hypothesized in the previous chapter. In particular, the experimental set-up is described in substantial detail, including variables and their measurements.

Chapter 5 presents the results of the statistical tests and analysis of data collected through a laboratory experiment.

Finally, chapter 6 discusses the results and draws conclusions about the study.

CHAPTER 2 – LITERATURE REVIEW

U-COMMERCE – AN INFORMATION SYSTEMS' VIEW

Some authors introduce m-commerce as the "second wave" in business revolution, continuing the impact of the Internet (or: e-commerce) as being the "first wave" and the introducer of the digital economy era (Currie, 2000). Before that, we experienced something that we would like to call g-commerce (or geographic commerce). People had to physically come together in order to do business. Businesses had been biased by geography and located near rivers, roads, and other transport services so that the cost of being reached by customers or reaching customers were minimal. The other end of the evolutionary spectrum, however, is formed by u-commerce—a state of commerce that we have not reached yet, and that provides the ultimate form of ubiquitous networks and universal devices leading to unique applications (Figure 1).

Figure 1: X-commerce over time with x = g, e, m, u

A glimpse of u-commerce can be seen in the news today already. For instance, in Texas people are able to pay gas with their mobile phones at the pump. Soon, they will also be able to pay for parking, fast food, etc. (Wireless Newsfactor, 2002). IBM has launched smart laundry machines for colleges. Students can visit a Web site to find out when a machine will be available and can select functions, including soap and fabric softener dispensing. When the load is done, they are notified via an e-mail sent to a mobile device or PC (Wireless Newsfactor, 2002). MommyTrack is a baby monitor that allows remote viewing from a PDA (Personal Digital Assistant) device running Microsoft's PocketPC Phone Edition. Cenuco is working with Nokia and Symbian-powered smartphones, with an eye toward enlarging the spectrum of handhelds that can use the system (Wireless Newsfactor, 2003). The hotel industry is about to bring wireless Internet to lounges and conference rooms. Marriott said it will install wireless Internet in the public areas of 400 hotels by next spring. Hilton plans to equip 200 hotels with the service (Wireless Newsfactor, 2003).

In the following, we will derive a u-commerce definition by drawing on existing definitions for m-commerce and the foundational work of (Watson, 2000, Watson, et al., 2002). After that, we will establish the conceptual building blocks of u-commerce, or so-called u-constructs. Likewise, we will extend the four constructs (ubiquity, uniqueness, universality, and unison) by drawing on m-commerce parallels. First, we will examine m-commerce characteristics and what makes them distinct from the traditional setting, in particular from e-commerce. And second, we will look at inhibitors that prevent a transition from m- to u-commerce at present time. Based on this, we will be able to extrapolate u-characteristics, i.e., four higher-level constructs that are visionary in nature and that form the crux of u-commerce.

Defining Mobile Commerce

Even though mobile business (or in short: m-business) and mobile commerce (or in short: m-commerce) are currently the mostly used terms in business literature, there is none—or almost none—appropriate or satisfying definition for either one. What is even worse is the vast amount of terminology that is used synonymously, including terms such as "*mobile electronic commerce*", "*wireless electronic commerce*", or simply "*wireless*".

Among the few authors that took the challenge of posing a definition, m-commerce is described as "*any transaction with a monetary value that is conducted via a mobile telecommunication network*" (Durlacher, 1999). Other definitions, however, expand on the mere commercial focus by including activities, such as communicative and informative services, that do not necessarily lead to monetary transactions. They define m-commerce as "*the use of mobile hand-held devices to communicate, inform, transact and using text and data via connection to public or private networks*" (Lehman Brothers, 2000). Nevertheless, even this definition appears too narrow for the purpose of this paper.

Since the main difference between e- and m-commerce is based on the underlying technology used, we are able to establish an encompassing working definition that is in congruence with the existing e-commerce terminology. As such, we define *m-commerce* or *m-business* as

> "*the use of wireless technology for communications and transactions between an organization and its various stakeholders to improve organizational performance*"—with stakeholders including customers, suppliers, governments,

financial institutions, managers, employees, and the public at large (adopted and revised form (Pigneur, et al., 2000) and (Berthon, et al., 2000)).[2]

Even though, terms can be used interchangeably, we prefer to use the term "commerce" in the following.

M-Commerce Characteristics

Compared to the e-commerce, m-commerce has some unique characteristics that make it distinct. Based on current literature, these characteristics comprise five clusters, including reachability (Lehman Brothers, 2000), accessibility ((Durlacher, 1999); (Buckler and Buxel, 2000)), localization ((Durlacher, 1999); (Lehman Brothers, 2000); (Buckler and Buxel, 2000)), identification,[3] and portability.[4] Figure 2 provides a graphical overview of those and their dependencies. In order to linguistically distinguish between the same characteristics in the electronic and the mobile commerce world, the prefix e- or m- is used respectively.

In the following, a definition for each of these characteristics is given. As the m-commerce characteristic model (see Figure 2) illustrates, the portability construct seems to play a distinct role compared to the other four characteristics. As such, we start with this construct.

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[2] We deliberately use the term "wireless technology" instead of "cell phone technology" (Pigneur, et al., 2000) in order to account for a broader range of technology, including e.g. Bluetooth technology.

[3] (Durlacher, 1999) refers to this as "security."

[4] (Lehman Brothers, 2000) refers to this as "form factors."

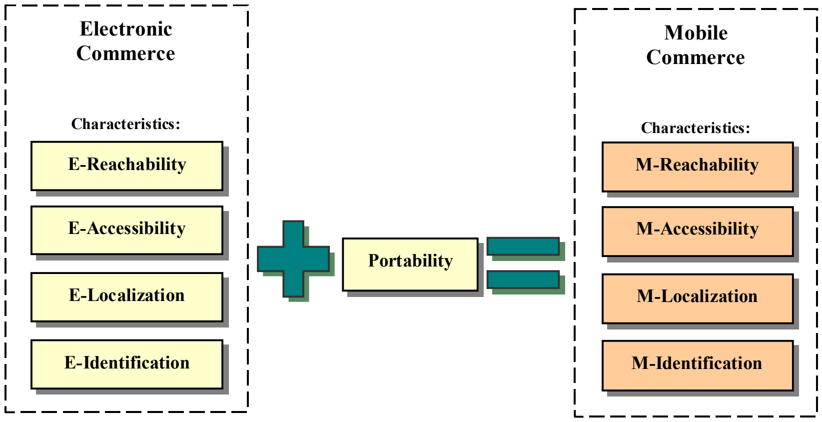

Figure 2: M-commerce characteristics model

Portability

Portability comprises the physical aspects of mobile devices—one is able to readily carry them. We deliberately use the term "mobile device" to cover the aspect that extends beyond cellular phones which form only one end of the spectrum, providing a small, lightweight device for voice (and data) communication. The other end is formed by laptops equipped with a wireless communication facility, providing multi-purpose capabilities at the cost of a bigger device. Along that spectrum, Smart Phones, Communicators, Personal Digital Assistants (PDA), etc. line up accordingly. The list is just a momentary snap-shot of the current products available. One can expect the range and the form of mobile devices to proliferate. Nevertheless, all mobile devices have and will have in common the striving for miniaturization while maximizing their capabilities.

Among the five m-characteristics, portability has a unique standing among all the other characteristics. In fact, it enables the other four constructs to be unique and distinct from traditional e-commerce characteristics, i.e. reachability, accessibility, localization, and identity are only inherent characteristics of the mobile world if—and only if—they occur in the context of portability. As such, portability causes a quantum shift in the other four characteristics.

M-Reachability

M-reachability means that a mobile user can be in touch and reached by other people 24 hours, 7 days a week—assuming that the mobile network coverage is sufficient and the mobile device is switched on. Nevertheless, users have the possibility to restrict their m-reachability to particular persons or times.

With the current transmission technologies (i.e., GSM (Global System Mobile) and WAP (Wireless Application Protocol)), mobile devices require a user to actively initiate a session and invoke an application—just like an Internet session. With future mobile technologies such as GPRS (General Packet Radio Service) however, users will stay connected permanently—without explicitly establishing a connection any more.[5]

In an e-commerce setting, e-reachability is limited to the computer level, or rather the plug-in level. An Internet user is reachable only (in synchronous terms) when sitting in front of a computer that is plugged into an Internet socket close by. In the mobile world however, a "true" any time-any place reachability (also labeled m-reachability) can be provided based on the aforementioned portability characteristic.

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[5] (Durlacher, 1999) calls it "instant connectivity" and states it to be an m-commerce characteristic on it own.

M-Accessibility

Opposed to m-reachability, m-accessibility describes the fact that a user can access the mobile network at any time from any location—again, assuming adequate mobile network coverage. With current transmission technologies, a user has to proactively initiate a session. Future mobile technologies however will allow users to stay connected permanently.

In contrast, e-accessibility (just like e-reachability) is limited to the plug-in level only. A user can access the Internet only when sitting in front of a computer.

In combination, both m-reachability and -accessibility enhance the traditional time/place continuum as can be seen in Figure 3. Even though we are currently experiencing m-commerce, we still have not yet reached the highest level of m-reachability and m-accessibility. Network coverage is not a given at every place on the earth's surface, neither is the availability of synchronized data or mobile applications. As a result, u-commerce can be viewed as a state in which the m-characteristics are exploited in full range. Such a world is characterized by ubiquitous reachability and accessibility.

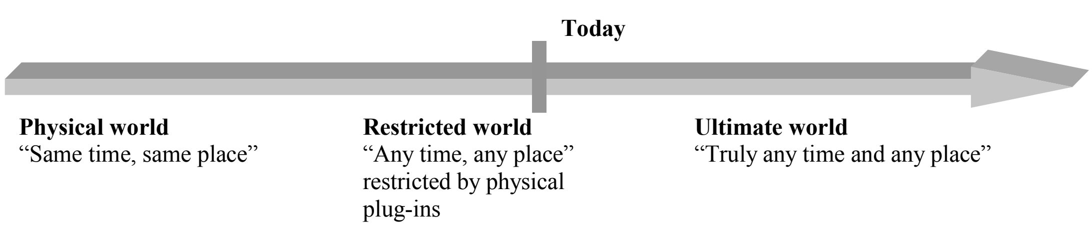

Figure 3: Time/place continuum

M-Localization

M-localization describes the ability to locate the position of a mobile user. As such, m-localization is key to providing geographically specific value-added services (so-called location-based services) and is expected to be the most distinct characteristic of m-commerce compared to e-commerce.

Currently, mobile networks are already able to determine the physical position of a mobile user on a cell level. From a technological point of view, this is to ensure a reliable connection when a mobile user roams across cell boundaries. Future technology, however, will make it possible to determine the exact geographical latitude and longitude of a mobile user— assuming that person wants to be localized. These mobile location technologies are either terminal or network based, i.e., requiring modifications of the actual mobile device (e.g., GPS)[6], or of the network infrastructure (e.g., TOA[7], E-OTD [8]) (Durlacher, 1999).[9] [10]

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[6] GPS (Global Positioning System) comprises a series of 24 geosynchronous satellites orbiting the earth. It provides location information on a latitude, longitude, and altitude basis in addition to the exact time of day. The location accuracy is anywhere from 100 to 10 meters (320 to 32 feet) for most equipment. Accuracy can be pinpointed to within one meter (3 feet) with special military-approved equipment.

[7] TOA (Time of Arrival) is a method that determines the position based on the time of arrival of the signals.

[8] E-OTD (Enhanced Observed Time Difference) is a positioning method that generally relies upon measuring the time at which signals from the Base Transceiver Station (BTS) arrive at two geographically dispersed locations—the mobile phone/station (MS) itself and a fixed measuring point known as the Location Measurement Unit (LMU) whose location is known. The position of the MS is determined by comparing the time differences between the two sets of timing measurements.

[9] In 1999, ETSI (European Telecommunications Standards Institute) has standardized three location fixing schemes (LFS): GPS, TOA, and E-OTD (Durlacher, 1999).

[10] A more detailed description of the underlying technologies can be found in (Junglas and Lehner, 2001).

In 1996, the FCC (Federal Communications Commissions) mandated that wireless carriers provide location information for emergency calls from mobile devices. The mandate includes that by October 2001 at least half of the new handsets, and by October 2002 95 percent of the new handsets must be location enabled.

Contrarily, in the Internet context, the geographical position of a user cannot be determined at any point during the session. The only possibility is to identify a computer's physical IP address, and based on that its physical location. However, even his approach is not always applicable since most computers use a dynamic addressing scheme.[11]

M-Identification

Mobile devices of the second generation[12] employ a smart card as a secure device for the authentication of the subscription and the mobile user. The smart card, also called a SIM card (Subscriber Identity Module), contains subscription and security related data as well as user data, and is plugged into the mobile device (Vedder, 2001).[13] By doing so, it decouples the identity of the mobile user from the device used, thus, allowing a user to switch physical devices without changing identities. The SIM card can be viewed as a

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[11] Using dial-up connections to the Internet requires dynamic IP addressing schemes, i.e. each time a computer connects to the Internet, a different IP address is assigned.

[12] For a summary of mobile generations, please refer to appendix A.

[13] A more detailed description of the underlying technologies can be found in (Junglas and Lehner, 2001).

virtual substitute of an individual's identity, containing not only personal information, but also billing information.[14] We therefore label this construct m-identity.

In contrast, in the Internet context the identity of a user is bound to his computer, i.e., it is device-dependent (versus device-independent). Two approaches of e-identification are conceivable: (1) on application level, and (2) on hardware level.

On the application level, Internet applications can store limited information about a user's identity using cookies. However, due to the technical nature of the HTTP protocol, one cannot gather a consistent and comprehensive profile using these. In addition, actions such as users switching computers, or users deliberately providing false information, etc. exacerbate the problem. One user may have multiple profiles for a single application. In this case, a unique identification from an application's point of view (or rather from a company's point of view) is not possible.

On the hardware level, the IP address of the networked computer may reveal identity information. However (and as mentioned before), dynamic IP addressing schemes may impair or even thwart this approach.

In combination, both m-localization and m-identity enhance the traditional understanding of personalization as can be seen in Figure 4. Just like with m-reachability and m-accessibility, we have not yet reached the highest level of m-localization and m-

[14] Network operators and providers have to authenticate a user and test his financial status first before he can become a mobile subscriber. As a result, the personal information provided is close to 100 percent accuracy.

identification. In the state of u-commerce, however, both are exploited in full range and provide unequivocal profiles so that users can be uniquely identified.

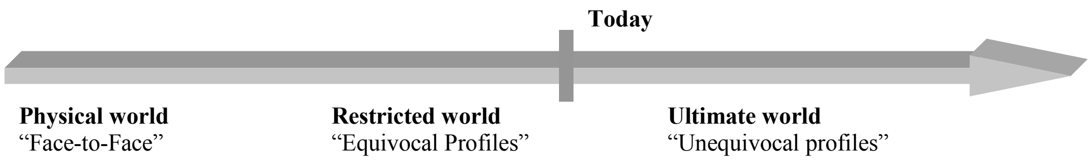

Figure 4: Personalization continuum

Combining the uni-dimensional axes of Figure 3 and 4, we can span the following two-dimensional matrix:

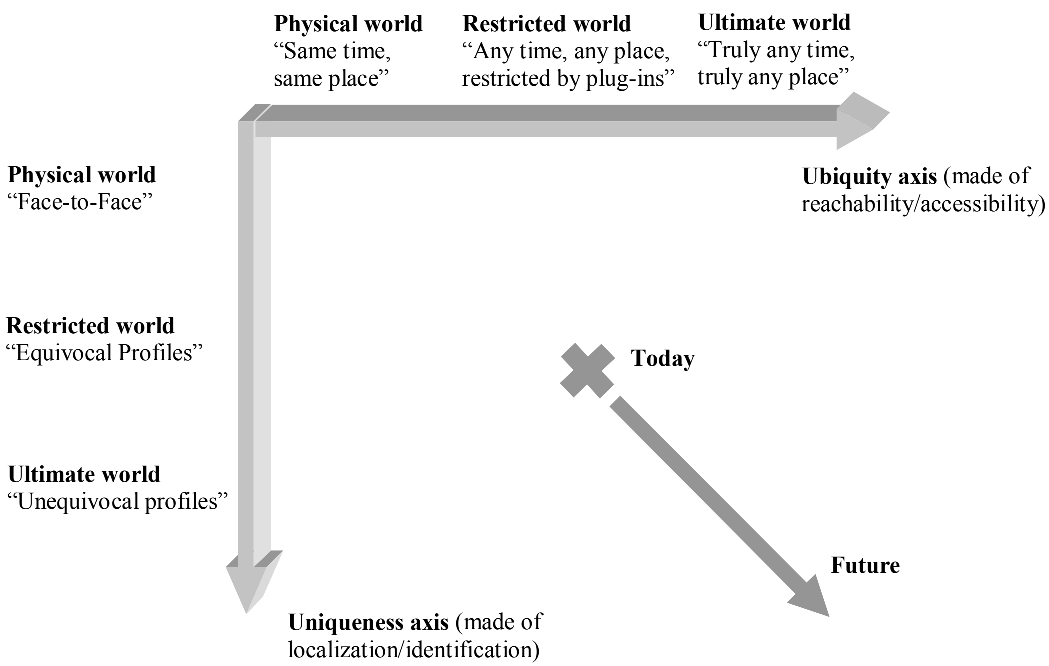

Figure 5: The ultimate matrix

The u-matrix in Figure 5 not only represents g-commerce, but also e- and m-commerce (in which we are right now) as well as u-commerce,[15] the ultimate level of reachability, accessibility, localization, and identification. Currently, we are experiencing a transition from the middle to the bottom right, from a world that is typically characterized by decent network coverage, where one has to search for an Internet connected computer to read emails, and in which one has profiles stored that are inconsistent across multiple platforms to a world that provides ultimate ubiquity and uniqueness. However, there are determinants that will inhibit this transition, which we will examine in the next section.

The following table gives an overview on different devices and their m-commerce characteristics.

Table 1: Multiple devices and their m-commerce characteristics

	Desktop	**Wired Laptop**	**Wireless Laptop**	**PDA**	**Wireless PDA**	**Cellular phone**
Reachability	At dedicated places	At dedicated places	Ubiquitous	None	Ubiquitous	Ubiquitous
Accessibility	At dedicated places	At dedicated places	Ubiquitous	None	Ubiquitous	Ubiquitous
Localization	Network-level	Network-level	Cell-level (today) Latitude	None	Cell-level (today) Latitude	Cell-level (today) Latitude

[15] The term "u-commerce" is adopted from (Watson, 2000), (Watson, et al., 2002) and (Accenture, 2001).

			and longitude coordinates (future)		and longitude coordinates (future)	and longitude coordinates (future)
Identification	Device-level	Device-level	Device-level	Device-level	Device-level	Individual-level
Portability	Low	Medium	Medium	High	High	High

From M- To U-Commerce: What Are The Determinants?

In order to answer this question, we reflect on possible determinants from the viewpoints of (1) mobile applications, (2) mobile networks, (3) mobile devices, and (4) data integration. The different levels of abstractions help to reflect on the "mobile-to-ultimate" transition by considering differing technological aspects that contribute (or impair) the degree to which m-commerce can finally lead to u-commerce. Currently, these determinants appear as limitations, with time however, these limitations are expected to vanish, i.e., mobile applications, networks and devices are forecasted to merge, and data are predicted to be fully synchronized. The categorization used in this context maps the idea of the OSI reference model specification.[16]

[16] OSI (Open Systems Interconnection) is a reference model for how messages should be transmitted between any two points in a telecommunication network. The main idea in OSI is that the process of communication between two end points in a network can be divided into layers, with each layer adding its own set of special, related functions. OSI comprises seven layers: (1) physical layer, (2) data link layer, (3) network layer, (4) transport layer, (5) session layer, (6) presentation layer, and (7) application layer. OSI was officially adopted as an international standard by the International Organization of Standards (ISO) (Stallings, 2000).

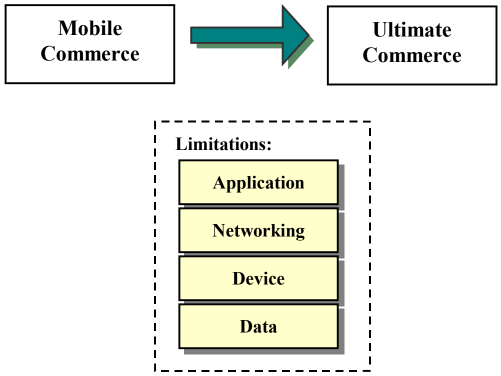

Figure 6: The "mobile-to-ultimate" transition

Mobile Applications

Typically, mobile users manage to learn their mobile device's functionalities very fast—contrarily to using e.g. a PC for the first time. This is partly because current mobile devices are limited in their range of applications: for instance, cell phones are mainly used for placing calls, PDAs are mainly used for scheduling purposes, etc. Their limitation to specific applications is mainly due to technological reasons. With merging networks, devices and data, however, we expect mobile applications to span a broader range of functionality and be universally usable, independent of the underlying network, data, or the device used.

Mobile Networks

We experience a heterogeneous landscape of mobile networks. Ranging from analog systems at one end to digital systems of different generations (such as 2G, 3G, etc.) on the other.[17] Even though the latter underwent a thorough standardization process by institutions such as the ITU, ETSI, and others,[18] there are variations that typically differ in terms of technical protocols and frequencies used. For example, a U.S. cell phone is unlikely to work in Europe because of different network frequencies. In the future, however, and as can be seen by various standardization movements (such as 3G), we expect mobile networks to be universally usable across multiple platforms and across all countries.

Mobile Devices

Users can pick from a broad range of electronic tools to perform a certain task. This varies from cell phones to PDAs, to laptops, etc. With time, we expect more and more traditionally separated applications to be integrated into one mobile device. As can be seen by smart phones (a hybrid between cellular phone and PDA) already, this trend is on its way. It will be propagated by combining cellular devices with "traditionally non-IS" devices such as jewelry or even clothes. Samsung for instance provides a watch that integrates cellular phone functionality (Samsung, 2001).

Data Synchronization

Ideally, mobile devices provide integrated and synchronized data. For instance, the phonebook stored on a cellular phone not only matches all other electronic

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[17] For a summary of mobile generations, please refer to appendix A.

[18] ITU (International Telecommunication Union), ETSI (European Telecommunication Standards Institute).

phonebooks stored on other (wired as well as wireless) devices, but it also matches personal calendars, to do lists, etc. A data change in one application on one particular device is automatically transmitted to all other associated applications and devices. Currently however, due to heterogeneous networking standards, incompatible applications and devices, we still experience some limitations. Nevertheless, future development in data integration will support a cross-network, cross-device, and cross-application functionality.

All aforementioned limitations encountered on the way to the u-world are intertwined in nature. For example, merging mobile devices influence the spectrum of mobile applications available. In parallel, with an increasing possibility of synchronizing data across multiple platforms, the functionalities of a single device will increase as well. Future development expects all of these streams to merge into one, providing the highest level of universality and unison.

Table 2: Summary of determinants

Integration level	**Impact**
Application level	Traditionally separate mobile applications are integrated and available for increasingly smaller mobile devices.
Network level	Different mobile networking standards are becoming integrated and interoperable.
Device level	Physical devices incorporate multiple traditionally separate devices, e.g. cell phone, watch, key, etc.
Data level	Data are integrated and consistent across multiple applications, networks, and devices.

The next step taken is aggregating the m-commerce findings into constructs that form the fundamental dimensions in u-commerce.

Defining U-Commerce

In accordance with our previous definition of m-commerce, we define *u-commerce* as "*the use of ubiquitous networks to support personalized and uninterrupted communications and transactions between a firm and its various stakeholders to provide a level of value over, above, and beyond traditional commerce"*(Watson, et al., 2002). We now elaborate on each of the different characteristics of the next generation of commerce.

U-Commerce Characteristics

U-characteristics (also called u-constructs) are defined by aggregating the m-characteristics as well as the determinants from the mobile-to-ultimate transition found in the previous section into four higher-level constructs (adapted from (Watson, 2000)). These constructs comprise *<u>u</u>biquity*, *<u>u</u>niqueness*, *<u>u</u>niversality*, and *<u>u</u>nison* and can be described as follows:

Ubiquity = Ultimate form of (M-Reachability + M-Accessibility)

Uniqueness = Ultimate form of (M-Localization + M-Identification)

Universality = Ultimate merge of (Mobile Networks + Mobile Devices)

Unison = Ultimate merge of (Mobile Applications + Data Synchronization)

Ubiquity

Ubiquity can be described as networks that "*can fulfill the need both for real-time information and for communication anywhere, independent of the user's location"* (Durlacher, 1999).[19] Taking this definition into account, ubiquity can be viewed as an aggregate construct of (1) m-reachability and (2) m-accessibility drawn from the m-commerce characteristics proposed. While reachability/accessibility provides "any time" availability, portability takes care of the "any place" component—thus, introducing a "truly any place" level into our traditional thinking. In summary, both aspects, m-reachability and m-accessibility, complement each other.

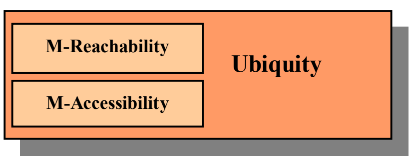

Figure 7: The ubiquity construct

Uniqueness

Uniqueness covers the aspect of personalization—the availability of personalized products and services via mobile devices. Referring to the model proposed, uniqueness can be seen as the aggregate construct of (1) m-localization and (2) m-identification drawn from the m-characteristics found in the previous chapter. Whereas identification

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[19] (Lehman Brothers, 2000) has a similar understanding of ubiquity.

provides an unequivocal and unique assignment, localization provides the geographical position component—thus, for instance, allowing for “true” one-to-one marketing (Pine J. B., et al., 1995).

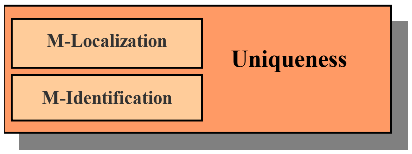


Figure 8: The uniqueness construct

Universality

Universality describes the aspect that the current collection of mobile devices is limited in their usefulness because they are not universally usable (Watson, 2000). For example, U.S. cell phones are unlikely to work in Europe because of different standards and network frequencies. The same applies to European cell phones used in an U.S. mobile environment. In the future, however, we expect not only to have universal mobile devices that will enable one to stay connected independently of the location but also globally integrated mobile networks. Taken this definition into account, universality refers to the determinants mentioned in previous section about the “mobile-to-ultimate transition”. Universality incorporates the abstraction levels of merging mobile (1) networks and (2) devices.

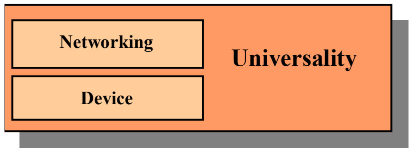


Figure 9: The universality construct

Unison

Unison covers the idea of integrated data across multiple applications that are synchronized automatically (Watson, 2000). For example, the phonebook on a computer matches that on the cell phone and all other electronic phonebooks one maintains. A change in one phonebook is transmitted to all others. As such, unison lays the foundation for using *any* single mobile device for sending, receiving and storing information, organizing contacts and schedules, locating goods and services, etc. Unison (just like universality) refers to the determinants of the "mobile-to-ultimate transition" mentioned in the previous section. Unison incorporates the abstraction levels of merging mobile (1) applications and (2) data.

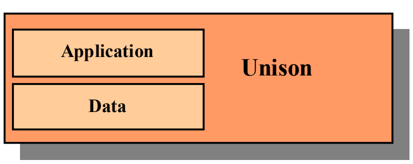


Figure 10: The unison construct

In sum, the combination of single m-commerce characteristics and their determinants has lead to four higher-level constructs that are visionary in nature. Each of them spans a dimension along which information systems are able to advance. Some technologies provide high levels of one characteristic and low levels of others. The ultimate vision, however, is to create an information system that is strong on all four dimensions. Current information systems, in contrast, can be viewed as one particular manifestation or instantiation of the four dimensions.

Empirical Support for the U-Constructs

In order to empirically support the theoretical findings of the four u-constructs, interviews with IS practitioners were conducted. The pool of interviewees was confined by the following criteria: (1) interviewees should be drawn from an industry that is characterized as "early-adopter of new technologies", and (2) interviewees should be drawn from a region where wireless communication is most advanced. In addition, more detailed stipulations regarding the individual interviewee were made: (3) interviewees should have no experience with wireless technology prior to their hiring, (4) interviewees should be working with the company for at least one year but no more than three, and (5) interviewee's cellular spending should be more than $200 U.S. dollars a month. Restrictions (4) and (5) made sure that an individual's perceptional shift introduced through a wireless device is still salient enough to be remembered, and —at the same time—has been experienced for quite a while.

Since the researcher has been working for various consulting companies in Germany throughout her career, and since Germany, as stated by (Durlacher, 1999), is further advanced in wireless communication than the U.S., three higher-level consultants working for two different well-known U.S. headquartered consulting companies based in Germany were identified and interviewed. As the corporate communication language was English (including their corporate knowledge management system), all interviewees felt comfortable in conducting their interviews in English.

All three interviews were unstructured in nature and were addressed to capture the domain of experiences individuals had with their mobile devices. Out of the three, two interviews focused on cellular phones only, the other one mainly on PDAs. In the latter case, the interviewee was also asked for his cellular phone experience, however, to a less extent than the other ones. All interview transcripts are listed in appendix B.

Based on coding analysis of the interview transcripts, three major findings occurred. First, any experience that consultants had with their mobile device could be categorized into the four u-constructs. Second, ubiquity appears to be the most salient. Every interviewee mentioned it as one of the first issues that came to mind. Third, the u-constructs are perceived to have positive as well as negative aspects. For instance, ubiquity is perceived to be a curse and a blessing at the same time. The following table contains an excerpt of mapping u-phrases that were used by the interviewees.

Table 3: Interview phrases supporting the u-constructs

U-constructs	Phrases used by interviewees
Ubiquity	*"I don't have to think about [it], there is no limit to when or where I could call, I just do it."* *"Strengths [of mobile devices] are definitely mobility. You can be reached anywhere."* *"[Strengths are that] you are always available […] and at the same time there [are] downsides that you are always reachable and everybody knows that you should be reachable."* *"You can always reach people unless they are flying."*
Uniqueness	*"And [I have a] kind of feeling that my filofax (a.k.a. planner) number address book lost its importance because I had them in my cellular phone and I always had the cellular phone with me."* *"They call you, they don't call your house, they call you, so this is my number, and so they call me and not just my house, and if they'd call my house they would accept if I'm […] not there."*
Universality	*(Entering the U.S. and realizing that his Triband Mobile did not work) "It was quite a shocking experience because I was immediately at the same situation I have been all my life when I entered two years ago. I had to look for a public phone and [that was] quite a pain."* *"People would be on the move all the time, it didn't matter you could also reach them on the one number if they were in Sweden or Switzerland."*
Unison	*"I could synchronize on the mobile, on the PDA, and on the laptop having the same base of addresses, laptop and organizer having the same appointments."* *"You find new ways of using the thin like linking up your digital camera and then taking photos and then taking all the Compaq flash card and then plugging it into the machine and sending it out via e-mail […]"*

Noticeable is the level of abstraction of each u-construct. Even though every interviewee supported every one of them by providing proof of experience, ubiquity and uniqueness are more conceptual in nature, whereas universality and unison are rather technical constructs. This is determined by the way the constructs were derived. As shown previously, ubiquity and uniqueness form the dimensional end points of u-commerce, whereas universality and unison are determinants that contribute (or impair) the degree to which the ultimate form of commerce can be lived. As such, universality as well as unison should be viewed as antecedents of ubiquity and uniqueness since they lay the foundation for the latter ones to emerge and be exploitable to their full extent.

However, ubiquity and uniqueness provide a conceptual understanding that can be extended beyond information systems. As can be seen in the following, the constructs of ubiquity and uniqueness can also be used to characterize tasks.

U-COMMERCE – A TASK VIEW

Most often, IS researchers do not distinguish clearly between task and technology, in fact, they use both terms interchangeably (Goodhue, et al., 2001). For those that do, the fundamental question arising is if technology drives task, or vice versa. As such, current literature distinguishes between *"underlying tasks which are constant across changes in technology, and tasks as presented to the task doer which can change because of technological change"* (Goodhue, et al., 2001). In case of a (visionary) information system that can provide the ultimate form of any u-construct, it does indeed change tasks. It even creates new opportunities for tasks that were non-existent before, such as gathering information about a historical monument while passing by, or doing on-line trading from any location on the globe. Vice versa, if ubiquitous and unique tasks are in demand, technology should provide the foundation to support these. In summary, task and technology form an interactive cycle, one initiating and perpetuating the other.

For the purpose of this dissertation, we assume that tasks requiring the ultimate level of the u-constructs exist already, as well as the technology that is able to support them. However, this assumption requires a valid task classification scheme to be in place with which we are able to systemize task fulfillment using different u-commerce technologies.

Traditional Task Classification Schemes

Traditional classification schemes, such as the ones listed in Table 4, can be viewed from four different perspectives (Hackman, 1969): (1) "Task as behavior descriptions" in which a task is defined by what a task doer actually does, (2) "task as ability requirements" in which a task is defined by the characteristics of the performer, (3) "task qua task" in which the task is characterized by the task material that is given out to the task doer, and (4) "task as behavior requirements" in which a task is characterized by its objective and how to achieve this objective.

Table 4: Examples of task classifications (Zigurs and Buckland, 1998)

Author(s)	Task categories
Carter, Hayhorn, and Howell (1950)	Clerical, discussion, intellectual construction, mechanical assembly, motor coordination, reasoning
Shaw (1954)	Simple vs. complex
Bass, Pryer, Gaier, and Flint (1958)	Easy vs. difficult
Hackman (1968)	Production, discussion, problem solving
O'Neill and Alexander (1971)	Discussion, decision, performance
Steiner (1972)	Unitary vs. divisible, maximizing vs. optimizing, prescribed process vs. permitted process (disjunctive, conjunctive, additive,

	discretionary)
Shaw (1973)	Difficulty, solution multiplicity, intrinsic interest, cooperation requirements, population familiarity, intellectual-manipulative requirements
Poole (1978), McGrath (1984), DeSanctis and Gallupe (1987)	Generate (planning vs. creativity), choose (intellective vs. decision making), negotiate (cognitive conflict vs. mixed motive), execute (contests/battles vs. performance/psychomotor)
Wood (1986)	Task complexity is comprised of the building blocks: products, (required) acts, and information cues
Campbell (1988)	Simple, decision, judgment, problem, fuzzy

None of these perspectives incorporates time or location as one of its distinguishing components. As such, it is essential for this dissertation to create a classification scheme that is able to serve as an overall framework for tasks, such as the ones specifically found in u-commerce.

A Task Classification Scheme based on Ubiquity and Uniqueness

The fundamentals of the new task classification scheme will use the same building blocks as the framework for information systems developed in the previous section, i.e., we base it on the u-constructs of ubiquity and uniqueness. Note that the nature of universality and unison are rather technological and, as such, do not apply to the context of tasks. As can be seen in Table 5 and Table 6, the task classification schemes for ubiquity and uniqueness distinguish between an intrinsic and an extrinsic component, each of which are explained in the following.

Ubiquity Requirement of a Task

Ubiquity requirements for a task can be inferred from two stimuli, intrinsic and extrinsic. Whereas "*intrinsic*" refers to a task in which a person takes an active role in initiating it, "*extrinsic*" refers to a task that is initiated by someone else or some agent (see also Table 5).

In case of high ubiquity task requirements, intrinsic tasks mainly comprise three different situations: (1) A person needs to initiate an entirely new process irrespective of time and location, (2) for an initiated process, a person might need to dispatch a sub-process instantaneously in response to an urgent request, and (3) a person may need to actively monitor a process on a frequent basis irrespective of time and location. Typically this is done while performing other tasks. Noteworthy is that the person is not reminded to do so, but has to initiate the monitoring task himself. In contrast, in an extrinsic situation, a person would be reminded of the monitoring process. A good example is tracking stock quotes. An intrinsic monitoring of stock quotes would involve the person actively checking stock quotes on a regular basis, whereas an extrinsic monitoring uses an external source (typically a computer) announcing or displaying current information. Besides process monitoring, extrinsic tasks also captures process triggers, i.e., some external source triggers a task that a person has to perform instantaneously. Prerequisite is the person's reachability at any time and any location. A typical example would be somebody "on call" (e.g., a father-to-be waiting for important project information, etc.).

In the case of low ubiquity task requirements, the same distinction between intrinsic and extrinsic tasks can be used. Depending on whether task motivation comes from the inside (e.g., initiating, responding, and intrinsic-initiated monitoring), or the outside (e.g., triggering, and extrinsic-initiated monitoring). In contrast to high ubiquity requirements, however, tasks that require low ubiquity can generally be characterized by the absence of time-pressuring aspects. Along the same lines, the location from where a process is initiated, responded to, monitored, or triggered is of no importance for low ubiquity tasks.

Table 5: Task ubiquity requirements

Low ubiquity		High ubiquity	
Intrinsic	**Extrinsic**	**Intrinsic**	**Extrinsic**
• **Process initiation** Initiating a process is not time-critical and can be done at any time and from any location • **Process response** Replying to a process is not time-critical and can be done at any time and from any location • **Intrinsic-initiated process monitoring** A person does not need to actively monitor an initiated process with high frequency	• **Process trigger** A person does not expect a task that requires a prompt response. It's sufficient to check his task list at random times • **Extrinsic-initiated process monitoring** A person does not need to monitor an initiated process with high frequency	• **Process initiation** A person needs to initiate a process instantaneously, i.e., irrespective of time and location • **Process response** For an initiated process, a person needs to perform a subprocess instantaneously • **Intrinsic-initiated process monitoring** A person needs to actively monitor an initiated process with high frequency while performing other tasks irrespective of time and location	• **Process trigger** A person needs to be reachable in order to receive a task • **Extrinsic-initiated process monitoring** A person is reminded to monitor an initiated process with high frequency while performing other tasks irrespective of time and location

Uniqueness Requirement of a Task

Like the ubiquity requirements, uniqueness requirements for a task can be inferred from two stimuli, intrinsic and extrinsic. Whereas "*intrinsic*" refers to a task that requires identity and location-based information about the person, "*extrinsic*" requires the same kind of information about others.[20]

In case of high uniqueness, one can think of an intrinsic task that requires a person to have full information about his physical location, such as getting road navigation in a foreign city. Opposed to that, one can think of an extrinsic counterpart in the form of a task that requires location-based information but about another person. Noteworthy is that this person is moving, either by foot, or some other means of transportation. Multiple scenarios are possible, examples include: locating a friend in a crowded place, sending promotion ads to a person passing by a store, the logistics department changing truck routes on the fly, locating a car accident scene, etc. Besides location-based information, task uniqueness requirements also comprise identity information, either about a person himself (intrinsic), or about others (extrinsic). Intrinsic examples include factual information about the person, such as personal information, addresses, time planner, account information, etc., as well as preferences, including certain interests, buying intentions, opinions, etc. Extrinsic identification requirements typically emerge when a company tries to identify a person's needs, and based on that, offers tailored products and

[20] Note that the terms "intrinsic" and "extrinsic" do have different connotations depending on the u-context. "Intrinsic" captures aspects "from the inside" (ubiquity) as well as "about the inside" (uniqueness), while "extrinsic" captures "from the outside" (ubiquity) as well as "about the outside" (uniqueness).

services. In combination, location-based and identity information lay the foundation for an unequivocal profiling, which has positive as well as negative connotations. In the context of this dissertation it is viewed positively, because it allows for tailoring products and services in a way never experienced before—eventually leading to the ultimate form of commerce. However, it can also be viewed negatively because the same information can be abused so that "Big Brother" eventually becomes real.[21] A more detailed discussion, however, is left to future research.

Table 6: Task uniqueness requirements

Low uniqueness		High uniqueness	
Intrinsic	**Extrinsic**	**Intrinsic**	**Extrinsic**
• Task does not require location-based information about the person • Task does not require profile information from the person	• Task does not require location-based information about another person • Task does not require person profile about another person	• Task requires location-based information about the person • Task requires person profile from person	• Task requires location-based information about another person • Task requires person profile about another person

[21] A survey conducted by IDC in 2000 found out that 27 percent of all respondents are interested in a service that allows their location to be determined within 400 feet for concierge purposes. Among these, 18-24 years old and 25-34 years old showed particular interest (41 percent and 37 percent, respectively). Similar results occurred when respondents were asked for a directory service based on location. 30 percent answered very interested, out of which, again, the group of the 18-24 years old and 25-34 years old showed particular interest (51 percent and 41 percent, respectively) (IDC, 2000a).

When aggregating both perspectives of ubiquity and uniqueness task requirements, three dimensions become salient: (1) time-dependent, (2) location-dependent, and (3) identity-dependent tasks (Figure 11). Time-dependency builds upon the idea of the technical constructs of m-accessibility and m-reachability (= ubiquity), identity-dependency on the construct of m-identity, and location-dependency on the construct of m-localization.

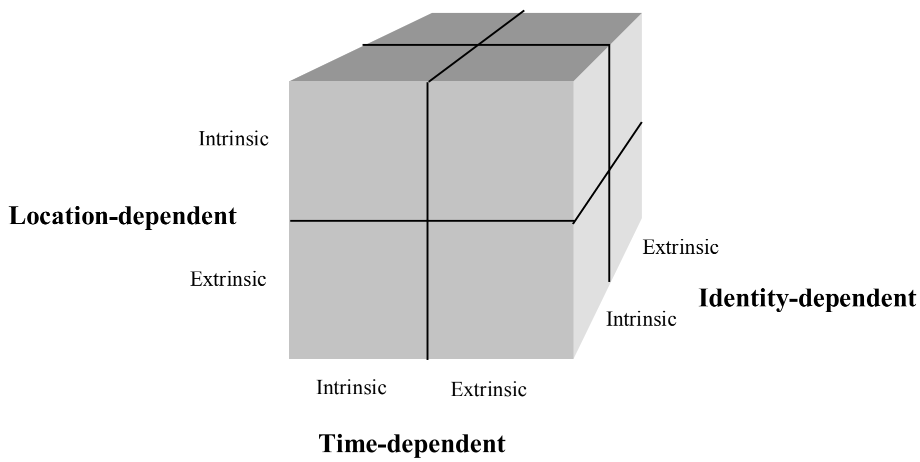


Figure 11: The task cube

Time-dependent tasks are those that have to be fulfilled as soon as possible. Depending on whether the task is initiated by the task doer or triggered by somebody external, the taxonomy distinguishes between intrinsic and extrinsic time-dependent tasks. Location-dependent tasks are those that require location information either about the person himself (intrinsic), or about somebody else (extrinsic). Finally, identity-dependent tasks are those that require a unique identification of a person, including his preferences. Identity information can either be provided about the person himself (intrinsic, e.g., billing information), or about others (extrinsic, e.g., person preferences for a one-to-one marketing).

As will be seen later in the methods section, for the purpose of this dissertation, we focus on the two dimensions time and location only, i.e., solely the front slice of the cube goes into further examination.

Up to this point, we have introduced the first set of a research stream selected for this dissertation. U-commerce was defined and a set of u-commerce constructs was presented whose conceptual idea can be applied not only to information systems but also to tasks. In the following, we will introduce the second stream of research that reviews traditional IS utilization and performance models. The final step will be to collapse both streams into the conceptual model depicted on page 52.

TRADITIONAL INFORMATION SYSTEMS UTILIZATION AND PERFORMANCE MODELS

IS research has long recognized the importance of understanding how and why people use information systems. During the past decade, two significant models have emerged which provide a strong theoretical base for studies of information system utilization behavior: the technology acceptance model (TAM), and the task-technology fit model (TTF). Both are now explained in detail.

Technology Acceptance Model (TAM)

One of the most widely applied individual-level technology adoption models in IS literature is TAM (Technology Acceptance Model, (Davis, 1986; 1989, Davis, et al., 1989)), an adaptation of the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975) specifically tailored to modeling information system usage (Plouffe, et al., 2001). Its goal is to represent antecedents of system usage through beliefs of two factors: perceived ease of use and perceived usefulness. Both are considered to be determinants of attitude towards usage intentions, which, in turn, is the sole determinant of usage.

In the past, several modifications were proposed to TAM. These range from incorporating entire models into TAM, such as the Theory of Planned Behavior (Taylor and Todd, 1995), to including only single constructs, such as prior experience (Taylor, 1995), self-efficacy (Venkatesh and Davis, 1996), experience (Venkatesh and Davis, 1996), extrinsic and intrinsic motivation (Davis, et al., 1992, Venkatesh, 1999), and emotion (Mathieson, 1991, Venkatesh, 2000), to cutting out entire constructs, such as attitude (Adams, et al., 1992, Chau, 1996, Lu and Gustafson, 1994). The latest version of the TAM model (as used by (Davis, 1996)) excludes the attitude construct because it does not fully mediate the effect of perceived usefulness on intention, i.e., people use information technology even though they do not have a positive attitude towards using it (see Figure 12).

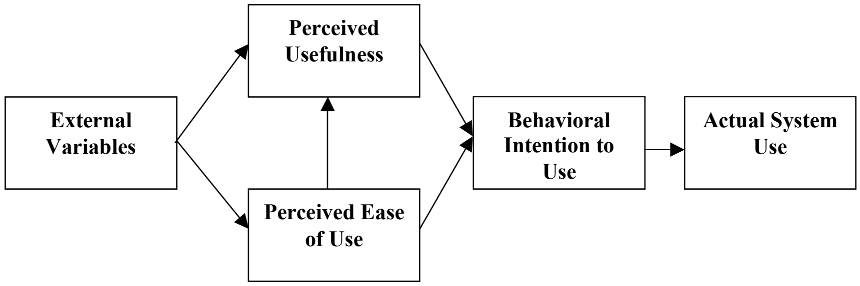


Figure 12: Technology acceptance model (TAM) (Davis, 1996)

TAM has been prized for its parsimony and robustness. It is intended to explain user behavior across a broad range of end-user computing technologies and user populations by only using two main constructs: perceived ease of use and perceived usefulness. From a statistical point of view, TAM explains a large amount of variance (maximum: 52 percent) for various settings (see also Table 9).

Table 7: Constructs used in TAM (Davis, 1986, Davis, et al., 1989)

Construct	**Description given by** (Davis, 1986, Davis, et al., 1989)
External Variables	Other factors not explicitly included in the model are expected to impact intentions and usage solely through ease of use and perceived usefulness. These external variables might include: system design characteristics, training, documentation and other types of support as well as decision characteristics that might influence usage.
Perceived Usefulness	Prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context.
Perceived Ease of Use	Degree to which the prospective user expects the target system to be free of effort.
Behavioral Intention to Use	A measure of the strength of one's intention to perform a specified behavior.

One major drawback of TAM, however, is that the nature of the task is not included. Many scholars have argued that an information system in order to have a positive impact on performance, the technology must be a good fit with the task it supports (Goodhue and Thompson, 1995, Vessey, 1991, Zigurs and Buckland, 1998). TTF (Task-technology Fit) (Goodhue and Thompson, 1995) provides a conceptual basis for explaining in which way the nature of the task impacts individual and organizational performance.

Task-Technology Fit Model (TTF)

Task-technology fit (TTF) (see Figure 13) describes the degree to which a technology assists an individual in performing a portfolio of tasks. More specifically, it reflects the correspondence between task requirements, individual abilities, and the functionality of the technology (Goodhue and Thompson, 1995, Goodhue, 1998). An information system will have positive performance impacts if, and only if, (a) it is used, and (b) the functionality provided by the information system fits the task the user has to perform. As such, rational users will choose tools and methods that enable them to complete the task with the greatest net benefit. In consequence, if a technology has exactly the functionality needed to complete a required task, it is more likely to be used and higher performance should result (Goodhue, 1995, Goodhue, et al., 2000).

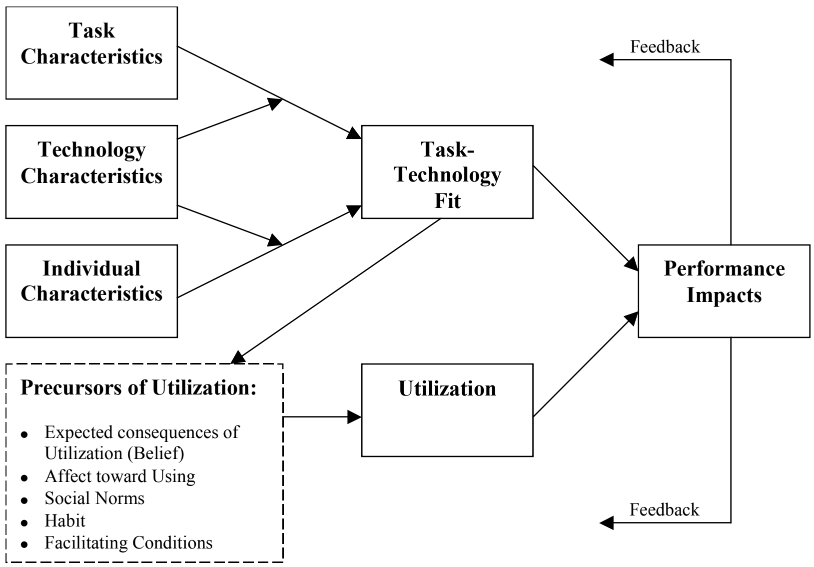


Figure 13: Task-technology fit model (Goodhue and Thompson, 1995)

Although TTF is relatively new in the IS literature, the concept of fit exists in other disciplines. In the strategy literature, for example, (Venkatraman, 1989) distinguishes between six different perspectives of fit: fit as (1) matching, (2) covariation, (3) gestalts, (4) moderation, (5) mediation, and (6) profile deviation. Research on problem solving and problem representation has developed the concept of "cognitive fit" (Vessey, 1991, Vessey and Galletta, 1991) and "congruence" (Jarvenpaa, 1989), i.e., problem solving works best when the problem representation in combination with the appropriate tools support the processes required to perform the task. In the organizational literature, (Thompson, et al., 1991) for instance use a "job fit" construct to account for the fact that an information system is more likely to be used when it is compatible with individuals' job responsibilities.

Since its genesis, TTF has been applied to various technologies and settings, such as in the context of group support systems (GSS) (Zigurs and Buckland, 1998), software maintenance (Dishaw, 1999, Dishaw and Strong, 1998), and to measure performance impacts of an Integrated Information Center on end-users (Goodhue, 1997, Goodhue, et al., 1997). In its original form, TTF explains up to 33 percent of variance for task-technology fit (see Table 8).

Table 8: Constructs used in TTF (Goodhue and Thompson, 1995)

Construct	**Description given by (Goodhue and Thompson, 1995)**
Task Characteristics	Tasks are defined as the actions carried out by individuals in turning inputs into outputs.
Individual Characteristics	Individuals may use technologies to assist them in the performance of their tasks. Characteristics of the individual training, computer expertise, motivation) could affect how easily and well he or she will utilize the technology.
Technology Characteristics	Tools used by individuals to carry out their tasks. In the context of information systems research, technology refers to computer systems (hardware, software, and data) and user support services (training, help lines, etc.) provided to assist users in their tasks.
Task Technology Fit (TTF)	Degree to which a technology assists an individual in performing his or her portfolio of tasks; more specifically, TTF is the correspondence between task requirements, individual abilities, and the functionality of the technology.
Utilization	Proportion of times users choose to utilize systems.
Performance	Describes the perceived impact of computer systems and services on their effectiveness, productivity, and performance in their job.

Table 9: TAM Model

Author(s)	Context	Constructs Measured	Variance Explained
(Davis, 1989, Davis, et al., 1989)	Longitudinal study of 107 MBA students using a word processing program	Intention to use, perceived usefulness, perceived ease of use, attitude toward using, actual system use	Intention to use: R^2 = 0.47 and 0.51
(Mathieson, 1991)	Cross-sectional study of 262 students using two different applications	Same as original TAM	TAM: Intention to use: R^2 = 0.70
(Adams, et al., 1992)	Two studies of (1) 118 users in 10 organizations using two different applications, and (2) 73 undergraduate and MBA students using three different applications	Reduced TAM only: Ease of use, usefulness, usage	Study 1: Actual system use: R^2 = 0.155 and 0.17 Study 2: Actual system use: R^2 = 0.04 and 0.35 and 0.29
(Davis, 1993)	Field study of 112 professional and managerial employees using an e-mail system and a text editor	Same as original TAM	Actual system use: R^2 = 0.36
(Taylor and Todd, 1995)	Cross-sectional study of 786 students using a computing resource center	Same as original TAM	Intention to use: R^2 = 0.52 Attitude: R^2 = 0.73 Actual system use: R^2 = 0.34
(Venkatesh and Davis, 2000)	Longitudinal study of 156 users regarding four different systems at four different organizations	Same as original TAM, in addition: Subjective norm, voluntariness, image, job	Intention to use: R^2 = [0.34, 0.52]

		relevance, output quality, result demonstrability	
(Plouffe, et al., 2001)	Cross-sectional study of 176 merchants of a market trial of a smart card-based electronic payment system	Same as original TAM	Intention to use: $R^2 = 0.32$

Table 10: TTF Model

Author(s)	Context	Constructs Measured	Variance Explained
(Goodhue and Thompson, 1995)	Cross-sectional study of 600 users, employing 25 different technologies, working in 26 non-IS departments in two very different organizations	Task characteristics, technology characteristics, task-technology fit, utilization, performance impact	Fit: R^2 = [0.14, 0.33] Fit: Adj. R^2 = [0.04, 0.25] Utilization: Adj. R^2 = 0.02 Performance impact: Adj. R^2 = 0.16
(Goodhue, et al., 1997)	Study of two types of individuals of three organizational groups at two time periods (N = 270 and 231)	Same as above, in addition: Allocate resources	Fit: Adj. R^2 = 0.25 Utilization: Adj. R^2 = 0.43 Performance impact: Adj. R^2 = 0.39 Allocate resources: Adj. R^2 = 0.34
(Dishaw, 1999)	Study of 60 programmer analysts completing maintenance projects in three firms	Integrated model using both, TAM and TTF	TTF: Fit: R^2 = 0.17 Integrated model: Fit: R^2 = 0.29
(Goodhue, et al., 2001)	Experimental study of 107 pairs of undergraduate business students on the impact of semantically integrated data on an information-retrieval task using a computer-based query system	Different performance measures than original TTF	

The Technology Impact Model (TIM) – An Integrated Model

TAM as well as TTF provides a strong theoretical base for studies of information systems utilization. Rather than arguing for TTF as an alternative to TAM, adding the strengths of both into an integrated model seems a legitimate approach to take (see Figure 14). As already demonstrated by Dishaw (1999), an integrated model of TAM and TTF explains 51 percent of the variance in utilization, contrarily to TAM 36 percent and TTF 41 percent.[22]

As can be seen in Figure 14, we posit that the fit constructs of the TTF model affects both perceptual measures of the TAM model. User's perceptions about the usefulness and ease of use of an information system are likely to be derived from evaluating the fit between technology characteristics and the tasks for which it can be used. As such, TAM substitutes for the constructs of "precursors of utilization" and "utilization" in the original TTF model.

In previous literature, both models use different lenses on how to explain information system utilization. TAM uses the lens of explaining utilization through beliefs and perceptions a user has towards an information system, neglecting the fact that people use an information system even though they do not like it. TTF on the other hand, uses the lens of explaining utilization through the expected performance increase, neglecting which kind of beliefs or perceptions a user has towards the information

[22] The integrated model used for the purpose of this dissertation is slightly different from the one used by Dishaw (1999), whose model differs in that it uses: (1) a previous version of the TAM model (Davis, 1989), and (2) an additional construct called "tool experience" as an exogenous variable that influences perceived ease of use and perceived usefulness.

system. The combination of TAM and TTF, which we call the Technology Impact Model (TIM), provides the foundation of this work's conceptual and research models.

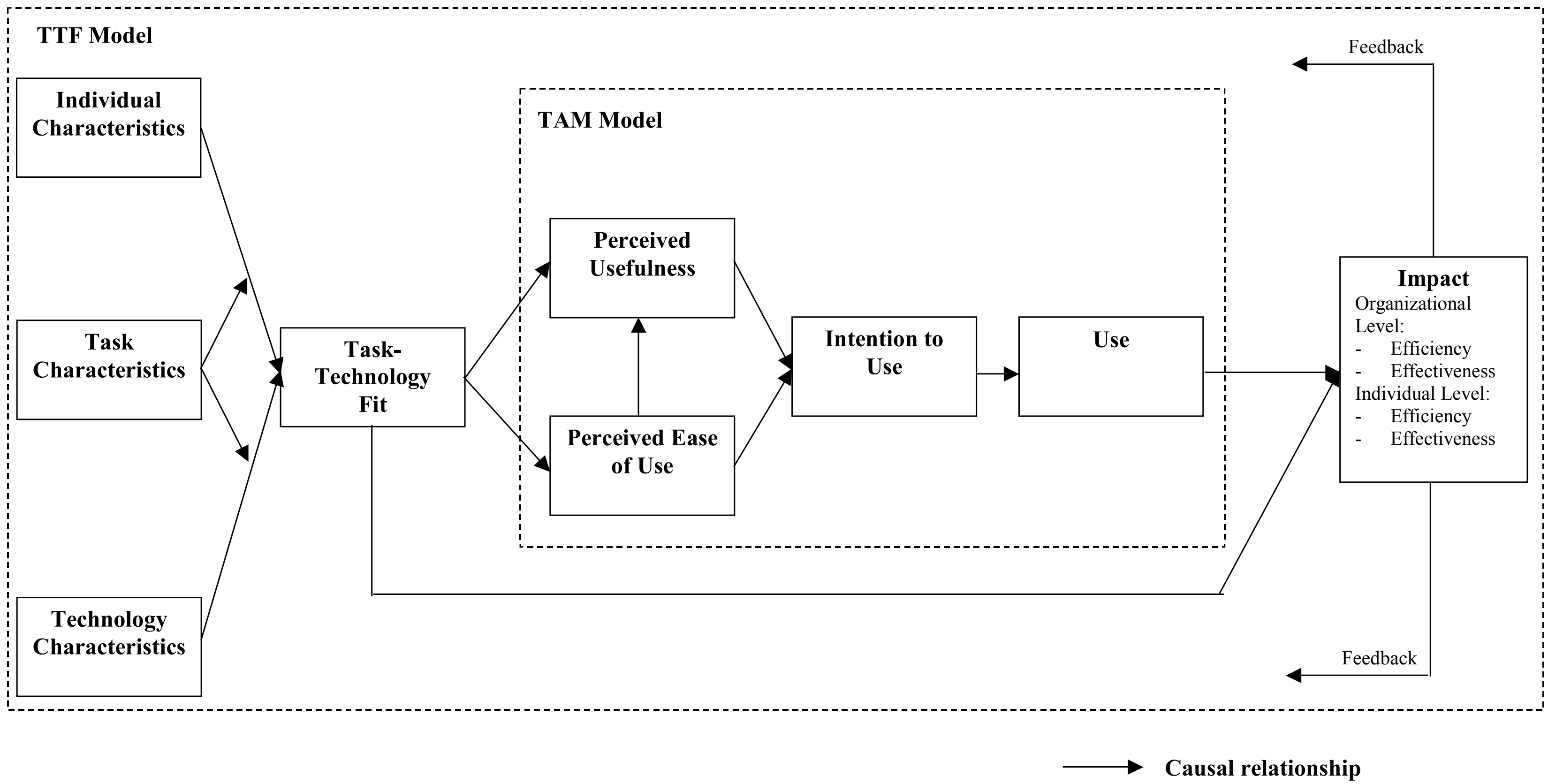


Figure 14: The Technology Impact Model (TIM)

Conceptual Model

The conceptual model (shown in Figure 15) unites three research streams introduced in this chapter. In particular, it combines the task and technology aspects of u-commerce with the integrated technology impact model (TIM). This is achieved by the following steps:

First, the constructs of ubiquity, uniqueness, universality and unison span four new dimensions along which technology can be described. An information system that provides high ubiquity can be described as a system with 24 hours reachability and accessibility. In addition, an information system that provides personalized services including location-based services is categorized as offering high uniqueness.

Note that for the purpose of the dissertation the u-constructs are assumed to be equivalent to each other, i.e., all of them form true dimensions along which technology can be classified. However, one could also think about universality and unison as prerequisites of ubiquity and uniqueness. As mentioned already in a previous section, universality and unison are rather technical in nature—which, among others, can be seen by the way they are conceptually derived. Whereas ubiquity and uniqueness form the dimensional end points of u-commerce, universality and unison are determinants that contribute (or impair) the degree to which the ultimate form of commerce can be implemented. As such, universality, as well as unison, lay the (technical) foundation for the latter ones to emerge. For example, a mobile device that is universally usable across multiple networks enables ubiquity. Also, providing highly integrated applications and synchronized data across multiple platforms enables unequivocal user profiling.

Since the dissertation focuses on ubiquity and uniqueness only, a further examination of the u-construct relationships is left for future research.

Second, the constructs of ubiquity and uniqueness, in their derived form of time-, location-, and identity-dependency, span three new dimensions along which tasks can be described. Tasks that are strongly time-, location-, and identity-dependent are those that demand ultimate accessibility and reachability as well as identification and location-based information.

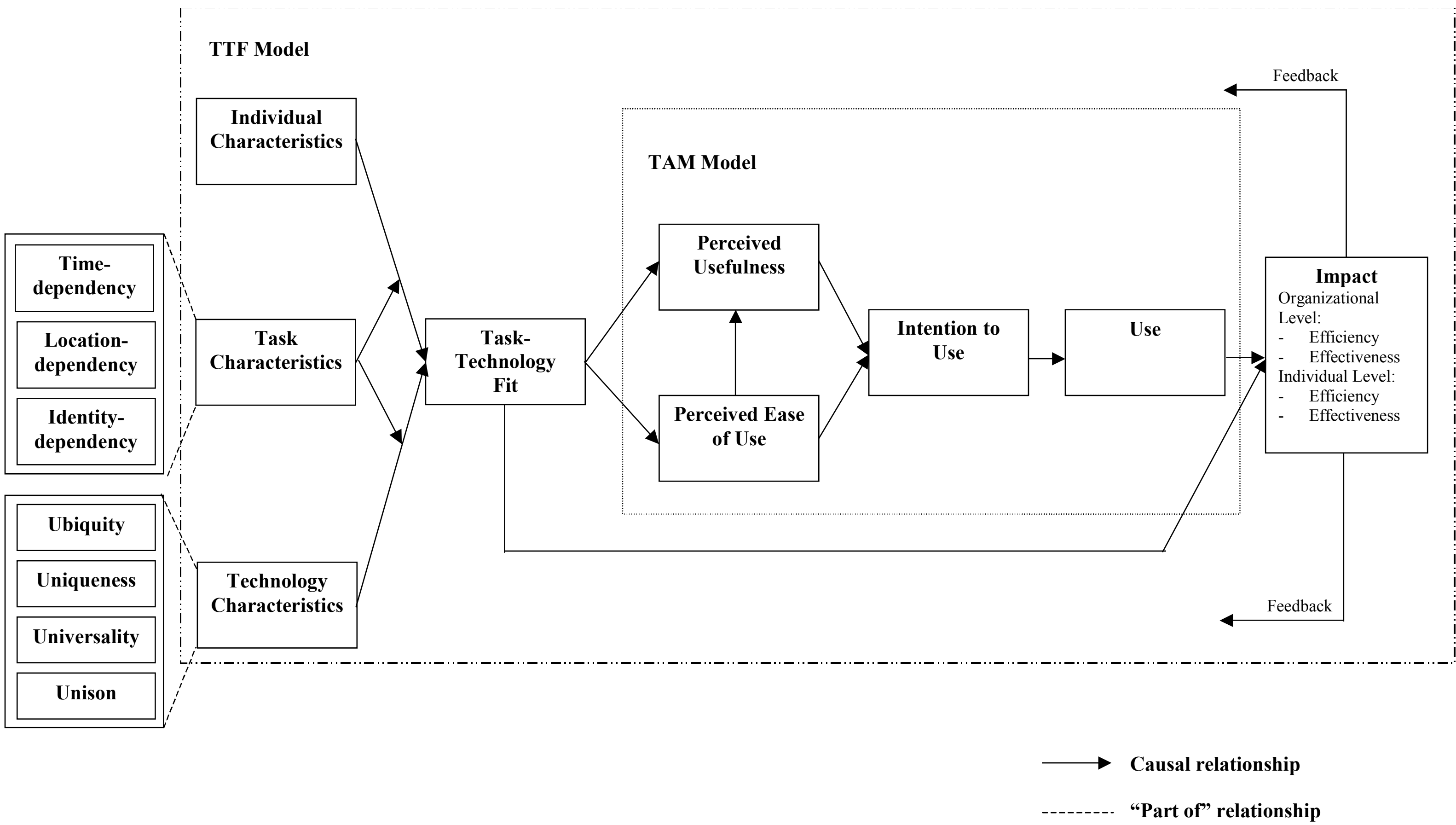


Figure 15: Conceptual model

The Construct of Fit

As can be seen in Figure 15, fit plays a very important role in mediating the effects of the u- and d-constructs on performance. As mentioned before, task-technology fit is defined as the extent to which technology functionality matches task requirements and individual abilities. This means that each combination of task, technology and individual characteristic can be described through the level of fit achieved. Unfortunately, there has been limited progress in defining precisely what fit is and how to measure it (Goodhue, et al., 2001). In general however, two conceivable fit conceptualizations exist: a subjective and an objective conceptualization of fit.[23]

Taking a subjective stance means measuring fit from a user's perspective. Users that utilize a technology because of its instrumentality in their task are believed to be capable of evaluating that technology's fit from their personal experience. That is, users will give evaluations based on the extent to which they perceive the system meets their needs and abilities. In this case, user evaluations serve as surrogates for task-technology fit (Goodhue, 1995).

Taking an objective stance of fit means determining fit from an external position, i.e., fit is not determined by system users, but by system builders. Any software development can serve as an example. When developing an application, system specifications are always made in such a way that they match the task that the application

[23] The objective form of fit is sometimes referred to as "engineering fit" (Nance and Straub, 1996) whereas the subjective form of fit is called "tool fit" (Davern, 1996).

is expected to solve with user characteristics. One way of incorporating user characteristics, for instance, could include providing several functionalities to invoke parts of the application. This could include using shortcut keys versus tool bars versus built-in menus. In this case, fit is measured by system specifications.

For the purpose of this study, we use an objective measure of fit only. For that, we distinguish between three different stages: ideal fit, over-fit, and under-fit. Whereas ideal fit reflects the ideal mapping of ubiquity and uniqueness task requirements and technological functionality, over- and under-fit, respectively, describe a digression from the ideal mapping. In case of over-fitting, the technology provides more functionality than required for the task. In case of under-fitting, a technology does not provide sufficient functionality to perform that task efficiently.

In analogy with the conceptual model, a four-by-four matrix of fit combinations can be established. All conceivable permutations of task and technology are summarized in Table 11.

Table 11: Conceptual task/technology combinations and their fit

Technology / Task	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L
Ti-H/Lo-H	Ideal fit	Under-fit	Under-fit	Under-fit
Ti-H/Lo-L	Over-fit	Ideal fit	Under-fit	Under-fit
Ti-L/Lo-H	Over-fit	Under-fit	Ideal fit	Under-fit
Ti-L/Lo-L	Over-fit	Over-fit	Over-fit	Ideal fit

Legend:

Ub	Ubiquity
Un	Uniqueness
Ti	Time-dependency
Lo	Location-dependency
L	Low
H	High

Please note that the matrix is not symmetric. A combination of Ti-L/Lo-H task with a technology that provides Ub-H/Un-L results in an under-fit. This situation can also be called "misfit" since the technology provided does not fit the task requirements at all. For instance, technology that provides ubiquity but no uniqueness is provided in order to solve tasks that are not time- but location-dependent.

Propositions

According to the conceptual model in Figure 15 and the task/technology combinations in Table 11, three clusters of propositions can be posed: propositions about performance (PERF), about usefulness (USE) and ease of use (EOU).

PERF1: *An ideal fit between technology and task will lead to higher individual performance than over-fit.*

PERF2: *An ideal fit between technology and task will lead to higher individual performance than under-fit.*

PERF3: *An over-fit between technology and task will lead to higher individual performance than under-fit.*

USE1: *An ideal fit between technology and task will lead to higher perceptions of usefulness than over-fit.*

USE2: *An ideal fit between technology and task will lead to higher perceptions of usefulness than under-fit.*

USE3: *An over-fit between technology and task will lead to higher perceptions of usefulness than under-fit.*

EOU1: *An ideal fit between technology and task will lead to higher perceptions of ease of use than over-fit.*

EOU2: *An ideal fit between technology and task will lead to higher perceptions of ease of use than under-fit.*

EOU3: *An over-fit between technology and task will lead to higher perceptions of ease of use than under-fit*

In summary, we propose that ideal fit will lead to the highest level of individual performance, usefulness and ease of use, whereas over-fit is expected to lead to a high level of performance, usefulness and ease of use, but not to the same extent as ideal fit. The rationale for this relationship is that technology providing more functionality than required by the task reduces the overall individual performance because users are either too overwhelmed with features and functionalities, or are too distracted by the same so that the task at hand suffers severe losses (Ackerman and Cianciolo, 2002, Klein, et al., 1999). Under-fit, in contrast, is expected to lead to the lowest levels of all three. Please note that in order to define the sequence proposed, i.e., “ideal➔over➔under,” logically only three comparisons per dependent variable are necessary.

Other Constructs Influencing the Conceptual Model

The conceptual model focuses on the Technology Acceptance model (TAM) and Task-technology Fit model (TTF) only, i.e., we take a very narrow technology/task view. However, as can be inferred from the interviews conducted, interviewees perceived their mobile devices as becoming an integral part of their lives that tremendously reduces their stress level. A survey commissioned by the International Stress Management Association (ISMA) and Royal & SunAlliance (R&SA) conducted in the United Kingdom in 2000 supports this assumption. It reveals that 70 percent of all adults experience stress at their workplace (Management Services, 2000). Out of these, more than half (52 percent) disagreed strongly that new technology was the cause of workplace stress and a third of all workers believe that their quality of life has been improved by e-technology (Management Services, 2000). When asked what situations they find stressful, 45 percent replied rush hour travel, and 31 percent managing work and home balance (Management Services, 2000).

As a conclusion, other constructs, such as "quality of life" and "quality of work life," seem worthwhile to be investigated as an extension of the current study. For example, it can be hypothesized that mobile devices reduce the level of stress and as such contribute to a higher level of (work) life quality. The interested reader is referred to (Hackman, 1970, Igbaria, et al., 1994, Kahn, 1970, Loscocco and Roschelle, 1991, McGrath, 1970a; 1970b, Parasuranam and Alutto, 1984, Weiz, 1970).

ORGANIZATION OF THE RESEARCH

The research process follows the following structure:

1. Establishing the conceptual model by drawing on existing theories and incorporating the newly found u-constructs of task and technology.
2. Gaining support for the u-constructs through interviews; validate model through feedback from IS experts.
3. Establishing a research model and research method that is subject of this dissertation.

4. Designing an experimental setting to test the research model, in particular defining the variables.
5. Developing measurements for each construct used in the research model.
6. Designing an experiment action plan.
7. Setting up the experimental environment (including programming) for testing the research model.
8. Analyzing the data collected using various statistical tools.
9. Drawing conclusions from the data collected.

CHAPTER 3 – RESEARCH METHOD

RESEARCH MODEL

For the purpose of this dissertation, we examine a subset of the conceptual model only (see Figure 16). Differences between the conceptual and research model and their rationale are described in the following.

First, contrary to the conceptual model, the research model focuses on the individual performance level only. Since this dissertation is the first of its kind to take the challenge exploring a terra incognita, we try to find answers to the most fundamental questions and those that can be measured in an experimental set-up. As such, we leave the organizational aspect of the conceptual model for future research (e.g., (Abraham, 2003)).

Second, the research model does not include the constructs of universality and unison. As mentioned previously, compared to ubiquity and uniqueness, universality and unison are rather technical in nature—which, among others, can be seen by the way they were derived. Whereas ubiquity and uniqueness form the dimensional end points of u-commerce, universality and unison are determinants that contribute (or impair) the degree to which the ultimate form of commerce can be exercised. As such, universality as well as unison lay the (technical) foundation for the latter ones to emerge and be exploitable to their full extent. In that sense, universality and unison can be viewed as facilitating conditions.[24] As can be seen later in the research design section, universality and unison can be easily be implemented when the research is framed as an experiment. Additionally, the interviews conducted with IS practitioners have shown that ubiquity is the most prevalent construct (see also Appendix B), and thus, should be researched. The construct of uniqueness that—among other things—includes location-based services is expected to play an important role in future developments (IDC, 2001c).

Third, compared to the conceptual model, the research model leaves out the constructs of intention to use and usage. As can be seen later in the experimental set-up, using a mobile device is mandated, i.e., intention becomes irrelevant in this context. As a result, fit directly influences individual performance—moderated only by a construct that we now call "mandated use."

Fourth, contrary to the conceptual model, the research model focuses on task and technology characteristics only and leaves out individual characteristics. As can be seen later in the experimental setup, the study uses a homogenous pool of subjects.

Fifth, the causal relationship between usefulness and ease of use has been extensively examined in previous research (Davis, 1986; 1989, Davis, et al., 1989,

[24] In analogy with the Theory of Reasoned Action (TRA) by (Fishbein and Ajzen, 1975).

Venkatesh, 1999; 2000, Venkatesh and Davis, 1996; 2000), and thus, is not part of this dissertation.

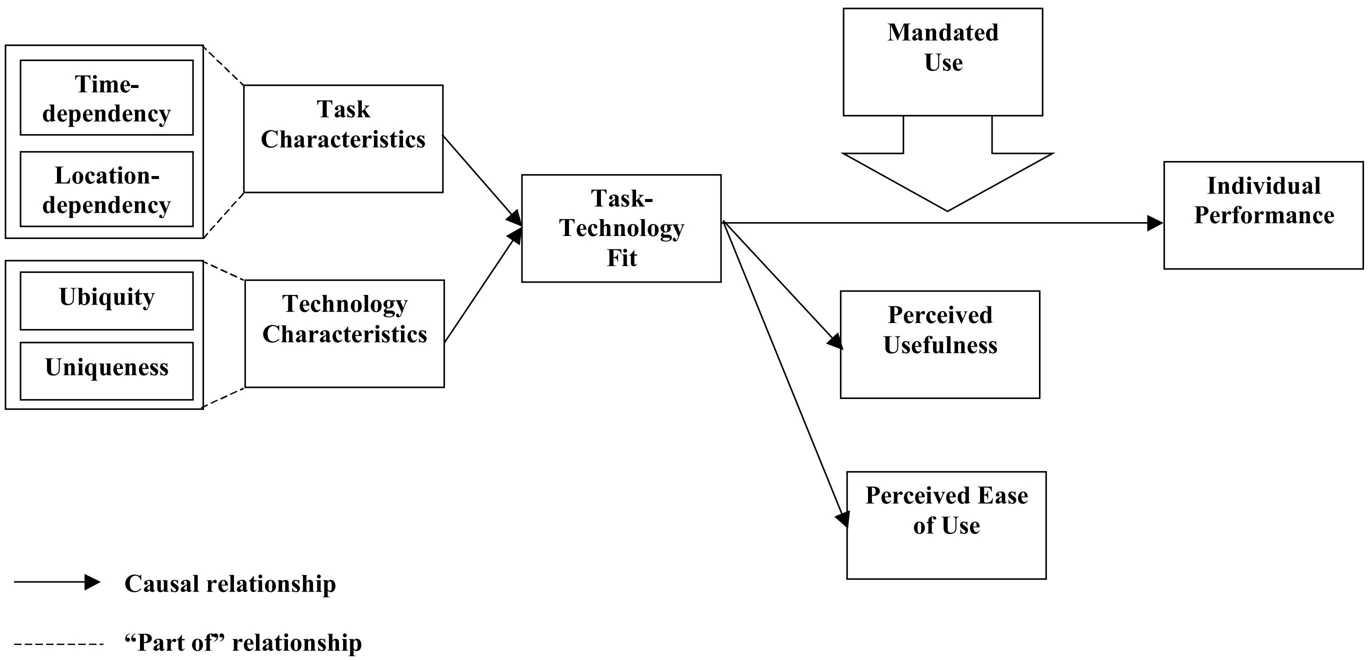


Figure 16: Research model

RESEARCH DESIGN

No research design is perfect. In fact, a *"research process can be viewed as a series of interlocking choices, in which we try simultaneously to maximize several conflicting desiderata […] [i.e., a research process is] a set of dilemmas to be lived with and a series of choices as an attempt to keep from becoming impaled on one or another horn of one or more of these dilemmas* (McGrath, 1982)." Therefore, the various approaches must be weighed against research objectives to determine the appropriate strategy. The following table summarizes the research design choices made for the purpose of this dissertation. Each of these is explained in detail in the following.

Table 12: Summary of the research design choices

Purpose of research	Explanation
Mode of observation	Laboratory experiment
Level of analysis	Individual level
Time dimension	Cross-sectional

Purpose of Research

Research is conducted for exploratory, descriptive, or explanatory purposes (Babbie, 2000). Exploratory research occurs when an area of interest is relatively new and unstudied, and variables are not identified or well defined yet. Descriptive research occurs when researchers want to describe situations and events in a careful and deliberate manner (such as the U.S. Census), i.e., questions of "what, where, when, and how" are answered. The purpose of explanatory studies, in contrast, is answering the "why" question, i.e., discovering and reporting relationships among different aspects of a phenomenon of interest.

The purpose of this dissertation primarily falls into the category of explanation. Relationships between constructs are tested in a controlled environment in order to understand in which way the newly developed u-constructs contribute to the explanatory power of the overall model.

Mode of Observation

"Experimentation is a process of observation, to be carried out in a situation especially brought about for that purpose" (Kaplan, 1964). Laboratory experiments, as one particular form of experiments, allow for testing research hypotheses by providing a means for studying relationships under controlled conditions. They allow researchers to precisely manipulate an independent variable so that the effects on a dependent variable can be examined. As such, laboratory experiments are the only research method that allows one to conclude that there is a causal relationship between two variables, i.e., the law of implication is applicable only to a laboratory setting: IF *treatment T* is given to *subject S* in *environment E*, THEN *response R* occurs (or is expected to occur) (Mason, 1989). In a laboratory setting, the experimenter should and can isolate and control the influence of extraneous variables that are not relevant for the study. Furthermore, replication of the laboratory experiments is much easier than with any other research method (Benbasat, 1989). In the context of the dissertation, this can be very beneficial since it raises the opportunity to apply the same study to future wireless devices and applications. Last but not least, laboratory experiments allow creating conditions that do

not necessarily have real-life counterparts (Benbasat, 1989). Since u-commerce is a phenomenon that—due to technical reasons—has not been able to grow to its fullest extent yet, a laboratory environment is the only form capable of simulating these visionary conditions. In addition, the University of Georgia is one of the first schools in the U.S. that is able of providing the technical infrastructure for a u-commerce test-bed.

In general, laboratory experiments are characterized by the following features (Stone, 1978):

- The research takes place in an artificial setting, i.e., one created by the experimenter for the purpose of studying a phenomenon
- The researcher assigns subjects to treatment and control conditions
- The researcher manipulates one or more independent variables and assesses their impact on the dependent variables
- The experimenter has control over virtually all the independent and intervening variables that affect the dependent variables

Laboratory experiments have been used in MIS research since the early days. Based on different surveys, laboratory experiments account for 7 percent to 23 percent of research methods used in MIS, depending on the journals chosen (Farhoomand, 1987, Hamilton and Ives, 1982, Vogel and Wetherbe, 1984).

Level of Analysis

The most typical level of analysis in social research is individuals, groups, organizations, and social artifacts (Babbie, 2000). The level of analysis for the purpose of this dissertation is the individual.

Time Dimension

Research studies can occur over several periods of time (e.g., longitudinal studies) or at a single point in time (e.g., cross-sectional studies) (Babbie, 2000). Longitudinal studies are best used to examine a process and to investigate causality and changes in relationships. Longitudinal studies, however, come at high cost in terms of money, effort, and time. Cross-sectional studies collect data at one point in time across a large sample to test differences in the population. This approach has several limitations, the most important being that data are collected at one point in time. For the purpose of this dissertation, a cross-sectional approach is used because it is the most feasible in terms of resources.

CHAPTER 4 – OPERATIONALIZATION OF THE RESEARCH MODEL

Operationalization is the process of developing specific research procedures that will result in empirical observations (Babbie, 2000). Since the objective of the dissertation is to measure perceptual and performance effects of u-commerce technology, an artificial environment had to be created. Up to the point of the dissertation, no environment existed worldwide that was able to provide both, technology ubiquity and uniqueness. As such, the Terry College of Business at the University of Georgia is the first to be able to offer a ubiquitous and unique u-commerce environment for experimental research.

In the following, the design of the laboratory experiment is described in more detail. In particular, variables are categorized as dependent, independent, and mediating variables, and appropriate measurement instruments are identified.

INDEPENDENT VARIABLES

The independent variables used are (1) technology characteristics, (2) task characteristics, and (3) fit—a construct based on the previous two, reflecting the conditional relationship between technology and task.

Technology Characteristics

Technology has two components that are simulated: ubiquity and uniqueness. Both are simulated in a binary fashion, i.e., high versus low.

High technology ubiquity is simulated by providing full access to a wireless network using a PocketPC with a wireless connection card (a.k.a. Wireless Fidelity card, or WiFi card). Since the range of the wireless local network at UGA is currently limited to two buildings (i.e., Brooks Hall and Sanford Hall), full ubiquity can only be provided within this area. In contrast, *low technology ubiquity* is simulated by PocketPCs that do not provide unlimited wireless access but stationary access only. Subjects are forced to go to predefined PDA locations in order to surf the Internet. For both settings, it is important to use the same device (i.e., a PocketPC) in order to cancel out differences that may occur due to varying interfaces and response times.

High technology uniqueness is simulated by providing location-based services to individuals, whereas *low technology uniqueness* is simulated by not providing any of these features. Location-based services are defined as any kind of service that takes into account the geographic position of an individual. That includes geographic information about the individual himself (e.g., navigational services), or location information about others (e.g., services that help finding people). Location-based services in a wireless local area network environment (WLAN) were not available prior to this study. The researcher holds a provisional patent on this system (United States Patent and Trademark Office, filing number: 60/386,403).

As a result, four permutations of technology characteristics can be distinguished. Each permutation is a combination of ubiquity and uniqueness with its manifestation of high or low.

Ubiquity

		Low	High
Uniqueness	Low	**Ub-L/Un-L**	**Ub-H/Un-L**
	High	**Ub-L/Un-H**	**Ub-L/Un-H**

Legend:
Ub Ubiquity
Un Uniqueness
H High
L Low

Figure 17: Technology Characteristics Simulation

Every subject is randomly assigned to a technology treatment. The advantage of randomization is that it tends to average out between the treatments whatever systematic effects may be present, apparent or hidden, so that comparisons between treatments measure only the pure treatment effects. Thus, randomization tends to eliminate the influence of extraneous factors not under the direct control of the experimenter and thereby precludes the presence of selection bias (Neter, et al., 1996).

Task Characteristics

From a cognitive science perspective, a task is a specification of what has to be achieved – of goals – not how it is to be achieved (McClamrock, 1995). In order to create tasks for the experiment, we use the task cube developed in chapter 2, however, focusing on time-pressure and location-based tasks only. As a result, we are able to differentiate between four permutations. Each permutation is a combination of time- and localization-dependent characteristics with its manifestation of high or low. The resulting two-by-two matrix is depicted in Figure 18.

		Time-Dependency	
		Low	High
Localization-Dependency	Low	**Ti-L/Lo-L**	**Ti-H/Lo-L**
	High	**Ti-L/Lo-H**	**Ti-L/Lo-H**

Legend:

Ti	Time-dependency
Lo	Location-dependency
H	High
L	Low

Figure 18: Task Characteristics Simulation

For each quadrant of the matrix, a task is created. A set of four tasks is aggregated into one scenario. For the purpose of this dissertation, two different scenarios are built that cover two fundamental aspects of life: social and professional. Whereas the professional scenario draws the situation of an upcoming group project presentation, the social scenario comprises a winning of a three-day trip to Cancun. Both scenarios were chosen in such a way to make them most relevant to the targeted subject group of MIS seniors at the University of Georgia. As a result, the above figure yields two tasks per cell. Each cell represents what is called a "task set" in the following.

For the purpose of the dissertation, every subject is exposed to every task, i.e., a repeated measures design is chosen, which has two main advantages. First, it allows controlling for individual-level differences that may affect the within-group variance (Hair, et al., 1988). Subjects serve as their own control group (Leik, 1997), resulting in increased statistical power (Baroudi and Orlikowski, 1989) and in increased ability to detect significant statistical effects (Leik, 1997). Second, a lower number of participants is required, thus, the potential problem of the availability of subjects is partially circumvented. One major disadvantage of repeated measures is that order does have an impact on the learning effect of subjects. In order to avoid this effect, the order of tasks is randomized. More precisely, randomization is applied on multiple levels. At the aggregated level, the order of task sets is chosen randomly. Within each task set, individual tasks are also assigned in random order. The first task of a task set is issued at a random point in time, varying between 0 and 10 minutes after the last event.[25] After completion of the first task of that set, the second task of the same set is given to the subject at a random point in time, again varying between 0 and 10 minutes. After completing the second task of a task set, the subject is issued a questionnaire on perceived usefulness and ease of use, i.e., both perceptual measures are taken after every task set. Here again, the order of questionnaire items is randomized. For more detailed information on the questionnaire, see the following section. The individual scenario descriptions are given in the following.

Table 13: General scenario description

For the purpose of this research, please imagine the following situation… You are a senior in MIS at the University of Georgia, and the semester is about to finish. Luckily, you don't have any finals; you don't have any papers due. The only thing that you have left is to give a presentation tomorrow about a group project that you did in your MIST 4610 class (data management). The project developed a database for Apex Airlines' new automated luggage tracking system. You've been working on this project for the entire semester, and you've really enjoyed doing it. It involved several Apex site visits and working together with key Apex professionals. In fact, you've enjoyed the project experience so much that Apex Airlines is your top choice as an employer. You had your first interview last week, and the interviewer was very delighted with your skills. Tomorrow, some Apex representatives, among them the person that interviewed you, are coming to campus to attend your group's presentation. You're really excited and looking forward to this event. While preparing for the presentation at home, you get a phone call from Mexican Vacations Inc., informing you that you've won the grand prize in its sweepstakes. The agent tells you the prize includes a round-trip flight to Cancun leaving this Friday afternoon, a limousine to take you to and from the Cancun airport, and three nights at the five-star Wyatt Royal Resort Hotel on the waterfront. You feel that this will work out perfectly, since you'll be finished with the semester after the presentation tomorrow and you definitely can use three days of vacation as a nice treat after four years of hard work.

[25] An event can be a task completion or a questionnaire completion.

Table 14: Task scenario focusing on professional life

Scenario 1, Task 1 **Ti-H/Lo-H** **Variable Name:** **S1T1**	Goodness! You've just read through the presentation again, and you've detected approximately 10 potential misunderstandings. In order to take care of this problem, you must physically meet with your group member Amy immediately before she prints up the handouts for tomorrow's presentation. Your task is to physically go and search for her within the range of Brooks and Sanford Hall. Status: urgent.
Scenario 1, Task 2 **Ti-H/Lo-L** **Variable Name:** **S1T2**	As you've just heard from your professor via email, there is a time and room change for tomorrow's presentation. Since you had the most dealings with the people at Apex, your professor asks you to inform them about the changes by sending the following email: "*Dear Ladies and Gentlemen, there has been a time and room change for tomorrow's presentation. We will be meeting at 8:00 a.m. (an hour earlier than scheduled) in room 327, Brooks Hall. Looking forward to seeing you tomorrow.*" You happen to know that many of the Apex people involved will be leaving the office for the rest of the day, so getting your email to them before they leave is critical. Status: urgent
Scenario 1, Task 3 **Ti-L/Lo-H** **Variable Name:** **S1T3**	For tomorrow's presentation, your professor has put you in charge of getting a "Terry College of Business Marketing Brochure" in order to hand it to the Apex representatives tomorrow. The folder is available at the "Office for Terry Public Relations." You know that the "Office for Terry Public Relations" has exactly five different offices within the Terry College of Business (which spans Brooks and Sanford Hall). However, you have no idea where these offices are located, let alone what their business hours are. Thus, what you have to do now is to go and find one office (out of the five) that is currently open. Once you have found an open one, you will receive an invoice number for your brochure.
Scenario 1, Task 4 **Ti-L/Lo-L** **Variable Name:** **S1T4**	For tomorrow's presentation, you would need to check the closing stock prices of competing airlines. In particular, you need to find out the stock prices of the last two days (i.e., yesterday, and the day before) of Delta Airlines (ticker symbol: DAL).

Table 15: Task scenario focusing on social life

Scenario 2, Task 1 **Ti-H/Lo-H** **Variable Name:** **S2T1**	Because of all the excitement, you forgot to contact Mexican Vacations Inc. to ensure your participation by showing its agent your ID. You know that Mexican Vacations Inc. has just opened five new offices in the Terry College of Business (which spans Brooks and Sanford Halls). However, you don't know exactly where these offices are, let alone what their business hours are. Thus, what you have to do now is to locate one of the Mexican Vacations Inc. offices (out of the five) that is currently open and show them your ID. Subsequently, you will receive a confirmation number. **Status: very urgent**
Scenario 2, Task 2 **Ti-H/Lo-L** **Variable Name:** **S2T2**	Mexican Vacations Inc. is able to offer this promotion to one person only. However, if a friend, is willing to cover airfare expenses, Mexican Vacations Inc. will take care of any other expenses, including hotel charges, restaurant visits, and any amenities that you and your friend would like to use. Since you definitely want to bring your friend, you have to search for a flight to Cancun and make a reservation as soon as possible. As you have probably experienced in the past, the sooner you find a flight, the better the price (and your budget is tight). Here are the dates again: Leaving this Friday, returning the following Monday. Status: urgent
Scenario 2, Task 3 **Ti-L/Lo-H** **Variable Name:** **S2T3**	You've called David, another group member who had traveled to Cancun about 6 months ago, in order to ask him for his Cancun travel guide. Since he was leaving for campus anyways, he gladly offered to bring it with him. Unfortunately, both of you totally forgot to agree on a meeting location. Therefore, your task is to physically go and search for him (within the range of Brooks and Sanford Hall) in order to receive the book.
Scenario 2, Task 4 **Ti-L/Lo-L** **Variable Name:** **S2T4**	You start dreaming about your trip to Cancun, and you are wondering what the weather is. Find out about the temperature of the next few days (today, tomorrow, and the day after tomorrow) in Cancun.

Task-Technology Fit

Task-technology fit is formed out of the previous two independent variables: task and technology. As mentioned earlier, task *and* technology are fundamental in forming fit. We distinguish between three different stages of task technology fit: ideal fit, over-fit, and under-fit. Whereas ideal fit reflects the ideal mapping of ubiquity and uniqueness task requirements and technological functionality, over- and under-fit, respectively, describe a deviation from the ideal mapping. In the case of over-fitting, the technology provides more functionality than required by the task. In the case of under-fitting, a technology does not provide sufficient functionality to perform that task. For the purpose of the experiment, solely an objective fit measure is applied determined by the experimenter. Table 16 contains all feasible combinations of task and technology, varying on high and low ubiquity and uniqueness.

Table 16: Experimental task/technology combinations and their anticipated fit

Task \ Technology	**Ub-H/Un-H** (wireless card; location-based functionality)	**Ub-H/Un-L** (wireless card, but no location-based functionality)	**Ub-L/Un-H** (no wireless card, but location-based functionality)	**Ub-L/Un-L** (no wireless card; no location-based functionality)
Ti-H/Lo-H (time-critical; location-based information required) Example: Find a person immediately	Ideal fit	Under-fit	Under-fit	Under-fit
Ti-H/Lo-L (time-critical; no location-based information required) Example: Write email or book flight immediately	Over-fit	Ideal fit	Under-fit	Under-fit
Ti-L/Lo-H (not time-critical; location based-information required) Example: Find closest office that is currently open	Over-fit	Under-fit	Ideal fit	Under-fit
Ti-L/Lo-L (not time-critical; no location-based information required) Example: Find specific information	Over-fit	Over-fit	Over-fit	Ideal fit

Legend:

Ub-L	Low ubiquity	**Ti-L**	Low time-dependency
Ub-H	High ubiquity	**Ti-H**	High time-dependency
Un-L	Low uniqueness	**Lo-L**	Low location-dependency
Un-H	High uniqueness	**Lo-H**	High location-dependency

DEPENDENT VARIABLES

Three dependent variables are used: (1) perceived usefulness, (2) perceived ease of use, and (3) individual task performance.

Perceived Usefulness

Perceived usefulness is defined as *"perceptions of the degree to which using a particular system will improve her/his performance"* (Davis, 1996). The items used to measure perceived usefulness are adopted from (Davis, et al., 1989) with the appropriate modifications to make them specifically relevant to u-commerce. Subjects are asked to indicate the extent of agreement with the four statements concerning mobile computing on a seven-point Likert-type scale ranging from "strongly agree" to "strongly disagree" (see Table 18). For the purpose of the experiment, usefulness measures are taken before the experiment and after each task category is finished. Whereas the pre-experimental measures are very general in nature, the measures taken during the experiment are task specific.

As can be seen later, measures of perceived usefulness are mixed with measures of perceived ease of use. Two sequences of questionnaires are developed that are presented to every subject on a random basis.

Table 17: Measures of perceived usefulness

Instrument	Questionnaire Items
Original measures used by Davis et al. (1989) on a scale from 1 to 7	Using WriteOne would improve my performance in the MBA program Using WriteOne in the MBA program would increase my productivity Using WriteOne would enhance my effectiveness in the MBA program I would find WriteOne useful in the MBA program
Measures used by Venkatesh and Davis (1996) on a scale from 1 to 7	Using WordPerfect would improve my performance in my degree program Using WordPerfect in my degree program would increase my productivity Using WordPerfect would enhance my effectiveness in the degree program I find WordPerfect would be useful in my degree program
Measures used by Venkatesh and Davis (2000) on a scale from 1 to 7	Using the system improves my performance in the job Using the system in my job increases productivity Using the system enhances my effectiveness in my job I find the system to be useful in my job

Table 18: Measures of usefulness in u-commerce

	Questionnaire Item	Scale	Variable Name
Pre-experimental	Using a PDA improves my performance	7-point Likert	AU1
	Using a PDA increases my productivity	7-point Likert	AU2
	Using a PDA enhances my effectiveness	7-point Likert	AU3
	I find a PDA useful	7-point Likert	AU4
Post-experimental	Using a PDA improves my performance for tasks similar to those two I have just completed	7-point Likert	BU1
	Using a PDA increases my productivity for tasks similar to those two I have just completed	7-point Likert	BU2
	Using a PDA enhances my effectiveness for tasks similar to those two I have just completed	7-point Likert	BU3
	I find a PDA useful for tasks similar to those two I have just completed	7-point Likert	BU4

Perceived Ease of Use

Perceived ease of use is defined as the *"degree to which an individual believes that using a particular system would be free of effort"* (Davis, 1989). As (Davis, 1989) suggests, perceived ease of use not only influences the intention to use, but also can also be viewed as an antecedent to perceived usefulness of an information system.

The items used to measure perceived ease of use are adopted from (Davis, et al., 1989) with the appropriate modifications to make them specifically relevant to u-commerce. Subjects are asked to indicate the extent of agreement with the four statements concerning u-commerce on a seven-point Likert-type scale ranging from "strongly agree" to "strongly disagree." Table 20 describes the measures used. Like usefulness measures, ease of use measures are recorded before the experiment as well as during the experiment.

As mentioned before, measures of ease of use are mixed with the measures of perceived usefulness. Two different sets of sequences are issued to the every subject on a random basis.

Table 19: Measures of perceived ease of use

Instrument	Questionnaire Items
Original measures used by Davis et al. (1989) on a scale from 1 to 7	Learning to operate WriteOne would be easy for me I would find it easy to get WriteOne to doe what I want it to do It would be easy for me to become skillful at using WriteOne I would find Write One easy to use
Measures used by Venkatesh and Davis (1996) on a scale from 1 to 7	My interaction with WordPerfect is clear and understandable Interacting with WordPerfect does not require a lot of my mental effort I find WordPerfect would be easy to use

	I would find it easy to get WordPerfect to do what I want it to do My interaction with the computer is clear and understandable Interacting with a computer does not require a lot of my mental effort I find a computer would be easy to use I would find it easy to get a computer to do what I want it to do
Measures used by Venkatesh and Davis (2000) on a scale from 1 to 7	My interaction with the system is clear and understandable Interacting with the system does not require a lot of my mental effort I find the system to be easy to use I find it easy to get the system to do what I want it to do

Table 20: Measures of perceived ease of use in u-commerce

	Questionnaire Item	**Scale**	**Variable Name**
Pre-experimental	My interaction with the PDA is clear and understandable	7-point Likert	AEOU1
	Interacting with the PDA does not require a lot of personal mental effort by me.	7-point Likert	AEOU2
	I find the PDA to be easy to use	7-point Likert	AEOU3
	I find it easy to get the PDA to do what I want it to do	7-point Likert	AEOU4
Post-experimental	My interaction with the PDA is clear and understandable for tasks similar to those two I have just completed	7-point Likert	BEOU1
	Interacting with the PDA does not require a lot of personal mental effort by me for tasks similar to those two I have just completed	7-point Likert	BEOU2
	I find the PDA to be easy to use for tasks similar to those two I have just completed	7-point Likert	BEOU3
	I find it easy to get the PDA to do what I want it to do for tasks similar to those two I have just completed	7-point Likert	BEOU4

Individual Task Performance

Individual task performance covers aspects of effectiveness as well as efficiency (Keen and Morton, 1978), and is measured by three indicators: (1) time-to-start, (2) time-to-completion, and (3) answer correctness. All of these are now explained in more detail.

Time-To-Completion (TTC) and Time-To-Start (TTS)

Time-to-start and time-to-completion required a series of three time measurements. First, a timestamp was recorded whenever a task was issued to a subject (t(issue)). Second, a timestamp was recorded whenever a subject started working on a task (t(start)), i.e., whenever the subject read through the task description for the first time. Third, a timestamp was set whenever a subject submitted an answer (t(end)). In parallel, for every timestamp the relevant location was recorded, i.e., the location of the subject when the task was issued to him (l(issue)), when he read through the task description for the first time (l(start)), and when he answered the task (l(end)). Additionally, for every subject the relevant target location (i.e., the location he was supposed to find, or the location of the person he was supposed to find) was recorded.

As a result, time-to-start is calculated as the difference between t(start)-t(issue), and time-to-completion as the difference between t(end)-t(start). The following figure graphically displays the time measures taken.

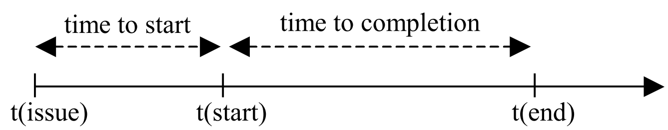


Figure 19: Time measures

As one fundamental outcome of the pre-test, a subjective interruption measure was added. As the pilot showed, some subjects of the treatment groups with wireless technology were interrupted when performing a task. Subjects were mainly approached from outsiders who wondered about the kind of technology. As such, in order to enhance validity of the performance measures, an additional subjective measure that captured the reason and the estimated length of the interruption was added. The questions were posed to the subject after every task and are shown in the Table 21. For every task, time-to-completion measures were corrected by interruption measures.

Table 21: Interruption measures

Questionnaire Item	Scale	Variable Name
Were you interrupted?	Categorical (Yes/No)	I1
If yes, by what?	Categorical	I2
If yes, can you also estimate the time?	Ratio	I3

Answer Correctness (AC)

Answer correctness was measured on a binary scale: either the task was solved correctly, or it was not. An exemplary answer and scaling scheme is given below (Table 22). Reference answers were changed every week in order to increase research validity and to avoid learning effects.

Table 22: Accuracy evaluation scheme

Scenario, Task	**Exemplary answers**	**Scale**
S1T1	amy-apexpres-v3.ppt	Categorical: correct, incorrect
S1T2	Dear Ladies and Gentlemen, there has been a time and room change for tomorrow's presentation. We will be meeting at 8:00 a.m. (an hour earlier than scheduled) in room 327, Brooks Hall. Looking forward to seeing you tomorrow.	Categorical: correct, incorrect
S1T3	1-23-2-833-1	Categorical: correct, incorrect
S1T4	Two-part-answer: 11.93, 11.5	Categorical: correct, incorrect
S2T1	1-78-3-903-1	Categorical: correct, incorrect
S2T2	Junglas, Iris, ijunglas@uga.edu	Categorical: correct, incorrect
S2T3	0-8053-7565-1	Categorical: correct, incorrect
S2T4	Three-part answer: 90, 92, 88	Categorical: correct, incorrect

Typographical mistakes were considered to be correct answers since the objective of the experiment was not to measure editing abilities of the subjects. In contrast, solutions providing only partially correct answers, such as in the cases of tasks S1T4 and S2T4, were considered to be wrong answers.

CONTROL VARIABLES

There is only one controlled variable: use, which is defined as the actual usage of the information system by an individual (Davis, 1986). Since information system usage is mandated in the context of this dissertation, use measures have only a crosscheck character. Usage data was recorded in form of a log file that tracked which Web sites subjects went to while waiting for the next task to arrive.

OTHER VARIABLES

Beyond dependent, independent and controlled variables, additional variables were recorded. In general, one can distinguish between pre-experimental and post-experimental measures.

Pre-experimental measures comprise (1) demographic data, (2) the level of subject motivation, and (3) subject experience with technology in general. Post-experimental measures include (4) perceived enjoyment, and (5) experimental manipulation checks.

Demographic Measures

Demographic measures included gender, age, major field of study, and their year of study. Table 23 lists the questionnaire items used.

Table 23: Pre-experimental measures on demographics

Variable	Questionnaire Item	Scale	Variable Name
—Gender	What is your gender?	Categorical (male/female)	DG
—Age	What is your age?	Ratio	DA
—Major	What is your major?	Categorical	DMA
—Year	What year of school are you in?	Categorical (freshman, sophomore, junior, senior, graduate, other)	DY

Motivational Measures

Subjects were also asked to rate their level of motivation at the beginning of the experiment. Motivation was measured on a 7-point Likert scale, ranging from extremely high to extremely low. Table 24 lists the questionnaire item used.

Table 24: Pre-experimental measure on motivation

Questionnaire Item	Scale	Variable Name
I rate my motivation for participating in this research study as X	7-point Likert	MO

Experience Measures

Subjects were also asked to rate their level of experience with the Internet and computers in general as well as with PDAs and cellular phones in particular. Experience was measured on a 4-point Likert scale, including extensive, moderate, little, nonexistent as selectable attributes. The according questionnaire items are listed in Table 25.

Table 25: Pre-experimental measure on experience

Questionnaire Item	Scale	Variable Name
I rate my experience with the Internet as X	4-point Likert	EX1
I rate my experience with computers in general as X	4-point Likert	EX2
I rate my experience with PDAs as X	4-point Likert	EX3
I rate my experience with cellular phones as X	4-point Likert	EX4

Perceived Enjoyment

The construct of perceived enjoyment is incorporated into our study based on our findings from pre-testing the experiment. Theoretically, the construct of perceived enjoyment is embedded in the more general construct of intrinsic motivation. Intrinsic motivation refers to perceptions of pleasure and satisfaction from performing the behavior for no apparent reinforcement other than the process of performing the behavior per se (Davis, et al., 1992, Venkatesh, 2000). As such, perceived playfulness is defined as the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use (Davis, et al., 1992).

The items used to measure perceived enjoyment are adopted from (Davis, et al., 1992) with the appropriate modifications to make them specifically relevant to the context. Subjects are asked to indicate the extent of agreement with the three statements on a seven-point Likert-type scale ranging from “strongly agree” to “strongly disagree.” Table 26 describes the measures used. Measures of perceived enjoyment were taken for every subject after completion of all tasks.

Table 26: Post-experimental measure on perceived enjoyment

Questionnaire Item	Scale	Variable Name
I had fun interacting with the PDA	7-point Likert	J1
Using a PDA provided me with a lot of enjoyment	7-point Likert	J2
I enjoyed using a PDA	7-point Likert	J3

Manipulation Checks

In addition to the aforementioned variables, manipulation checks are issued to each subject, using questionnaire items on ubiquity and uniqueness on a 7-point Likert scale. Manipulation checks are designed to test that subjects in fact perceive differences in different treatments. As such, manipulation checks support the validity of the study. The following table gives an overview on the items asked.

Table 27: Manipulation checks

U-Construct	Questionnaire Item	Variable Name
Ubiquity	I felt that I could access needed information at any time during the day	UB1
	I felt that I could access needed information from any location (within the scope of the wireless local area network) during the day	UB2
	I felt that I could be reached at any time during the day	UB3
	I felt that I could be reached at any location (within the scope of the wireless local area network) during the day	UB4

Uniqueness	I felt that I received individually tailored information that supported my overall task accomplishment	UN1
	I felt that I received individually tailored information	UN2
	I felt that I received location-based information	UN3
	I felt that I received location-based information that supported my overall task accomplishment	UN4

RESEARCH HYPOTHESES

Based on the research model shown in Figure 16 and the propositions stated, the following clusters of hypotheses can be formed: hypotheses about time-to-completion (PERFa), time-to-start (PERFb), and answer correctness (PERFc) constituting performance measures; and hypotheses about perceived usefulness (USE) and ease of use (EOU). For that, we use the notion of fit as operationalized in Table 16.

HPERF1a: An ideal fit between technology and task will lead to a lower time-to-completion than over-fit.

HPERF2a: An ideal fit between technology and task will lead to a lower time-to-completion than under-fit.

HPERF3a: An over-fit between technology and task will lead to a lower time-to-completion than under-fit.

HPERF1b: An ideal fit between technology and task will lead to a lower time-to-start than over-fit.

HPERF2b: An ideal fit between technology and task will lead to a lower time-to-start than under-fit.

HPERF3b: An over-fit between technology and task will lead to a lower time-to-start than under-fit.

HPERF1c: *An ideal fit between technology and task will lead to higher answer correctness than over-fit.*

HPERF2c: *An ideal fit between technology and task will lead to higher answer correctness than under-fit.*

HPERF3c: *An over-fit between technology and task will lead to higher answer correctness than under-fit.*

HUSE1: *An ideal fit between technology and task will lead to higher perceptions of usefulness than over-fit.*

HUSE2: *An ideal fit between technology and task will lead to higher perceptions of usefulness than under-fit.*

HUSE3: *An over-fit between technology and task will lead to higher perceptions of usefulness than under-fit.*

HEOU1: *An ideal fit between technology and task will lead to higher perceptions of ease of use than over-fit.*

HEOU2: *An ideal fit between technology and task will lead to higher perceptions of ease of use than under-fit.*

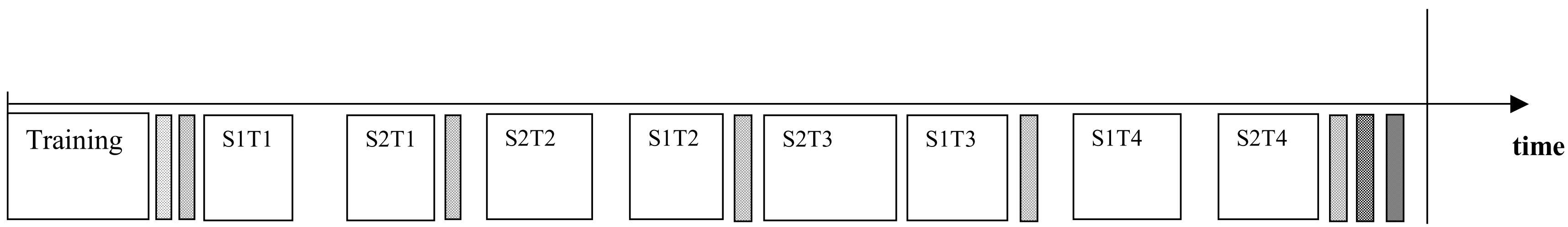
HEOU3: *An over-fit between technology and task will lead to higher perceptions of ease of use than under-fit.*

EXPERIMENTAL PROCEDURE—A TIME PERSPECTIVE

This section describes the procedures followed to complete the laboratory experiment from a time perspective. The experimental procedure consists of the following steps:

1. Every subject is issued a PDA and randomly assigned to a technology treatment group. After that, every subject undergoes a PDA training session that last for half an hour. The training session also includes a registration process. Here subjects are asked to provide information regarding their demographics, technology experience, and motivation for participation.
2. Every subject is asked to fill out a pre-experimental online questionnaire, testing for perceptions of usefulness and ease of use regarding PDAs in general.
3. Every subject is given an online scenario description. After that, every subject has to undergo four task categories with two tasks each. After each task category, an online questionnaire on perceived usefulness and ease of use is issued. In order to perform a total of eight tasks, one and a half hours of time are allotted.
4. After completion of all eight tasks, each subject is asked to fill out an online questionnaire on perceived enjoyment and manipulation checks.

A graphical overview of the experimental procedure is given in Figure 20.



Legend

SxTy Scenario x, Task y

Scenario description

Measuring ease of use and usefulness

Measuring perceived enjoyment

Manipulation checks

Figure 20: Experimental procedure time chart (exemplary for one subject)

SUBJECT SAMPLING & INCENTIVE SCHEME

Sampling is concerned with drawing entities or individuals from a population in such a way as to permit generalization about the phenomenon of interest to a larger population (Pinsonneault and Kraemer, 1993).

For the purpose of the dissertation, undergraduate MIS students from the University of Georgia are chosen. The advantages of using student subjects are twofold. First, they are available in sufficient numbers to provide adequate statistical power. Second, students are relatively homogeneous in terms of their age, business experience, intelligence, and knowledge. This homogeneity reduces variance in performance measures, and consequently increases statistical power of the results.

Students were given extra course credit. Every student that made it to the top 50% of his treatment group had the chance to participate in a drawing that provided 10 monetary prizes of $30 each.

Subjects were randomly assigned to technology treatment groups. Randomization tends to average out between the treatments whatever systematic effects may present, apparent or hidden, so that comparisons between treatments measure only the pure treatment effects. Thus, randomization tends to eliminate the influence of extraneous factors not under the direct control of the experimenter and thereby precludes the presence of selection bias (Neter, et al., 1996).

TECHNICAL IMPLEMENTATION OF THE EXPERIMENT

The technical implementation of the experimental set-up required the following components:

- Wireless local area network (WLAN)

  For the purpose of this research, a WLAN spanning the 3rd floor of Brooks Hall and entire Sanford Hall (see also Figure 21) was installed, yielding a total of nine wireless access points. The total territorial size of the experimental zone was calculated at 80,525 square feet (= 7,481 square meters) (Table 28).

- End-user devices

  12 PocketPCs (here: Compaq IPAQ 3870) were provided by the New Media Institute (NMI) of the University of Georgia (UGA) as mobile handheld devices, running Windows CE.

- Middleware components

  Multiple network functions had to be installed on the Terry College LAN (UNIX environment) in order to enable, manage and supervise wireless applications—in particular, location-based services. Up to the point of the experiment, location-based functionality existed only in a WAN environment. In order to implement this functionality into a LAN environment, a cell-based localization scheme was applied. Every cell (represented by an access point) was configured to recognize a mobile device entering or leaving its wireless range. Whenever such an event occurred, this piece of information was sent to a central database. As a result, the database provided an up-to-date status of all existing "device-access point" connections. Retrieving location information about oneself or others simply required querying the database based on the person information. The technology is provisionally patented with the United States Patent and Trademark Office (Application Number: 60/386,403).

- Database component

  A MySQL database was created in order to capture and store subject, questionnaire, and connection information as well as log files. This was necessary in order to allow for simulating location-based services in a LAN environment.

- User applications

  For every task, an application was developed. Application development was done using PHP scripting language. A listing of all the files can be found in appendix D. A complete listing of the source code is available as a separate document.

Figure 21: Terry College of Business campus map

Table 28: Territory size of the "experimental zone"

		Width in meters (in feet)	Length in meters (in feet)	Number of floors	m^2 (square feet)
Sanford Hall	Overall	21.34 (70)	56.39 (185)	3	3,609.28 (38,850)
	Used	21.34 (70)	56.39 (185)	3	3,609.28 (38,850)
Brooks Hall	Overall	70.1 (230)	68.58 (225)	5	24,038.7 (258,750)
	Used	70.1 (230)	44.2 (145)	1	3,098.32 (33,350)
Distance between buildings		13.72 (45)	44.2 (145)		
"Experimental zone"					7,481.02 (80,525)

PRE-TESTING THE EXPERIMENT

When conducting an experiment, the procedures and instruments used should be pre-tested to reduce potential problems. The pre-test for this research involved piloting the experiment with subjects drawn from the same population as those to be used in the actual experiment. A total of 26 subjects participated in pre-testing.

In particular, the researcher was interested in solving the following issues: (1) working out details of administering the experiment, (2) checking for equivocal task descriptions, (3) checking for equivocal questionnaire descriptions, and (4) checking for technical obstacles.

Administering the Experiment

Piloting was very important to get the experimental routine set up in a timely and coordinated fashion. Only minor wording changes were made to the hand out material.

Modifying Task Descriptions

The task descriptions were well understood by the subjects. Only minor changes were made in their wording.

Modifying Questionnaire Descriptions

In general, the questionnaire descriptions of the two measures, usefulness and perceived ease of use, were well understood by the subjects. However, two modifications were necessary. First, a short comment had to be inserted at the beginning of each perceptual questionnaire, stating that subjects are supposed to answer the following questions based on only the two previous tasks. For that, the two last tasks were explicitly mentioned by name. Second, a short comment had to be inserted at the beginning of the pre-experimental questionnaire as well. Some of the subjects remarked that they had never worked with a PDA and as such were not able to answer perceptual questions about PDA usage. For that case, a short comment on the pre-experimental questionnaire requested subjects to enter their "general" PDA perceptions. Other minor changes included the wording of the manipulation checks.

Eliminating Technical Obstacles

Technical obstacles occurred many-fold. First, the existing wireless network at the Terry College of Business needed major modifications. Access points were re-arranged in order to provide a seamless wireless cloud throughout the 3rd floor of Brooks Hall and the entire Sanford Hall. Also, signal strength adjustments had to be made for every wireless access point.

Second, the addressing scheme of the LANs at the Terry College had to be modified. Initially, two logical networks existed at Brooks and Sanford Hall which caused subjects to re-eject their wireless card every time they switched buildings. The addressing scheme was changed so that both networks form one logical network across the two buildings.

Third, when performing tasks such as finding the current weather information or stock quotes, all of the participants issued complaints. Subjects were requested to use public Web sites in order to answer the questions at hand. Since the majority of the public Web sites do not comply PDA screen formats, time-to-completion varied extraordinarily. Custom-made Web sites were implemented instead.

IRB Approval

The study has been approved by the Institutional Review Board (IRB) at the University of Georgia (DHHS Assurance ID No: M1047, Project Number: H2002-10821-3). The consent form is listed in appendix D.

Reliability and Validity Issues

In order to achieve high level of rigor, before as well as during the study the researcher has to make sure that reliability and validity issues are addressed in an appropriate way.

Reliability

Reliability describes "*whether a particular technique, applied repeatedly to the same object, would yield the same result each time*" (Babbie, 2000). I.e., a subject's score on a measure (such as a questionnaire item or a scale of items designed to measure a single latent variable) yields the same result each time the measure is applied.

In mathematical terms, a subject's score is a function of the subject's true score and some random error. As such, reliability (or its square root) is the estimate of the correlation between a subject's true score on a measure and the score that was actually observed.

The most commonly accepted measure for reliability is Cronbach's Alpha (Bollen and Long, 1993, Cronbach, 1951). This measure is based on comparing all possible ways of splitting a set of items into half and measuring the correlation between each (Peter, 1979). Alpha values of 0.7 or more are acceptable (Hair, et al., 1988, Nunnally, 1994), however, values of 0.8 or better are preferable. As can be seen in Table 29, all measures are above 0.8—except one pre-experimental measure (ease of use) that yields a value of 0.77.

Table 29: Cronbach's Alpha

Measure	Alpha	N
Pre-experimental perceived usefulness	0.8702	117
Pre-experimental perceived ease of use	0.7741	117
Perceived usefulness of task set 1	0.9565	116
Perceived usefulness of task set 2	0.9449	115
Perceived usefulness of task set 3	0.9622	115
Perceived usefulness of task set 4	0.9267	117
Perceived ease of use of task set 1	0.8339	117
Perceived ease of use of task set 2	0.9066	116
Perceived ease of use of task set 3	0.8352	115
Perceived ease of use of task set 4	0.8990	117
Perceived enjoyment	0.8491	117
Manipulation check on ubiquity	0.9414	117
Manipulation check on uniqueness	0.8066	117

Validity

"*Validity and invaldity […] refer to the best available approximation to the truth or falsify of propositions*" (Cook and Campbell, 1979).

Construct Validity

Construct validity is the extent to which a measure *"adequately reflects the real meaning of the concept under consideration"* (Babbie, 2000), i.e., the instrument *"validly measures what it purports to measure"* (Nunnally, 1994, Peter, 1981), i.e., whether the measures chosen are true constructs describing the event or merely artifacts of the methodology itself (Campbell and Fiske, 1959, Cronbach and Meehl, 1955).

Construct validity cannot be measured directly but can only be inferred (Peter, 1981). A single study does not establish construct validity; it's rather an ever-extending process of investigation and development (Peter, 1981). As such, in order to establish construct validity, different facets must be demonstrated, including convergent, discriminant, content, internal, and external validity. All of these complement each other in practice.

Content Validity

Content validity refers to the extent to which the items of an instrument represent all aspects of variable of interest (Babbie, 2000), i.e., it addresses the representativeness and comprehensiveness of the items used in the measurement.

A thorough review of past literature, the use of validated instruments, interviews with IS practitioners as well as feedback from IS experts were used to establish content validity.

Discriminant and Convergent Validity

Discriminant validity is the extent to which the measure is indeed novel and not simply a reflection of some other variable, i.e., the extent to which a concept differs from other concepts (Bagozzi, 1978). Scales that correlate too highly may be measuring the same rather than different constructs (Churchill, 1979).

Convergent validity is the degree to which two attempts to measure the same concept through maximally different methods are convergent (Bagozzi, 1978). Evidence of convergent validity of the measure is provided by the extent to which it correlates highly with other methods designed to measure the same construct (Churchill, 1979).

In order to establish discriminant and convergent validity, existing measurements are used. These measures comprise the TAM and TTF model and have been validated over a long time in different settings, such as in (Adams, et al., 1992, Davis, 1989; 1993, Davis, et al., 1989, Dishaw, 1999, Goodhue and Thompson, 1995, Goodhue, 1997, Goodhue, et al., 2001, Mathieson, 1991, Plouffe, et al., 2001, Taylor, 1995, Venkatesh, 2000).

Internal Validity

Internal validity addresses the question of whether the data collected are sufficient to rule out alternative explanations, i.e., "*whether the observed effects could have been caused by or correlated with a set of unhypothesized and/or unmeasured variables*" (Cronbach and Meehl, 1955), i.e., the researcher's conclusion that the relationship between independent and dependent variables is causal or that the absence of such a relationship implies lack of causality (Cook and Campbell, 1979).

High internal validity is one of the major advantages of laboratory experiments (Benbasat, 1989). Compared to other research methods, laboratory experiments are the only methods that allow one to conclude that there is a causal relationship between two variables, i.e., the experimenter is able to isolate and control the influence of extraneous variables that are not relevant for the study (Mason, 1989). In order to increase the level of internal validity of the current study, the experimenter applied multiple techniques: (1) treatments were assigned randomly, (2) the experimental tasks were designed to make them relevant to the subject, (3) the experimental tasks were issued in random order to the subjects, (4) the order of the questionnaire items was randomized, (5) subjects were asked not to share any information about the experiment with others; in addition answers were changed on a weekly basis, (6) for every subject, the level of motivation was recorded prior to the study, (7) a pre-test was conducted and findings were implemented into the experimental process accordingly (i.e. interruption measures), and (8) manipulation checks were performed.

External Validity

External validity refers to the extent to which "*we can infer that the presumed causal relationship can be generalized to and across alternate measures of the cause and effect and across different types of persons, settings, and times*" (Cook and Campbell, 1979).

Due to the nature of the research method, a dilemma between internal and external validity arises (McGrath, 1982). Since experimental methods allow for a high internal validity, establishing external validity, by default, is limited (Benbasat, 1989). However, in order to support external validity, choosing a sample population that reflects the general population, is essential. Subjects participating in the study fit demographic characteristics of general Internet, computer, cellular, and PDA users as shown below (IDC, 2001a).

Table 30: Comparison of user demographics (adopted from (IDC, 2001a))

	The "average" user ((IDC, 2001a))	**The "experimental" user**
Question	For each of the following products and services, please state if your household currently has and uses it on a regular basis.	Please state if you have moderate or intensive experience with one of the following.
Cellular service for home or business	96.2%	88.8%
Home computer	82.8%	96.6%
Internet service	72.3%	99.2%
Personal digital assistant	12.0%	18%

In addition, the experimental set-up was chosen in such a way that it provided the most realistic environment possible. Experimental tasks were drawn from personal and professional life scenarios of a senior MIS student. As a result, subjects were able to easily identify themselves with the task at hand.

CHAPTER 5 – DATA COLLECTION AND ANALYSIS

The following chapter is divided into two parts: First, we briefly describe different data analysis techniques used for the purpose of the dissertation. Second, the data analysis is conducted. For that, hypotheses (as stated on page 88) are tested statistically, and then post-hoc analyses of data related to the hypothesis' dependent variable are performed.

DATA ANALYSIS TECHNIQUES

Data analysis was performed using two statistical packages: JMP for Macintosh and SPSS for Windows Version 11.0.

Descriptive Statistics

Descriptive statistics (i.e., means, standard deviations, frequencies, etc.) are useful in providing an overview and a preliminary understanding of the sample responses under examination. In particular, identification of data entry mistakes and possible outliers are made easily. Out of the entire data set, three outliers were deleted: (subject 68, task S1T2), (subject 69, task S2T4), and (subject 29, task S2T2). All of them had in common that subjects encountered severe technical problems during the session.

ANOVA and MANOVA

ANOVA (Analysis of Variance) is a statistical technique used to determine whether samples from two or more groups come from populations with equal means. Whereas ANOVA employs one dependent measure, MANOVA (Multivariate Analysis of Variance) compares samples based on two or more dependent variables (Hair, et al., 1988). In ANOVA and MANOVA respectively, two independent estimates of the variance for the dependent variable are compared (Hair, et al., 1988):

- Within-groups estimate of variance (mean square within groups): This is an estimate of the average random respondent variability on the dependent variable within a treatment group and is based on deviations of individual scores from their respective group means.
- Between-groups estimate of variance (mean square between groups): This is an estimate of the variability of the treatment group means on the dependent variable. It is based on deviations of group means from the overall grand mean of all scores.

Assumptions in ANOVA and MANOVA

- Independence of observations

  Standard ANOVA and MANOVA procedures assume independence among groups of respondents. If this assumption is not met, e.g., a subject is measured twice under different treatment conditions, a repeated measures design has to be used and analyzed accordingly.
- Homogeneity of variance and covariance matrix

  Standard ANOVA procedures assume that variances are equal for all treatment groups. Fortunately, a violation of this assumption has minimal impact if the groups are approximately equal size (Hair, et al., 1988).[26] The most common statistical test, the *Levene test*, can be used to assess whether the variances of a single metric variable are equal across any number of groups. A non-significant Lavene test will signify that the assumption of homogeneous variances cannot be rejected. Heteroscedasticity reduces the power of ANOVA to discover significant results (Ntoumanis, 2001).

In addition to the homogeneity of variances, MANOVA procedures require the homogeneity of the covariance matrices (sphericity assumption). Here a *Box M test* is applicable. The *Box M test* is very sensitive to departures from normality (Hair, et al., 1988). Thus, it is recommended to check for univariate normality of all dependent measures first before performing a Box M test (Hair, et al., 1988).

- Normality of dependent variables

  Standard ANOVA and MANOVA procedures assume that the dependent variable is normally distributed. Multiple tests are available in order to test for non-normality. Besides graphical tests, such as histograms, boxplots, and normal probability plots, an examination of the calculated skewness and kurtosis provides evidence if the data follows a normal distribution. In addition, statistical test are available that mainly include the Kolmogorov-Smirnov test (K-S test using D statistics), and the Lilliefors test.

[26] ANOVA is relatively robust to violations of this assumption provided that the largest group variance is not more than two times greater than the smallest group variance (Ntoumanis, 2001).

    - The K-S test is a goodness of fit test for continuous data to determine if a sample comes from a given hypothesized distribution. Today it continues to be one of the best known and most widely used goodness of fit tests because of its simplicity and because it is based on the empirical distribution function (edf), which converges uniformly to the population cumulative distribution function (cdf) with probability measure one (Glivenko-Cantelli theorem).
    - The *Lilliefors test* for normality adjusts the K-S test specifically for testing for normality when the mean and variance are unknown.
- Linearity/multicollinearity among the dependent variables

  Standard ANOVA and MANOVA procedures assume a linear relationship between dependent and independent variable, i.e., values fall in a straight line by having a constant unit change (slope) of the dependent variable for a constant unit change of the independent variable. The most common way to assess linearity is to examine scatterplots of variables and to identify nonlinear patterns in the data.

Post-hoc Tests

Many procedures are available for further investigation of specific group mean differences of interest. They are generally intended to be used only if the overall F of the ANOVA is significant. One of the most common procedures that do not require equal sample size is the *Bonferroni Inequality Test* that adjusts the selected α level to control for the overall Type I error rate. The procedure involves (1) computing the adjusted rate as α divided by the number of statistical tests to be performed, and then (2) using the adjusted rate as the critical value in each separate test (Hair, et al., 1988).

Nonparametric Tests

Opposed to parametric tests (such as regression or ANOVA), nonparametric tests make limited assumptions about the underlying distributions of the data. If the data at hand do not meet the basic assumptions of parametric tests, and transformations fail to produce a remedy, nonparametric methods can provide an attractive alternative (Harwell, 1988, Norušis, 2002, Ntoumanis, 2001). Besides the fact that non-parametric tests are less sensitive to the presence of outliers, they are also most appropriate when using ordinal scales (i.e., ranks rather than raw data) (Hanke and Reitsch, 1994, Ntoumanis, 2001, Siegel, 1956).

A disadvantage of nonparametric tests is that they are said to be less powerful than nonparametric tests, i.e., a false null hypothesis is more likely to be correctly rejected if a parametric test, rather than a nonparametric test is used to analyze the data. However, this statement is not always true. If the assumptions underlying parametric tests are seriously violated, nonparametric tests can be more powerful (Hanke and Reitsch, 1994, Mendenhall, et al., 1986, Siegel, 1956, Tanizaki, 1997, Vaughan, 1998). This may happen, for example, if the populations are (a) very skewed and/or (b) the sample sizes are small (Vaughan, 1998). Thus, many statisticians advocate the use of nonparametric procedures only if violations of normality are extreme.

Mann-Whitney Test (U test)

The Mann-Whitney test is the most commonly employed test for two independent samples (Ntoumanis, 2001). It tests the hypothesis that two independent groups come from populations with the same distribution. As such, the Mann-Whitney test is a non-parametric alternative to the independent-samples t test.

Kruskal-Wallis Test (H test)

When the number of independent groups is greater than 2, the Mann-Whitney test cannot be used. An appropriate nonparametric test for ranks, which is essentially an extension of the Mann-Whitney test, is the Kruskal-Wallis test (Chan and Walmsley, 1997, Vaughan, 1998). As such, the Kruskal-Wallis test is the nonparametric alternative to one-way ANOVA.

Assumptions (Daniel, 1990):

- The observations are independent both within and among samples
- The variable of interest is continuous
- The measurement scale is at least ordinal
- The populations are identical except for a possible difference in location for at least one population

WilcoxonTest

The Wilcoxon test is the most commonly employed test for two related samples, i.e., it is used when the same group of people is tested twice. As such, it's equivalent to a paired samples t test (Ntoumanis, 2001, Zimmermann, 2000).

Friedman Test

The Friedman test is an extension of the Wilcoxon test and is used when the same group of individuals is assessed more than twice (Norušis, 2002, Ntoumanis, 2001). Thus, it is the non-parametric equivalent of a two-way analysis of variance and repeated measures ANOVA, respectively.[27]

Assumptions (Daniel, 1990):

- The data consists of mutually independent samples (blocks)
- The variable of interest is continuous
- There is not interaction between blocks and treatments
- The observations within each block may be ranked in order of magnitude

Power and Effect Sizes

The power of a statistical test is defined as 1-β, with beta being the probability of falsely accepting H_0 when in fact H_1 is true. Thus, the power of a statistical test is reported only when H_0 is accepted. Effect size, in contrast, can be viewed as a distance measure between H_0 and H_1. For the purpose of the dissertation we apply the effects size index established by (Cohen, 1988; 1992) who distinguishes between "large," "medium," and "small" effect sizes which are denoted as an apostrophe “L”, “M”, and “S” in the following analyses.

Table 31: Effect sizes (adapted from (Cohen, 1988; 1992))

Effect size index	Small	Medium	Large
t test on means	.2	.5	.8
F test (ANOVA)	.1	.25	.4
χ^2 test	.1	.3	.5

ANALYSIS STRUCTURE

The structure of the data analysis is multifold. First, demographic data and manipulation checks are analyzed. Second, perceptual measures are analyzed; this includes: perceived usefulness, perceived ease of use, and perceived enjoyment. Third and last, performance is analyzed in a multivariate as well as in a univariate fashion with its three components: time-to-completion, time-to-start, and answer accuracy. For the latter part, we will not only conduct an analysis on task set level but also, even more fundamentally, on task level.

For every analysis conducted in the following, an initial analysis of the (M)ANOVA assumptions is performed. This includes Kolmogorov-Smirnov tests for normality and Levene tests for the homogeneity of variances. Depending on the outcome, a parametric or nonparametric analysis is chosen.

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[27] Repeated measures one-way ANOVA is the same as two-way ANOVA without any replicates.

Analysis of Demographics

A total of 117 MIS students participated in the experiment out of which 41.9% were female and 58.1% were male. The majority of students (88.3%) were between 19 and 23 years old (see Table 32). 83.8% were MIS students, 11% from other business-related majors (e.g., accounting, finance, etc.), 2.6% from non-business-related areas, and 2.6% were undecided in their choice of a major. Overall, 80.3% seniors participated (opposed to 14.5% sophomores, 2.6% juniors, and 2.6% graduate students) (see Table 33).

Table 32: Demographics - Distribution of ages

Age	Frequency	Percent
18	1	.9
19	14	12.0
20	5	4.3
21	26	22.2
22	46	39.3
23	17	14.5
24	1	.9
26	1	.9
27	1	.9
30	2	1.7
31	1	.9
36	1	.9
43	1	.9
Total	117	100.0

Table 33: Demographics - Distribution of majors

Major	Sophomore	Junior	Senior	Graduate	Total
MIS major	1	1	93	3	98
Business-related majors (e.g. accounting, finance, etc.)	12	0	1	0	13
Other non-business related majors	3	0	0	0	3
Undecided majors	1	2	0	0	3
Total	17	3	94	3	117

Students stated that they had experience with the Internet, computers, or cellular phones (Table 34). The majority of students (> 88%) had either moderate or intensive experience with either one of the three—with one exception: PDA experience. Here 35.9% had no experience, 46% little, 15.4% moderate, and only 2.6% intensive experience with PDAs prior to the experiment.

Table 34: Internet, computer, PDA, and cellular phone experience

Experience level	Experience Internet (in percent)	Experience computer (in percent)	Experience PDA (in percent)	Experience cellular phone (in percent)
Nonexistent	0	0	35.9	0
Little	.9	3.4	46.2	11.1
Moderate	43.6	43.6	15.4	53.8
Intensive	55.6	53.0	2.6	35.0

As the demographic data further shows, none of the students was negatively motivated to participate in the experiment; only 12% had no feelings at all. Motivational measures ranged from slightly high (26.5%), to quite high (47%), to extremely high

(14.5%). As can be seen later, these findings are also supported by the findings for perceived enjoyment. Overall, the experiment was perceived very enjoyable, irrespective of treatment groups.

Analysis of the Manipulation Checks

Manipulation checks were conducted in order to assess if subjects perceived their technology treatment as intended by the experimenter. A Kolmogorov-Smirnov test with Lilliefors significance correction shows that both manipulation checks for ubiquity (D(117) = 0.210, p = 0.000) and uniqueness (D(117) = 0.195, p = 0.000) are not normally distributed (Table 38). In addition, the assumption of homogeneity of variances does not hold either (Table 39). Since both were measured on an ordinal 7-point Likert scale, a nonparametric approach is chosen.

Table 35: Nonparametric analysis of manipulation checks

Manipulation	Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	χ^2 and p-value
Ubiquity	82.07	72.02	43.32	39.14	$\chi^2(3) = 34.628$, p = .000*
Uniqueness	82.76	51.1	65.32	36.6	$\chi^2(3) = 30.064$, p = .024*

* $p < \alpha = .05$

The Kruskal-Wallis tests in Table 35 show that subjects perceived differences in technology ubiquity ($\chi^2(3) = 34.628$, p = .000) and technology uniqueness ($\chi^2(3) = 30.064$, p = .000). In order to conduct a post-hoc analysis, six Mann-Whitney tests were performed with α adjusted accordingly for each treatment comparison (i.e., $\alpha = 0.05/6 = 0.0083$).

Table 36: Post-hoc tests on manipulation checks

Manipulation	Comparison between treatments	U test	p-value
Ubiquity	**Ub-H/Un-H and Ub-H/Un-L**	326.5	.130
	Ub-H/Un-H and Ub-L/Un-H	141.5	.000*
	Ub-H/Un-H and Ub-L/Un-L	139	.000*
	Ub-H/Un-L and Ub-L/Un-H	199	.000*
	Ub-H/Un-L and Ub-L/Un-L	185	.000*
	Ub-L/Un-H and Ub-L/Un-L	376	.369
Uniqueness	**Ub-H/Un-H and Ub-H/Un-L**	193	.000*
	Ub-H/Un-H and Ub-L/Un-H	298	.034
	Ub-H/Un-H and Ub-L/Un-L	96	.000*
	Ub-H/Un-L and Ub-L/Un-H	96	.000*
	Ub-H/Un-L and Ub-L/Un-L	314.5	.097
	Ub-L/Un-H and Ub-L/Un-L	216	.001*

* Adjusted $\alpha = .5/6 = .0083$

For both manipulations checks significant statistical differences exist between those pairs that were expected to differ, and no significant statistical differences exist between those that were not expected to differ. Hence, subjects perceived the experimental manipulations the way they were anticipated which in turn supports the validity of the experimental setup.

Table 37: Descriptive statistics of manipulation checks (mean, standard deviation, cell size)

Manipulation	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ubiquity	2.569 (.52567) (29)	2.3879 (.49365) (29)	1.4583 (1.17276) (30)	.9483 (1.65748) (29)	1.8376 (1.25573) (117)
Uniqueness	2.5603 (.39897) (29)	1.7931 (.88909) (29)	2.1 (.84995) (30)	1.2672 (1.09978) (29)	1.9316 (.96077) (117)

Table 38: Kolmogorov-Smirnov with Lilliefors significance correction of manipulation checks (D, df, p-value)

Manipulation	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ubiquity	.242 (29) .000*	.198 (29) .005*	.214 (30) .001*	.182 (29) .015	.210 (117) .000*
Uniqueness	.21 (29) .002	.101 (29) .2	.253 (30) .000*	.152 (29) .083	.195 (117) .000*

H_0: The dependent variable is normally distributed.

* $p < \alpha = .05$

Table 39: Levene statistic of manipulation checks

Manipulation		**Levene statistic**	**df1**	**df2**	**p-value**
Ubiquity	Based on Mean	17.476	3	113	.000*
	Based on Median	9.869	3	113	.000*
Uniqueness	Based on Mean	5.918	3	113	.001*
	Based on Median	4.868	3	113	.003*

H_0: The error variance of the dependent variable is equal across groups.

* $p < \alpha = .05$

Analysis of Perceived Usefulness

The results of an initial descriptive analysis on perceptions of usefulness can be found at the end of the section in Table 46. As a further statistical analysis shows, the perceptional data are not normally distributed (Table 47) and do not obey the assumptions of equality of variance (Table 48). Due to this and the fact that it is ordinal data, nonparametric tests are chosen in the following. The different levels of fit, i.e., over-, ideal and under-fit, are determined by summing all values across the relevant cells (see Table 46).

Table 40: Nonparametric analysis of perceived usefulness

Fit	N	Mean rank	χ^2 and p-value	Partial η^2
Under-fit	201	194.68	$\chi^2(2) = 28.586$, p = .000*	.062^S
Ideal fit	116	259.50		
Over-fit	146	261.53		

* $p < \alpha = .05$

A Kruskal-Wallis test, the nonparametric equivalent of ANOVA, yields a significant result (Table 40), i.e., differences in perceptions of usefulness exist between differing levels of fit. In particular, differences exist between ideal and under-fit, and over- and under-fit. Conditions of ideal and over-fit do not statistically differ (Table 41).

Table 41: Post-hoc analysis of perceived usefulness

Perceived usefulness between differing levels of fit	U test	p-value	Tested hypothesis
Ideal and over-fit	8457.500	.986	HUSE1
Ideal and under-fit	8457.000	.000*	HUSE2
Over- and under-fit	10372.000	.000*	HUSE3

* $p < \alpha = .05$

As a result, we can conclude that hypothesis USE2 ("*An ideal fit between technology and task will lead to higher perceptions of usefulness than under-fit*") and hypothesis USE3 (*"An over-fit between technology and task will lead to higher perceptions of usefulness than under-fit"*) are supported by the data whereas hypothesis USE1 (*"An ideal fit between technology and task will lead to higher perceptions of usefulness than over-fit"*) is not. Subjects seem to perceive no difference when confronted with either over- or ideal fit conditions.

In order to examine the results further, more detailed analyses are conducted in the following. In particular, we will conduct (1) individual analyses for every task set, and (2) comparisons between pre- and post-experimental measures.

(1) Analysis of Perceived Usefulness on Task Level

In order to conduct an analysis on task set level, perceived usefulness measures are calculated by averaging all usefulness items for each task set.

Table 42: Nonparametric analysis of perceived usefulness on task set level

Perceived usefulness for task set	Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	χ^2 and p-value	Partial η^2	Power
Ti-H/Lo-H (T1)	76.47	49.4	66.48	40.77	$\chi^2(3) = 20.463$ $p = .000$*	.189^S	
Ti-H/Lo-L (T2)	47.71	62.66	70.53	50.13	$\chi^2(3) = 9.396$ $p = .024$*	.083^S	
Ti-L/Lo-H (T3)	79.19	47.84	69.43	35.19	$\chi^2(3) = 32.311$ $p = .000$*	.304^L	
Ti-L/Lo-L (T4)	52.67	61.78	67.83	53.41	$\chi^2(3) = 4.228$ $p = .238$	.042	.406

* $p < \alpha = .05$

As the Kruskal-Wallis tests in Table 42 show, only Ti-L/Lo-L (T4) turns out to be insignificant. The other task sets are examined in more detail by performing six Mann-Whitney U tests.

Table 43: Post-hoc tests for perceived usefulness on task set level

Task set	Perceived usefulness between treatments	U test	p-value	Fit levels tested
Ti-H/Lo-H (T1)	**Ub-H/Un-H and Ub-H/Un-L**	224	.002*	Ideal and under-fit
	Ub-H/Un-H and Ub-L/Un-H	355.5	.211	Ideal and under-fit
	Ub-H/Un-H and Ub-L/Un-L	161	.000*	Ideal and under-fit
	Ub-H/Un-L and Ub-L/Un-H	302.5	.042*	Under- and under-fit
	Ub-H/Un-L and Ub-L/Un-L	341	.295	Under- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	233.5	.003*	Under- and under-fit
Ti-H/Lo-L (T2)	**Ub-H/Un-H and Ub-H/Un-L**	301	.060	Over- and ideal fit
	Ub-H/Un-H and Ub-L/Un-H	266	.009*	Over- and under-fit
	Ub-H/Un-H and Ub-L/Un-L	381.5	.868	Over- and under-fit
	Ub-H/Un-L and Ub-L/Un-H	362	.251	Ideal and under-fit

	Ub-H/Un-L and Ub-L/Un-L	303	.141	Ideal and under-fit
	Ub-L/Un-H and Ub-L/Un-L	271	.027	Under- and under-fit
Ti-L/Lo-H (T3)	**Ub-H/Un-H and Ub-H/Un-L**	171.5	.000*	Over- and over-fit
	Ub-H/Un-H and Ub-L/Un-H	343	.213	Over- and ideal fit
	Ub-H/Un-H and Ub-L/Un-L	118	.000*	Over- and under-fit
	Ub-H/Un-L and Ub-L/Un-H	246	.009*	Over- and ideal fit
	Ub-H/Un-L and Ub-L/Un-L	296	.074	Over- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	171.5	.000*	Ideal and under-fit

* $p < \alpha = .05$

As can be seen in Table 43, for tasks that are location-dependent (i.e., Ti-H/Lo-H (T1) and Ti-L/Lo-H (T3)), perceptions of usefulness differ across different treatment groups. In both cases where subjects had to find a person or location with or without time pressure, differences exist between the same set of groups: Ub-H/Un-H and Ub-H/Un-L, Ub-H/Un-H and Ub-L/Un-L, Ub-H/Un-L and Ub-L/Un-H, and between Ub-L/Un-H and Ub-L/Un-L. For both task sets, subjects that have ubiquitous access and location-based services perceive their technology condition to be more useful than those that have only ubiquitous access, or those that have neither one of the components. Furthermore, subjects that were only provided with location-based services but no wireless access perceived their technology more useful than those with wireless access only and those that had neither one of the functionalities.

Contrary, non-location-dependent tasks seem not to be impacted by the provided technology—with one small exception: for tasks, such as writing an email and booking a flight, a significant difference exists between Ub-H/Un-H and Ub-L/Un-H. Subject provided with wireless technology and location-based services perceived their u-commerce technology less useful for these tasks than those provided with no wireless access but location-based services. Further examining the means reveals that those provided with wireless access and location-based services perceive their technology less useful than any other group for tasks—but only for tasks that are not location-dependent. For location-dependent tasks, in contrast, the same technology treatment group ranks first regarding their means. This observation is against our expectations. At this point, we do not have a valid explanation for this finding.

Overall, it seems that tasks that are well known to subjects in a "non-u-commerce" environment do not cause major differences in usefulness perceptions. However, when subjects are confronted with location-dependent tasks, u-commerce technology causes a shift in their perceptions.

(2) Analysis of Pre- and Post-Experimental Measures of Perceived Usefulness

In order to take another perspective on the data, a different analysis is performed that compares the perceptions of usefulness for each task set with the pre-experimental measures taken before the experiment. A Friedman test, the nonparametric equivalent of a repeated ANOVA, is conducted (Table 44).

Table 44: Pre- and post-experimental comparison of perceived usefulness

Pre-experimental mean rank	**Ti-H/Lo-H (T1) mean rank**	**Ti-H/Lo-L (T2) mean rank**	**Ti-L/Lo-H (T3) mean rank**	**Ti-L/Lo-L (T4) mean rank**	**χ^2 and p-value**	**Partial η^2**	**Power**
2.15	2.97	3.34	2.96	3.58	$\chi^2(4) = 62.806$ $p = .000$*	.881[L]	

* $p < \alpha = .05$

Here a post-hoc analysis shows that differences exist across all task sets (Table 45). For all task sets, perceived usefulness is higher than stated at the beginning of the experiment, i.e., subjects perceived the technology provided during the experiment as more useful than anticipated.

Table 45: Post-hoc analysis of pre-experimental perceived usefulness

Perceived usefulness between	U test	p-value
Pre-experimental and task set Ti-H/Lo-H (T1)	-3.535	.000*
Pre-experimental and task set Ti-H/Lo-L (T2)	-5.128	.000*
Pre-experimental and task set Ti-L/Lo-H (T3)	-2.282	.022*
Pre-experimental and task set Ti-L/Lo-L (T4)	-6.642	.000*

* $p < \alpha = 0.05$

Table 46: Descriptive statistics of perceived usefulness (mean, standard deviation, cell size)

Task set	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	2.4138 (.62061) (29)	1.7143 (.97114) (28)	2.0862 (.98033) (29)	1.1827 (1.40812) (26)	1.8683 (1.10535) (112)
Ti-H/Lo-L (T2)	1.9138 (.83258) (29)	2.2411 (.85657) (28)	2.3534 (1.02102) (29)	1.8654 (1.11855) (26)	2.0982 (.97049) (112)
Ti-L/Lo-H (T3)	2.4914 (.59568) (29)	1.4554 (1.28209) (28)	2.2414 (.75144) (29)	.7404 (1.47221) (26)	1.7612 (1.25982) (112)
Ti-L/Lo-L (T4)	2.0690 (.94703) (29)	2.3571 (.64703) (28)	2.4741 (.64899) (29)	2.0385 (.97132) (26)	2.2388 (.82568) (112)
Pre-experimental	1.5086 (.61775) (29)	1.5 (.80456) (29)	1.6333 (.91617) (30)	1.5776 (.75623) (29)	1.5556 (.77412) (117)

Table 47: Kolmogorov-Smirnov with Lilliefors significance correction of perceived usefulness (D, df, p-value)

Task set	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	.276 (29) .000*	.193 (28) .009*	.224 (29) .001*	.218 (26) .003*	.217 (112) .000*
Ti-H/Lo-L (T2)	.231 (29) .000*	.226 (28) .001*	.281 (29) .000*	.202 (26) .008*	.176 (112) .000*
Ti-L/Lo-H (T3)	.217 (29) .001*	.2 (28) .005*	.188 (29) .01*	.15 (26) .137	.209 (112) .000*
Ti-L/Lo-L (T4)	.264 (29) .000*	.197 (28) .007*	.239 (29) .000*	.191 (26) .015*	.178 (112) .000*
Pre-experimental	.184 (29) .013*	.122 (28) .2	.16 (29) .055	.233 (26) .001*	.105 (112) .000*

H_0: The dependent variable is normally distributed.

* $p < \alpha = .05$

Table 48: Levene statistic of perceived usefulness

Task set		Levene statistic	df1	df2	p-value
Ti-H/Lo-H (T1)	Based on Mean	2.328	3	108	.079
	Based on Median	1.966	3	108	.123
Ti-H/Lo-L (T2)	Based on Mean	1.252	3	108	.294
	Based on Median	.655	3	108	.582
Ti-L/Lo-H (T3)	Based on Mean	5.861	3	108	.001*
	Based on Median	3.992	3	108	.010*
Ti-L/Lo-L (T4)	Based on Mean	1.709	3	108	.169
	Based on Median	1.624	3	108	.188
Pre-experimental	Based on Mean	2.691	3	108	.050*
	Based on Median	2.031	3	108	.114

H_0: The error variance of the dependent variable is equal across groups.

* $p < \alpha = .05$

Analysis of Perceived Ease of Use

The results of an initial descriptive analysis on perceptions of ease of use can be found at the end of the section in Table 55. As a further statistical analysis shows, the perceptional data are not normally distributed (Table 56) and the assumption of homogeneity is violated (Table 57). Due to this and the fact that the data are ordinal in nature make a nonparametric test most appropriate. The different levels of fit, i.e., over-, ideal and under-fit, are determined by summing all values across the relevant cells (see Table 51).

Table 49: Nonparametric analysis of perceived ease of use

Fit	N	Mean rank	χ^2 and p-value	Partial η^2
Under-fit	201	212.80	$\chi^2(2) = 8.105$, $p = .017$*	.018^S
Ideal fit	116	253.42		
Over-fit	146	241.41		

* $p < \alpha = .05$

A Kruskal-Wallis test yields a significant result (Table 49), i.e., differences in perceptions of ease of use exist between differing levels of fit. In particular, differences exist between ideal and under-fit, and over- and under-fit. Conditions of ideal and over-fit do not statistically differ (Table 50).

Table 50: Post-hoc analysis of perceived ease of use

Perceived usefulness between differing levels of fit	**U test**	**p-value**	**Tested hypothesis**
Ideal and over-fit	7989.000	.421	HEOU1
Ideal and under-fit	9652.000	.010*	HEOU2
Over- and under-fit	12820.000	.042*	HEOU3

* $p < \alpha = .05$

As a result, we can conclude that hypothesis EOU2 (*"An ideal fit between technology and task will lead to higher perceptions of ease of use than under-fit"*) and hypothesis EOU3 (*"An over-fit between technology and task will lead to higher perceptions of ease of use than under-fit"*) are supported by the data whereas hypothesis EOU1 (*"An ideal fit between technology and task will lead to higher perceptions of ease of use than over-fit"*) is not. Subjects seem to perceive no difference in their perceptions of ease of use when confronted with either over- or ideal fit conditions.

In order to examine the results further, more detailed analyses are conducted in the following. In particular, we will conduct (1) individual analyses for every task set, and (2) comparisons between pre- and post-experimental measures.

(1) Analysis of Perceived Ease of Use

In order to conduct an analysis on task set level, perceived ease of use measures are calculated by averaging all ease of use items for each task set.

Table 51: Nonparametric analysis of perceived ease of use on task set level

Perceived ease of use for task set	Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	χ^2 and p-value	Partial η^2	Power
Ti-H/Lo-H (T1)	68.21	54.02	64.48	46.68	$\chi^2(3) = 7.618$ $p = .055$	$.073^S$	.663
Ti-H/Lo-L (T2)	49.9	60.16	68.4	52.83	$\chi^2(3) = 5.555$ $p = .135$	$.056^S$	.535
Ti-L/Lo-H (T3)	73.79	49.64	68.47	39.81	$\chi^2(3) = 20.385$ $p = .000$*	$.191^S$	
Ti-L/Lo-L (T4)	53.81	62.66	61.15	58.31	$\chi^2(3) = 1.2$ $p = .753$	$.014^S$	.151

* $p < \alpha = .05$

A Kruskal-Wallis test yields a significant result for task set Ti-L/Lo-H (T3) only (Table 51). Task set Ti-H/Lo-H (T1) barely fails the significance level of $\alpha = .05$. Both task sets have in common that they encompass location-dependent tasks. In contrast, tasks such as booking a flight, writing an email, or searching for specific data (T2 and T4) do not differ at all. Subjects perceive their ease of use as equivalent across the different technology treatment groups.

A post-hoc analysis for Ti-L/Lo-H (T3) shows that subjects provided with ubiquitous access and location-based services perceive their technology easier to use than those that have only ubiquitous access, or those that have neither one of the components. Furthermore, subjects that were provided only with location-based services but no ubiquitous access perceived their technology easier to use than those with ubiquitous access only, or those that had none of the ubiquitous or unique functionalities.

Table 52: Post-hoc analysis of perceived ease of use on task set level

Task set	Perceived ease of use between treatments	U test	p-value	Fit level tested
Ti-L/Lo-H (T3)	**Ub-H/Un-H and Ub-H/Un-L**	233.5	.005*	Over- and over-fit
	Ub-H/Un-H and Ub-L/Un-H	365.5	.368	Over- and ideal fit
	Ub-H/Un-H and Ub-L/Un-L	190	.000*	Over- and under-fit
	Ub-H/Un-L and Ub-L/Un-H	261	.019*	Over- and ideal fit
	Ub-H/Un-L and Ub-L/Un-L	322.5	.18	Over- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	207	.001*	Ideal and under-fit

* $p < \alpha = .05$

We expected that the perceived ease of using a technology would change across fit levels. However, it seems that only for tasks that are location-dependent, subjects perceive differences in the ease of use. More specifically, in situations where subjects are presented with an under-fit, perceptions of ease of use seem to deflate.

(2) Analysis of Pre- and Post-Experimental Measures of Perceived Ease of Use

In order to take another perspective on the data, a different analysis is performed that compares the perceptions of ease of use for each task set with the pre-experimental perceptions before the experiment. A Friedman test, the nonparametric equivalent of a repeated ANOVA, is performed (Table 53).

Table 53: Pre-and post-experimental analysis of perceived ease of use

Pre-experimental mean rank	Ti-H/Lo-H mean rank	Ti-H/Lo-L mean rank	Ti-L/Lo-H mean rank	Ti-L/Lo-L mean rank	χ^2 and p-value	Partial η^2
1.83	3.32	3.14	3.29	3.41	$\chi^2(4) = 95.384$ p = .000*	$.849^{L}$

* $p < \alpha = .05$

Here a post-hoc analysis shows that significant differences exist across all task sets. Subjects perceived using the system easier to use than initially anticipated.

Table 54: Post-hoc analysis of pre-experimental perceived ease of use

Perceived ease of use between	U test	p-value
Pre-experimental and task set Ti-H/Lo-H (T1)	-6.632	.000*
Pre-experimental and task set Ti-H/Lo-L (T2)	-5.922	.000*
Pre-experimental and task set Ti-L/Lo-H (T3)	-5.561	.000*
Pre-experimental and task set Ti-L/Lo-L (T4)	-6.414	.000*

* $p < \alpha = .05$

Table 55: Descriptive statistics of perceived ease of use (mean, standard deviation, cell size)

Task set	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	2.4483 (.59903) (29)	2.1518 (.74641) (28)	2.3362 (.63834) (29)	1.8942 (.76542) (26)	2.2165 (.70988) (112)
Ti-H/Lo-L (T2)	1.9914 (.79474) (29)	2.1607 (.87722) (28)	2.4052 (.76594) (29)	1.9712 (1.04002) (26)	2.1362 (.87694) (112)
Ti-L/Lo-H (T3)	2.5259 (.69867) (29)	2.0089 (.81218) (28)	2.5 (.52610) (29)	1.6058 (1.02268) (26)	2.1763 (.85532) (112)
Ti-L/Lo-L (T4)	2.0517 (.98963) (29)	2.3839 (.48820) (28)	2.3793 (.58866) (29)	2.1827 (.89039) (26)	2.25 (.76891) (112)
Pre-experimental	1.6638 (.60606) (29)	1.625 (.92421) (29)	1.6724 (.76795) (30)	1.5962 (.73511) (29)	1.6406 (.75619) (117)

Table 56: Kolmogorov-Smirnov with Lilliefors significance correction of perceived ease of use (D, df. p-value)

Task set	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	.244 (29) .000*	.181 (28) .019*	.196 (29) .006*	.17 (26) .051	.16 (112) .000*
Ti-H/Lo-L (T2)	.118 (29) .2	.249 (28) .000*	.26 (29) .000*	.203 (26) .007*	.162 (112) .000*
Ti-L/Lo-H (T3)	.303 (29) .000*	.174 (28) .029*	.234 (29) .000*	.171 (26) .048*	.168 (112) .000*
Ti-L/Lo-L (T4)	.203 (29) .003*	.215 (28) .002*	.199 (29) .005*	.226 (26) .001*	.185 (112) .000*
Pre-experimental	.152 (29) .087	.2 (28) .006*	.182 (29) .015*	.198 (26) .1	.147 (112) .000*

H_0: The dependent variable is normally distributed.

* $p < \alpha = .05$

Table 57: Levene statistic of perceived ease of use

Task set		Levene statistic	df1	df2	p-value
Ti-H/Lo-H (T1)	Based on Mean	.720	3	108	.542
	Based on Median	.567	3	108	.638
Ti-H/Lo-L (T2)	Based on Mean	.261	3	108	.854
	Based on Median	.348	3	108	.791
Ti-L/Lo-H (T3)	Based on Mean	3.994	3	108	.010*
	Based on Median	2.370	3	108	.075
Ti-L/Lo-L (T4)	Based on Mean	2.296	3	108	.082
	Based on Median	2.284	3	108	.083
Pre-experimental	Based on Mean	.749	3	108	.525
	Based on Median	.418	3	108	.741

H_0: The error variance of the dependent variable is equal across groups.

* $p < \alpha = .05$

Analysis of Perceived Enjoyment

The overall perceived enjoyment variable was calculated by averaging the three individual enjoyment items (J1 to J3). The descriptive statistics can be found in Table 59. A Kolmogorov-Smirnov test of normality with Lilliefors significance correction shows that the normality assumption is not met (Table 60). Furthermore, the assumption of homogeneity is also violated (Table 61). Based on this finding and the fact that perceived enjoyment was measured on an ordinal scale, a non-parametric test is chosen.

The nonparametric equivalent of a one-way ANOVA i.e., a Kruskal-Wallis test, yields an insignificant results (χ^2 (3) = 2.861, p = 0.414). Since the p value is large, the data do not provide any reason to conclude that the overall medians differ, i.e., subjects perceived performing the tasks as very enjoyable (μ = 2.49 on a scale ranging from –3 to +3), irrespective of their technology treatment.

Table 58: Nonparametric analysis of perceived enjoyment

Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	χ^2 and p-value	Partial η^2	Power
63.62	57.14	63.70	51.38	$\chi^2(3) = 2.861$, $p = .414$	.025[S]	.255

* $p < \alpha = .05$

Table 59: Descriptive statistics of perceived enjoyment (mean, standard deviation, cell size)

Variable	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Perceived enjoyment	2.5517 (.55831) (29)	2.4598 (.55929) (29)	2.5667 (.54772) (30)	2.4023 (.49904) (29)	2.4957 (.53893) (117)

Table 60: Kolmogorov-Smirnov with Lilliefors significance correction of perceived enjoyment (D, df, p-value)

Variable	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Perceived enjoyment	.237 (29) .000*	.212 (29) .002*	.330 (30) .000*	.16 (29) .055	.223 (117) .000*

H_0: The dependent variable is normally distributed.

* $p < \alpha = .05$

Table 61: Levene statistic of perceived enjoyment

Variable		Levene Statistic	df1	df2	p-value
Perceived enjoyment	Based on Mean	.281	3	113	.839
	Based on Median	.485	3	113	.694

H_0: The error variance of the dependent variable is equal across groups.

* $p < \alpha = .05$

Summary of Findings for Perceptual Measures

The following table provides an overview of the perceptual findings in regard to the hypotheses stated.

Table 62: Summary of perceptual findings

Hypothesis	**Statistical finding**
HUSE1: An **ideal fit** between technology and task will lead to higher perceptions of **usefulness** than **over-fit**.	Not supported
HUSE2: An **ideal fit** between technology and task will lead to higher perceptions of **usefulness** than **under-fit**.	**Supported**
HUSE3: An **over-fit** between technology and task will lead to higher perceptions of **usefulness** than **under-fit**.	**Supported**
HEOU1:An **ideal fit** between technology and task will lead to higher perceptions of **ease of use** than **over-fit**.	Not supported
HEOU2:An **ideal fit** between technology and task will lead to higher perceptions of **ease of use** than **under-fit**.	**Supported**
HEOU3:An **over-fit** between technology and task will lead to higher perceptions of **ease of use** than **under-fit**.	**Supported**

We found that perceptions differ between under- and ideal fit as well as between under- and over-fit situations. No significant differences in perceptions were prevalent when subjects encountered either ideal or over-fit conditions. Here two assumptions can be made: Either ideal and over-fit conditions are indeed perceived to be the same regarding technology usefulness, or the over-fit technology provided in the experiment was insufficiently intrusive to be perceived as an over-fit. That is, its deviation from an ideal fit was too small to have caused any differences in the perceptual measures.

Multiple analyses were conducted that examined the different treatments on a task set level basis. As a result, we are able to provide a broader and more detailed analysis as well as expanding our hypotheses for specific task sets. The resulting (extended) hypotheses are stated in Table 63. Some hypothesis instances are not applicable (denoted as NA). For example, for task set 1, a comparison between ideal and over-fit is not applicable since Ti-H/Lo-H tasks only distinguish between ideal and under-fit situations (see also Table 11). In contrast, other hypothesis instances are made of two or more individual comparisons. For example, task set 2 reveals of two over-fit conditions. In order for the hypotheses involving over-fit to be supported (Table 63), all comparisons involving both over-fit conditions have to be significant (which equals a logical AND). In cases were only one but not all comparisons turn out to be significant, the hypothesis is considered to be partially supported.

Table 63: Summary of perceptual findings on task set level

Hypothesis	Extended hypothesis	Task set	Statistical finding
HUSE1	For each of the task sets, an **ideal fit** between technology and task will lead to higher perceptions of **usefulness** than **over-fit**.	Ti-H/Lo-H (T1)	NA
		Ti-H/Lo-L (T2)	Not supported
		Ti-L/Lo-H (T3)	**Partially supported**
		Ti-L/Lo-L (T4)	Not supported
HUSE2	For each of the task sets, an **ideal fit** between technology and task will lead to higher perceptions of **usefulness** than **under-fit**.	Ti-H/Lo-H (T1)	**Partially supported**
		Ti-H/Lo-L (T2)	Not supported
		Ti-L/Lo-H (T3)	**Supported**
		Ti-L/Lo-L (T4)	NA
HUSE3	For each of the task sets, an **over-fit** between technology and task will lead to higher perceptions of **usefulness** than **under-fit**.	Ti-H/Lo-H (T1)	NA
		Ti-H/Lo-L (T2)	**Partially supported**
		Ti-L/Lo-H (T3)	**Partially supported**
		Ti-L/Lo-L (T4)	NA

HEOU1	For each of the task sets, an **ideal fit** between technology and task will lead to higher perceptions of **ease of use** than **over-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported **Partially supported** No
HEOU2	For each of the task sets, an **ideal fit** between technology and task will lead to higher perceptions of **ease of use** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	Not supported Not supported **Supported** NA
HEOU3	For each of the task sets, an **over-fit** between technology and task will lead to higher perceptions of **ease of use** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported **Partially supported** NA

In summary, multiple findings can be made about the perceptual measures. First, u-commerce technology is not perceived to be different regarding its usefulness for non-location-dependent tasks. These tasks comprise activities such as writing emails, browsing the Internet to search for specific information, etc. Subjects master these tasks routinely and—as will be seen in the next section—do not differ in either time or accuracy.

Second, for tasks that are location-dependent, however, u-commerce technology is perceived to be useful. In line with this finding are market reports that identify location-based services to be the “killer application” for future wireless developments (IDC, 2000b; 2001b). By 2005, 149 million location-enabled subscribers are expected to generate revenues of 5,762 million USD in the US (IDC, 2001c).

Third, against our expectations, ease of use does not significantly differ across treatment groups that provide an over-fit or ideal fit. Neither of the treatments seems to be superior to the other. However, it seems that situations in which subjects are presented with an under-fit condition tend to devalue the perceptions of ease of use dramatically. Since the u-commerce technology provided was not harder to use, the logical explanation would be that perceptions of usefulness (which tend to be low for under-fit conditions) create a halo effect in ease of use perceptions.

Fourth, on average the perceptions of usefulness and ease of use during the experiment differed significantly from those initially anticipated. Subjects perceived the technology provided as more useful and easier to use than initially anticipated.

Fifth, even though not formally hypothesized, perceived enjoyment is on average very high ($\mu = 2.49$ on a scale from –3 to +3) and does not vary across treatments. On average, subjects perceived experiencing PDA technology as very enjoyable.

Analysis of Performance

Three measures of performance were recorded: (1) time-to-completion (TTC), (2) time-to-start (TTS), and (3) answer correctness (AC). Several steps of data preparation were necessary before a multivariate analysis could be conducted.

In the case of time-to-completion, every individual time-to-completion measure was corrected by its interruption measure first. Then, values for location-dependent tasks needed to be standardized by calculating the ratio between distance and time. The rationale behind this is that different subjects had to bridge different distances in order to accomplish a task. Therefore, the velocity (= distance/time) was calculated for task sets

T1 and T3.[28] Both modifications were made possible because the distance between target and subject location as well as the length of a potential interruption was recorded for every subject and every task. Lastly, individual z-scores were calculated.[29] In the case of time-to-completion and answer correctness only z-scores needed to be calculated.

The descriptive statistics can be found in Table 73 and Table 86; tests of normality and homogeneity of variances can be found in Table 74, Table 75, Table 87 and Table 88, respectively. The different levels of fit, i.e., over-, ideal and under-fit, are determined by summing all values across the relevant cells (see Table 16).

Due to severe violations of normality, homogeneity of variance and covariance matrices (Box's M test of .011), a nonparametric approach is chosen to conduct a multivariate analysis. Values are ranked based on their order and fed into the regular standard parametric MANOVA procedures.[30]

Table 64: Nonparametric multivariate analysis of performance

	Value	F	Hypothesis df	Error df	p-value	Partial η^2	Power
Pillai's Trace	.015	1.120	6.000	908.000	.348	.007^S	.447
Wilks' Lambda	.985	1.121	6.000	906.000	.348	.007^S	.447
Hotelling's Trace	.015	1.121	6.000	904.000	.348	.007^S	.448

[28] Other quotients are also conceivable, e.g., time/distance. For interpretation purposes, however, we have chosen velocity.

[29] For this particular analysis, we had to switch signs of the velocity measures in order to accommodate for the fact that all task sets needed to use a common scale, i.e., a scale that represents bigger values as worse performance.

As can be seen in Table 64, a nonparametric multivariate analysis yields no significant results. In addition, individual ANOVAs also show that there is no difference in performance with regard to time-to-completion, time-to-start, and answer correctness (Table 65).

Table 65: Nonparametric analysis of performance

Dependent variable	Source	Sum of squares	df	Mean square	F	p-value	Partial η^2	Power
Time-to-completion (TTC)	Model	27624.148	2	13812.074	.784	.457	$.003^S$	.184
	Error	8020823.986	455	17628.185				
	Total	8048448.134	457					
	R Squared = .003 (Adjusted R Squared = -.001)							
Time-to-start (TTS)	Model	17787.898	2	8893.949	.496	.609	$.002^S$	.131
	Error	8161010.563	455	17936.287				
	Total	8178798.461	457					
	R Squared = .002 (Adjusted R Squared = -.002)							
Answer correctness (AC)	Model	29831.379	2	14915.689	2.215	.110	$.010^S$	.452
	Error	3064332.237	455	6734.796				
	Total	3094163.616	457					
	R Squared = .017 (Adjusted R Squared = .012)							

* $p < \alpha = .05$

Based on this analysis, we can conclude that neither of the hypotheses is supported by the data. A more detailed analysis is conducted in the following. In particular, we will conduct individual analyses for time-to-completion (TTC), time-to-

[30] This equals a rankit procedure.

start (TTS), and answer correctness (AC) on an individual task set level in the following. Since each task set consists of two tasks, individual task measures needed to be aggregated in order to map our pre-defined task classification scheme. I.e., task S1T1 and S2T1 were aggregated into T1, task S1T2 and S2T2 into T2, task S1T3 and S2T3 into T3, and task S1T4 and S2T4 into T4.

Analysis of Time-To-Completion (TTC)

Four steps of data preparation were necessary before aggregating the individual tasks into task sets. First, every individual time-to-completion measure was corrected by its interruption measure. Second, in case of location-dependent tasks, individual time-to-completion needed to be standardized by calculating the ratio between distance and time (= velocity).[31] Third and fourth, individual z-scores were calculated and then added into a cumulative score for task sets T1 to T4. The descriptive statistics for task set T1 to T4 can be found in Table 73.

An initial statistical analysis of the ANOVA assumptions shows that out of the four task sets, only T1 and T3 obey normality as well as homogeneity of variances (Table 74 and Table 75). Therefore, T1 and T3 can apply a parametric analysis, whereas T2 and T4 are analyzed in a nonparametric fashion.

[31] Other quotients are also conceivable, e.g., time/distance. For interpretation purposes, however, we have chosen velocity.

Table 66: Parametric analysis of time-to-completion for task set Ti-H/Lo-H (T1) and Ti-L/Lo-H (T3)

Task set	Source	Sum of squares	df	Mean square	F	p-value	Partial η^2	Power
Time-to-completion for Ti-H/Lo-H (T1)	Between Groups	14.116	3	4.705	2.073	.108	.054^S	.518
	Within Groups	247.408	109	2.270				
	Total	261.524	112					
	R Squared = .054 (Adjusted R Squared = .0028)							
Time-to-completion for Ti-L/Lo-H (T3)	Between Groups	21.775	3	7.258	2.835	.041*	.071^S	
	Within Groups	286.735	112	2.560				
	Total	308.510	115					
	R Squared = .071 (Adjusted R Squared = .046)							

* $p < \alpha = .05$

Table 67: Nonparametric analysis of time-to-completion for task sets Ti-H/Lo-L (T2) and Ti-L/Lo-L (T4)

Time-to-completion for task set	Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	X^2 and p-value	Partial η2	Power
Ti-H/Lo-L (T2)	50.86	61.31	53.4	66.64	$\chi^2(3) = 4.023$ p = .259	.029^S	.278
Ti-L/Lo-L (T4)	63.48	55.03	57.68	55.79	$\chi^2(3) = 1.143$ p = .767	.012^S	.133

* $p < \alpha = .05$

Subjects' performances do not differ for tasks such as writing emails and booking flights under time pressure (T2), or searching for specific information (T4). All of these task sets have in common that they do not contain a location component (see Table 67).

For those tasks that do, only those where subjects were under no time pressure differ across technology treatments (i.e., T3). In particular, differences exist between those that are equipped with wireless technology and location-based services and those that do not have either one (Table 68).

Table 68: Post-hoc test for task set Ti-L/Lo-H (T3)

Task set	Time-to-completion between treatments	Bonferroni difference	p-value	Fit level tested
Ti-L/Lo-H (T3)	**Ub-H/Un-H and Ub-H/Un-L**	.9620	.144	Over- and over-fit
	Ub-H/Un-H and Ub-L/Un-H	.6693	.684	Over- and ideal fit
	Ub-H/Un-H and Ub-L/Un-L	1.1377	.047*	Over- and under-fit
	Ub-H/Un-L and Ub-L/Un-H	-.2927	1.000	Over- and ideal fit
	Ub-H/Un-L and Ub-L/Un-L	.1757	1.000	Over- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	.4684	1.000	Ideal and under-fit

* $p < \alpha = .05$

Interestingly, however, subjects with an ideal fit performed a task set that includes tasks, such as finding a person or location with no time pressure, as only second best (μ = 0.13 σ = 1.33). Best in class were those that were provide with wireless technology and location-based services (μ = .65, σ = 1.89). Third and fourth in the sequences were those with wireless but no location-based services (μ = -.19, σ = 1.66), followed by those with neither one (μ = -.43, σ = 1.46) (see Table 73).

Analysis of Time-To-Start (TTS)

Contrarily to the time-to-completion, time-to-start did not require any interruption or location standardizations. In order to aggregate time-to-start into the aggregated task sets, the two measures for every task set were averaged. The descriptive statistics can be found in Table 73. An initial statistical analysis shows that time-to-start does not obey the ANOVA assumptions of normality and homogeneity of variance (Table 74 and Table 75). Therefore, a nonparametric approach is chosen.

Table 69: Nonparametric analysis of time-to-start

Time-to-start for task set	Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	χ^2 and p-value	Partial η^2	Power
Ti-H/Lo-H (T1)	56.18	49.43	53.38	69.14	$\chi^2(3) = 5.714$ $p = .126$	.065^S	.59
Ti-H/Lo-L (T2)	59.03	59.45	55.78	61.84	$\chi^2(3) = .479$ $p = .923$	.004^S	.075
Ti-L/Lo-H (T3)	60.02	60.1	54.48	59.4	$\chi^2(3) = .559$ $p = .906$	.001^S	.054
Ti-L/Lo-L (T4)	61.64	62.67	56.48	53.21	$\chi^2(3) = 1.522$ $p = .677$	.006^S	.089

* $p < \alpha = .05$

As can be seen in Table 69, subjects do not differ across different levels of technology treatments. Against our expectations that those with ubiquitous access should be aware of a new task earlier than those without, the data show no significant differences. This effect may be an artifact caused by the experimental setup. All subjects expected tasks to arrive and, thus, checked their email frequently.

Analysis of Answer Correctness (AC)

In order to form an aggregated answer correctness measure on task set level, individual measures were averaged. A crosstabulation analysis can be found in Table 70.

Table 70: Crosstabulation of answer correctness

Task set	**Answer correctness**	**Ub-H/Un-H**	**Ub-H/Un-L**	**Ub-L/Un-H**	**Ub-L/Un-L**	**Total**
Ti-H/Lo-H (T1)	Partially	3	11	2	4	20
	Correct	25	17	27	24	93
Ti-H/Lo-L (T2)	Partially	7	2	3	2	14
	Correct	22	27	27	27	103
Ti-L/Lo-H (T3)	Partially	3	4	1	7	15
	Correct	26	25	28	22	101
Ti-L/Lo-L (T4)	Wrong		1	1	2	4
	Partially	4	4	5	2	15
	Correct	25	24	23	25	97

Since answer correctness on the task level is a dichotomous variable, aggregating this variable results into task sets results in three potential outcomes. An answer is assumed to be correct if all individual tasks were correctly answered; an answer is assumed to be wrong if both individual tasks were incorrectly answered; and an answer is assumed to be partially correct if only one of the two tasks was correctly answered. In the following, a nonparametric approach is chosen; in particular, several Kruskal-Wallis tests are performed.

Table 71: Nonparametric analysis of answer correctness

Answer correctness for task set	Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	χ^2 and p-value	Partial η^2	Power
Ti-H/Lo-H (T1)	60.95	44.8	63.1	58.93	$\chi^2(3) = 12.332$ $p = .006$*	$.105^S$	
Ti-H/Lo-L (T2)	51.88	61.97	60.15	61.97	$\chi^2(3) = 5.556$ $p = .135$	$.036^S$	.342
Ti-L/Lo-H (T3)	60	58	64	52	$\chi^2(3) = 5.693$ $p = .128$	$.062^S$	.566
Ti-L/Lo-L (T4)	60.28	58.02	56.09	59.62	$\chi^2(3) = .65$ $p = .885$	$.003^S$	.068

* $p < \alpha = .05$

As can be seen in Table 71, differences exist only for task set Ti-H/Lo-H (T1). Here a post-hoc analysis shows that significant differences exist between those that have wireless and location-based services and those that have only wireless, as well as between those that have only wireless and those that do have location-based functionality only (Table 72). As a third comparison reveals, a difference exists also between those with wireless only and those that do not have any functionalities.

Table 72: Post-hoc test of answer correctness for task set Ti-H/Lo-H (T1)

Task set	Answer correctness between treatments	U test	p-value	Fit level tested
Ti-L/Lo-H (T3)	**Ub-H/Un-H and Ub-H/Un-L**	280	.014*	Over- and over-fit
	Ub-H/Un-H and Ub-L/Un-H	390.5	.614	Over- and ideal fit
	Ub-H/Un-H and Ub-L/Un-L	378	.689	Over- and under-fit
	Ub-H/Un-L and Ub-L/Un-H	274.5	.004*	Over- and ideal fit
	Ub-H/Un-L and Ub-L/Un-L	294	.036*	Over- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	376	.368	Ideal and under-fit

* $p < \alpha = .0$

Table 73: Descriptive statistics of performance (mean, standard deviation, cell size)

Task set		Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	TTC[1*]	.2253 (1.57066) (27)	.2281 (1.72028) (28)	.1480 (1.113) (26)	-.605 (1.61528) (28)	-.0057 (1.5489) (111)
	TTS[2]	59.9259 (63.65664) (27)	47.0714 (39.76335 (28)	53.4231 (63.48034) (26)	77.9286 (69.75217) (28)	56.6972 (60.47271) (111)
Ti-H/Lo-L (T2)	TTC[1]	-.2656 (1.25789) (27)	.0836 (1.54785) (28)	-.2538 (1.25067) (26)	.5371 (1.91907) (28)	.0331 (1.53990) (111)
	TTS[2]	56.9259 (48.22717) (27)	61.5179 (48.23198) (28)	50.9615 (37.20724) (26)	58.5714 (39.18373) (28)	57.1055 (43.13362) (111)
Ti-L/Lo-H (T3)	TTC[1*]	.6547 (1.88714) (27)	-.1866 (1.66376) (28)	.1308 (1.33056) (26)	-.4302 (1.46074) (28)	.0052 (1.63789) (111)
	TTS[2]	56.0185 (47.05571) (27)	50.375 (219.98349) (28)	88.9231 (219.98349) (26)	63.4464 (84.68475) (28)	64.3257 (118.84211) (111)
Ti-L/Lo-L (T4)	TTC[1]	-.157 (.596) (27)	-.1925 (1.12682) (28)	.2949 (2.2146) (26)	.0015 (1.52106) (28)	-.0176 (1.46732) (111)
	TTS[2]	59.5 (56.49149) (27)	67.8393 (69.99405) (28)	55.3654 (51.54329) (26)	60.9286 (91.51995) (28)	61.0229 (68.71938) (111)

[1] TTC = time-to-completion = t(end)-t(start), corrected by interruption measures

[2] TTS = time-to-start = t(start)-t(issue)

* Please note that these values are velocities (= distance/time); all other time measures are measured in seconds

Table 74: Kolmogorov-Smirnov tests wit h Lilliefors significance correction of performance (D, df, p-value)

Task set		Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	TTC[1]	.083 (27) .2	.102 (28) .2	1.3 (26) .2	.208 (28) .003*	.057 (109) .2
	TTS[2]	.269 (28) .000*	.281 (28) .000*	.316 (27) .000*	.238 (28) .000*	.199 (109) .000*
Ti-H/Lo-L (T2)	TTC[1]	.167 (27) .052	.149 (28) .116	.137 (26) .2	.115 (28) .2	.12 (109) .001*
	TTS[2]	.268 (28) .000*	.212 (28) .002*	.213 (27) .003*	.142 (28) .156	.175 (109) .000*
Ti-L/Lo-H (T3)	TTC[1]	.08 (27) .2	.128 (28) .2	.104 (26) .2	.136 (28) .196	.062 (109) .2
	TTS[2]	.205 (28) .004*	.164 (28) .051	.415 (27) .000*	.356 (28) .000*	.321 (109) .000*
Ti-L/Lo-L (T4)	TTC[1]	.144 (27) .16	.185 (28) .015*	.268 (26) .000*	.25 (28) .000*	.218 (109) .000*
	TTS[2]	.205 (28) .004*	.198 (28) .006*	.24 (27) .000*	.299 (28) .000*	.203 (109) .000*

H_0: The dependent variable is normally distributed.

[1] TTC = time-to-completion = t(end)-t(start), corrected by interruption measures

[2] TTS = time-to-start = t(start)-t(issue)

* $p < \alpha = .05$

Table 75: Levene statistic of performance

Task set			Levene Statistic	df1	df2	p-value
Ti-H/Lo-H (T1)	TTC[1]	Based on Mean	1.667	3	105	.179
		Based on Median	1.523	3	105	.213
	TTS[2]	Based on Mean	1.436	3	107	.236
		Based on Median	.676	3	107	.569
Ti-H/Lo-L (T2)	TTC[1]	Based on Mean	1.841	3	105	.144
		Based on Median	1.692	3	105	.173
	TTS[2]	Based on Mean	.510	3	107	.676
		Based on Median	.437	3	107	.727
Ti-L/Lo-H (T3)	TTC[1]	Based on Mean	1.576	3	105	.2
		Based on Median	1.365	3	105	.258
	TTS[2]	Based on Mean	1.361	3	107	.259
		Based on Median	.606	3	107	.613

Ti-L/Lo-L (T4)	TTC[1]	Based on Mean	2.225	3	105	.090
		Based on Median	1.216	3	105	.308
	TTS[2]	Based on Mean	.398	3	107	.755
		Based on Median	.256	3	107	.857

H_0: The error variance of the dependent variable is equal across groups.

[1] TTC = time-to-completion = t(end)-t(start), corrected by interruption measures

[2] TTS = time-to-start = t(start)-t(issue)

* $p < \alpha = .05$

Summary of Findings for Performance Measures

The following table provides a summary of the findings of the previous section with regard to the hypotheses stated.

Table 76: Summary of performance findings

Hypothesis	**Statistical finding**
HPERF1a: An **ideal fit** between technology and task will lead to a lower **time-to-completion** than **over-fit**.	Not supported
HPERF2a: An **ideal fit** between technology and task will lead to a lower **time-to-completion** than **under-fit**.	Not supported
HPERF3a: An **over-fit** between technology and task will lead to a lower **time-to-completion** than **under-fit**.	Not supported
HPERF1b: An **ideal fit** between technology and task will lead to a lower **time-to-start** than **over-fit**.	Not supported
HPERF2b: An **ideal fit** between technology and task will lead to a lower **time-to-start** than **under-fit**.	Not supported
HPERF3b: An **over-fit** between technology and task will lead to a lower **time-to-start** than **under-fit**.	Not supported
HPERF1c: An **ideal fit** between technology and task will lead to higher **answer correctness** than **over-fit**.	Not supported
HPERF2c: An **ideal fit** between technology and task will lead to higher **answer correctness** than **under-fit**.	Not supported
HPERF3c: An **over-fit** between technology and task will lead to higher **answer correctness** than **under-fit**.	Not supported

We found that none of the stated hypotheses is supported. That is, u-commerce technology does not impact time-to-completion, time-to-start, and answer correctness. Multiple analyses were conducted that examined the different treatments on a task level basis. As a result, we are able to provide a broader and more detailed analysis as well as expanding our hypotheses for specific task sets. The resulting (extended) hypotheses are stated in Table 77. Please note that some comparisons are not applicable (denoted as NA). For example, for task set 1, a comparison between ideal and over-fit is not applicable since Ti-H/Lo-H tasks only distinguish between ideal and under-fit situations (see also Table 11). In contrast, other hypothesis instances are made of two or more individual comparisons. For example, task set 2 reveals of two over-fit conditions. In order for the hypotheses involving over-fit to be supported (Table 77), all comparisons involving both over-fit conditions have to be significant (which equals a logical AND). In cases were only one but not all comparisons turn out to be significant, the hypothesis is considered to be partially supported.

Table 77: Summary of performance findings on task set level

Hypotheses	Extended hypotheses	Task set	Statistical finding
HPERF1a	For each of the task sets, an **ideal fit** between technology and task will lead to a better **time-to-completion** than **over-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported Not supported Not supported
HPERF2a	For each of the task sets, an **ideal fit** between technology and task will lead to a better **time-to-completion** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	Not supported Not supported Not supported NA
HPERF3a	For each of the task sets, an **over-fit** between technology and task will lead to a better **time-to-completion** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported **Partially supported** NA

HPERF1b	For each of the task sets, an **ideal fit** between technology and task will lead to a better **time-to-start** than **over-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported Not supported Not supported
HPERF2b	For each of the task sets, an **ideal fit** between technology and task will lead to a better **time-to-start** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	Not supported Not supported Not supported NA
HPERF3b	For each of the task sets, an **over-fit** between technology and task will lead to a better **time-to-start** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported Not supported NA
HPERF1c	For each of the task sets, an **ideal fit** between technology and task will lead to better **answer correctness** than **over-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported **Partially supported** Not supported
HPERF2c	For each of the task sets, an **ideal fit** between technology and task will lead to better **answer correctness** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	Not supported Not supported **Supported** NA
HPERF3c	For each of the task sets, an **over-fit** between technology and task will lead to better **answer correctness** than **under-fit**.	Ti-H/Lo-H (T1) Ti-H/Lo-L (T2) Ti-L/Lo-H (T3) Ti-L/Lo-L (T4)	NA Not supported Not supported NA

In summary, multiple findings can be made about the performance measures. First, the time-to-completion for non-location-dependent tasks does not differ across technology treatments. For tasks such as writing an email, booking a flight, or searching for specific data, technology has no impact. Those tasks are performed similarly by every subject—not only in terms of their time-to-completion but also in terms of their time-to-start as well in their answer correctness.

Second, for non-time-dependent, location-dependent tasks (T3) such as finding a person or office, time-to-completion differences exist across treatment groups. Subjects that had ubiquitous access to networks in combination with location-based services were able to perform significantly faster than those equipped without these functionalities.

Third, for time- and location-dependent tasks (T1), answer correctness varies across technology treatments. Here subjects equipped with wireless access but no location-based services performed significantly worse than any other treatment group—even worse than the ones equipped with neither one of the functionalities. Some of the subject that were not equipped with location-based services tried to compensate for that handicap by running and, thus, inflating the time measures. Overall, the conclusion can be drawn that subjects provided with location-based information were able to achieve a higher quality of answer than those that had none.

Fourth, for time-dependent tasks, the time-to-start did not differ across treatments groups. Against our expectations, subjects that were equipped with wireless technology were not aware of the subsequent task earlier than others. This however might be an artifact of the experimental setup. Subjects expected a task to arrive, and thus checked their email frequently. In addition, another artifact became apparent throughout the experiment. Some of the subject that were not equipped with location-based services tried to compensate for that handicap by running and, thus, inflating the time measures. As a conclusion, the assumption can be made that time-dependency as an experimental manipulation was not effective.

In order to elaborate on the different effects, conducting a more detailed analysis for time-to-completion and answer correctness seems recommendable. Contrary to our previous examination of performance for which we aggregated tasks into task sets, we will now conduct an analysis on the individual task level (S1T1–S2T4). A brief overview of the individual tasks is listed in the following table.

Table 78: Brief task descriptions

Task Set	Task	Brief task description
T1 Ti-H/Lo-H	S1T1	Find a nominated person as soon as possible
	S2T1	Find the closest office that is currently open as soon as possible
T2 Ti-H/Lo-L	S1T2	Write an email as soon as possible
	S2T2	Book a flight as soon as possible
T3 Ti-L/Lo-H	S1T3	Find the closest office that is currently open
	S2T3	Find a nominated person
T4 Ti-L/Lo-L	S1T4	Get stock quotes
	S2T4	Get weather information

Legend:

Ub	Ubiquity
Un	Uniqueness
Ti	Time-dependency
Lo	Location-dependency
L	Low
H	High

Analysis of Time-To-Completion (TTC) – Individual Task Level

Two steps of data preparation were necessary before using individual measures of time-to-completion. First, every individual time-to-completion measure was corrected by its interruption measure. And second, in case of location-dependent tasks, individual time-to-completion needed to be standardized by calculating the ratio between distance and time. Therefore, the velocity (= distance/time) was calculated for task sets S1T1, S2T1, S1T3, and S2T3. The descriptive statistics for all tasks can be found in Table 86.

An initial statistical test shows that only task S2T1 obeys both ANOVA assumptions: normality and homogeneity of variances. All other tasks fail either one of the assumptions, or even both. As a consequence, S2T1 is analyzed in a parametric fashion, whereas tasks S1T1, S2T3, S2T1, S1T2, S2T2, S1T4, and S2T4 are analyzed using a nonparametric approach.

Table 79: Parametric analysis of time-to-completion for S2T1

Task	Source	Sum of squares	df	Mean square	F	p-value	Partial η^2	Power
S2T1	Between Groups	.562	3	.187	1.380	.253	$.036^S$	.358
	Within Groups	15.082	111	.136				
	Total	15.645	114					
	R Squared = .036 (Adjusted R Squared = .010)							

Table 80: Nonparametric analysis of time-to-completion for S1T1, S1T2, S1T3, S1T4, S2T2, S2T3, and S2T4

Time-to-completion for task	Ub-H/Un-H mean rank	Ub-H/Un-L mean rank	Ub-L/Un-H mean rank	Ub-L/Un-L mean rank	X^2 and p-value	Partial η^2	Power
S1T1	71.53	56.31	57.36	46.39	$X^2(3) = 31.44$ $p = .041$*	$.283^M$	
S1T2	57.46	58.12	57.68	60.72	$X^2(3) = .175$ $p = .982$	$.004^S$	.075
S1T3	57.71	52.14	65.07	60.88	$X^2(3) = 32.68$ $p = .000$*	$.318^M$	
S1T4	56.4	56.4	58.72	62.9	$X^2(3) = .581$ $p = .901$	$.009^S$	.108
S2T2	53.4	66.93	49.58	64.61	$X^2(3) = 5.523$ $p = .137$	$.037^S$	.35
S2T3	79.52	53.93	58.76	41.79	$X^2(3) = 21.47$ $p = .000$*	$.218^M$	
S2T4	65.79	53.9	58.25	54.07	$X^2(3) = 2.429$ $p = .488$	$.027^S$	.262

* $p < \alpha = .05$

As can be seen in Table 80, tasks S1T2, S1T4, S2T2, and S2T4 turn out to be insignificant; the same finding applies to task S2T1 as shown in Table 79. Tasks, such as writing emails (S1T2), booking flights (S2T2), or searching for specific information on the Internet (S1T4 and S2T4), can be performed with either one: with or without wireless technology, and with or without the availability of location-based services.

Out of the two tasks that required a subject to find a currently open office, only the one turned out to be significant. Whereas S2T1 (time-dependent) does not differ across treatments, S1T3 (non-time-dependent) shows obvious differences between those that were provided with location-based services and those that were not (Table 81).

Table 81: Post-hoc tests of time-to-completion for S1T3

S1T3	**Ub-H/Un-H and Ub-H/Un-L**	328	.15	Over- and over-fit
	Ub-H/Un-H and Ub-L/Un-H	134.5	.000*	Over- and ideal fit
	Ub-H/Un-H and Ub-L/Un-L	128.5	.000*	Over- and under-fit
	Ub-H/Un-L and Ub-L/Un-H	216.5	.001*	Over- and ideal fit
	Ub-H/Un-L and Ub-L/Un-L	213	.001*	Over- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	426	.891	Ideal and under-fit

In the case of the insignificant finding for S2T1, an explanation might be that the experimental setup for those tasks was not effective. It seems that the time it took to find an office by chance was not significantly different from the time it took to use the location-based services, i.e., the likelihood was too high that a subject could find an open office by random chance. In some cases, subjects were even seen running through the hallways in order to compensate for non-existing location technology.

Both tasks that comprised finding a moving person showed significant differences in their time-to-completion across treatment groups (Table 80). In the case of task S1T1 a post-hoc analysis shows that subjects that had neither one, the possibility to have ubiquitous access and location-based functionality for solving the task, differ clearly from any other treatment group. Furthermore, those with both functionalities differ also from those that only had wireless technology provided to them.

In the case of task S2T3 where subjects have both, technology ubiquity and uniqueness, the analysis shows that time-to-completion differs significantly from all other groups—most significantly, as expected, from treatment group Ub-L/Un-L.

Table 82: Post-hoc tests of time-to-completion for S1T1 and S2T3

Task	Time-to-completion between treatments	U-test	p-value	Fit level tested
S1T1	**Ub-H/Un-H and Ub-H/Un-L**	327.5	.148	Ideal and under-fit
	Ub-H/Un-H and Ub-L/Un-H	163	.000*	Ideal and under-fit
	Ub-H/Un-H and Ub-L/Un-L	88	.000*	Ideal and under-fit
	Ub-H/Un-L and Ub-L/Un-H	336	.189	Under- and under-fit
	Ub-H/Un-L and Ub-L/Un-L	210.5	.002*	Under- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	219.5	.003*	Under- and under-fit
S2T3	**Ub-H/Un-H and Ub-H/Un-L**	248	.007*	Over- and over-fit
	Ub-H/Un-H and Ub-L/Un-H	155.5	.000*	Over- and ideal fit
	Ub-H/Un-H and Ub-L/Un-L	176.5	.000*	Over- and under-fit
	Ub-H/Un-L and Ub-L/Un-H	378.5	.514	Over- and ideal fit
	Ub-H/Un-L and Ub-L/Un-L	318.5	.113	Over- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	326	.142	Ideal and under-fit

* $p < \alpha = .05$

As the descriptive statistics in Table 86 shows, the velocity of solving tasks S1T1 and S2T3 decreases along the chain “HH-LH-HL-LL”, i.e. subjects that have ubiquitous access and location-based services (Ub-H/Un-H) perform tasks, such as finding a person, most efficiently. Second in line are subjects that have location-based services but no ubiquitous access (Ub-L/Un-H). Third are those that have ubiquitous access but no location-based services (Ub-L/Un-H). And lastly, subjects that have none of the above (Ub-L/Un-L) perform this task most inefficiently.

As a conclusion, wireless technology in combination with location-based services seems to have tremendous impact on the time-to-completion. This is in accordance with our findings from the previous chapter where this kind of technology is also perceived to be the most useful.

Analysis of Answer Correctness (AC) – Individual Task Level

Answer correctness was measured as a dichotomous variable with two outcomes: correct and incorrect. The following table provides a crosstabluation analysis across the different treatment groups.

Table 83: Crosstabulation of answer correctness

Task	Answer correctness	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
S1T1	Incorrect	0	0	0	0	0
	Correct	29	29	29	28	115
S1T2	Incorrect	5	2	3	2	12
	Correct	24	27	27	27	105
S1T3	Incorrect	3	4	1	7	15
	Correct	26	25	29	22	102

S1T4	Incorrect	3	2	3	4	12
	Correct	26	27	27	25	105
S2T1	Incorrect	3	11	2	5	21
	Correct	25	17	28	24	94
S2T2	Incorrect	2	0	0	0	2
	Correct	27	29	30	29	115
S2T3	Incorrect	0	0	0	0	0
	Correct	29	29	29	29	116
S2T4	Incorrect	1	4	4	2	11
	Correct	28	25	25	27	105

In the cases of tasks S1T1 and S2T3, the outcome shows that all subjects delivered the correct answer. Subjects either found the person they were requested to, or they did not.

A nonparametric analysis of the different task set levels in Table 84 shows that answer correctness differs for task S2T1 only. S2T1 comprised a task where a person had to find a store that is currently open under no time pressure.

Table 84: Nonparametric analysis of answer correctness for individual tasks

Task set	Task	Ub-H/ Un-H mean rank	Ub-H/ Un-L mean rank	Ub-L/ Un-H mean rank	Ub-L/ Un-L mean rank	χ^2 and p-value	Partial η^2	Power
Ti-H/Lo-H	**S1T1**	58	58	58	58	$\chi^2(3) = .000$, $p = 1$		
	S2T1	62.34	45.91	64.67	58.59	$\chi^2(3) = 11.977$, $p = .007$*	$.107^S$	.853
Ti-H/Lo-L	**S1T2**	54.91	60.97	59.15	60.97	$\chi^2(3) = 2.231$, $p = .526$	$.02^S$	.201
	S2T2	55.57	60	60	60	$\chi^2(3) = 6.122$, $p = .106$	$.054^S$	.513

Ti-L/Lo-H	**S1T3**	60.45	58.43	64.55	52.38	$\chi^2(3) = 5.872$, p = .118	$.063^{S}$	.589
	S2T3	58.5	58.5	58.5	58.5	$\chi^2(3) = .000$, p = 1		
Ti-L/Lo-L	**S1T4**	58.95	60.97	59.15	56.93	$\chi^2(3) = .746$, p = .862	$.007^{S}$	.094
	S2T4	62	56	56	60	$\chi^2(3) = 2.688$, p = .442	$.013^{S}$	.138

$p < \alpha = .05$

A post-hoc analysis shows that for S2T1 differences exist between Ub-H/Un-L and Ub-L/Un-H, and Ub-H/Un-H and Ub-H/Un-L. That is, subjects that were provided with wireless technology but no location-based services delivered lower quality answers than those equipped with location-based services only or those provided with both. In summary, it became apparent that location-based services do have a positive impact on the quality of answer for location-based tasks.

Table 85: Post-hoc comparisons of answer correctness for S2T1

Task	Answer correctness between treatments	U test	p-value	Fit level tested
S2T1	**Ub-H/Un-H and Ub-H/Un-L**	280	.014*	Ideal and under-fit
	Ub-H/Un-H and Ub-L/Un-H	403	.586	Ideal and under-fit
	Ub-H/Un-H and Ub-L/Un-L	379.5	.482	Ideal and under-fit
	Ub-H/Un-L and Ub-L/Un-H	283	.003*	Under- and under-fit
	Ub-H/Un-L and Ub-L/Un-L	316.5	.066	Under- and under-fit
	Ub-L/Un-H and Ub-L/Un-L	389	.213	Under- and under-fit

* $p < \alpha = .05$

Table 86: Descriptive statistics of time-to-completion (TTC) and time-to-start (TTS) (mean, standard deviation, cell size)

Task set	Task	Variable	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	**S1T1**	TTC[1]*	.6502471 (.34471850) (27)	.5765110 (.36890094) (28)	.5046703 (.19122509) (26)	.4433965 (.17838940) (28)	.5431331 (.28854513) (109)
		TTS[2]	56.9286 (55.48902) (28)	40.6429 (37.41976) (28)	63.7778 (64.08548) (27)	46.4286 (48.28728) (28)	58.5405 (57.39794) (111)
	S2T1	TTC[1]*	.5139474 (.30749262) (27)	.5929389 (.41721360) (28)	.5413159 (.24465926) (26)	.4061558 (.20785539) (28)	.5512865 (.37044913) (109)
		TTS[2]	55.4643 (75.8866) (28)	53.5 (60.33517) (28)	89.6296 (203.67624) (27)	78.0357 (109.75410) (28)	68.973 (123.7018) (111)
Ti-H/Lo-L (T2)	**S1T2**	TTC[1]	155.96 (74.149) (27)	161.28 (81.860) (28)	173.64 (95.895) (26)	188.82 (126.454) (28)	168.78 (95.178) (109)
		TTS[2]	53.3214 (49.80484) (28)	56.9286 (55.48902) (28)	63.7778 (64.08548) (27)	46.4286 (48.28728) (28)	55.036 (54.28576) (111)
	S2T2	TTC[1]	221.96 (59.993) (27)	257.21 (95.508) (28)	211.18 (54.677) (26)	268.21 (132.788) (28)	237.93 (92.751) (109)
		TTS[2]	61.5 (71.35851) (28)	66.1071 (76.32015) (28)	47.2593 (47.75466) (27)	70.7143 (57.47647) (28)	61.5225 (64.08018) (111)
Ti-L/Lo-H (T3)	**S1T3**	TTC[1]*	.5534897 (.39921374) (27)	.4809705 (.33405317) (28)	.5675247 (.25963364) (26)	.5352389 (.31922354) (28)	.5295153 (.32662672) (109)
		TTS[2]	65.7143 (59.16321) (28)	47.8571 (57.97171) (28)	126.4074 (435.22843) (27)	69.3929 (94.08678) (28)	76.9009 (222.46867) (111)
	S2T3	TTC[1]*	.7932633 (.39479234) (27)	.5478430 (.38458195) (28)	.5413159 (.24465926) (26)	.4061558 (.20785539) (28)	.5609667 (.34573506) (109)
		TTS[2]	43.75 (54.18666) (28)	52.8929 (50.06613) (28)	45.8889 (42.50008) (27)	57.5 (82.78777) (28)	50.045 (58.95536) (111)

Ti-L/Lo-L (T4)	**S1T4**	TTC[1]	112.57 (34.676) (27)	133.69 (118.479) (28)	161.79 (217.743) (26)	125.00 (46.321) (28)	133.19 (124.601) (109)
		TTS[2]	56.9286 (56.95673) (28)	65.5357 (87.0383) (28)	57.9259 (58.93538) (27)	77.2857 (170.81284) (28)	64.4775 (103.46715) (111)
	S2T4	TTC[1]	125.18 (41.750) (27)	117.10 (41.339) (28)	129.86 (66.508) (26)	130.04 (95.412) (28)	125.73 (64.089) (109)
		TTS[2]	60.0357 (102.45197) (28)	70.1429 (103.4654) (28)	52.8148 (70.16357) (27)	44.5714 (42.60797) (28)	56.9279 (83.08514) (111)

[1] TTC = time-to-completion = t(end)-t(start), corrected by interruption measures

[2] TTS = time-to-start = t(start)-t(issue)

* Please note that these values are velocities (= distance/time); all other time measures are measured in seconds

Table 87: Kolmogorov-Smirnov tests with Lilliefors significance correction of performance (D, df, p-value)

Task set	Task	Variable	Ub-H/Un-H	Ub-H/Un-L	Ub-L/Un-H	Ub-L/Un-L	Total
Ti-H/Lo-H (T1)	**S1T1**	TTC[1]	.111 (27) .2	.189 (28) .011*	.147 (26) .151	.105 (28) .2	.074 (109) .175
		TTS[2]	.295 (27) .000*	.196 (28) .007*	.231 (26) .001*	.176 (28) .026*	.210 (111) .000*
	S2T1	TTC[1]	.129 (27) .2	.119 (28) .2	.171 (26) .05*	.175 (28) .028*	.079 (109) .089
		TTS[2]	.325 (27) .000*	.282 (28) .000*	.298 (26) .000*	.256 (28) .000*	.3(111) .000*
Ti-H/Lo-L (T2)	**S1T2**	TTC[1]	.193 (27) .011*	.25 (28) .000*	.184 (26) .024*	.223 (28) .000*	.187 (109) .000*
		TTS[2]	.246 (27) .000*	.227 (28) .001*	.23 (26) .001*	.211 (28) .003*	.191 (111) .000*
	S2T2	TTC[1]	.107 (27) .2	.179 (28) .023*	.079 (26) .2	.197 (28) .007*	.286 (109) .000*
		TTS[2]	.281 (27) .000*	.251 (28) .000*	.256 (26) .000*	.181 (28) .02*	.223(111) .000*
Ti-L/Lo-H (T3)	**S1T3**	TTC[1]	.169 (27) .046*	.166 (28) .045*	.114 (26) .2	.117 (28) .2	.087 (109) .039*
		TTS[2]	.239 (27) .000*	.239 (28) .000*	.434 (26) .000*	.304 (28) .000*	.37 (111) .000*
	S2T3	TTC[1]	.155 (27) .095	.133 (28) .2	.106 (26) .2	.094 (28) .2	.082 (109) .069
		TTS[2]	.347 (27) .000*	.28 (28) .000*	.283 (26) .000*	.323 (28) .000*	.261(111) .000*
Ti-L/Lo-L (T4)	**S1T4**	TTC[1]	.133 (27) .2	.322 (28) .000*	.334 (26) .000*	.206 (28) .004*	.286 (109) .000*
		TTS[2]	.196 (27) .009*	.249 (28) .000*	.234 (26) .001*	.398 (28) .000*	.279 (111) .000*
	S2T4	TTC[1]	.127 (27) .2	.104 (28) .2	.231 (26) .001*	.306 (28) .000*	.193 (109) .000*
		TTS[2]	.298 (27) .000*	.261 (28) .000*	.316 (26) .000*	.196 (28) .007*	.254 (111) .000*

H_0: The dependent variable is normally distributed.

[1] TTC = time-to-completion = t(end)-t(start), corrected by interruption measures

[2] TTS = time-to-start = t(start)-t(issue)

* $p < \alpha = .05$

Table 88: Levene statistic of performance

Task set	Task	Variable		Levene statistic	df1	df2	p-value
Ti-H/Lo-H (T1)	**S1T1**	TTC[1]	Based on Mean	7.149	3	105	.000*
			Based on Median	4.980	3	105	.003*
		TTS[2]	Based on Mean	3.865	3	105	.011*
			Based on Median	2.011	3	105	.117
	S2T1	TTC[1]	Based on Mean	1.136	3	105	.338
			Based on Median	.921	3	105	.434
		TTS[2]	Based on Mean	.784	3	105	.505
			Based on Median	.539	3	105	.656
Ti-H/Lo-L (T2)	**S1T2**	TTC[1]	Based on Mean	2.210	3	109	.091
			Based on Median	1.113	3	109	.347
		TTS[2]	Based on Mean	.508	3	105	.678
			Based on Median	.191	3	105	.903
	S2T2	TTC[1]	Based on Mean	3.266	3	109	.024*
			Based on Median	1.727	3	109	.166
		TTS[2]	Based on Mean	1.495	3	105	.220
			Based on Median	.649	3	105	.586
Ti-L/Lo-H (T3)	**S1T3**	TTC[1]	Based on Mean	2.000	3	105	.119
			Based on Median	1.132	3	105	.340
		TTS[2]	Based on Mean	2.363	3	105	.075
			Based on Median	.675	3	105	.570

	S2T3	TTC[1]	Based on Mean	3.987	3	105	.010*
			Based on Median	3.245	3	105	.025*
		TTS[2]	Based on Mean	.296	3	105	.828
			Based on Median	.166	3	105	.919
Ti-L/Lo-L (T4)	**S1T4**	TTC[1]	Based on Mean	2.334	3	109	.078
			Based on Median	1.191	3	109	.317
		TTS[2]	Based on Mean	1.011	3	105	.391
			Based on Median	.214	3	105	.886
	S2T4	TTC[1]	Based on Mean	.494	3	109	.687
			Based on Median	.212	3	109	.888
		TTS[2]	Based on Mean	1.245	3	105	.297
			Based on Median	.466	3	105	.707

H_0: The error variance of the dependent variable is equal across groups.

[1] TTC = time-to-completion = t(end)-t(start), corrected by interruption measures

[2] TTS = time-to-start = t(start)-t(issue)

* $p < \alpha = .05$

Summary of Findings for Performance Measures

In order to achieve better insights into the different tasks, we conducted multiple analyses on individual task level basis. As a result, we are able to provide a broader and more detailed analysis as well as expanding our hypotheses for single tasks. The resulting (extended) hypotheses are stated in Table 89. Please note that some comparisons are not applicable (denoted as NA). For example, for task set 1, a comparison between ideal and over-fit is not applicable since Ti-H/Lo-H tasks only distinguish between ideal and under-fit situations (see also Table 11). In contrast, other hypothesis instances are made of two or more individual comparisons. For example, task set 2 reveals of two over-fit conditions. In order for the hypotheses involving over-fit to be supported (Table 89), all comparisons involving both over-fit conditions have to be significant (which equals a logical AND). In cases were only one but not all comparisons turn out to be significant, the hypothesis is considered to be partially supported.

Also note that time-to-start (equaled hypotheses B in the set of hypotheses) is not part of this overview. Due to the previous analysis, we did not expect any significant findings for time-to-start when analyzed on a more detailed level.

Table 89: Summary of performance findings on task level

Hypothesis	Extended hypothesis	Task set	Statistical finding
HPERF1a	For each task, an **ideal fit** between technology and task will lead to a better **time-to-completion** than **over-fit**.	Ti-H/Lo-H (S1T1)	NA
		Ti-H/Lo-H (S2T1)	NA
		Ti-H/Lo-L (S1T2)	Not supported
		Ti-H/Lo-L (S2T2)	Not supported
		Ti-L/Lo-H (S1T3)	**Supported**
		Ti-L/Lo-H (S2T3)	**Partially supported**
		Ti-L/Lo-L (S1T4)	Not supported
		Ti-L/Lo-L (S2T4)	Not supported
HPERF2a	For each task, an **ideal fit** between technology and task will lead to a better **time-to-completion** than **under-fit**.	Ti-H/Lo-H (S1T1)	**Partially supported**
		Ti-H/Lo-H (S2T1)	Not supported
		Ti-H/Lo-L (S1T2)	Not supported
		Ti-H/Lo-L (S2T2)	Not supported
		Ti-L/Lo-H (S1T3)	Not supported
		Ti-L/Lo-H (S2T3)	Not supported
		Ti-L/Lo-L (S1T4)	NA
		Ti-L/Lo-L (S2T4)	NA
HPERF3a	For each task, an **over-fit** between technology and task will lead to a better **time-to-completion** than **under-fit**.	Ti-H/Lo-H (S1T1)	NA
		Ti-H/Lo-H (S2T1)	NA
		Ti-H/Lo-L (S1T2)	Not supported
		Ti-H/Lo-L (S2T2)	Not supported
		Ti-L/Lo-H (S1T3)	**Supported**
		Ti-L/Lo-H (S2T3)	**Partially supported**
		Ti-L/Lo-L (S1T4)	NA
		Ti-L/Lo-L (S2T4)	NA
HPERF1c	For each task, an **ideal fit** between technology and task will lead to better **answer correctness** than **over-fit**.	Ti-H/Lo-H (S1T1)	NA
		Ti-H/Lo-H (S2T1)	NA
		Ti-H/Lo-L (S1T2)	Not supported
		Ti-H/Lo-L (S2T2)	Not supported
		Ti-L/Lo-H (S1T3)	Not supported
		Ti-L/Lo-H (S2T3)	Not supported
		Ti-L/Lo-L (S1T4)	Not supported
		Ti-L/Lo-L (S2T4)	Not supported

HPERF2c	For each task, an **ideal fit** between technology and task will lead to better **answer correctness** than **under-fit**.	Ti-H/Lo-H (S1T1) Ti-H/Lo-H (S2T1) Ti-H/Lo-L (S1T2) Ti-H/Lo-L (S2T2) Ti-L/Lo-H (S1T3) Ti-L/Lo-H (S2T3) Ti-L/Lo-L (S1T4) Ti-L/Lo-L (S2T4)	Not supported **Partially supported** Not supported Not supported Not supported Not supported NA NA
HPERF3c	For each of the task sets, an **over-fit** between technology and task will lead to better **answer correctness** than **under-fit**.	Ti-H/Lo-H (S1T1) Ti-H/Lo-H (S2T1) Ti-H/Lo-L (S1T2) Ti-H/Lo-L (S2T2) Ti-L/Lo-H (S1T3) Ti-L/Lo-H (S2T3) Ti-L/Lo-L (S1T4) Ti-L/Lo-L (S2T4)	NA NA Not supported Not supported Not supported Not supported NA NA

In summary, multiple findings can be made about the performance analysis on individual task level. First, one particular location-dependent task species turns out to be significant regarding its time-to-completion, namely the task species where subjects had to find a dedicated moving person. Since the time-dependency manipulation was not effective, we are able to make generalizations about both tasks—even though they stem from different task sets. As a conclusion, we can infer that for tasks such as finding a dedicated moving person wireless technology in combination with location-based services leads to a significant performance impact (regarding their time-to-completion).

Second, the other location-dependent task species, namely finding a currently open office, showed only partial differences in their time-to-completion. In the case of the time-independent task version, clear performance differences exist between those that were equipped with location-based services and those that were not; in the case of the time-dependent version of the task, differences were not apparent. One explanation could be that the time it took to find one of the five offices by chance equaled the time it took using location-based services. Some of the subjects even ran through the hallways in order to compensate for the non-existing location application. As a recommendation, future research has to make sure to modify this task species in choosing a lower ratio of the number of offices compared to the size of the experimental zone.

Third, for one particular location-dependent task, namely the one that showed no significance in its time-to-completion, the quality of answer differed across treatments. Answer correctness turned out to be significantly better for those that were equipped with location-based services versus those that had no access to any of these.

Fourth, as expected, for non-location-dependent tasks, such as such as writing an email, booking a flight, or searching for specific data, subjects do not differ across technology treatments. Those tasks were performed similarly by every subject in terms of their time-to-completion and their answer correctness.

CHAPTER 6 – CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH

CONCLUSIONS

U-commerce extends traditional commerce (geographic, electronic, and mobile) to a world of ubiquitous networks and universal devices, a world in which users can access networks at any time from any place, using a range of devices to invoke unique and personalized services. As such, u-commerce presents a new perspective on time and space. Specifically, four constructs were identified that form the fundamental dimensions of u-commerce: ubiquity, uniqueness, universality, and unison. This dissertation undertook an experimental investigation to examine how two of these u-constructs (ubiquity and uniqueness) impact individual task performance, perceptions of usefulness and ease of use across differing levels of technology fit. Multiple conclusions can be drawn from the study.

First, u-commerce technology is not perceived to be different regarding its usefulness for non-location-dependent tasks. These tasks comprise tasks such as writing emails, browsing the Internet to search for specific information, etc. Subjects master these tasks routinely and do not differ in either time or accuracy.

Second, wireless technology is perceived to be very useful for location-dependent tasks. In line with this finding are market reports that identify location-based services to be the "killer application" for future wireless developments (IDC, 2000b; 2001b). By

2005 149 million location-enabled subscribers are expected to generate revenues of 5,762 million USD in the US (IDC, 2001c).

Third, against our expectations, ease of use does not significantly differ across treatment groups that provide an over-fit or ideal fit. Neither of the treatments seems to be superior to the other. However, it seems that situations in which subjects are presented with an under-fit condition tend to devalue the perceptions of ease of use dramatically. Since the u-commerce technology provided was not harder to use, the logical explanation would be that perceptions of usefulness (which tend to be low for under-fit conditions) create a halo effect in ease of use perceptions.

Fourth, on average the perceptions of usefulness and ease of use during the experiment differed significantly from those initially anticipated. Subjects perceived the technology provided as more useful and easier to use than initially anticipated.

Fifth, even though not formally hypothesized, perceived enjoyment is on average very high and does not vary across treatments. On average, subjects perceived experiencing PDA technology as very enjoyable.

Sixth, for non-location-dependent tasks, such as such as writing an email, booking a flight, or searching for specific data, u-commerce technology did not make a difference. These tasks were performed equally by every subject in terms of their time-to-completion, time-to-start, and their answer correctness irrespective of the technology treatment.

Seventh, for tasks, such as finding a dedicated moving person, the analysis showed that wireless technology in combination with location-based services lead to reductions in the time-to-completion.

Eighth, since the manipulation of tasks where subjects had to find a currently open office was only partially effective, conclusions are rather equivocal. The time-independent version of the task showed statistical differences in its time-to-completion but not in its answer correctness; in contrast, the time-dependent version of the task showed statistical differences in its answer correctness but not in its time-to-completion. In both cases, answer correctness and time-to-completion were better for those that were equipped with location-based services versus those that had none. Overall the conclusion can be made that technology uniqueness causes a positive shift—either in time or quality of a task.

CONTRIBUTIONS

This dissertation is among the first to explore the terra incognita of u-commerce. Up to now, the majority of the attention has focused on e-commerce. In contrast, m-commerce has been relatively neglected. There are a growing number of publications on m-commerce sometimes labeled as research. Most of this work would be better called market studies or benchmarks (e.g., (Durlacher, 1999), (Lehman Brothers, 2000), and others), highlighting different aspects such as the number of prospective consumers, the estimated market volume, usage behavior, etc. Many of the remaining publications are rather technically oriented (e.g., (WAP Forum, 2000), (ETSI, 2001), etc.). All of them have in common that they praise location-based services as the "killer application" in m-commerce (IDC, 2000b; 2001b). None of the reports, however, approaches these statements in a scientific and rigorous way.

For IS scholars the u-constructs will force them to rethink and revisit the fundamentals of IS. Revalidating major IS theories will be essential because these were developed during the era of mainframe or end-user PC where an information system was viewed as a processing unit that transformed data and instructions into reports while operating in an centralized fashion, used for organizational purposes only. Here the u-constructs make two contributions.

First, they allow for formation of a new classification scheme for information systems. For each of the u-constructs, a dimension can be created along which information systems are able to advance. Some technologies provide high levels of one characteristic and low levels of others. The ultimate vision is to create an information system that is strong on all four dimensions. Current information systems, in contrast, can often be viewed as one particular manifestation or instantiation of the four dimensions.

Second, the idea of the u-constructs can also be used to develop a new task taxonomy. Since task and technology form an iterative cycle, it becomes more and more vivid that a task classification scheme is needed that abstracts from the geographical position of a user and his technology.

In combination, the u-constructs make a valuable contribution to enhance the explanatory and predictive power of the Task-technology Fit model (TTF by (Goodhue and Thompson, 1995)). U-constructs serve as antecedents not only to understand and explain technology characteristics but also task characteristics. An integrated model, the Technology Impact Model (TIM), is formed by drawing upon TTF by (Goodhue and Thompson, 1995), TAM by (Davis, et al., 1989), and its combined version by (Dishaw, 1999).

For IS practitioners, the same considerations apply. As mobile penetration increases and applications become more sophisticated, the transformation of the mobile phone into a fully integrated data, communications and commerce tool seems inevitable. As such, the u-constructs not only provide a means to understand the potential of future “u-technologies” but also are able to serve as an instrument for identifying u-commerce needs and evaluating potential business benefits.

Finally, another practical outcome of the dissertation is the development of software for location-based services for LAN settings, which has been provisionally patented (United States Patent and Trademark Office, filing number: 60/386,403). Existing localization technologies can be clustered into network-based and handset-based solutions (IDC, 2001c). Network-based solutions (such as Angle of Arrival (AOA), Time Difference of Arrival (TDOA)) enable positioning to be determined through modifications made to the underlying network. They typically use sophisticated triangulation techniques to determine the location of a wireless device. Handset-based solutions (such as the Global positioning System (GPS)) make use of satellite technology and require hardware modifications of the handset, which in turn are typically associated with high cost. Both streams of localization techniques have in common that they were invented for wireless wide area networks (WAN) only. WANs are characterized by low transmission rates that are not able to provide the transmission capabilities necessary for m-commerce applications to take effect. Third generation technologies (3G), for instance, are able to provide transmission rates at a maximum of 2Mbps (see also Appendix A). Furthermore, the frequency spectrum of WANs is regulated by the Federal Communications Commission (FCC).

Wireless local area networks (LAN), in contrast, are able to provide reasonable transmission rates (up to 54 Mbps) and are not regulated. However, one major drawback—at least up to the point of this dissertation—is that they are lacking location-based abilities. The following table classifies existing localization techniques and puts the software of the dissertation into perspective.

Table 90: Overview of localization techniques

Localization techniques	**WAN** "spans large areas" "low transmission rates" "regulated"	**LAN** "spans small areas" "high transmission rates" "not regulated"
Handset-based solutions "high cost"	GPS	None (since GPS is not applicable within a building)
Network-based solutions "low cost"	Cell-Sector Identification, Time Difference of Arrival, Angle of Arrival, RF Fingerprinting	Dissertation Experiment

LIMITATIONS AND RECOMMENDATIONS

The following section analyses weaknesses of the research and tries to find solutions to solve them for future research.

Limitation #1: Time-dependency manipulation was not effective.

As shown in the data analysis, subjects did not perform differently when exposed to time-pressuring versus non-time-pressuring tasks. Subjects expected a task to arrive and checked their email frequently. In addition, some of the subjects that were not equipped with location-based services tried to overcome this handicap by running and, thus, increasing the variability of time measures. From these observations, the assumption can be made that time-dependency was not effective in the experimental setup.

Recommendation #1:

Two recommendations can be made. First, future data analyses may want to collapse time-dependent and non-time-dependent tasks into one group. That is, the four tasks sets are reduced to two sets only, namely to location-dependent and location-independent task sets only that abstract from any time pressure.

Second, future research should extend the duration of the experiment. Instead of providing subjects with u-technology for only two to three hours, researchers may want to consider giving out PDAs for an entire day or even longer. Not only would this be a better u-technology usage simulation since it would be embedded in a user's daily routine but would also contribute to the external validity of the study. In the case of the current study, the researcher was limited by the battery lifetime span of two to three hours per device.

Limitation #2: The task "Searching for an office currently open" was not effective.

As mentioned in the data analysis section, one particular location-dependent task species, namely finding an office currently open, was not effective. It became apparent that the time it took to find one of the five offices by chance was similar to the time it took using location-based services. Some of the subjects even ran through the hallways in order to compensate for their lack of a location application.

Recommendation #2:

Future research using the same experimental setup is required to choose a lower quotient of offices to square feet. In our case, we have chosen five offices on an experimental zone of 80,525 square feet. At any point in time, on average 2.5 offices were concurrently open. Keeping the likelihood at a .5 level, we recommend that future research choose an effective area of more than 16,105 square feet per office.

Limitation #3: The fit construct needs to be researched in more detail.

Fit plays a very important role in mediating the effects of the task and technology Task-technology fit is defined as the extent to which technology functionality matches task requirements. Two fit conceptualizations exist: a subjective and an objective conceptualization of fit.[32] Whereas subjective fit is measured through the eyes of the user, objective fit is determined through system developers. In the context of the dissertation, we have chosen an objective fit measure and have distinguished between three manifestations: ideal fit, over-fit and under-fit. Here two questions arise.

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[32] The objective form of fit is sometimes referred to as "engineering fit" (Nance and Straub, 1996) whereas the subjective form of fit is called "tool fit" (Davern, 1996).

First, what exactly is the degree of performance impact of over-fit? One stream of research states that technology over-fit leads to better performance since people can explore things and find new ways of solving tasks and, thus, be more efficient (Griffin, 1991). Another stream of research, however, claims that technology over-fit reduces performance because users are either too overwhelmed with features and functionalities, or are too distracted by the same so that the task at hand suffers severe losses (Ackerman and Cianciolo, 2002, Klein, et al., 1999).

Second, even when able to answer the first question, a second question remains unsolved: What determines if a task/technology combination is considered to be an over-fit? Are there different levels of deviations from the ideal fit? In the context of the dissertation, the researcher has determined the levels of fit. However, a constitutive assumption that the u-technology provided indeed resulted into an over-fit situation cannot be made. It might be that the over-fit technology provided in the experiment was too small in effect size to be considered as an over-fit. That is, its deviation from an ideal fit was too small as that it could have caused any differences in performance measures. An alternative approach considers two kinds of over-fit as conceivable: an interfering and non-interfering over-fit. Whereas interfering over-fit distracts a user by overwhelming him with lots of functionalities while performing a task, non-interfering over-fit shows no impact at all. In an extreme case of non-interfering over-fit, a user would not even be aware that additional functionalities are present.

Recommendation #3:

Besides applying an objective fit measure, using a subjective fit measure in addition is recommended. Beyond that, the only recommendation that can be made is to explore the fit construct in a more rigorous way in future research. Unfortunately, there has been limited progress in defining precisely what fit is and how to measure it (Goodhue, et al., 2001).

Limitation #4: Generalizability of the research.

As mentioned earlier, research is subject to the universal dilemma faced by all social sciences. It must try to reconcile three mutually conflicting objectives (McGrath, 1982):

- Generalizability with respect to populations (external validity goal)
- Precision in control and measurement of variables (internal validity goal)
- Study the phenomenon of concern in a realistic setting (realism problem)

"There is no way […] to maximize all three conflicting desiderata of the research strategy domain" (McGrath, 1982). When conducting an experiment, a particular dilemma arises between internal and external validity (McGrath, 1982). Since experimental methods allow for a high internal validity, establishing external validity, by default, is limited (Benbasat, 1989).

However, in order to support external validity, choosing a sample population that reflects the general population, was essential. Subjects participating in the study fit demographic characteristics of general Internet, computer, cellular, and PDA users. In addition, the experimental set-up was chosen in such a way that it provided the most realistic environment possible. Experimental tasks were drawn from personal and professional life scenarios of a senior MIS student. As a result, subjects were able to easily identify themselves with the task at hand.

FUTURE RESEARCH

Organizations have recognized the importance of wireless technology for their businesses. For the year 2000, market studies calculated that the worldwide demand for mobile e-commerce services (that includes consulting, implementation, support, and operations) created 1.4 billion USD in revenues (IDC, 2000b). By 2005, the worldwide revenue stream is expected to grow up to 39.7 billion USD with a projected forecast of \$16.4 billion for the U.S. (IDC, 2001d). As a result, one future stream of research should be directed towards an examination of u-technology in an organizational context. Currently, a study is conducted at the University of Georgia that examines the effectiveness and efficiency gains of wireless technology in a medical environment using a grounded theory approach (Abraham, 2003).

By enabling geographic determination of devices, a whole host of new services and revenue opportunities arise for businesses. Current enterprise adoption is relatively low, partly due to the fact that location-based technology available is still rudimentary. Primarily companies in the transportation and public safety sectors may use location technology for asset and vehicle tracking. With the final implementation of the E911 mandate, however, market studies expect an increase in opportunity for enterprise deployment. The figure below shows the results of a survey study conducted with 107 corporations in 2001 (Yankee Group, 2001). Three application areas for location-based technology were developing: vehicle/mobile worker tracking, remote monitoring, and customer service.

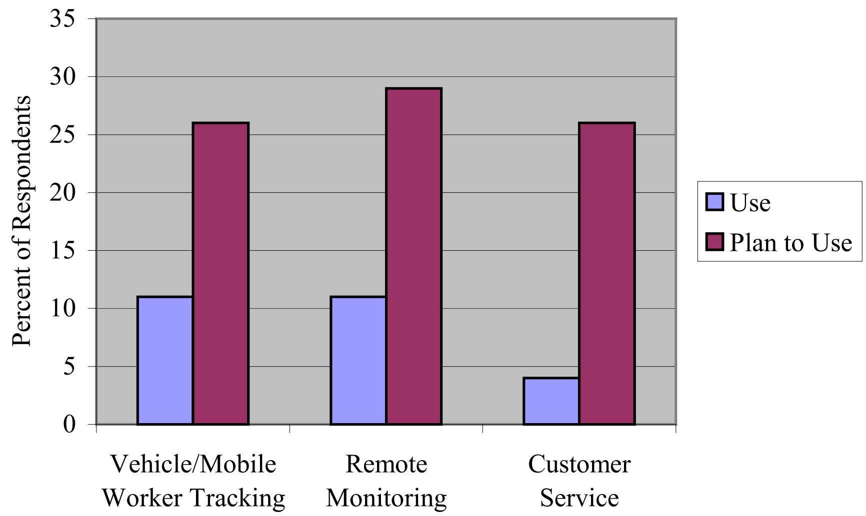

Figure 22: Location technology adoption (Yankee Group, 2001)

Potential factors impacting the adoption of location-based services, which are still in need of being addressed by the industry, include two main aspects: First, personal privacy issues related to the fact of knowing where a user is located at any point in time, and second, the lack of unified standards, technological capabilities, and the technological security of wireless devices. Here an examination of the two remaining constructs, universality and unison, can lead to valuable contributions. Since both constructs are rather technical in nature, a first study should examine their interrelationship with ubiquity and uniqueness. Contrary to the approach taken in this dissertation, some IS researchers have argued that universality and unison should rather be viewed as antecedents of ubiquity and uniqueness.[33]

Even though not part of the dissertation, additional data were recorded while conducting the experiment. This includes data about which Web sites subjects surfed to while waiting for the next task to arrive, and data regarding their left- and/or right-handedness. It became apparent throughout the course of the experiment that left-handed people block their line of sight when using a scroll bar that is typically located on the right side of the PDA screen. Future Web site design studies have to include this finding into their research.

Future research will be able to make use of advanced u-commerce settings. The University of Georgia (UGA), for instance, is currently in the process of installing a total of 43 access points throughout the Terry College of Business, which spans three buildings. This environment forms an ideal testing ground for research in the area of location-based services. In addition, the Wireless Athens Group (WAG) under the supervision of the New Media Institute (NMI) of the University of Georgia (UGA) is currently establishing a wireless cloud in downtown Athens that spans about 20 blocks of restaurants, stores, bars, etc. This environment will provide a very realistic laboratory environment when conducting the same research as proposed in the dissertation.

Based on our findings and current developments, we like to propose the following studies for future research.

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[33] Result from a discussion during the dissertation proposal defense (April 15th, 2002).

Study #1 (Laboratory Experiment):

As an initial experiment, we suggest conducting two separate studies in order to scrutinize location- and time-dependency manipulations independently. A first study would focus on location-based tasks only. With 43 access points in place at the Terry College of Business, an intensive examination of location-based services is possible. The second study would solely explore the effects of time-dependent tasks. In both cases, it would be essential to expand on the duration of the experiment to at least 12 hours. With these findings we would be able to validate our current findings and expand our knowledge on time- and location-manipulations.

Study #2 (Field Experiment):

The Office of Information Technology (OIT) at the Terry College of Business has stated its interest in applying the software developed for the experiment into their daily work. Since most of OIT’s work is concerned with maintaining end-user desktop PCs in a timely fashion, a location-based system would help them to schedule their operations more efficiently and thus operate more effectively. Qualitative research can be conducted that monitors OIT staff while performing these different activities.

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APPENDIX A – MOBILE GENERATIONS

Generation	Characteristics	Standards
1G	Analog Voice service centric (ITU, 1999)	AMPS (Advanced Mobile Phone System) TACS (Total Access Communications System) NMT (Nordic Mobile Telephony) (ITU, 1999)
2G	Digital Voice service centric (ITU, 1999) SIM Mobile Internet	GSM (Global System for Mobile) D-AMPS/TDMA (Digital Advanced Mobile Phone System/ Time Division Multiple Access) CDMA (Code Division Multiple Access) PDC (Personal Digital Cellular) PHS (Personal Handphone System) (ITU, 1999)
2+G	Digital Data service centric Transmission rate: up to 384 Kbps Frequency band: same as 2G (licensed)7 (ITU, 1999)	GPRS (General Packet Radio Service) EDGE (Enhanced Data Rates for Global Evolution) HCDCD (High Speed Switched Data) (ITU, 1999)

Generation	Characteristics	Standards
3G	Seamless global roaming which enables users to move across borders and to make and receive calls while using the same number and handset; Higher transmission rates offering a minimum speed of 2 Mbit/s for users who are stationary or moving at walking speed, and 384 kbit/s in a moving vehicle; Standard service delivery, for instance, via fixed, mobile, and satellite networks (ITU, 1999) Frequency band: 2GHz band (licensed) (WebProForum, 2000)	IMT-2000 family,[34] Including UMTS (Universal Mobile Telecommunications System)/ W-CDMA (Wideband CDMA) as the successor of GSM, CDMA2000 at the successor of IS-95 (Interim Standard ’95), and TD-SCDMA (Time Division-Synchronous CDMA) as the successor of D-AMPS/GSM (WebProForum, 2000)

[34] IMT stands for International Mobile Telecommunications, 2000 for the scheduled year for initial trial systems and the frequency range of 2000 Hz.

APPENDIX B – INTERVIEW TRANSCRIPTS

The following people were interviewed:

1. Michael Kieninger, Associate at Booz, Allen and Hamilton, 03/09/01, Düsseldorf, Germany
2. Eva Michel, Principal Consultant at PricewaterhouseCooopers, 03/14/01, Düsseldorf, Germany
3. Nico Steinkrauss, Senior Associate at Booz, Allen and Hamilton, 03/16/01, Düsseldorf, Germany

The interviews were conducted during a class on qualitative methods (ERSH8100) and have been approved by the IRB through the instructor.

The following transcript conventions were used:

U-huh = sound of agreement

Um = verbal pause for thinking

(.) = short pause

(X.0) = pause of X seconds

(…) = missing word/phrase

[XYZ] = any other notes on nonverbal behavior

Interview with Michael Kieninger, Associate at Booz, Allen and Hamilton, 03/09/01, Düsseldorf, Germany

Iris: Hallo [German greeting]

Michael: Hallo.

Iris: Thanks for participating in this study. I am currently working on a degree in Management Information Systems. Management Information Systems is a field that is mainly interested in the relationship between human beings and their interaction with information systems.

Michael: *U-huh*.

Iris: So, traditionally, an information system is understood as any computer-based system (.) *um* (.) that processes information in an organizational context, for instance, manufacturing systems, controlling systems (.) Nowadays however, *um* (.), the image of an information system has changed tremendously. And, *um* (.), as you may have noticed, more and more people are using mobile devices, such as cellular phones, PDAs, etc. – and that's also the reason why we have chosen you as one of our interviewees. Okay?

Michael: *U-huh*.

Iris: [cough] (.) From a MIS perspective, mobile devices are nothing but a new form of information systems. Thus, the purpose of my study is to explore (.) the interaction of mobile users with their mobile device (.) and descriptions of their interaction experiences will be very helpful for me. So that the reason why I interview you (.) *Um*. This study consists of one

interview, which we are doing right now. It will be recorded and transcribed later. It has bee approved by the IRB. And if you'd like, you may choose a pseudonym for yourself and your identity will not be revealed, if you want to. Okay?

Michael: *U-huh*. Okay.

Iris: After the interview, I will provide you with a copy of my transcripts so that, *um*, you have the opportunity to reflect on the interview and to make any corrections (.) you might have found (.) and, *um*, to expand, if you want to. And I will also provide you with a copy of the final transcripts.

Michael: Okay.

Iris: Okay (.) I hope to submit a paper based on this study (.) to to a professional journal later on in spring, and present some of the findings on a European Conference on Information Systems in August this year.

Michael: *U-huh*.

Iris: Do you have any questions so far?

Michael: No. I'm totally fine.

Iris: [Laugh] Do you want to choose a pseudonym, or…?

Michael: No.

Iris: You are fine with that?

Michael: *U-huh*.

Iris: Okay. So, we start the interview then?

Michael: *U-huh*.

Iris: So what I would like you to do is, *um* (.), think of a specific time (.) when you had a learning experience with your cellular phone (.) and tell me about it. (.) Take your time, just think about it.

Michael: (1.0) I guess the first time I used it (.). You basically, you know, switch it on (.) and this thing pops up and you have to enter like this the PIN numbers which is actually making me kind of nervous, because I am always afraid that I put in the wrong number like of my bank card, or I don't know (.) something goes wrong

Iris: *U-huh*.

Michael: And then it pops on and there you are, online and it starts ringing right away.

Iris: *U-huh*.

Michael: And I was totally scared. I was like: Okay, why is this ringing? [he he]

Iris: [he he]

Michael: And it's actually the welcome message you get from (.), from your network provider. This was like the first time I saw a written message, *um*, in my whole life?

Iris: *U-huh*.

Michael: So (1.0)

Iris: So how did you feel? Were you kind of (1.0) overwhelmed? Or, I mean, did you feel comfortable?

Michael: Well, the whole thing is (.), like the first time is a kind of an overwhelming experience, I think, 'cause you get this new device and you don't know (.) what it's going to do and how it's going to behave, and you get like this little booklet (1.0)

Iris: *U-huh*.

Michael: Too, where you can flip through, but I (.) I hate reading these manuals, so [hehe]

Iris: *U-huh*.

Michael: Just press some buttons and *um* (1.0), *um*, it's an (.), the the the scary thing about it is that all of a sudden you you can be reached (.) wherever you are and you feel a little controlled (.) once in a while (1.0) by (.) I don't know (.) anybody who (.) because they can reach you anywhere, so (.)

Iris: *U-huh*.

Michael: Like without even that thing I haven't talked to anybody yet, I just already felt (.) kind of (1.0) hooked [he he]

Iris: Hooked [he he]

Michael: [he he]. Yeah.

Iris: Can you tell me more about this feeling of being hooked?

Michael: Well, it's it's just because it's a company phone, so (.) and my job manager kept calling like in (.) 15 minutes cycles

Iris: *U-huh*.

Michael: And it's just like (.) I mean you're never sure you know (.) like (.) let's say you (.) I don't know (.) you go do the most private things, I go to a toilet and all of a sudden this thing goes off, you know, like (.), and he doesn't know where you are and he just starts talking away from (.), I don't know, some slides you are supposed to deliver and you're like, you know, it's kind of almost funny, because you're like, you know, I don't know (.) sitting there doing whatever and he's just like (1.0) talking about slides you are supposed to deliver because he doesn't know where you are kind of, on the other side, you feel kind of (.) controlled all the time, because you never like you are safe where you are or you have to switch it off

Iris: *U-huh*

Michael: But then, when you switch it off during the day (1.0) like he will know, that, you know, that you're, I don't know (.), not working

Iris: *U-huh*.

So (2.0), I think it feels like a means of control.

Iris: Means of control.

Michael: Yeah.

Iris: And you felt that from the very beginning?

Michael: Yeah, pretty much. Like in the beginning it was more like a tacky thing, so I kind of liked playing around with it, like you can enter your addresses and phone numbers, and (.), I don't know, like (.) just play around with it, and *um*, it has a positive sign, I mean you can call from wherever you are (.)

Iris: *U-huh*.

Michael: Which makes it, you know, very helpful (.) and and it gives you a feeling of security too, because, you know you know, wherever you get stranded you can still (.) kind of (.) do a call and call for help, or a cap, or (.) *um* call whoever and let somebody know where you are which gives you an immense feeling of (.) like security on the one hand, but on the other like the flip side of the same coin basically is that (.) everybody can reach you wherever you are, so (.) you are always kind of under control and and they they kind of check on you whether your phone is (.) like turned on or not, or *um* (1.0) like, they can reach you wherever you are it's just just a hard thing, like sometimes it used to be like that you just shut the door and you're out of the game

Iris: *U-huh*.

Michael: And and now, like even when you shut your door you still have this voice mail and and they just keep leaving messages so (.) when you switch it on the next time you have this feeling like this thing (.) within hours explodes basically because it rings off the hook

Iris: *U-huh*.

Michael: And you have like [takes deep breath] voice mail, voice mail, voice mail, voice mail, voice mail, and fifty things lined up to do which (.) didn't happen because you just go to know them the next day you went to the office and which is, you know

Iris: *U-huh*

Michael: There was like some messages and and most of it you could just (.), you know, put in the garbage can because (.) it already happened and now everybody feels like (.) like this email effect (.) they just feel like whatever happens, they just drop you a note, they reach you wherever you are so everybody keeps calling all the time and it just gets a little annoying

Iris: *U-huh*. (4.0) *Um*, so, [cough], from your point of view, you're rather, do you, your cellular phone is a kind of (.) , I mean you have to have it, right, that's what you said, it's a company phone

Michael: Yeah.

Iris: And at some point you feel kind of controlled (.) by it

Michael: Yeah.

Iris: But you also see (.) the *um* positive aspects

Michael: Yeah, I like it, I mean I would not (.) like to miss it at all, like, I would even, even if I even if I didn't have a company phone now, I would like one for me in private because I just like this (.), you know, wherever you are just got (.) because I am moving a lot (.) so I just got used to (.) wherever I am (.) I just take up my phone and I do a call and I just don't even think about (1.0) about whether there is a phone booth, or whether I have a phone card, or some change, I don't bother, I just, you know (.) call whoever. I mean I do the same thing, you know, whenever I think of something, I just call [he he]

Iris: [he he]

Michael: I don't have to think about, there is no (.) there is no (.) limit put to (.) to when or where I could call, I just do it (.) and *um* (.), and on the other hand, I like I like being reachable all the time, so, I like being kept in the loop and and knowing what's going on and I (.), it gives me a kind of feeling of security to (.) like from workwise know that my team is, you know, working and what they are doing and whenever there is a problem, they just call, so I don't (.) I don't bother that much and I don't have to call in all the time tell them where I am and leave hotel numbers or whatever, so they can reach me where I am and I just, I like this, I really do. But but just in the beginning I I felt like, I kind of lost this feeling of being controlled, now I just have this feeling sometimes of being pushed by it by it, because people keep calling and leaving messages and they can reach me anytime anywhere (1.0)

Iris: *U-huh*.

Michael: *Um*, I I kind of totally lost this feeling of being controlled by it, I just had this in the beginning when when you like (.) new to it, and you (.) all of a sudden, you know, like do whatever you did, you know, like you go home, you shut your door, you feel kind of save, *um* (.) and (.) and (.) all of a sudden this thing rings, you know(.), and like some colleague from (.), I don't know, Asia calls because they have a time difference and they got your cellular phone number and they call you (.) out of bed (.) like (.) I don't know (.) like 4 o'clock in the morning and (.) *um* (1.0) just because he got your cellular phone number, forgot to think about the time zones and just call you because (.) they call YOU, they don't call your house, they call YOU (.), so this is my number and and (.) so they can call ME and not just my house, and if they'd call my house (.), they would (.), they would accept if I'm there (.), it's okay, and if not (.), I am not there, so they would maybe leave a message on the answering machine if there is one and if not, you know (.), there is nothing they can do, but NOW, they calling ME (.) as a person and they are calling my number and they except ME to answer the phone, and not somebody else, and they don't expect that I don't answer it, because it's my phone, it's my number, so I have to be there, and that's the main difference.

And that’s why you feel haunted by it once in a while, because it’s just (.) people keep calling YOU and and all the time, *um*, day and night, and *um* (.), and sometimes it’s just nothing, they don’t (.), it feels like (1.0), like (1.0) before cellular phones people (.) tended to think a little more before they called somebody and bothered somebody and it took a lot to call you at home, *um* (.), whereas now, *um* (.), people don’t think that much any more, they just pick up the phone and they call, and they don’t call your home, and they don’t feel like they are, you know, invading your private space, they just (.) call YOU on your mobile and that’s, you know (.), so so you have to be there and you answer it, so you’re (.) at work basically, *um*, wherever you are and whenever, so that (.) kind of changes, I think (.), way more than (.) like this is way more than the way to communicate, I think, it it changes how people work and live basically, because (.) they can be reached anywhere any time and and they can can, *um* (1.0), so they are at work basically 24 hours, or they are on call, you know, like 24 hours whether it’s in their contracts or not, they are just there, so if your boss wants anything, he just calls your number

Iris: *U-huh*.

Michael: And if you have switched it off, that’s fine usually, nothing really happens, but sometimes *um* (.) his might lead to (.), you know, the boss thinking you are a lazy bum and you are just hang out and you don’t work enough, or you don’t show enough commitment to your company, because you switch of your mobile phone at 5 pm as soon as you walk out off your office (.)

Iris: *U-huh*.

Michael: So (.), *um*, it's a kind of a (.) away (.) it's a little it's a little more than *um* (.) just *um* you know having a phone and being reachable (.) anywhere and having fun with it what they show in the advertisement, I think, it changes the way we live and interact and work *um* (.), way more than people probably suspect it when they introduced it

Iris: *U-huh*. Can can we take a step back and (.) get to the point again, the first time you actually got the cellular phone and you used it. Before that you didn't have one, right?

Michael: Right.

Iris: And then the first time when you actually (.) you had it and it was in your hands (.) and and how did you feel, I mean, the the interaction that you had?

Michael: Well, first I just thought cool, now I got one too, because everybody else got one, I've been thinking about getting one for me in private, but now I got one from the company, I thought cool, they even pay my bills, that's excellent.

Iris: [he he]

Michael: Hm, and then (.), well, I just, you know, first I felt a little disappointed because nobody had my number, so nobody called (.), you know

Iris: *U-huh*.

Michael: Hm, you know, except my job manager which got which got a kind of annoying after a while (.) *um* (.) so in the beginning I I called people as much as I could and left them my number and told them, well, you know, I've been moving a lot, and you never got a hold of me, and this is my mobile number and and you can reach me now anytime (.) and, and all of a sudden (.) *um* (.) *um* (.) like this thing kept calling, when it first rang (.) *um* (.) I kind of felt this (1.0) enlifting (.)

Iris: [he he]

Michael: Joy [he he] This thing really worked. Hm, I even called myself from a fixed line phone just to see if it works

Iris: [cough]

Michael: (.) *um* (.) and I I just, you know, kept putting (.) transferring (.) names and numbers from my filofax [organizer] to my cellular phone (.)

Iris: *U-huh*

Michael: And kind of feeling that my filofax number address book (.) kind of (.) lost it its importance *um* because I had them in my cellular phone and and I always had the cellular phone with me, so I had always this address book with me as opposed to my filofax which was, *um* (.), I don’t know (.), with my with my laptop (.), and so I didn’t have that when I went out (.) in the evening, *um* (1.0). And I, and I kind of liked it, because I am like, *um*, you know, travelling a lot and and I never I never really know when I get off from work, so I could just call spontaneously, you know, and and I stopped doing fixed arrangements because they were totally stressing me out, so (.) I was always like ok let’s meet this evening, you know, let’s say 8, 8:30, and and (.) but I give you a call and so that, you know, kept calling for one appointment like five times, *um*, and (.) I liked it, *um*, I felt like a feeling of independence, *um*, like this (.) thing gave to me (.), *um*, yeah, being independent probably was, *um* (.), like at least after work, it it kind of gave me freedom

Iris: *U-huh*

Michael: As opposed to (.) during workday I felt kind of hooked to it, attached, *um*

Iris: *U-huh*.

Michael: In control, as I said

Iris: Yeah. Did you encounter any problems using it? (1.0) The very first time?

Michael: No, not really. I, *um*, I thought, like, you know, being a computer user, you are kind of used to these trees that menus, you know, you click your way through, *um*, from the windows, *um*, surfaces, each click your way through and I felt like the cellular phone I got was a Nokia and I I just felt that (.) it was very intuitive (.) in terms of the way you use it (.) and (.) the very logic, so once I knew that you could write an SMS, *um*, it was pretty clear that, *um*, you would find this menu point under messages, so, *um*, and address book, I I thought it was very clear. I mean, I called, yeah, I I never really encount(…) [skips the rest of the word and the phrase]. What I really had a problem with was this PIN thing in the beginning, because you get like a PIN for the network and a PIN for the (.) phone itself, and a whatever PUK, I don’t know, whatever, like five or six different numbers and I I was just totally lost in the beginning, and I felt a little fear that I put in the wrong number and this thing would basically blow up before I even, before I did my first call, *um*, and I thought, like, I mean, I am all in for security and things but I just thought it was (.) tough to use it in the beginning, because it had like two PINs and a PIN for the phone and I didn’t know which one to enter in the first time, so (.) I just (.) you have like three three trials, so I put in all three and the last one worked [he he]

Iris: [he he] Lucky you

Michael: [he he he]

So I thought it was very scary but besides from that, like (.), you know, it was pretty clear structured, *um* (.), what took me a little longer to get through was the (.) the options you have for the phone and the network, that you could (.), I don't know, like language selection

Iris: *U-huh*

Michael: And, *um*, I am still not, I am still not clear on (.) on how you can switch on and switch off, *um*, like the knocking, *um*, and hunting, and like these additional features and I still don't even know what they mean.

Iris: *U-huh*

Michael: So I (.), I'm I'm not a very technical person, I like to use it (.), and (.) when (.) I don't like to spend time (1.0) learning how to use it (.) so basically (1.0) what what I use it for is to make calls and receive calls

Iris: *U-huh*

Michael: And to send an SMS and to receive an SMS, and that's basically it

Iris: *U-huh*

Michael: And I don't use this as a multimedia message center or to connect three people in one phone and I don't care how it works (.) So, I think (.) my phone can do it, but I am not sure, and I don't even care [he he]. So I (.) I just limit to (.) what I need and I found this right away basically on top of on top of everything

Iris: *U-huh*

Michael: And so I didn't (1.0) but I'm not I'm not one of these tacky users and I don't know how to synchronize my phone with my laptop and I don't now how to do it with my PDA and (.) I don't really care (.) actually (.) [he he]

Iris: *U-huh*

Michael: So (.), like I I like to learn new tricks from people, like, you know, when they play around with their phone, and I just, you know, and they like "Did you know that...?", I like "Oh, no, I didn't…", so, I learn things that way. It's probably like with shortcuts with Excel, like, I don't I don't really know how to use them unless I use Excel all day long, I just don't (1.0) care

Iris: *U-huh*

Michael: So (.) *um*, so if people tell me that I can be 30% more efficient by using whatever (.) in my cell phone, I don't really (.) care about it (.) I just use it for calling and receiving calls, and (.) that's it.

Iris: *U-huh*. But you are aware of that probably your your cellular phone is able to do more than you use?

Michael: Yeah. I think so. I mean, the manual is pretty thick, so [he he]

Iris: [he he]

Michael: Hh, it should have more than like feature, you know, how you accept a call and how you do one.

Iris: *U-huh*

Michael: What I use is my voice mail, and I I've kind of got lost on that, like they they put in like five different ways to access your voice mail

Iris: *U-huh*

Michael: And I don't, I need like one (.), so

Iris: [he he]

Michael: This is like you dial 3311 and whenever I'm out off this network, I'm totally lost, like I don't know which number to call. I think there is a (.) foreign access number and and I think I even got it in my phone but I I never don't know the PIN of my voice mail, so (.)

Iris: *U-huh*

Michael: It's, *um* (.), like, once I once I get to work probably more abroad or in other countries where (.) my provider doesn't have a network, I might be forced to learn this, and I will [with emphasis], like, you know, whenever I need it, no problem I just call a hotline, or, you know, ask a friend and, hm (.), then I learn how to use that, but don't, I'm not one of these people like sitting, you know (.), at home and (.) trying to figure out all these tacky, fancy features my mobile phone can do which I will never use, because I don't really need them (.) and *um* (.), whenever I need one (.), I guess that there is something [chuckles] like this in my cell phone and I just, you know, check at this occasion.

Iris: *U-huh*

Michael: And that's pretty much, how I do it with computers, and how else I do it with my cellular phone.

Iris: *U-huh*. Anything else that you *um* you like to mention in terms (.) of your, you know, your learning experience with interaction with your cellular phone?

Michael: No. (.) No.

Iris: That’s pretty much it?

Michael: *U-huh*, that’s pretty much it, I think.

Iris: Yeah?

Michael: *U-huh*

Iris: Okay. Then I would like, *um*, to stop the interview (.) right at that point here, and what I am gonna do is (.), as I said, I am gonna transcribe the interview, and I’m gonna send you a copy of that (.) and you gonna have *um*, the possibility actually to review, *um*, your transcript, make changes if you like and, *um*, yeah, that’s the procedure that I’m gonna take. Okay? It will take me a couple of days [chuckless] actually, *um*, to get the transcripts done. *Um*, other than that, I would really like to thank you for participating I the interview

Michael: *U-huh*. You are welcome.

Iris: Thanks for your time and, *um*, talk to you then.

Michael: All right. Looking forward to the transcript.

Iris: Thanks

Michael: *U-huh*.

Interview with Eva Michel, Principal Consultant at PricewaterhouseCooopers, 03/14/01, Düsseldorf, Germany

Iris: Ok. Let's get started here (3.0) *Um* hello Eva [hehe]

Eva: [hehe] Hi

Iris: Thanks for participating in this study. I am currently working on a degree in Management Information Systems (.) and Management Information Systems is a field that it mainly interested in the relationship between human beings (.) and their interactions with information systems. So *um* traditionally an information system is understood as a computer-based system (.) that processes information in an organizational context, for instance, *um* manufacturing systems, controlling systems, etc. Nowadays, however, the image of an information system has changed tremendously (.) and *um* as you may have noticed, more and more people are using mobile devices such as cellular phones, or PDAs, like palmpilots and *um* that's the reason why we have chosen you as our interviewees. Ok [hehe]

Eva: U-huh

Iris: So from an MIS perspective mobile devices are nothing else but a new form of information system. And thus the purpose of my study is to explore the interaction of mobile users with their mobile device (.) and their a description of their interaction experiences would be very helpful for me. So that's the reason why I interview you as a frequent user of cellular phone. Um this study consists of one interview right now, *um* and will be recorded

and transcript later. It has been approved by the IRB and *um* if you'd like you can choose a pseudonym for yourself (.) and your identity will not be revealed. Do you want to do that?

Eva: No, that's fine.

Iris: That's fine. So I can call you Eva. [hehe]

Eva: Go ahead [he]

Iris: After the interview I will provide you with a copy of my transcripts so that *um* you have the opportunity to reflect on the interview and to make any corrections *um* you might have found (.) and to expand if you want to.

Eva: Um

Iris: Um I will also provide you with a copy of the final transcripts. *Um* I hope to use this interview for my dissertation (.) and *um* also to (.) pretty much write paper about and submit it to a journal later on. Do you have any questions so far?

Eva: No. It's straightforward

Iris: Ok. Let's start, *um*? What I would like you to do now (.) is (.) to go back pretty much when you got hired by the company that you are working for right now and you didn't have a mobile phone before, right?

Eva: No.

Iris: And that one for business purposes. So what I would like you to do now is think back at that point in time and think (.) about a specific learning experience that you had with your cellular phone.

Eva: Right [hehe]

Iris: [hehe]

Eva: Well, to be quite frankly I got my phone and I (.) didn't really use it for the first half year in a (.) professional context. So [hehe] I've been only using it privately, and I noticed (.) *um* that I didn't (.) bother planning any longer. Like you would say to your friends let's meet at 8 o'clock, and (.) well if I notice I'm not gonna make it,

Iris: U-huh

Eva: I found I could just ring them like on the platform going to the train it wouldn't matter any longer. Before I feel like (.) *um* very conscious always *um* getting somewhere on time and *um* because I knew I wouldn't be able to reach them and they'd be standing there and wondering where am I, and *um* that was the first thing I really noticed. I didn't bother to plan ahead any longer

[hehe]

Iris: [hehe] So that was the biggest change that you've experienced.

Eva: Yes.

Iris: Your behavioral pattern changed.

Eva: Yeah. Surely. Surely. Fatly. Yeah, it did

Iris: And in the business context, did you have any similar experiences?

Eva: Um (3.0). Well, not really similar yet but rather different. 'Cause (.) when I started using it, I (2.0) was on a project in Switzerland and actually the core place of the project was in Sweden and (.) people were moving (1.0) all over the place, and it not let's say ok (…2.0) I know how to phone them and they would be reachable on that phone, 'cause they would travel back and forth to meetings, and even within Switzerland from Zuerich to Remont. Um people would be on the move the whole time, it didn't matter you could also reach them on the one number if they were in Sweden or Switzerland. So that was quite different from (.) the internships that I had done before *um* where we didn't have mobile phones [he] and you could only reach people (.) unless they were flying.

Iris: Um How as that then? How was it different?

Eva: Well, it was more dynamic because (.) *um* you (.) again actually don't have to plan anymore advance *um* if you have a question for your boss *um* you don't have to (.) ask that question necessarily as long as you are in the office, even if it's at the airport you can still ring him which gives you another two or three hours and *um* [hehe]

Iris: [hehe]

Eva: [hehe] What was I about to say? You don't have to plan that much more you don't have to prepare in advance, the things becomes much more dynamic and spontaneous

Iris: Spontaneous.

Eva: Yeah

Iris: Is it more frequent too? Like you should rather call that write him an email?

Eva: Actually *um* (3.0) I write emails I write emails nowadays if I want to (3.0) save time I don't want to bring someone up and spent five minutes introducing myself, and saying hello, how were you doing, and how were your holidays, I just want to save this information, or the contrary if (.) it's something more complicated if I'm really asking for someone's recent things (.) and (.) if we are having an entire lesson I'm always thinking if I say it over the phone *um* it'll be (2.0) *um* how to say it, they would get half of it (.) so (3.0) oh Gott, oh Gott, I forgot [hehe]

Iris: It's ok. [hehe] It's ok.

Eva: [hehe] If I'd rather write use the phone than using email? Yeah. Actually (1.0), no, no, it has not become more. There is no difference

Iris: U-huh, but you were saying it's more spontaneous, right?

Eva: Yeah (2.0), yeah.

Iris: Can you somehow describe the tasks that you would use it for? (…2.0)

Eva: Um (3.0) [ha] What would I need my phone for? [he] Actually for nothing that I couldn't write an email about. Um I guess it ties back to a personal conversation, because I wouldn't know (.) it's more (.) you cannot *um* express (.) *um*, how do you say, intentional devoice (.) you cannot, it doesn't show if you are agitated or if you are sad or something and which *um* definitely makes contact more personally. (2.0) I guess it gives me the feeling *um* you're always talking to the person personally and email is just really (2.0) not at all (.) flat

Iris: What about tasks that are time-pressuring?

Eva: Would I rather take the phone or write emails?

Iris: U-huh

Eva: Actually, if it is really time-pressuring I use my mobile phone to write SMS

Iris: [hehe]

Eva: [hehe] Honestly, because (2.0) *um* with email you always have to, even though I'm on my computer you cannot be certain that the other person is logged on or reading his computer, so (.) maybe they get the message immediately, maybe it's just gonna take one or two days until they do that (.) so (.) I'm writing an SMS I just (…1.0) you can be definite that they get it as quickly as possible.

Iris: U-huh. I see (2.0). You mentioned something beforehand I would like to pick up on that. You said you were on this international project.

Eva: Um

Iris: And (2.0) you were saying they had one number, right? No matter where they were

Eva: Yeah. Apart form the US and the XXX because they have a different net and they have a (.) European mobile phone but when you are in the US you have to ring a different number [hehe] because they didn't have these Triband mobiles.

Iris: Um. What happened when you traveled to the US?

Eva: My one didn't work [hehe]

Iris: [hehe]

Eva: Although I had one of those Triband mobile phones but PwC had not bothered to sign up for the (.) roaming rights [hehe]. Actually it was quite funny that you mentioned it [hehe], it was (.) quite a shocking experience because I was immediately at the same situation I have been all my life (.) when I entered two years ago [hehe]. I had to look for a public phone [hehe] and quite a pain

Iris: Can you elaborate on that?

Eva: Yeah, yeah. I remember flying to Chicago and I *um* was gonna go on an flight to Atlanta, but there *um* was a big storm and I was gonna try to ring my friend, there was this huge chaos in the airport [hehe] and (.) I was thinking it's not a problem because you have an American friend in Chicago sitting, just ring him and he's gonna come and picks you up, well, (2.0) I had a problem [hehe] because my telephone didn't work, and of course I didn't have change because you need the change for the American telephones and (.) because there was such a chaos there were huge lines before the (.) telephones and I don't (.) I'd rather have my mobile phone

Iris: So you are quite happy to be back.

Eva: Well, not because of the (1.0) America, but because of that mobile phone experience [hehe]

Iris: I see. Any other experiences that strike you? (4.0) Anything peculiar? (2.0) Anything you have noticed?

Eva: I've noticed? I noticed that (2.0) *um* I have come to the point that I find it very difficult to give it up and I guess (.) almost irritated if I (.) can't reach other people (.) like my parents (.) it a pain in the neck (.) [hehe]

Iris: [hehe]

Eva: And you really have to plan in advance and you can't reach them and you can't even leave them an SMS (2.0) of course they don't use email either, so [hehe] either they answer the phone or (2.0) nothing and (.) I (.) was just talking to my brother the other day about buying our parents a mobile phone [hehe]

Iris: Um, *u-huh*. Have you (2.0) *um* are there any other events or something where that you've noticed other people maybe using the phone which you found very (.) surprising, or (.) something funny about it?

Eva: Um, I have an experience that (…4.0) if you are in a meeting I found their phone switched on and call, and to talk through the meeting with someone else, and I found that quite puzzling (.) and you have to (.) *um* just because it's a new device that all other manners just (2.0) cancel out for you [hehe]. Yeah

Iris: Um. So in summary if you had to put together strengths of your mobile phone and weaknesses on the other side. What would you put on the strength side?

Eva: Strengths definitely (2.0) *um* mobility. You can be reached anywhere (2.0) *um* what lets say (.) if someone else has a telephone, it really doesn't matter where they are, they are in the building, they are in the airport, if they are on the street, you can always reach them, and in that respects its *um* really unique (2.0) *um* I guess there is no other device except that for (.) *um* you can be pretty certain even if that person doesn't have their phone with her at least leave a message on the voice mail you can be pretty certain (.) that (.) under normal circumstances that person gets the message in a very short period of time (.) even if it's different. And that would be a strength [hehe]

Iris: [hehe]

Eva: Weakness would be *um* (2.0) *um* [he] I don't know how much about hazards, health hazards of mobile phones. It's really not something that's (.) very much discussed. Um (.) that definitely would be one thing that is not completely harmless [hehe]. One the other hand (.) I guess it's that some people *um* I got irritated about people using their phones really everywhere even if you are in the shop, in the dressing room and somebody next to you is just using the phone

Iris: U-huh. Anything else?

Eva: Um.

Iris: Strengths, weaknesses?

Eva: No.

Iris: Ok. That's fine. That's totally fine. Um you are saying that it became an essential part of your life pretty much?

Eva: Yeah

Iris: You would definitely say that?

Eva: Yeah

Iris: What (.) is it that you are using your phone only for calling (.) somebody? Or there any other functionalities that you are using with the phone?

Eva: I'm just using (.) it for voice, for calling (.) but also I'm not sure if you are using that in the US a lot, *um* SMS, short messages

Iris: *U-huh*

Eva: Um they are little actually tiny little emails you write on the (.) display and *um* I use them a lot very much

Iris: *U-huh*

Eva: And I *um* use them if I if I just want to write a *um* what is unverbindlich [hehe]

Iris: [hehe] Um yeah not committing

Eva: if you just write a very (.) *um* non-committal message to someone where you want to leave it open to the other person to say yes or no, whereas if I call him up, *um* that person might be *um* somehow feeling obliged to answer, not to hurt your feelings at that time, this is just very uncomittal, just give me an answer if yes or no (.) that would be definitely one thing, if you also sometimes you save time (.) ‘cause it does take time typing it in (.) it’s is a pain in the neck [hehe] point of improvement but it really (.) it really just it’s usually still quicker even if it takes two minutes of email to type it in it’s usually quicker that a phone call and of course it’s convenient (2.0) *um* if (2.0) *um* if you are just in inaccessible places but you have to put up a message like if you are in a meeting and you don’t want to call you just type it in and get off with it

Iris: Yeah. Um do you also use it for scheduling? Or calendar?

Eva: Not at all. Not at all. I used to use that but then I changed my phone and *um* I didn’t mange to, I used to put all the birthdays in there of my friends but I *um* couldn’t transfer it to my new phone when I changed so I’m not using that

Iris: Ok. Anything else you would like to mention? Anything that is still sitting on your mind?

Eva: Um [hehe]

Iris: [hehe] That’s fine [hehe] Ok. Thank you very much then

Eva: You are welcome

Iris: For participating in this study. I will send you the transcripts

Eva: Sure

228 **Iris: And you can do the revisions if you like to.**

229 Eva: Thank you.

Interview with Nico Steinkrauss, Senior Associate at Booz, Allen and Hamilton, 03/16/01, Düsseldorf, Germany

Iris: So, Hello Nico

Nico: Hello

Iris: [Hehe]

Nico: *U-huh*

Iris: [hehe] Thanks for participating in this study and what I would like to know from you I would like to talk about experiences that you have with your PDA.

Nico: *U-huh*

Iris: Anything that pops up (.) is (.) valuable and nice to have. So

Nico: Ok (.) Well, I should start with the motivations why I got the thing in the first place (.) and of course it started off with *um* contacts, *um* addresses, and and *um* appointments (.) keeping track and then writing them down then loosing *um* the address folder and then having it on some back-up *um* space and the the the birthdays for *um* every single year that was the important part, and plus checking emails from without using the laptop that was another major *um* buying criteria.

Iris: *U-huh*

Nico: Um actually I was started (.) when I (.) when I was that much on the Palm wave, I saw *um* (.) guys using it but not really I was not really keen on learning that writing language you have to (.) you have to adopt to communicate with that thing. I saw the Compaq Ipaq *um* while while interviewing from the job someone else who was in *um* (…1.0) and after the interview *um* we talked about his experiences (2.0) *um* and what I liked about that *um* machine was the capability to to use (.) Excel files, Word files and the Windows based programs as well (2.0) *um* and was actually when the entire team (.) *um* my company, my firm's team working there got excited, were looking for the things, trying to find the best deal and *um* funny funny enough *um* the very day we got thing an entire day of of consultants' work (.) spent (.) getting acquaintant with the thing, trying to synchronize it and understanding it and there was virtually *um* a whole day *um* that was *um* that was missing and then I think it already leads to the term of time effectiveness, or time saving that I don't think in the end you don't save time but you use it differently [hehe]

Iris: [hehe]

Nico: There's so many *um* new (.) *um* things you you explore and you have to understand and once you have understood them you use your machine more efficiently and maybe mange your time more efficiently, but then there is something else that you discover (.) be it the golf game, (.) be it *um* (.) I don't know you name it (.) so I wouldn't say actually I save time, I invest heavily

Iris: [hehe]

Nico: Time-wise and also [hehe] equipment-wise, those expansion packs and the charging cables, using cradles and that kind of thing *um* that as I said it's more investing than *um* absolutely saving time at the end, (2.0) *um* but I think I used the machine quite the way I intended it to do it, all contacts and *um* convenient synchronizing part of it so that I could synchronize on on the on the mobile, on the PDA and on the laptop having the same base of addresses *um* and laptop and and and organizer the same *um* appointments. Um I didn't (.) use it that much for the Windows based programs in the end, I mean for Excel and Word and stuff, maybe for reading things, but of course not for (.) like doing entire spreadsheets on the PDA because the display is far too (2.0) *um* far too small and the handling is too clumsy (…1.0) to work it out.

Iris: *U-huh*

Nico: For games of course it has golf thing, car racing, whatever, when you have to kill time [hehe]

Iris: [hehe]

Nico: At the airport or wherever that was very convenient and the mail checking part of it I used quite frequently (3.0) *um* yeah (.) until it got run over a couple of weeks ago [hehe]

Iris: [hehe]

Nico: At the parking space at a hotel. But I think I'm (.) maybe waiting half a generation more and (.) get another one

Iris: Yeah

Nico: And as I said really you find new ways of using the thing like linking up your (.) digital camera and then taking photos and then taking all the Compaq flash card and then (.) plugging it into (.) the (.) machine and sending it out via e-mail and I think there will be more of those applications popping up and you just hear from them (.) what others (…1.0) use it and read abut it in the Internet and then find new ways of (.) using the thing

Iris: Um. So you are saying that it is nice *um* to have and maybe you bought it with the intent of *um* time savings, or you know having your contacts all together

Nico: *U-huh*

Iris: but in the end you spent much more time than you intended to do

Nico: Exactly. And just for only (.) checking emails and your contacts and your appointments (.), a PDA half the price would have done the trick (.) definitely. It's really the toy aspect of course plays quite quite heavily into the whole equation

Iris: Um. You mentioned that funny incident that it got overrun by a car a couple a weeks ago.

Nico: Yeah

Iris: How did you feel without it?

Nico: In the beginning of course (2.0) I missed it every other (.) minute. Um (.) well, now, I (.) it's like two or three weeks ago and I still managed to (.) to be on time [hehe]

Iris: [hehe]

Nico: I let to know the people I *um* called the people and have their phone numbers of people (.) I needed to call but it's more of course I had to use the laptop and it's more *um* inconvenient and (2.0) also the email checking and time and contact management is still (.) valid and I'm kind of afraid right now of buying one because (.) the last generation is a bit *um* (2.0) is not that great improvement *um* as the one before so maybe I'll wait *um* some more time

Iris: But you definitely gonna get another one?

Nico: Yeah, I think so.

Iris: [hehe]

Nico: I mean *um* what I didn’t like about the technical (.) technically about the machine was kind of the size because it was it was a little bit larger than (2.0) like short pocket size

Iris: *U-huh*

Nico: And *um* the battery would last in really heavy duty circumstances like two (.) hours, two and half hours, that’s not too much actually, I mean it’s really if you use background lightning, and if you use sound and everything, it’s (.) it would be empty in two or three hours if you use it just for your daylight (.) and for (.) for (.) non-CPU *um* intense *um* applications, ten twelve hours which would usually, usually be enough before you need to recharge it

Iris: So you are using it mainly for contacts was one thing, then for email you were saying, right? How did you do the email, synchronize it?

Nico: No, with the mobile

Iris: With the mobile

Nico: Yeah. Via the infrared interface.

Iris: Ok, ok, I see. How often did you actually used it in connection with the mobile?

Nico: Once a day

Iris: Once a day. Did you also surf the Internet with it?

Nico: Very very (.) *um* occasionally because then you the screen size thing again and plus plus you would have to have special (.) specially designed Web sites for (.) to (.) to be (.) fun otherwise it is (.)

Iris: *U-huh*

Nico: I think I tried some group plan thing *um* but it's not really (.) *um* it's not really fun, it takes too much time, and well it's (2.0) not well designed for this

Iris: So the only thing that you actually had to use the wireless connection for was checking your email.

Nico: That's right

Iris: That's pretty much it. Why would you do that on a PDA instead of a laptop with wireless *um* also with a wireless device?

Nico: Because I don't always have the laptop with me

Iris: *U-huh*

Nico: And it's also it's faster (.) than the laptop, just take it out (.) and you have to boot it and stuff and the PDA is there in a second, I mean the moment you switch it on (2.0) *um* and most often it's like those ten minutes time window we have at the airport

Iris: *U-huh*

Nico: And you wouldn't (.) just wouldn't make it with the laptop but it's no problem with the PDA

Iris: I see. Ok. Um What about the entertainment (1.0) *um* aspect of it of a PDA?

Nico: That was the (.) I had some mp3 files on the thing (.) but (.) for that memory would not be enough (.) I mean with two or three *um* sound files which you find after two of three days you know them [hehe]

Iris: Um

Nico: And so *um* I was pretty much changing every single day *um* of course that's true for video as well, you would *um* interesting video content *um* that fits on this something like 20 megabit you have or whatever you have on this machine. But on a (.) there is quite a lot of those Windows-based, or Windows-powered, Windows CE *um* based games such as that golf game, the car-racing, (.) even the solitaire thing has a time-killing aspect and *um* again reading at the airport or being at the hotel room

Iris: *U-huh*. Did you use it in connection with others like playing against?

Nico: Um, I tried to but that would require some kind of (.) network connection to who you play against because for that golf thing for instance, there was the option to play network game (.) otherwise it was (.) not playing against them but always (.) updating *um* each other and then being in contact which is not really network play

Iris: *U-huh*. How often do you synchronize during the day?

Nico: Basically during the (.) entire day. The laptop is always switched on and then I (.) simultaneous charging and synchronizing cables basically as long as I was at the desk *um* be able to (…1.0)

Iris: Did you download any kind of newsticker or

Nico: Yeah. I did. Those Avantgo channels, like finance and some entertainment, the cinema, *um* cinema grid and some sport news

Iris: Um what about (.) imagine you have one device that incorporates a PDA with a cell phone altogether. (.) Would that be something you would be interested in? Or do you think

Nico: Yeah. On the one hand it would, (.) given that it has the same (.) performance characteristics I mean that already exists in a way but then you have always to (.) most likely to give in on the PDA side because the PDA is not that performed *um* in terms of what (.) *um* of speed or whatever *um* and then then on the other hand maybe just wait for the *um* yeah next generation and have (.) Bluetooth integrated thing, have one earplug, and (.) then it doesn't really matter whether it's (.) a connected thing you can wear (.) your mobile at one place and the PDA at the other and then always have the opportunity of the slimmest possible device with you when you have no (.) *um* storage room and only have the mobile and the mobile plus PDA when more pockets available and (.) yeah I would always go for (.) that *um* opportunity to have modular connection

Iris: Yeah. Rather modular kind of things. Ok. Um (3.0) in summary, if you had to come up with strengths and weaknesses of a PDA? What would you put on the strength side and what on the weaknesses?

Nico: Well, (3.0) in terms of weaknesses, *um* more on the technical side (.) like the battery *um* length and maybe some even better ways of (.) solving the (.) display problem, be it some kind of glasses or (.) whatever so that you (.) and not only display but the entire interface (.) *um* I mean the slidal place thing is a great improvement but still (.) poor Web site for instance it's not (.) really fun. Upsides that is of course the mobility factor, *um* great improvement, I mean nowadays you can also read your emails over the cell phone but then you can your display gets (.) even smaller and the connection is (.) not that ideal *um* (3.0) the computing gets more like it's more mobile and it's *um* interesting as a general (.) fact for email, be it for *um* viewing *um* presentation slides, *um* and again viewing your your Excel sheets but that is something that in the end I use quite frequently and it's a great upside

Iris: Cool. That's very good (.) for PDAs. What I would like to do so though is since you are also a frequent cellular phone user

Nico: *U-huh*

Iris: Ask you *um* about just one or two experiences you had with your cellular phone, I mean in particular I am looking for the impact that it has for your life, for your personal life, for your business life, you know, what bugs you

Nico: [hehe]

Iris: What's great about it, just briefly some ideas

Nico: Well, I don't think that is so peculiar, I mean it's always up and downsides, you are always available I mean upsides because there might be urgent things *um* that you and just you can solve and then there is great upsides for everyone (.) and at the same time there is downsides that you are always reachable and everyone knows that you should be reachable and that partly extents to the weekend *um* (2.0) which then shouldn't happen (.) or even privately there might (.) be (.)

moments where you prefer not to be available and then, they always but knowing in theory you should be available and that’s (2.0) at the same time up and down sides. I don’t feel *um* that much bugged by it (2.0), by the environment using cellular phones, by cell phones ringing everywhere that doesn’t really (.) doesn’t really annoy me. Um it’s more a personal view of how do you use things and again it’s a availability issue, (.) it might become a luxury to, (.) actually entitled or able to switch it off and have the right to switch it off

Iris: *U-huh*, *um*, as a last question in that concern is rather, you know, looking ahead of time *um* location-based services, those are services that providers will offer you based on the physical the actual physical location where you are

Nico: *U-huh*

Iris: And that can be determined by your cell phone, you know, with GPS system or whatever. Um (2.0) how do you *um* yeah how do you view that? Is this something beneficial to have? Or is it rather (.) **scary? Or?**

Nico: Well, I don’t see it that much scary, *um* (2.0) it very much depends on what benefits it will bring to me. I mean I don’t want to get every single (.) advert, or here’s a pizza, or here is a pair of shoes that might suit you, that I’m very much able to personally set the filters I want

Iris: *U-huh*

Nico: And get the information I really want and not get (.) *um* just for the sake of being at that location (.) where the information might suit (.) but (.) it’s location plus my interest *um* that you put together (.) *um* I will see it very (.) much value added some kind of navigation system that you have always one, so if you are (.) *um* not only the car but also *um* walking (.) always always aware of where you are (.) *um* and then for the rest I don't really know whether it be automatic location-based thing adds *um* that much value I mean the supplier needs to know (.) where his location is. In other words I wouldn't (.) I wouldn't (.) I wouldn't be ready to pay because I mean I always tell where I am, if somebody needs the information, I can always plug it in, be it street, *um* city, whatever, and then in the end it's me who decides what kind of *um* information about my whereabouts *um* I'm giving *um* in other (.) I can hardly imagine that (.) should be too complicated that's really a great value added that the system knows where I am

Iris: *U-huh*

Nico: And there are some other benefits I can see. I (2.0) for my side you can measure where I am and the supplier knows what valuable information he can give me based on where I am, be it how I can get to the next however restaurants (.), or items that I've been looking for (.) the last two weeks and they are just one street away, I could just shop it

Iris: *U-huh*. So pretty much location-based as another factor that contributes to this matching process of you, your profile (2.0) and what you want to do in regard to the location

Nico: And that profile should be narrowly defined by myself (2.0) and what I'm willing to

Iris: Ok. This is pretty much what I wanted to hear [hehe]

Nico: [hehe]

Iris: Do you have anything else in terms of PDAs, of cellular, what (.) just [finger smak] comes up, something else that you would like to mention

Nico: Um no, nothing (.) really (.) comes up to my mind, so.

Iris: [hehe]

Nico: [hehe] So, I'm really in a kind of grief period

Iris: [he] Thanks, Nico

Nico: You are welcome

APPENDIX C – VARIABLES AND THEIR MEASURES

Variable	**Abbreviation**	**Measure**	**Scale**
Demographics			
—Gender	DG	What is your gender?	Categorical (male/female)
—Age	DA	What is your age?	Ratio
—Major	DMA	What is your major?	Categorical
—Year	DY	What year of school are you in?	Categorical (freshman, sophomore, junior, senior, graduate, other)
Experience	EX1	I rate my experience with the Internet as X	4-point Likert
	EX2	I rate my experience with computers in general as X	4-point Likert
	EX3	I rate my experience with PDAs as X	4-point Likert
	EX4	I rate my experience with cellular phones as X	4-point Likert
Motivation	MO	I rate my motivation for participating in this research study as X	7-point Likert
Usefulness (pre-experimental)	AU1	Using a PDA improves my performance	7-point Likert
	AU2	Using a PDA increases my productivity	7-point Likert
	AU3	Using a PDA enhances my effectiveness	7-point Likert
	AU4	I find a PDA useful	7-point Likert
Usefulness (experimental)	BU1	Using a PDA improves my performance for tasks similar to those I have just completed	7-point Likert
	BU2	Using a PDA increases my productivity for tasks similar to those I have just completed	7-point Likert
	BU3	Using a PDA enhances my effectiveness for tasks similar to those I have just completed	7-point Likert

Variable	Abbreviation	Measure	Scale
	BU4	I find a PDA useful for tasks similar to those I have just completed	7-point Likert
Ease of use (pre-experimental)	AEOU1	My interaction with the PDA is clear and understandable	7-point Likert
	AEOU2	Interacting with the PDA does not require a lot of my mental effort	7-point Likert
	AEOU3	I find the PDA to be easy to use	7-point Likert
	AEOU4	I find it easy to get the PDA to do what I want it to do	7-point Likert
Ease of use (experimental)	BEOU1	My interaction with the PDA is clear and understandable for tasks similar to those I have just completed	7-point Likert
	BEOU2	Interacting with the PDA does not require a lot of my mental effort for tasks similar to those I have just completed	7-point Likert
	BEOU3	I find the PDA to be easy to use for tasks similar to those I have just completed	7-point Likert
	BEOU4	I find it easy to get the PDA to do what I want it to do for tasks similar to those I have just completed	7-point Likert
Manipulation Check	UB1	I felt that I could access needed information at any time during the day	7-point Likert
	UB2	I felt that I could access needed information from any location (within the scope of the wireless local area network) during the day	7-point Likert
	UB3	I felt that I could be reached at any time during the day	7-point Likert
	UB4	I felt that I could be reached at any location (within the scope of the wireless local area network) during the day	7-point Likert
Manipulation Check	UN1	I felt that I received individually tailored information that supported my overall task accomplishment	7-point Likert
	UN2	I felt that I received individually tailored information	7-point Likert

Variable	Abbreviation	Measure	Scale
	UN3	I felt that I received location-based information	7-point Likert
	UN4	I felt that I received location-based information that supported my overall task accomplishment	7-point Likert
Perceived Enjoyment	J1	I had fun interacting with the PDA	7-point Likert
	J2	Using a PDA provided me with a lot of enjoyment	7-point Likert
	J3	I enjoyed using a PDA	7-point Likert
Interruption	I1	Were you interrupted?	Categorical (Yes/No)
	I2	If yes, by what?	Categorical
	I3	If yes, can you also estimate the time?	Ratio

APPENDIX D – CONSENT FORM

CONSENT FORM

I ___________________________________ (fill in your name here) agree to take part in a research study titled "**U-Commerce: An Examination of Wired versus Wireless Technology and Location-based versus Non-location-based Services**" which is being conducted by Iris A. Junglas, Ph.D. student, University of Georgia, Management Information Systems Department, 312 Brooks Hall, Athens, GA 30602-6273, (706) 542-4665, under the direction of Professor Richard T. Watson, University of Georgia, Management Information Systems Department, 312 Brooks Hall, Athens, GA 30602-6273, (706) 542-3706.

I do not have to take part in this study; I can stop taking part at any time without giving any reason, and without penalty. I can ask to have information related to me returned to me, removed from the research records, or destroyed.

The purpose of the study is to examine how efficiently and effectively people perform tasks using wireless and non-wireless technology that provides location- and non-location-based services.

The benefits that I (the participant) may expect from the study are:

- Learn about the latest technology
- If I complete the experiment and I am among the top 50% of my treatment group, I qualify for participating in a drawing with 10 monetray prices of $30 each.
- Every student of the MIST 5640 class will receive the same amount of course credit for participation. If a student chooses not to participate in the study, s/he will get an alternative extra credit assignment.

In order to participate in this study, I (the participant) have to fulfill the following requirements:

- I am student at the Terry College of Business
- I am willing to spend approximately 2 hours participating in the study

If I volunteer to take part in this study, I (the participant) will be asked to do the following things:

- Participate in a training session that lasts for about half an hour. Within this time, I will be taught on how to use a PDA (Personal Digital Assistant).
- Fill out a 5 item online registration form and a 9 item online questionnaire on demographics.
- Fill out an 8 item pre-experimental online questionnaire on PDAs.
- Perform 8 tasks that are emailed to me using the technology provided to me (duration: approx. 1.5 hours). Each set of tasks is followed by an 8 item post-experimental online questionnaire that I will have to fill out as well.
- Fill out an 11 item online questionnaire after the experiment is done.

No discomforts, stresses or risks are expected.

Due to the nature of the experimental set-up, I will be asked to provide—among other things—identifying information. This information will remain confidential throughout the duration of the experiment and will be disclosed only with my permission or as required by law. Furthermore, I understand that there is a limit to the confidentiality that can be guaranteed due to the Internet technology itself. After the experiment is finished (i.e., at the end of my participation in the study), any identifying information will be destroyed immediately.

I also agree not to disclose any information about the content of the experiment to anyone until the study ends.
The researcher will answer any further questions about the research, now or during the course of the project, and can be reached by telephone at: (706) 542-4665.

I (the participant) understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____________________________________ ____

Signature of Researcher Date Signature of Participant Date

For questions or problems about your rights please call or write: Chris A. Joseph, Ph.D., Human Subjects Office, University of Georgia, 606A Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-6514; E-Mail Address IRB@uga.edu.

APPENDIX E – INSTRUCTIONS FOR SUBJECTS

The following descriptions were given to every participant at the beginning of each experimental session. Subjects were required to work through every step of the instruction sheet.

About the study…

The purpose of the study is to examine how people perform using *wireless and non-wireless* **technology that provides** *location- and non-location-based services* **to fulfill specific given tasks.**

How to get started with my PDA (Personal Digital Assistant)? By working through the following steps…

1. The card that sticks out at the top end of your PDA is called a WLAN (wireless local area network) card. It carries a number that you will need later.
2. Release the black colored stylus (=“pen”) by taping on its end located on the right side of the top end of your PDA (in the silver colored section near the WLAN card release). Remove the stylus.
3. Turn on your PDA by pressing the silver button in the upper right corner just above the words “Pocket PC.” Make sure that your WLAN card is blinking. You should see an introductory page with a blue background and the word “Microsoft Mobile Page” written vertically on the right side of the page. If not, close any window open by pressing “ok” (or “x”) with your stylus in the upper right corner of the window.
4. Click on “Start.”
5. Click on “Internet Explorer.”
6. Type a URL (anyone you like) into the address bar using the keyboard.
   In order to use the keyboard, click on the “keyboard icon” that is located in the right bottom corner of the screen. If you click on this icon again, the keyboard will disappear.
7. After having typed in the URL, hit the green arrow to the right of the address bar.
   See if the browser loads the page correctly. If not, please let the administrator know.
8. Check out the options of the Internet Explorer in the bottom menu. Here is a list of the most important ones that you may need later.

View	Text size	Here you can change the text size from medium to large if you want to.
Tools	Cut Copy Paste	For cutting, copying, and pasting text between different applications.
Refresh		Note that whenever a rotating globe in the upper right corner of the screen appears, the page is loading.
Favorites		This is where you can store your personal bookmarks. One of the

		most important bookmarks is already installed for you, namely a bookmark for the registration process (called "***Registration***") and your personal email application (called "***Check your email here!***"). In your spare time during the experiment, feel free to check out the other links as well, i.e., "AvantGo Channels" (news channel for Pocket PC), "Pocket PC Web Guide" (portal page for Pocket PCs), "WindowsMedia.com" (media applications for Pocket PCs).

9. When you are done getting familiar with the Internet Explorer, click on the "favorites icon" ( ) in the bottom menu bar. Then click on "Registration." You are almost ready to rumble!
10. But before you go to the final steps, please read through the following IMPORTANT NOTES.

- ***Never use the forward or back button ( ) in the bottom menu of the Internet Explorer for Web site navigation when on a web page that belongs to the experiment*** (you can tell by the mixed colored border pattern at the top or bottom of a page). If you do, you may cause double entries into the database. Always use the links provided on the screen. Whenever you leave the experimental sites, you are free to use the forward or back button as often as you'd like.
- ***Please make sure that your WLAN card is always blinking!***
- As you will soon find out, a lot of tasks will require you to move between and within buildings. Members of ***group 1 and 2*** are allowed to take their PDA with them from now on. ***Group 3 and 4***, however, won't have this opportunity; they have to leave the PDA on the table whenever they need to leave the room.
- Do not use any other means than the ones provided to perform a task! That includes: cell phones, laptops, desktops, exchanging answers with other participants, etc.
- Be as considerate and honest as possible when answering questionnaire items.
- Read through the ***entire*** Web page first before you continue to the next one.
- ***Once you have started working on a task, try not to get interrupted by anyone or anything.***
- The PDA automatically turns off its power if not used for 3 minutes. In order to turn it on again, just press the silver button in the upper right corner just above the words "Pocket PC." It will automatically return to the same application you were using before.
- In case you need to change the backlight settings, please click on "Start" – "Settings" – "System" – "backlight."
- Do not to disclose any information about the content of the experiment to anyone until the study ends at the end of November 2002.
- The top 50% performers of each group will participate in a drawing with 10 monetary prices of $30 each. The winners will be informed via email after data collection is finished, i.e., by the end of November.
- Make sure you've got some paper and pencil.

In addition, for members of group 1 and 2 the following rules apply:

- It is absolute essential that you stay within the boundaries of the wireless network infrastructure, i.e., Sanford Hall (1st, 2nd and 3rd floor) and the 3rd floor of Brooks Hall. Within these boundaries you can move freely.
- ***Please take this sheet with you!***
- Technical problems might occur. These include that your PDA doesn't seem to respond or one (or more) of the following error messages occur:

"Page was not found" "Could not receive DHCP" "Unable to obtain a server-assigned IP address." "Unable to communicate with device driver"

Don't worry. In order to resolve the problem, please do the following (in the order listed):

Plan A. Check if the PDA is simply stuck loading a page. You can tell by the rotating globe in the upper right corner of the screen. Be patient. This might be due to increased traffic on the network. Try to call the URL again after some time. If this doesn't work, try plan B.

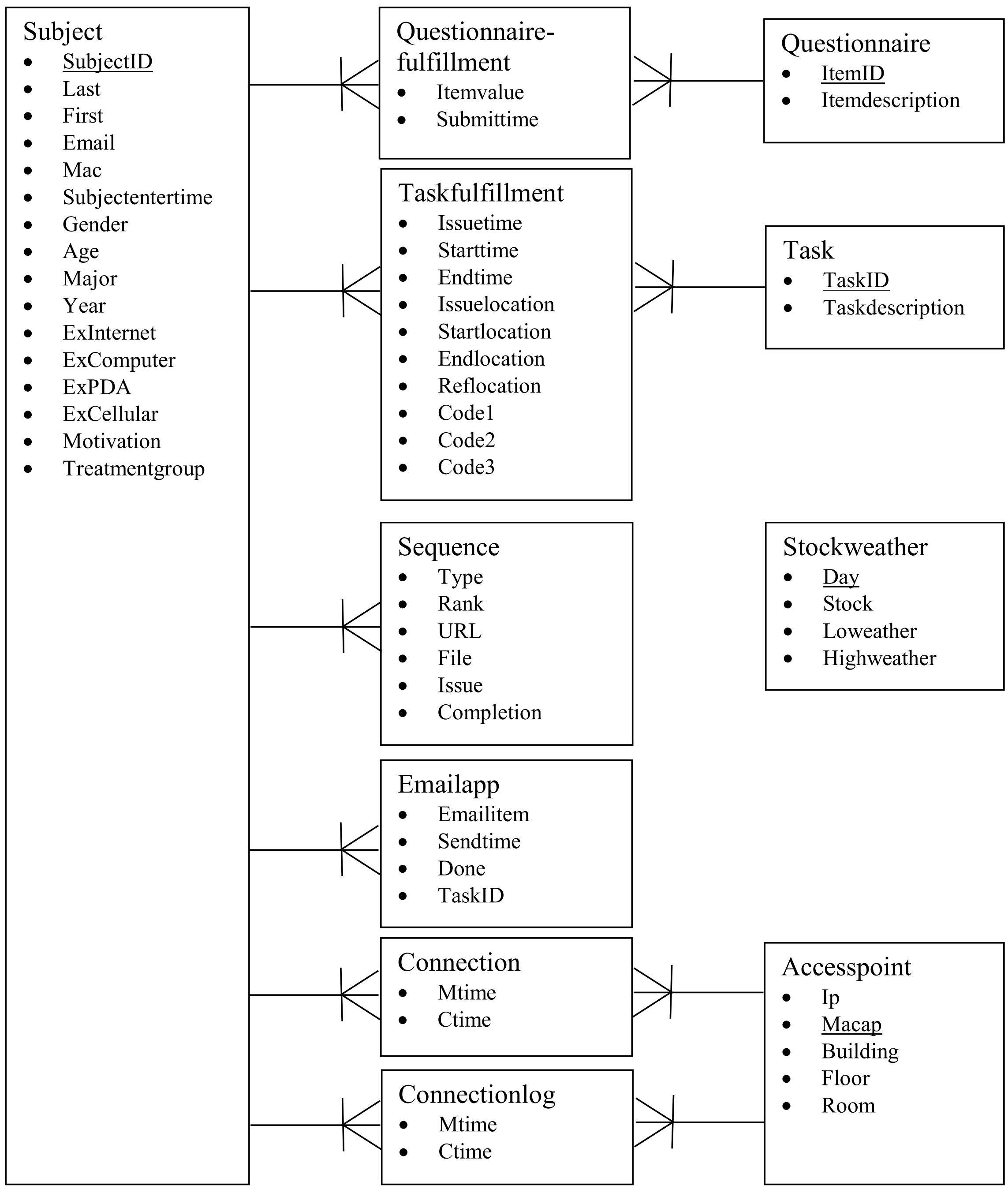
Plan B. Eject the wireless LAN card and insert it again. You can do so by pressing the black button next to the edge of the card slot. The button rises. Press it again in order to eject the card. Then hit "refresh." Make sure your WLAN card is blinking. If this doesn't work, try plan C.

Plan C. Move to another location where the signal strength is stronger. You can check on the signal strength by pressing "Start" and then "Wireless LAN Client." Please note that the signal strength is stronger inside a building within the Terry College. If this approach doesn't work either, try plan D.

Plan D. Contact the administrator.

11. Now you are ready to rumble! Follow the link on the screen that says "Go to the login screen" and enter the information requested. Your WLAN card number is the one indicated on your WLAN card; your group number is indicated on the yellow post-it that was sticking on your PDA previously.
12. After the registration page, follow the links provided on the screen. Answer a sequence of questions and read carefully through the scenario description. Stop when you get to a page that says "waiting page" and let the administrator know.

APPENDIX F – DATA MODEL



APPENDIX G – FILE DOCUMENTATION

The following table lists all the files that were necessary to implement the experiment. For every file, its name, the action taken within the file (i.e., inserting, updating, or retrieving data from the database), the according tables and attributes, and the next file in the sequence is listed.

File	Action	Table	Attribute	Links to
register				login
login				loginset
loginset	insert cookiesubjectID cookiedevicemac cookieorder select	subject subject	last, first, MAC, email, treatmentgroup subjectID	quDG
quDG	select	questionnaire	itemdescription	quDA
quDA	update select	subject questionnaire	gender itemdescription	quDMA
quDMA	update select	subject questionnaire	age itemdescription	quDY
quDY	update select	subject questionnaire	major itemdescription	quEX1
quDEX1	update select	subject questionnaire	year itemdescription	quEX2
quDEX2	update select	subject questionnaire	exComputer itemdescription	quEX3
quDEX3	update select	subject questionnaire	exInternet itemdescription	quEX4
quDEX4	update select	subject questionnaire	exCellular itemdescription	quMO
quMO	update select	subject questionnaire	exPDA itemdescription	sequence
sequence	update	sequence	type, rank, URL, subjectID	quset1AU1 or quset2AU2
quset1AU1	select update	questionnaire sequence	itemdescription issue	quset1AEOU3
quset1AEOU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1AEOU2
quset1AEOU2	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1AU4
quset1AU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1AEOU1

quset1AEOU1	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1AU2
quset1AU2	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1AEOU4
quset1AEOU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1AU3
quset1AU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1AZ
quset1AZ	insert update cookieorder +1	questionnairefulfillment sequence	itemvalue, subjectID, itemID completion	scenario
quset2AU2	select update	questionnaire sequence	itemdescription issue	quset2AU4
quset2AU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2AEOU4
quset2AEOU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2AEOU1
quset2AEOU1	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2AU1
quset2AU1	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2AEOU2
quset2AEOU2	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2AU3
quset2AU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2AEOU3
quset2AEOU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2AZ
quset2AZ	insert update cookieorder +1	questionnairefulfillment sequence	itemvalue, subjectID, itemID completion	scenario
scenario	select	task	taskdescription	wait
wait				emailapplication
emailapplication	select	emailapp	emailitem, sendtime	
issue				issueset

issueset	insert update insert select insert	taskfulfillment sequence emailapp sequence taskfulfillment	issuetime, subjectID, taskID issue emailitem, sendtime, subjectID, sender, number, taskID URL starttime=0	issue
s1t1hdescription	select select|update Task: Search for a person	task taskfulfillment	taskdescription if starttime=0 then update	s1t1application
s1t1happlication	selection form		$person	s1t1description s1t1application2
s1t1happlication2	select	connection, accesspoint	$building, $floor, $room	s1t1description s1t1application s1t1happlication2 s1t1answer
s1t1hanswer	enter form		$file	s1t1hdescription s1t1happlication2 s1t1hanswerset
s1t1hanswerset	update update update cookieorder + 1 cookietaskgroup=tg1	sequence taskfulfillment emailapp	completion code1, endtime done	s1hanswer
s1hanswer	select link update	 taskfulfillment	 ilen, irrupt, iwhy	wait quset1BU1 quset2BU2
s1t2hdescription	select select|update Task: Write email	task taskfulfillment	taskdescription if starttime=0 then update	s1t2answer
s1t2hanswer	enter form		$emailsubject $emailcontent	s1t2hdescription s1t2hanswerset

s1t2hanswerset	update update update cookieorder + 1 cookietaskgroup=tg2	sequence taskfulfillment emailapp	completion code1, code2, endtime done	s1hanswer
s1t3hdescription	select select|update Task: Find room numbers	task taskfulfillment	taskdescription if starttime=0 then update	s1t3happlication
s1t3application.php	select	connection, subject, accesspoint	$building, $floor, $room	s1t3hdescription s1t3happlication s1t3hanswer
s1t3hanswer	enter form		$helpdesk, $misoffice, $cocacola	s1t3hdescription s1t3happlication s1t3hanswerset
s1t3hanswerset	update update update cookieorder + 1 cookietaskgroup=tg3	sequence taskfulfillment emailapp	completion code1, code2, code3, code 4, endtime done	s1hanswer
s1t4hdescription	select Task: Find stock prices	task taskfulfillment	taskdescription if starttime=0 then update	s1t4hanswer
s1t4hanswer				s1t4hdescription s1t4hanswerset
s1t4hanswerset	update update update cookieorder + 1 cookietaskgroup=tg4	sequence taskfulfillment emailapp	completion code1, code2, code3, endtime done	s1hanswer
s2t1hdescription	select select|update Task: Find office	task taskfulfillment	taskdescription if starttime=0 then update	s2t1happlication
s2t1happlication	select	connection, subject, accesspoint	building, floor, room	s2t1hdescription s2t1happlication s2t1hanswer

s2t1hanswer	enter form		$confnumber	s2t1hdescription s2t1happlication s2t1hanswerset
s2t1hanswerset	update update update cookieorder + 1 cookietaskgroup=tg1	sequence taskfulfillment emailapp	completion code1, endtime done	s1hanswer
s2t2hdescription	select select|update Task: Search for flight	task taskfulfillment	taskdescription if starttime=0 then update	s2t2happlication
s2t2happlication			$location1, $location2, $traveldate1, $traveldate2, $price	s2t2hdescription
s2t2hanswer			$last, $first, $email	s2t2hdescription s2t2happlication s2t2hanswer
s2t2hanswerset	update update update cookieorder + 1 cookietaskgroup=tg2	sequence taskfulfillment emailapp	completion code1, code2, code3, endtime done	s2hanswer
s2t3hdescription	select select|update Task: Search for person	task	taskdescription	s2t3happlication
s2t3happlication			$person	s2t3hdescription s2t3happlication2
s2t3happlication2	select	connection, accesspoint	building, floor, room	s2t3hdescription s2t3happlication s2t3happlication2 s2t3hanswer
s2t3hanswer	enter form		$isbn	s2t3hdescription s2t3happlication s2t3hanswerset

s2t3hanswerset	update update update cookieorder + 1 cookietaskgroup=tg3	sequence taskfulfillment emailapp	completion code1, code2, endtime done	s1hanswer
s2t4hdescription	select select|update Task: Search for weather	task taskfulfillment	taskdescription if starttime=0 then update	s2t4hanswer
s2t4hanswer			$today, $yesterday, $daybefore	s2t4hdescription s2t4hanswerset
s2t4hanswerset	update update update cookieorder + 1 cookietaskgroup=tg4	sequence taskfulfillment emailapp	completion code1, code2, code3, endtime done	s1hanswer
s1t1ldescription	select select|update Task: Search for a person	task taskfulfillment	taskdescription if starttime=0 then update	s1t1lanswer
s1t1lanswer	enter form		$file	s1t1ldescription s1t1hanswerset
s1t2ldescription	select select|update	task taskfulfillment	taskdescription if starttime=0 then update	s1t2hanswer
s1t3ldescription	select select|update Task: Find room numbers	task	taskdescription	s1t3lanswer
s1t3lanswer	enter form		$helpdesk, $misoffice, $cocacola	s1t3ldescription s1t3hanswerset
s1t4ldescription	select select|update Task: Find stock prices	task taskfulfillment	taskdescription if starttime=0 then update	s1t4hanswer
s2t1ldescription	select select|update Task: Find office	task taskfulfillment	taskdescription if starttime=0 then update	s2t1lanswer
s2t1lanswer	enter form		$confnumber	s2t1ldescription s2t1hanswerset

s2t2ldescription	select select|update Task: Search for flight	task taskfulfillment	taskdescription if starttime=0 then update	s2t2lanswer
s2t3ldescription	select select|update Task: Search for person	task taskfulfillment	taskdescription if starttime=0 then update	s2t3lanswer
s2t3lanswer	enter form		$isbn	s2t3lanswer s2t3hanswerset
s2t4ldescription	select select|update Task: Search for weather	task taskfulfillment	taskdescription if starttime=0 then update	s2t4hanswer
quset1BU1	select update	questionnaire sequence	itemdescription issue	quset1BEOU3
quset1BEOU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1BEOU2
quset1BEOU2	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1BU4
quset1BU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1BEOU1
quset1BEOU1	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1BU2
quset1BU2	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1BEOU4
quset1BEOU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1BU3
quset1BU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset1BZ
quset1BZ	insert update cookieorder +1	questionnairefulfillment sequence	itemvalue, subjectID, itemID completion	wait
quset2BU2	select update	questionnaire sequence	itemdescription issue	quset2BU4
quset2BU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2BEOU4

quset2BEOU4	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2BEOU1
quset2BEOU1	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2BU1
quset2BU1	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2BEOU2
quset2BEOU2	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2BU3
quset2BU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2BEOU3
quset2BEOU3	insert select	questionnairefulfillment questionnaire	itemvalue, subjectID, itemID itemdescription	quset2BZ
quset2BZ	insert update cookieorder +1	questionnairefulfillment sequence	itemvalue, subjectID, itemID completion	wait
quUB1	select	questionnaire	itemdescription	quUN1
quUN1	select insert	questionnaire questionnairefulfillment	itemdescription itemvalue, subjectID, itemID	quUB2
quUB2	select insert	questionnaire questionnairefulfillment	itemdescription itemvalue, subjectID, itemID	quUN2
quUN2	select insert	questionnaire questionnairefulfillment	itemdescription itemvalue, subjectID, itemID	quUB3
quUB3	select insert	questionnaire questionnairefulfillment	itemdescription itemvalue, subjectID, itemID	quUN3
quUN3	select insert	questionnaire questionnairefulfillment	itemdescription itemvalue, subjectID, itemID	quUB4
quUB4	select insert	questionnaire questionnairefulfillment	itemdescription itemvalue, subjectID, itemID	quUN4
quUN4	select insert	questionnaire questionnairefulfillment	itemdescription itemvalue, subjectID, itemID	quUZ
quUZ	insert	questionnairefulfillment	itemvalue, subjectID, itemID	

APPENDIX H – CORRELATION MATRIX

Table 91: Pearson correlations

		USE	EOU	FIT	TTS	AC	TTC
USE	Pearson Correlation	1	.750	.255	.007	-.002	-.090
	Sig. (2-tailed)	.	.000	.000	.886	.970	.055
	N	463	463	463	457	457	454
EOU	Pearson Correlation	.750	1	.117	.014	.106	-.001
	Sig. (2-tailed)	.000	.	.012	.758	.023	.980
	N	463	463	463	457	457	454
FIT	Pearson Correlation	.255	.117	1	.006	-.007	.088
	Sig. (2-tailed)	.000	.012	.	.896	.874	.060
	N	463	463	468	462	462	459
TTS	Pearson Correlation	.007	.014	.006	1	1	.005
	Sig. (2-tailed)	.886	.758	.896	.	.	.922
	N	457	457	462	462	462	458
AC	Pearson Correlation	-.002	.106	-.007	1	-.036	-.002
	Sig. (2-tailed)	.970	.023	.874	.	.444	.970
	N	457	457	462	462	458	457
TTC	Pearson Correlation	-.090	-.001	.088	.005	-.002	1
	Sig. (2-tailed)	.055	.980	.060	.922	.970	.
	N	454	454	459	458	458	459

Legend:

USE	Perceived usefulness	**TTS**	Time-to-start
EOU	Perceived ease of use	**AC**	Answer correctness
FIT	Fit	**TTC**	Time-to-completion

Table 92: Spearman correlations

		USE	EOU	FIT	TTS	AC	TTC
USE	Spearman Correlation	1.000	.750	.002	.039	-.105	1.000
	Sig. (2-tailed)	.	.000	.971	.404	.025	.
	N	463	463	457	457	454	463
EOU	Spearman Correlation	.750	1.000	.022	.092	-.013	.750
	Sig. (2-tailed)	.000	.	.644	.050	.778	.000
	N	463	463	457	457	454	463
FIT	Spearman Correlation	.002	.022	1.000	-.030	.004	.002
	Sig. (2-tailed)	.971	.644	.	.518	.927	.971
	N	457	457	462	462	458	457
TTS	Spearman Correlation	.039	.092	-.030	1.000	-.032	.039
	Sig. (2-tailed)	.404	.050	.518	.	.494	.404
	N	457	457	462	462	458	457
AC	Spearman Correlation	-.105	-.013	.004	-.032	1.000	-.105
	Sig. (2-tailed)	.025	.778	.927	.494	.	.025
	N	454	454	458	458	459	454
TTC	Spearman Correlation	1.000	.750	.002	.039	-.105	1.000
	Sig. (2-tailed)	.	.000	.971	.404	.025	.
	N	463	463	457	457	454	463

Legend:

USE	Perceived usefulness	**TTS**	Time-to-start
EOU	Perceived ease of use	**AC**	Answer correctness
FIT	Fit	**TTC**	Time-to-completion