A CROSS-PLATFORM USABILITY EVALUATION OF 2D VISUAL TAGGING SYSTEMS

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ABSTRACT

By encoding 2D bar codes that store URL links, SMS or plain text, 2D visual tags link information about objects in the physical world to online or offline content. The existence of physical world hyperlinks in the form of 2D visual tags that are placed in the natural environment therefore makes new social and cultural interaction modes possible. Although 2D visual tagging systems have much potential to positively influence the way people, and Africans in particular, interact with the physical world, there has been no in-depth evaluation or cross-platform usability assessment of available 2D visual tagging systems. Research in the field has primarily focused on the description and evaluation of prototype visual tagging applications. The deployment and use of 2D visual tagging systems have also not been comprehensively tested in Africa.

To evaluate the 2D visual tagging paradigm, five 2D visual tagging systems were selected for this study. These 2D visual tagging systems were selected because of their robustness and high visibility in the field of physical world hyperlinks; and also because a Nokia 6280 handset (which was the camera phone that was used for this study) can be used to interact with any of these systems. A hybrid methodology that consisted of three discrete sets of questionnaires, observations, interviews and the application of the Real Access criteria as well as the actual scenario-based usability testing sessions was adopted. This hybrid approach was adopted because it is a guaranteed and viable pathway for the provision of comprehensive illumination and feedback on the key usability issues that were investigated during this study.

The evaluation results showed that participants were generally satisfied with the performance of the 2D visual tagging systems with low decoding latency, intuitive interface and feedback mechanism. Most participants also indicated a willingness to use visual tagging systems on a regular basis, in spite of perceived limitations. Furthermore, test results showed that the single most important attribute of a visual tagging system, from a user perspective, is its decoding latency. Similarly, it was found that the most important factor that could influence the adoption of the 2D visual tagging paradigm is mobile Web browsing costs. An evaluation of the 2D visual tagging paradigm against the Real Access criteria framework indicates that 2D visual tagging systems surpass the minimal criteria threshold for effective and efficient deployment within an African context. The study concludes with a list of twenty recommendations that 2D visual tagging system providers may adopt to make their systems and by extension, the 2D visual tagging paradigm, more efficient, attractive and accessible to users.

DEDICATION

This research project is dedicated to the Almighty God, the Creator of our vast and magnificent planet who is yet to initiate a project He could not bring to completion, for enabling me to start and complete the MIT program as well as this dissertation.

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Ubiquitous Computing also known as Everyware, Ubicomp and Pervasive Computing promises to change the way we people live, work and play. The main thrust of Ubicomp is the creation of intelligent systems that are woven seamlessly into everyday life and activities. Mark Weiser [Weiser, 1991], who is considered the founder of Ubicomp, describes the goal of Ubicomp as the enhancement of "…computer use by making computers available throughout the physical environment, but making them effectively invisible to the user".

In the same vein, Adam Greenfield [Greenfield, 2006] postulated that "…all the information we now look to our phones to or Web browsers to provide becomes accessible from just about anywhere, at any time, and is delivered in a manner that is appropriate to our location and context". An application scenario for Ubicomp is that in the future home, people will be able to use mobile devices to control and manage other Internet-enabled appliances including kitchen equipment, house cleaning gear, furnishings, et cetera. Ubicomp will make possible a future where a disabled person – blind, deaf, wheelchair bound, et cetera - can have a quality of life that's as good as that of the average able-bodied citizen. Thanks to Everyware, quadriplegics will be able to drive cars entirely via remote control, work from home using WiFi/WiMAX and VoIP, as well as work from an office using the appropriate technology like audio, smell or touch recognition software depending on the disability.

Another application scenario for Ubicomp is the deployment of 2D visual tagging systems which are 2D barcode or visual tag-based systems for ubiquitous computing. 2D visual tagging systems connect objects in the environment to online or offline information about them – that is, about the objects. Meanwhile, a 2D visual tagging system consists of a 2D visual tag and 2D visual tag reader which is downloaded onto (usually a camera) phone which has the capability to run the application. A 2D visual tag may encode a URL (Web address) link, text, images or personal information. A 2D visual tag reader may then be used to decode a visual tag for it to yield the information that is stored in it. Individuals may consequently interact with the natural environment through the use of 2D visual tagging systems.

To investigate the 2D visual tagging paradigm, this study will focus on a cross-platform usability evaluation of the following 2D visual tagging systems: BeeTagg[1], ConnexTo[2], Shotcode[3], Semacode[4] and UpCode[5]. These five 2D visual tagging systems were selected for study basically because their individual applications can be run from a Nokia 6280 phone, the handset that will be used for the usability evaluation testing sessions. In addition, these systems have high visibility in the 2D visual tagging field and are also free for private use. The Semacode, Shotcode, BeeTagg, ConnexTo and UpCode 2D visual tagging systems are therefore 2D barcode or visual tag-based systems for ubiquitous computing. This means that specific objects or locations are tagged in a clearly defined format. A software program called a 2D visual tag reader can then read or decode the visual tag and retrieve relevant information about the object the tag is affixed to. The reader is able to do this because the visual tags have URLs or some other offline information embedded in them. 2D visual tags that provide online or offline information about tagged objects will be created for each of the BeeTagg, ConnexTo, Shotcode, Semacode and UpCode 2D visual tagging platforms. The visual tags will then be read through a Nokia 6280 phone on which the visual tag readers for the BeeTagg, ConnexTo, Shotcode, Semacode and UpCode readers had been installed.

In summary, a BeeTagg, ConnexTo, Shotcode, Semacode or UpCode visual tagging system consists of a 2D visual tag reader and 2D visual tag(s) in which a URL or text has been embedded. The visual tag is usually a two-dimensional barcode which can be read by a reader that has been developed for this specific purpose. The visual tag reader has to

1 www.beetagg.com
2 www.connexto.com
3 www.shotcode.com
4 www.semacode.org
5 www.upcode.fi

be downloaded and installed on the user's smart or camera phone. However, some phones, especially in Japan, come equipped with the QR code reader software. The visual tag reader decodes the visual tag by extracting (usually) the URL or offline data such as text or images from the visual tag, using image recognition, and then processing the image. In the case of offline information, the text or other non- Internet related data is displayed on the screen of the phone. But for Web-linked data, the display of the Web-based information is transferred to the built-in browser of the phone of the user via Wireless Application Processing (WAP). So the phone has to be WAP-enabled for URL-based visual tagging. But this is a mute point as all smart or camera phones are WAP-capable.

1.2 Research Questions

This research project will focus, at a high level, on the investigation of the 2D visual tagging systems that are currently available for the linking of physical objects to information about the objects in ways that make social, educational and other interactions with the tagged objects possible. The 2D visual tagging platforms that will be examined are the BeeTagg, ConnexTo, Shotcode, Semacode and UpCode 2D visual tagging systems. The physical objects could be anything including buildings, manuscripts and art works which are tagged via the use of visual code reader-enabled camera phones such as a Semacode reader [SEMA1]. This research project will be designed around answering the following questions:

1. What is the contextual application and deployment of this technology in the African environment? Are 2D visual tagging applications appropriate for deployment in the African environment?

2. What are the usability issues that arise as a result of the use of 2D visual tagging systems? This research question is further composed of the following questions:

- What mental model or perceptions do users have about how to use mobile 2D visual tagging technology?
- How natural and easy is it for novice users to interact with, and use a 2D visual tagging system without explicit guidance?
- What are the attitudes that users have towards the adoption of the 2D visual tagging paradigm?
- What are the strengths and weaknesses of the currently available free-for-private use 2D visual tagging systems from a usability perspective?
- How do lighting conditions affect the performance of 2D visual tag-reading applications?

Although the "first alpha of the symbology code" [SEMA2] for the Semacode visual tag reader was initially developed in Ghana, the 2D visual tagging systems being investigated for this study were all developed in the Industrial world (in countries such as USA, Canada, Switzerland, and Finland). Moreover, there is no record of 2D visual tagging applications being substantially tested or used in Sub-Saharan Africa. This is why one of the research questions addresses the feasibility of using 2D visual tagging systems in Africa. Therefore the usability testing of the selected 2D visual tagging systems in Cape Town will be a novel activity on the African continent. Meanwhile, the other research questions basically address the usability issues that the use of 2D visual tagging applications may raise. The resolution of these research questions will inter alia shed light on whether the 2D visual paradigm will be (widely or otherwise) adopted by camera phone users based on the portability, ease of use and relevance of 2D visual tagging systems.

1.3 Significance of Research

Although visual tagging technology has been around for about five years, its use has been almost non-existent on the African continent. Mobile phone usage did not become popular in most of Africa until about a decade ago. For instance, cell phones became available in Nigeria in 2001. Yet today, it's one of the countries experiencing massive growth in cellular telephony with over 15 million mobile phone subscribers. Similarly, it can be argued that the adoption of the Semacode or Shotcode visual tagging system, for example, can have a major influence on how Africans socialize and interact with their physical environment.

One way the technology can be deployed is as an enhancer of the educational process. Images of manuscripts, artworks and textbooks can be captured by students via the use of a camera phone. The student can then later on find out more about the art work in question by going to the relevant URL while outside the school or in a more relaxed environment. So, learning continues wherever the student is. Also, books can be tagged and information from the book's URL retrieved for study purposes. The disadvantage of this approach is that the book must have a companion URL. This is particularly significant in those parts of Africa where books are either too expensive for students to afford or they are unavailable.

Moreover, there are a couple of commercial applications that the technology may be deployed for. Researchers at Intel and the Computer Laboratory at the University of Cambridge have developed systems – based on a similar technology – for on-site services that are offered in restaurants and tourist centres. There is also a citywide effort in Tokyo, Japan to visually tag the whole city. Visitors looking for a particular place or location can then find their way around the city by using their camera phones to snap the tags provided.

In summary, 2D visual tagging systems enable the connection of physical media to mobile content thereby creating new affordances and pathways for interacting with objects and media in the physical, educational and social environment. Thus, visual tagging technologies may be deployed in any number of industries including education, tourism, gaming and marketing where the technology can be used to improve the way people interact and communicate. For instance, John Steys, [SEMA3] the director of data communications services for Sprint, a US telecommunications firm recently commented that Semacode can be used as a replacement for shotgun marketing which traditionally costs millions. However, this study will not be focusing on an in-depth investigation of deployment opportunities for 2D visual tagging systems. This study will instead be limited to a usability evaluation of selected 2D visual tagging systems.

1.4 Research Premise and Motivation

The success and significance of this project are premised on three factors: the extent and penetration of mobile phone usage in Africa, the availability of various visual code systems for tagging objects in the physical world and linking them to information online, and the relative accessibility and affordability of mobile Internet.

Africa is the fastest-growing mobile phone market in the world. According to a Commission for Africa report, less than 3% of the African peoples had access to a telephone (fixed line) in 2001. But by 2003, Africa had 51.8 million subscribers to mobile services, a number that far outstripped the Continent's 25.1 million fixed-line subscribers [Momo, 2005]. At the end of 2004, over 7% of the population had a mobile phone. [Nigel, 2004] The breakdown of the figures shows that Africa's largest mobile phone firm, Vodacom, had 14.4 million users while MTN with operations in South Africa, Nigeria, Cameroon, Uganda, Rwanda and Swaziland had 14 million subscribers. The use of mobile phones has been increasing at an annual rate of 65%, more than twice the global average. Moreover, Africa's mobile penetration rate - the number of people using mobile phones - may reach up to 20% by 2010 [Kelly, 2004].

The Wireless Application Protocol (WAP) is a technology that enables mobile phones to access the Internet wirelessly. WAP usage and uptake was initially slow as users shunned the service due to high costs (especially in Africa) and the very unpleasant task of trying to view and scroll Internet pages on the small display screen of a cell phone. WAP usage and popularity has however picked up since then. A 2006 BBC report claimed that "page views for WAP usage are growing at 100% year on year [BBC1]". Moreover, the BBC report indicated that far more people in Africa access the Internet (the BBC news site) through their mobile phones than through PCs.

The 2D visual tagging systems that will be a main focus of this study are composed primarily of 2D bar codes that are an enhancement of the traditional 1D bar codes which are a permanent fixture of consumer products. 2D codes are structurally either stacked or matrix bar codes. Stacked codes are traditional bar codes that are 'stacked' on top of one another and hold limited data. On the contrary, matrix codes are able to store more data because information is encoded in both horizontal and vertical directions. The 2D visual tagging systems that this study investigates make use of matrix 2D bar codes and proprietary 2D symbologies such as mCode (for the ConnexTo visual tagging system).

1.5 Existing Research

The field of visual tagging is relatively new, and therefore very little has been published on the subject. A review of pertinent research will be presented in this section – a more detailed literature review is presented in Chapter Two. Assaf Feldman et al [Feldman, 2005] of the MIT Media Lab created a system they called ReachMedia which consists of a wireless wristband that includes an RFID reader, 3-axis accelerometers and RF communication facilities. The distinguishing feature of the system is that it features a mobile and wearable interface and allows "socially acceptable, on-the-move interaction" [Feldman, 2005] with target objects in the surrounding environment.

David Scott et al of Intel Research and Computer Lab at the University of Cambridge [Toye, 2005] developed a system for accessing site-specific services such as ticket machines and information kiosks using a technology similar to the Semacode visual tagging application. Their system was based on a client-server model and consisted of the Mobile Service Toolkit (MST) client software which runs on users' camera phones and the MST server software which runs on a device such as a PC which provides a site-specific service.

It is important to point out however that none of the research currently available explicitly investigates 2D visual tagging technology usage in Africa. Also, none of the papers has exclusively focused on the usability issues that may hamper the smooth adoption of social computing technologies like Semacode or Shotcode. This is one reason why this research project is relevant.

1.6 Methodology

A hybrid approach that will consist of a series of questionnaires (Nielsen's Five Attributes of Usability, the System Usability Scale, and a customized questionnaire), observations, interviews, and the application of the Real Access criteria developed by bridges.org as well as scenario-based usability testing sessions will be adopted for the study. The educational materials will be tagged using the selected 2D visual tagging systems, and students from the target educational institution(s) will be asked to interact with the tagged educational materials over a period of time. Data collection will be through observations, questionnaires and interviews, and feedback from usability evaluation assessments.

The respondents for the MDSQ instruments and the sample for the usability evaluation testing sessions will consist of 72 individuals. The test environments will include the Department of Manuscript and Archives at the University of Cape Town and the Baxter Theatre Centre, also in Cape Town. The equipment for this study will basically comprise a Nokia 6280 camera phone; printed BeeTagg, ConnexTo, Shotcode, Semacode and UpCode 2D visual tags; and BeeTagg, ConnexTo, Shotcode, Semacode and UpCode 2D visual tag readers (software for reading or decoding the visual tags) which have been pre-installed on the Nokia 6280 phone.

1.7 Usability Focus

The introduction of a new technology, especially one that holds great promise for changing existing paradigms of social interaction is usually accompanied by hype and fanfare. But the performances of such technologies often fall short of the initial promise. This is known as the Dancing Bear phenomenon. Yes, the bear is on its fore limbs but is it really dancing well? The use of visual tagging techniques can provide many benefits from the social interaction perspective but is the technology easy to use and intuitive to learn? Will it be widely used as a functional tool for getting information on physical objects? To get answers to these and other questions that will arise in the course of the research, five visual tagging systems namely: BeeTagg, ConnexTo, Shotcode, Semacode and UpCode will be investigated. Therefore, one of the main goals of the research project will be to explore as well as compare and contrast the usability issues that surround the deployment and use of the BeeTagg, ConnexTo, Shotcode, Semacode and UpCode platforms.

1.8 Anticipated Outcomes

The usability testing of the selected 2D visual tagging platforms will indicate whether there is support for the adoption and use of the 2D visual tagging paradigm within an African context. Also, usability constraints that need to be fixed will be identified and possible solutions proffered. There will also be suggestions for future work and additional usability testing to be conducted on the different visual tagging platforms. This research should also lead to the development of a list of recommendations that, if adopted by 2D visual tagging system providers, should improve the overall efficiency and attractiveness of the 2D visual tagging paradigm.

1.9 Dissertation Outline

This dissertation consists of eight chapters and the outline of the structure of the dissertation is as follows:

Chapter One is an overview of this study. The concept of ubiquitous computing, visual code and tagging systems, and the various applications of 2D bar codes are introduced. The research goals, methodology and usability focus of the project are also broached. This chapter concludes with a presentation of the significance of the research as well as anticipated outcomes.

Chapter Two focuses on the literature review of relevant publications in the field of ubiquitous computing, mobile and wearable interfaces, visual code technology, personal computing and usability.

In **Chapter Three**, a detailed description of 2D barcode systems or symbologies for which documentation are available is presented. 2D barcodes are introduced together with a commentary on the different visual codes that have been deployed both for research and commercial purposes. This is followed by a description of the architecture and equipment that make the 2D visual tagging paradigm possible.

In **Chapter Four**, the methodology employed for this research is detailed. The procedures, experimental order, survey instruments and usability evaluation techniques and processes as well as test environment are described.

Chapter Five focuses on presentation of data from the Mobile Data Services Questionnaires (MDSQ 1 and 2).

In **Chapter Six**, the results of the cross-platform usability evaluation of the selected 2D visual tagging systems are presented.

Chapter Seven presents the analysis of the MDSQ 1 and 2 and usability evaluation data.

Chapter Eight is the concluding section where the summaries of the results, analyses, insights, comments, and recommendations are presented.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Literature search in the field of visual tagging yields relatively few publications because the study of the subject is still at the infancy stage. Moreover, evaluation studies so far have tended to focus on tagging applications developed in-house. The interaction paradigm both from the user and technology perspectives has not been comprehensively studied. The contribution of this research in this regard is that emphasis is placed on the investigation of user perceptions, the usability issues that arise as a result of user interaction with visual tagging technologies that are currently commercially available, and the performance of the selected 2D visual systems under different operating conditions.

The literature review of pertinent research in the physical hyperlinks field will be addressed under four categories and these are:

- Earliest Work: papers that introduced concepts such as ubiquitous/nomadic computing, physical hyperlinks, mobile computing, et cetera and also laid the foundation for current research in the field of visual tagging
- ICT4D: How the application of the Real Access [BRID1] criteria can be used to predict and evaluate the effectiveness of ICTs as tools for development
- Related Work: literature in supporting fields like 2D barcode and marker technologies, mobile phone usage, WAP, et cetera
- Most Relevant Work: publications that address usability research in the field of visual tagging

2.2 Earliest Work

This section is devoted to the description of three efforts that contributed to laying down the framework for current work in the field of 2D barcodes and visual tagging. These are "Computer for the 21st Century" by Mark Weiser, the HP Cooltown project and the 1997 paper on nomadicity by Kleinrock.

Accessing information stored on computer systems such as PCs and similar devices which are usually conspicuous in living and working environments requires conscious thought and effort. A user has to deliberately enter the world of computers and information systems to get what he needs. In contrast, Mark Weiser's visionary work [Weiser, 1991] in 1991 laid out a world where computers and electronic devices recede into the background and become embedded in the natural human environment. He envisions interaction with data storage and retrieval systems that will be as natural as taking a walk in the woods or talking to a colleague. Through a concept he termed "embodied virtuality"; computers become embedded objects in natural milieu such as desks, offices, and trees. A strong metaphor he used in his paper to describe embodied virtuality is the use of electric motors in cars. The average automobile has twenty-two or more electric motors but the typical (car) driver is unaware of the existence of these motors. Yet these electric motors start the engine of the car and open and close the doors among other functions. Another example of embodied virtuality at work is the use of embedded computers in "light switches, thermostats, stereos and ovens".

But in laying out the framework for pervasive computing, Weiser and colleagues identified two main requirements that ubiquitous devices needed to satisfy. First, a ubiquitous computer must primarily know where it is and be aware of its surrounding. The other criterion is that ubiquitous systems will have different dimensions to perform different tasks. Based upon this reasoning, Weiser described the functions of the three prototypes of different sizes that were developed for demonstrating ubiquitous computing.

"Tabs", "the smallest components of embodied virtuality", as envisioned by Weiser, are "inch-scale machines that approximate active Post-it notes". A real world example is the use of active badges. A "pad" ranges in size from A4 paper to Laptop computer size and its application is analogous to the use of scrap paper in an office environment. The third component of embodied virtuality, "boards", are "yard-size displays" that are similar in function to electronic displays, bulletin boards, etc cetera. Weiser envisioned a backup technology for tabs, pads and boards - and any other ubiquitous applications to be developed – that will consist of a connecting network and software systems implementing the ubiquitous applications.

The study [Weiser, 1991] highlighted the potential of ubiquitous computing for privacy infringements and as a tool of oppression in totalitarian regimes. While it was pointed out that privacy concerns may be overcome by the application of cryptographic and similar techniques, no valid options were advanced for making ubiquitous applications immune to being used as a mechanism for repression by terrorists or despots. A major impact of the study [Weiser, 1991] is that Weiser's forecast that "ubiquitous computing will gradually emerge as the dominant mode of computer access over the next twenty years" is gradually being fulfilled. Applications are increasingly being designed to "fit the human environment" – an example is the passive and wearable digital camera, SenseCam[6]. Software that connects the hitherto disconnected physical and virtual worlds is also being deployed. One such application - and the focus of this study - is the use of 2D visual tags as physical hyperlinks that connect physical objects to online or offline content.

In 2000 as part of the HP "Cooltown" project, Tim Kindberg et al. published the seminal People, Places, Things: Web Presence for the Real world [Kindberg, 2000]. Their work was premised on two arguments. First, they argued that users can benefit from the connection of physical objects to the virtual world. Second, they posited that the best platform to implement the connection was the Web. The crux of their design was that to make physical objects Web-present, they had to have Web servers embedded in them, or

[6] http://research.microsoft.com/sendev/projects/sensecam/

their Web-presence could be hosted on dedicated servers. Access to services was therefore provided through the use of "sensing and service discovery technologies to feed the Web with URLs". This was achieved via direct and indirect sensing methods such as beacons and resolvers respectively. The aim was to provide a "location-aware but ubiquitous system to support nomadic users".

Furthermore, they classified the tangible world into three groups namely: People, Places, and Things. The corresponding supporting structures were e-squirt technique and form-exchange, PlaceManager, and WebLink for People, Places, and Things respectively. The security infrastructure was implemented via restricted access points and reverse proxies, authentication and secure WebTunnel mechanisms. In essence, one of the major contributions of the authors of the HP Cooltown research was their ability to demonstrate how their model was able to fulfill the Kleinrock [Kleinrock, 1997] architectural requirements for nomadicity by providing location awareness and also ad hoc access to services for mobile users. These were requirements that were not met in the Web platform.

The Kleinrock study extended Weiser's inventive work [Weiser, 1991] and was one of the earliest publications to consider the needs of the mobile or nomadic user. In the study, Kleinrock argued that most people are "nomads when it comes to computing and communications" and that a differently configured application infrastructure needed to be developed to support the notion of "anytime, anywhere access" for such nomadic users. Moreover, he listed the following as key requirements for a comprehensive understanding of nomadicity:

- Development of a systems architecture and network protocols for nomadicity
- Development of a nomadicity reference model
- Development of performance models for the nomadic environment

The main contribution of Kleinrock was the laying out of a roadmap for the adoption of nomadicity including the suggestion of solutions to the plausible technical challenges that may arise during the real world implementation of a nomadic system architecture.

2.3 Information and Communication Technologies for Development

bridges.org[7] is an organization whose primary mission is to study and facilitate how Information and Communication Technologies (ICTs) may be used as a development tool to enhance social and economic progress in developing countries with particular emphasis on Sub-Saharan Africa. The organization has published the "Real Access/Real Impact" framework[8], a paper that lists the twelve key criteria that technologies introduced into Africa must meet before they can be effectively deployed and adopted in their target environment. These criteria are:

1. Physical access to technology
2. Appropriateness of technology
3. Affordability of technology and technology use
4. Human capacity and training
5. Locally relevant content, applications and services
6. integration into daily routines
7. Socio-cultural focus
8. Trust in technology
9. Local economic environment
10. Macro-economic environment
11. Legal and regulatory framework
12. Political will and public support

This study will measure the usability of the 2D visual tagging platforms to be evaluated against the key criteria highlighted above. A preliminary examination of the Real Access

[7] www.bridges.org
[8] http://www.bridges.org/Real_Access

criteria against the attributes of the tagging platforms under study reveals that they satisfy Criteria 7 – "Socio-Cultural Focus". This is because tagging applications are intentionally designed to bridge the physical and online worlds; thus they are a mechanism for enabling social and cultural interaction.

2.4 Related Work

The review under this section focuses on publications that address supporting or enabling technologies for tagging applications and mobile interaction systems. Hence, some of the more relevant studies – for example, studies on camera phone use, WAP technology, 2D barcodes, et cetera - will be described under this section.

The adoption of the 2D visual tagging paradigm depends to a significant degree on the picture-taking function of smart phones. But there is dearth of research on where, how and what kind of pictures individuals take with their camera phones. Tim Kindberg et al. fill this void by carrying out an exhaustive study – presented in [Kindberg, 2005] and [Kindberg, 2004] on the use of camera phones. The study sought to "explore the range and diversity" as well as "elucidate the characteristics and context of" camera phone use. Their findings showed that camera phones are used for varying purposes and activities ranging from the capture of personal memories to the performance of specific tasks. The authors classified the type of pictures taken into six classes based on the reasons for the image capture. Their investigation indicated that most of the study respondents personally captured the images on their cell phones as opposed to the images being sent to them by a third party. Likewise, most did not forward the captured images to others within their network due to associated costs, complexity, mediocre image quality, and the relatively few number of people with camera phones in their personal networks. Moreover, most intended to store or archive the images on a longer term basis.

The authors reported that camera phones were generally used in three ways:

- As a "flipbook' of photographs for reflection and sharing with friends and associates. This function is due to the 'capture and view anywhere' quality of the camera phone
- As a tool or aid for the performance of individual or group tasks
- In out-of-the-way places such as offices, schools and restaurants where people do not typically take a digital camera to.

Perhaps the most striking finding of the study was the observation that camera phones make new forms of social interaction and affective communication possible. The authors pointed out that although the camera phones have functions similar to those of digital cameras; they are different in that they support a different "range of activities". Consequently, they (i.e. the authors) came up with guidelines that would help camera phone designers to incorporate functions that would support these different 'range of activities'. The recommendations include:

- Improvement of the image storage, browsing and retrieval facilities
- Users should be able to broadcast images to multiple recipients, especially just after image capture
- Augmentation of images such that image context, background and explanatory notes are included in the image capture for a more meaningful image-sharing experience
- Inclusion of advanced photo management tools such as deletion and archiving functions

In their study which was based on the Delphi research methodology [Lindstone, 1975], Hughes and Viehland [Viehland, 2002] concluded that the "long term outlook" for WAP adoption and usage was "very narrow". This conclusion is no longer relevant as there has been an upsurge in the use of WAP in recent times [BBC1]. The inability of the authors to accurately predict future WAP usage is due to the relative newness and dynamism of the WAP technology – and this feature was understandably highlighted in the study. However, they also forecasted that future WAP use will be "limited to specialized, short transaction-oriented applications for WAP-enabled cell phones". The use of mobile phones for decoding 2D visual tags and viewing linked URLs falls into the 'short transaction-oriented applications' category. This is because user interaction with a visual tag is usually a short-term oriented experience

J.P. Shim et al. in their research paper [Shim, 2002] sought to identify the primary requirements for the massive adoption of the m-commerce platform. This is important because as they noted, "actual computer use has lagged far behind anticipated use of the mobile Internet" despite the unique capability of mobile devices to provide information whenever and wherever needed. The authors postulated that "perceived lack of ease-of-use and, to a lesser extent, perceived lack of usefulness… [would be]…stronger negative influences [on the adoption of the m-commerce platform] than perceived risks associated with transactions and security."

Michael Rohs [Rohs, 2005] has implemented a 2D visual code system for marker-based interaction. A main feature of the system is the organization of the visual code menus into four different groups but the widgets are similar in function to standard 2D barcodes. In [Rohs, 2005B], Michael Rohs presents a 2D visual code system whose main distinguishing features from other 2D tagging systems that are commercially available are that the system provides "an orientation independent code coordinate system" and it also detects "relative camera movement [i.e. code rotation, image tilting, etc] independent from codes in the camera image".

In [Diego, 2002], TRIP a 2D marker technology for 3D vision-based (sensor) location-tracking system is described. The main features of TRIP – and by extension, [Rohs, 2005], and [Rekimoto, 2000] are that it is relatively inexpensive and easy to deploy. The TRIP system is composed of 2D barcodes/ringcodes and CCD cameras, and is used to determine the 3D position and identifier of tagged objects. On the other hand, Sony Japan [Rekimoto, 2000] developed a 2D tagging system, CyberCode, which could specify the 3D location and ID number of tagged objects. The CyberCode system is designed for the augmented reality environment and work with stationary cameras such as those on PDAs or notebooks.

In their paper [Scott, 2005], David Scott et al. described a scheme where camera phones can connect to mobile site-specific services via visual tags without using the Bluetooth automatic device discovery function of the camera phone. By making each 2D visual tag encode a unique Bluetooth Address (BD_ADDR), camera phone users were able to connect wirelessly with site-specific services through the Bluetooth-bypassing mechanism devised by the authors. The main advantage of this implementation over the conventional Bluetooth device discovery method is the speed and ease of use of the Bluetooth-bypassing mechanism in an environment with a preponderance of Bluetooth-enabled devices. David Scott et al. of Intel Research and Computer Lab at the University of Cambridge [Toye, 2005] also developed a system for accessing site-specific services such as ticket machines and info kiosks using a technology similar to Semacode. Their system was based on a client-server model known as the Mobile Service Toolkit (MST). The MST client software runs on the camera phones of users, while the MST server software runs on a device such as a PC which in turn provides a site-specific service.

In ReachMedia [Feldman, 2005], Assaf Feldman et al. present a wearable computer system that is composed of an RFID reader and a wireless wrist band based on the MITes wireless sensor described in [Tapia, 2004]. The RFID reader detects signals or gestures that were designed to work with the Continuous Gesture Recognition (CGR) System. Interaction with the system occurs when an object is touched or held in a way that makes the experience both implicit and unobtrusive – that is, it is a "natural and socially acceptable interaction". The major drawback of the ReachMedia system [Feldman, 2005] is that the gesture recognition system is complex and has a steep learning curve for the novice user. In a similar study [Want, 1999], Roy Want et al. present a system built around "RFID tags and readers, RF networking, infrared beacons, and portable computing". The novelty of their work was that their study was one of the early efforts to demonstrate the possibility of bridging the physical and virtual worlds relatively inexpensively and easily.

The other publications of interest include some of the studies on using cell phones as input devices and these include [Roto, 2005] which focuses on the usability challenges for mobile Internet browsing and [Roto, 2006] which presents a cost model for mobile Internet browsing. In [Tapa, 2005], the use of a mobile phone as a "primary data-capture and -entry device in a document-processing system" that is targeted at the micro-finance industry in a rural African setting is described. In [Mbogho, 2005], Mbogho et al. explores the reliability of visual tag readers for tagging applications while [Siegemund, 2006] describes the use of tags to connect new users to an existing user group. The C-blink system and the Advanced User Resource Annotation system are presented in [Miyaoku, 2004] and [Smith, 2004] respectively. The other publications of interest that focus on the use of cell phones as input devices are [Madhavapeddy, 2004], [Aalto, 2004], [Rohs, 2004], [Ballagas, 2006] and [Ballagas, 2005], while research that describes specific tagging applications includes [Pasi, 2006], [Constanza, 2006], and [Karodia, 2007].

2.5 Most Relevant Work

The literature search indicates that [Toye, 2006] is a pioneering work in the evaluation of 2D visual tagging platforms. The visual tagging system described in [Toye, 2006] focuses exclusively on the use of visual tags to interact with electronic services that augment a specific location, and is based on a client-server framework which consists of two components, the Mobile Service Toolkit (MST) and the Mobile Service Explorer (MSE). The MST runs on Linux with Bluez Bluetooth Stack, FreeBSD, and MacOS X. The MSE is run from the camera phone of a user and it "performs three functions: (I) tag reading; (II) personalization with respect to a user-defined privacy policy; and (III) rendering UI controls on the camera-phone's screen and relaying user responses back to mobile services".

Two prototype applications were implemented to simulate virtual queuing system and a personalized flight information display for a Theme Park and airport environments respectively. A user experience study as well as a pointing device experiment was also conducted to evaluate the decoding latency and efficiency of the visual tagging system. Three main distinctions of the approach in [Toye, 2006] are: First, private data on the phones of users are used to push customized context-aware services to each user. Second, users connect to the site-specific services via visual tag-enabled (the visual tags encode a Bluetooth Device Address, BD_ADDR) Bluetooth connections. Third, the user can specify the level of privacy they want when they need to provide personal information to a mobile service via the visual tagging system.

At the time of publication of [Toye, 2006], only a few free for private use 2D visual tagging systems were available. However as at March 1st, 2007, there were over 15 free visual tagging platforms on the market[9]. Hence, one of the main differences between this study and [Toye, 2006] as well as [Mitchell, 2005], [Belt, 2006] and [Kindberg, 2006] below is that this study involves a comprehensive evaluation of more than one (or five) visual tagging platforms. Moreover, the performance of the visual tag decoding software of the selected 2D visual tagging systems under different lighting conditions, the general ease-of-use of the 2D visual tagging platforms and attitudes towards the adoption of the 2D visual tagging paradigm will be evaluated. Furthermore, an investigation of the issues surrounding the creation of 2D visual tags and the recruitment of friends and associates to the mobile visual tagging paradigm will be carried out.

Another research effort with a significant evaluation component is the study [Mitchell, 2005] which demonstrates the use of visual codes to support independent learning for children based on themed deployment in a park and museum in Lancaster, UK. The 2D visual tagging system described in [Mitchell, 2005] is designed in such a way that the information retrieved upon the decoding of a visual tag depends on the position of the camera phone that was used to capture the tag. When the camera phone is held in an upright position, the outcome of the reading of a visual tag is a URL link. But when the camera phone is held in a downward position, an image is the result of the tag decode.

[9] http://theponderingprimate.blogspot.com/2005/06/physical-world-connection-companies.html

Likewise, pointing the camera phone in a left or right direction serves as a navigational tool to move the 2D visual tagging interaction process backwards or forwards. So pointing the camera phone leftwards moves the interaction backward one step while pointing to the right takes a user to the next image in the visual tag decoding process.

The main differences between this study and [Mitchell, 2005] are sample composition and the (type of) visual tagging system used. The sample for [Mitchell, 2005] is composed of young children, so the participants who interacted with the visual tagging system were all children. On the contrary, none of the respondents or participants for this study is below 11 years of age. Moreover, it can be argued that the sample for this study is more representative of the general South African (adult) population. Second, this study focuses on the evaluation of fully functional and already deployed 2D visual tagging systems in contrast to the prototype applications that were employed in [Mitchell, 2005] as well as [Toye, 2006] and [Kindberg, 2006]. Last, the [Mitchell, 2005] study did not involve cross-platform investigation as the research was based only on the evaluation of the Active Print visual tagging application.

In their study [Belt, 2006], Sara Belt, et al. presents a study of an evaluation of users' perceptions about interacting with tagging technologies. Their study also involved a usability comparison of RFID tags and 2D visual tags. The strengths of the [Belt, 2006] research were that the sample was representative of the Finnish population and the user studies was conducted in a shopping mall which is a realistic "everyday life environment". They also reported that users currently do not have any mental models on which to base their interaction with tagging systems on.

A major distinction of the [Belt, 2006] study is the evaluation of a 2D visual tagging system that was not developed by the authors to investigate user perceptions about mobile interactions with visual tagging technologies. The authors instead employed Semacode, a 2D visual tagging system that is free for limited private use, for their study. But the study did not focus or attempt an evaluation of the any of the other available 2D visual tagging platforms. Also, Finland (and Helsinki by extension), has a very IT literate and sophisticated citizenry; so the results of a user evaluation done in that country may not necessarily be valid in a Sub-Saharan Africa context.

In "You Are Here..." [Kindberg, 2006], Tim Kindberg and Kenton O'Hara, in partnership with the Active Print project and the BBC, present the results of a research project that builds on the early work of the HP Cooltown [Kindberg, 2000] project. The 2D visual tagging system described in [Kindberg, 2006] employs the use of visual tags known as Active Prints. The corresponding image recognition software, Glass, which can decode both QR and DataMatrix codes, makes use of Lavasphere[10], a proprietary software application. To interact with the visual tagging system, participants used their camera phones to capture and decode the Active Prints in order "to obtain content about their surroundings at seaside locations". The content returned upon the decoding of the Active Print tags ranged from a URL and SMS to a telephone number to be dialed and some other specific data.

A finding of the [Kindberg, 2006] study was that the visual tags were often not easy to find. It can be argued, and this has also been demonstrated in [Toye, 2004] and [Toye, 2006], that the problem of poor visibility for the visual tags could be remedied by placing signs describing the purpose and mode of interacting with the visual tags near each visual tag. However this research project will involve an investigation of how the placement of signs describing individual visual tags impacts the interaction experience from a user perspective. Second, the [Kindberg, 2006] study showed that users had a flawed mental model about how to appropriately interact with the Active Print tags. Users thought they had to continue to stay close to an Active Print tag to be able "to continue to receive info", even after the Active Print tag had been successfully decoded.

A distinguishing feature of the [Kindberg, 2006] project is that the usability evaluation was very comprehensive in terms of sample and location size. Another feature is that the visual tagging application – that is, the Active Print/Glass system saves captured Active Prints on a "history" screen for later access. However, the visual tagging application has

[10] http://www.lavasphere.de/

limited phone support and usage is restricted to the EU. Therefore the Active Print interaction paradigm could not be tested in Africa for instance. The study was also based solely on the use of Active Prints as other 2D visual tagging mechanisms were not investigated.

Apart from the differences between this study and the four research efforts (reviewed under this section) that have been highlighted before, an additional difference is the type of camera phone used in the various studies. The [Toye, 2006] study made use of Nokia 3650 phones while [Belt, 2006] and [Mitchell, 2005] both employed the use of Nokia 7610 handsets. In contrast, a Nokia 6280 phone will be used for this study. It is quite plausible therefore that the kind of camera phone used to interact with a 2D visual tagging system may affect user perceptions of the ease of use or efficiency of the system. Consequently, the influence that the type of camera phone used for visual tagging has on user experience(s) will be investigated during this study subject to time and capital constraints.

In summary, this study will focus on the investigation of some of the aspects of the 2D visual tagging paradigm issues that have either not been investigated at all or have not been comprehensively studied. First, this study will principally involve a cross-platform usability evaluation of selected 2D visual tagging systems. The other aspects of the 2D visual tagging paradigm that will be evaluated include how camera and visual tag positioning affect visual tag decoding latency, and the speed of upload of target Web pages or other target data. Another issue that will be investigated is the ease of downloading the 2D visual tag readers together with how the placements of text or icons that describe a visual tag function(s) close to the tag itself impact the 2D visual tagging experience.

In addition, a questionnaire will be served to a general audience before the usability study is conducted to measure mobile phone usage patterns and more specifically, the use of data services on cell phones. User perceptions about mobile Internet browsing costs and willingness to pay for the use of 2D visual tagging systems will also be investigated.

Last, the potential of visual tags to attract undesirable elements who focus on stealing camera phones will be considered. Participants in the [Toye, 2006] study, for instance, were of the opinion that visual tag locations may attract thieves who are familiar with the visual tagging interaction experience.

CHAPTER THREE
THE TECHNOLOGY BEHIND THE VISUAL TAGGING PARADIGM

3.1 Introduction

The existence of physical world hyperlinks in the form of 2D visual tags that are placed in the natural environment makes new social and cultural interaction modes possible. The natural world consequently becomes a mine of information from which desired content may be retrieved anytime and anywhere by any individual through the use of a mobile device that is equipped with the appropriate software. The net result is that 2D visual tagging technology serves the individual, and not the other way around. This is because anyone can create, manipulate and retrieve information based on individual preferences. The ability to control when, where and how information may be accessed therefore makes the user the master of his universe. It was therefore not surprising when that Time Magazine[11] decided to name the IT-literate 'Individual' as its 2006 Person of the Year for the powers conferred on the individual by pervasive technologies to enable the individual to order, rearrange and otherwise interact with the tangible and digital worlds as fitting.

In the same vein, the use of 2D visual tagging systems exemplifies the empowerment of individuals by pervasive (mobile) technology platforms such that they (i.e. individuals) can determine when and how they interact with the tangible and digital worlds. A suite of technologies and equipment facilitate this new interaction mode. In this chapter therefore, the technologies and the equipment behind the 2D visual tagging paradigm will be described through the provision of answers to the questions:

- What happens when a user captures a 2D visual tag with a camera phone and the data that is associated with the tag is displayed on the phone's browser?

[11] http://www.cnn.com/2006/US/12/16/time.you.tm/index.html

- What are the underlying technologies and equipment that make this interaction possible?

In general, the 2D visual tagging paradigm (see Figure 1) consists of a 2D visual tag which is a based on a 2D symbology or barcode system, camera phone, (WAP) Internet browser, mobile data transmission network, and a 2D visual tag reader.

3.2 Two-Dimensional (2D) Symbologies

Barcodes are machine-readable tags that encode specific information. Although first generation (1D) barcodes are binary i.e. they consist of a series of 1s and 0s, they have limited data storage capacity. They can encode data in horizontal dimensions only due to their linear structure. In contrast, 2D symbologies have a much bigger data encoding capacity as data is stacked both horizontally and vertically. A visual tag such as a Semacode or Shotcode is essentially a 2D barcode, and there are well over thirty proprietary and open source symbologies available today. But only two types of 2D bar codes are currently in use and these are *stacked* codes and *matrix* codes. Stacked codes are multi-row bar codes that have horizontal layers which are stacked on top of each other. Examples include Code 40 and Code 16K. On the other hand, Matrix codes are composed of a pattern of cells that can be square, rectangular or hexagonal in shape. This section is devoted to a brief description of the more popular symbologies.

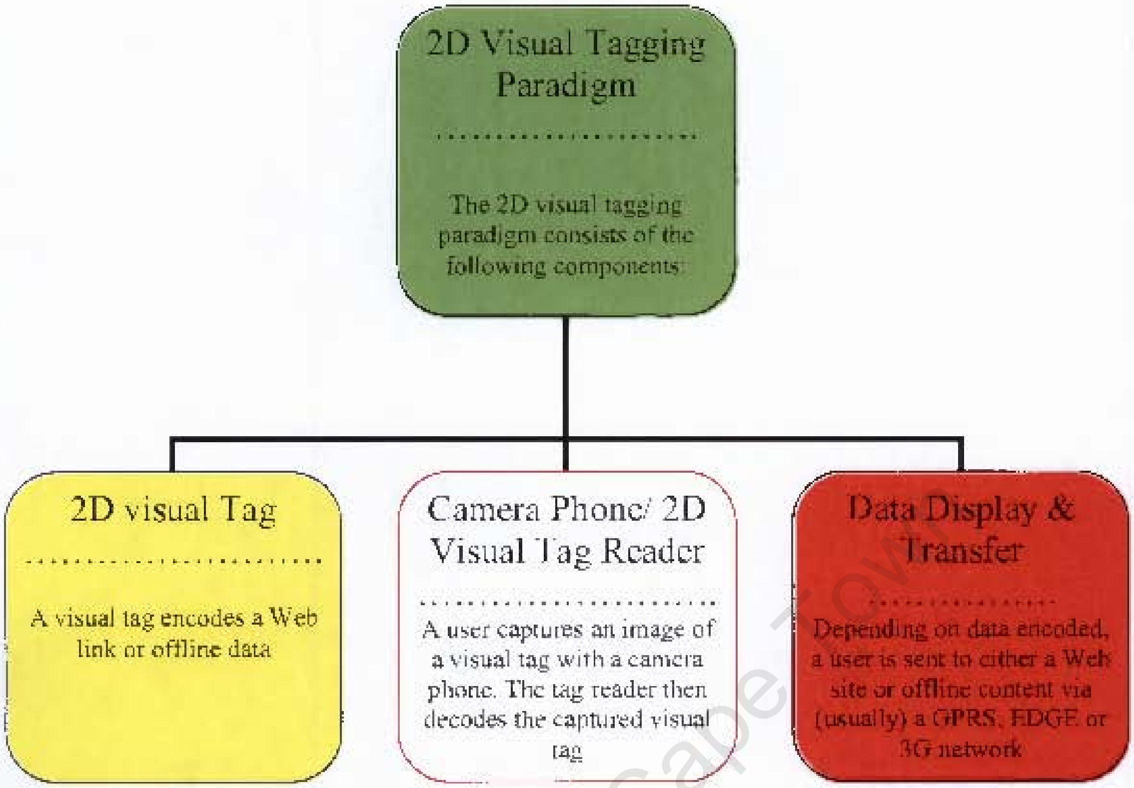

Figure 1: An illustration of the components of the 2D visual tagging paradigm

3.2.1 DataMatrix

Matrix symbologies or 2D barcode systems consist of an array of circular, square, or hexagonal cells which are highlighted by a cross section of light and dark areas. The contrast between the dark and light areas facilitates data encoding but error detection and image enhancement techniques are essential for reliable barcode decoding latency.

A typical Matrix symbology is the DataMatrix[12] code (see Figure 2) which was developed by Siemens and is in the public domain. Each DataMatrix symbol is between a 1-mil square to a 14-inch square and can store up to 500 characters. The orientation and printing density of each symbol is given by the spacing and positioning of the code's

[12] http://www.idautomation.com/datamatrixfaq.html

adjacent sides. All but two of the adjacent sides are printed as a series of equally spaced square dots. Two adjacent sides are however printed as solid bars while the coding scheme exhibits a high level of redundancy.

Figure 2: A DataMatrix barcode

DataMatrix codes make use of two different error correction mechanisms depending on the version of DataMatrix used. DataMatrix versions ECC-000 to ECC-140 correct errors in symbols by using convolutional coding. On the contrary, version ECC-200 employs the Reed-Solomon algorithm for error correction. DataMatrix symbols are widely used in industrial applications such as integrated circuits and printed circuit boards and can be read by CCD (and also CMOS) video cameras, scanners or camera phones. Together with QR Codes, DataMatrix is the most widely used symbology for encoding visual tags. Semacode, for instance, is based on DataMatrix symbology.

3.2.2 QR Code

The Quick Response (QR)[13] Code is another popular 2D symbology. It was developed by Denso[14] and is freely available. QR Code symbols have square shapes that consist of so-called position-detection or 'finder' patterns (see Figure 3) of nested alternating dark and light squares at three corners of the symbol. These patterns facilitate omni-directional barcode reading and also enable encoded data to be decoded rapidly, hence the name 'Quick Response'. A QR symbol can encode up to 7,089 characters including Japanese

[13] http://www.denso-wave.com/qrcode/qrgene2-e.html
[14] http://www.denso-wave.com/qrcode/qrfeature-e.html

characters, Kanji and Kana. QR Code is popularly used in Japan for visual tag-based applications, and it is standard practice for Japanese camera phone manufacturers to include QR reader software in cell phones.

Figure 3: A QR barcode

The other 2D symbologies - which are mostly proprietary, include 3-DI, ArrayTag, Codablock, CP Code, DataGlyphs, Dot Code A, hueCode, MiniCode, SmartCode, Snowflake Code, Color Code, INTACTA.CODE, VeriCode and WaterCode.

3.3 Camera Phones

The first component of the visual tagging paradigm is the printed tag which is a 2D barcode. However, to interact with a 2D visual tagging system, a user has to take a photograph of a visual tag using the camera on the mobile phone of the user. This means that interacting with a 2D visual tagging system (usually) requires the use of a camera phone. However, first generation camera phones (as well as current low-end cell phones) only offered a VGA imaging capability with a resolution of 0.3 megapixels. The pictures were of poor quality because, apart from the low resolution, the images lacked focus and were displayed on low-quality screens. In contrast, the current generation of camera phones together with high-end phones can usually be used to capture images of much higher quality and resolution. The image quality output of a cell phone therefore depends on the phone make and type. For the purposes of this study, mobile phones may be categorized into three different classes based on criteria such as functionality, number of features, density, bandwidth, system architecture and burst operation specifications. The three mobile phone categorizations are [Feeley, 2005]:

3.3.1 Basic Phones

Phones in this category have low memory requirements i.e. 4Mb to 8Mb of working memory and sometimes have talk-only functions. The data storage requirements are also minimal as space is usually only required for saving contacts, messages, and call logs. The RAM capacity of the lower–end basic phones lies between 8Mb and 32 Mb (together with 16-64 Mb of flash memory) with a processing speed of 14.4 Kbps. Most basic phones support SMS and MMS messaging as well as polyphonic tone ringer. Basic phones are the "least expensive type of mobile phone and represent a large portion of the mobile phone market" [Feeley, 2005]. Most of the first generation camera phones and entry level cell phones fall into this category. However, the basic phones on the high end have baseband processors that also use a single bus system. In addition, these high-end basic phones have a RAM capacity of 64Mb and also support up to 256Mb of flash memory at a bandwidth of 153Kbps.

3.3.2 Smart Phones

The distinguishing feature of smart phone devices is that they enable the integration of information management and the capabilities of features-rich phones on the same device. Smart phones usually have impressive LCD screens, full QWERTY keyboards, and are capable of running Office applications, since a significant number of smart phones have, among other things, PDA capabilities and some also run on Windows Mobile. Smart phones usually have enormous memory requirements, sometimes as high as 2GB, because of the number of rich applications they support. Although Smart phones usually have the same RAM capacity as Feature-rich phones, their processing speeds are much higher, usually in excess of 384 Kbps. Examples of smart phones include the i-Mate and the popular Blackberry.

3.3.3 Features-rich Phones

The phones under this group have an advanced level of functionality and so have greater memory requirements. A working memory of 16Mb to 128 Mb is usually sufficient, but some top-of-the-range phones require as much as 1 GB of space. Features-rich phones have a RAM capacity of at least 256Mb, a flash memory of 1 GB upwards, and run at a bandwidth speed of 348Kbps. This set of phones can usually support services such as games, MP3 players, advanced SMS, MMS and Instant messaging, and Web browsing. Some also offer support for video and audio streaming, interactive games and mobile commerce. Features-rich phones "make up the largest part of the consumer market" [Feeley, 2005]. Features-rich phones that run on the Symbian operating system are also called Symbian mobile phones. The Symbian operating system is a highly advanced mobile computing platform that supports high-end software applications such as Google Maps, MS Office and Sat Nav.

A common feature of Features-rich phones is that they are usually equipped with digital cameras with at least VGA resolution i.e. 0.3 megapixels and are also called camera phones. Some of the higher end features-rich or camera phones such as the Nokia N93 or Sony Ericsson K750i have a resolution of at least 2.0 megapixels, thus offering print-quality images. The cell phone that will be used for this study, a Nokia 6280 handset, is on the high-end side.

3.3.4 Camera Phone Technology

Although camera phones first became available commercially about 6 years ago, camera phone technology has evolved to the level that the imaging modules of top-tier camera phones – such as Samsung's SCH-S250 - produce high quality pictures that rival digital camera imagery. The print-quality pictures are due to significantly improved camera technology and imaging modules. Some of the high-end camera phones not only resemble digital cameras in look and feel, but they also have flash, zoom, auto-focus, multi-shoot and night modes. The imaging modules in camera phones usually consist of an imaging chip, a digital signal processor (DSP) and a lens.

There are two types of imaging chips or sensors - which are a core component of camera phone technology - and these are: the Complimentary Metal Oxide Semiconductor (CMOS) and the Charge-coupled Devices (CCD). The major advantage of CCD image sensors over CMOS is that CCD sensors generally produce images of a much higher quality because they have a greater degree of accuracy at capturing incident light than CMOS modules. CCD-enabled images also produce less noise. However, CMOS sensors have a number of advantages over CCD technology. First, they have much less power or energy requirements and so tend to prolong battery life. This is a very important consideration for using a cell phone. Second, they are considerably cheaper to produce as they can be manufactured through standardized fabrication processes and they also enable 'on-chip' integration. Most of the camera phones being produced today make use of CMOS image sensors due to the aforementioned advantages. But CCD technology is still the image sensor of choice in Japan. The prevalence of CCD sensors in Japan can be attributed to the country's sophisticated cellular communication market and huge demand for very high quality camera phone pictures.

3.4 Visual Tag Reading

An image of a visual tag is captured through the imaging capability of a camera phone. But to decode the tag, special applications known as tag readers need to be downloaded onto the camera phone. Each visual tagging platform usually has its own visual tag reader, and in this section, the function of the Semacode reader will be detailed to provide an understanding of how a visual tag reader functions (the readers of visual tagging systems generally have similar operational modes).

3.4.1 Image Capture and Recognition

The extraction of the data encoded by a Semacode visual tag is a result of the following three processes: image capture and recognition, error correction, and message extraction. However, the Semacode reader can only work with camera phones that have the following features [SEMA2]:

1. Minimum VGA resolution (640x480 pixels or 0.3 megapixel),
2. Adequate image quality (some cameras produce grainy images), and
3. Adequate focus at close range.

A Semacode is a 2D barcode that is based on the DataMatrix standard. To locate the Semacode visual tag within the image captured by the camera phone, the object recognizer component of the reader must detect the edges of the DataMatrix-based symbol, eliminate objects that are not visual tags and ascertain the geometry of the symbol. The Semacode reader accomplishes this by, first, massaging the image to smooth out or eliminate any lighting variations which might introduce noise into the decoding process. The reader then locates the edges of the symbols that are square in shape –that is, those edges that resemble Semacodes as Semacodes have a square shape. The next step in the process is the determination of the logical dimensions of the square shape that is assumed to be a Semacode. This logical determination is effected by overlaying the bitmap image grid and extracting the light and dark values for each bit. The result of this stage is then fed into the error correction module.

3.4.2 Error Correction

The error correction module of the Semacode reader incorporates the Reed-Solomon technique and is used to fix errors that are present during the image recognition process. There are different kinds of errors that need to be fixed. A false positive occurs when an image that is not a visual tag is mistakenly represented as a tag. In contrast, a false negative occurs when a valid barcode or visual tag is not recognized because it fails to conform to expected algorithm standards. Other errors may be due to the distortion or blurring of the image. The Reed-Solomon technique may be used to restore images that are impaired as a result of tears or poor reproduction. Overall, the function of the error correction module is to ensure that the image decoded is a valid Semacode visual tag.

3.4.3 Message Extraction

The final output of the image recognition and error correction processes is the binary value of light or dark (binary 1 or 0) areas for each module in the symbol on a 2D matrix. The encoded message, usually a URL, but which could be addresses, text, and small images, is extracted by subjecting the final output to the DataMatrix decoding algorithm. The decoded URL is then passed to camera phone's Web browser for processing. In summary, in order to extract the message encoded in a Semacode visual tag which was captured by a camera phone, the Semacode reader performs analysis to [SEMA2]:

1. Locate the Semacode visual tag inside the image
2. Correct for image distortion, and
3. Acquire the raw data from the image

3.5 Decoded Message Handling

The data that a Semacode (and by extension, BeeTagg, ConnexTo, Shotcode, Shotcode or UpCode) visual tag encodes is typically a Universal Resource Locator, URL or Web site. When a Semacode visual tag is accurately decoded, the message, a URL, is loaded via the Internet browser, onto the phone screen. There are two standards for making the delivery of Web content to mobile devices possible and these are the Wireless Application Protocol (WAP) and the iMode system. The iMode system was launched by service provider, NTT DoCoMo in 1999 and the high speed, packet-switched system is based on C-HTML - derived from HTML together with the proprietary protocols ALP and TLP. The adoption of the iMode system is mostly restricted to Japan although the standard has been adopted in other parts of the world such as Israel. The success of iMode in Japan can be partly attributed to the business model of the standard and the huge push for mobile data services in Japan.

In contrast, WAP is a standard developed by the WAP Forum, a body that has since been absorbed into the Open Mobile Alliance[15]. WAP is an *application communication protocol* that is used to access Internet-based services and information on handheld wireless devices such as mobile phones and Personal Digital Assistants (PDAs). WAP can be built on any operating system and it provides service interoperability even between different device families. In essence, WAP is a standardized technology for cross-platform, distributed computing. The WAP standard is based on Internet standards (HTML, XML, and TCP/IP), and consists of a Wireless Markup Language (WML) language specification, WMLScript specification, and a Wireless Telephony Application Interface (WTAI) specification.

A WAP browser is basically a wireless device that has a micro browser. A micro browser is a small piece of software that makes minimal demands on hardware, memory and CPU and it used WML to display information. WML is undoubtedly the single most popular component of WAP and it allows developers to specify how content will be presented to a WAP browser. WML is a markup language inherited from HTML, but is based on XML; so it is much stricter than HTML. Pages in WML are called *decks* while a set of *cards* make one deck. Meanwhile, WAP 2.0, an upgrade of WAP 1.0, is now the global protocol of choice for the provision of Internet access on wireless devices such as PDAs and mobile phones. A user with a WAP-enabled cell phone may view the Web site or associated data that was decoded by a tag reader on the phone's browser of a user.

3.6 Mobile Data Transmission

After a visual tag has been decoded, the extracted message is then displayed in the appropriate format. In the case of a URL, the message is passed on to (usually the WAP) browser which attempts to retrieve the desired information from the target Web site. The

[15] www.openmobilealliance.org/

speed and reliability of the data download from the site may vary, depending on the mobile data service mechanism used. Four different mobile data transmission mechanisms are currently in use in South Africa. These are: The Global System for Mobile communication (GSM), General Packet Radio Services (GPRS), the Enhanced Data Rates for GSM Evolution (EDGE), and Third-Generation (3G) services.

GSM: GSM is a digital platform for the routing of the voice and data traffic on a mobile phone network. The data transmission mechanism of a GSM network is based on the Circuit Switched Data (CSD) connection pattern, which utilizes dedicated full-bandwidth circuits for data connection and transmission. The data transfer rate of GSM networks under the best operating conditions is 9.6kbit/s and subscribers are billed per second. GSM coverage is achieved by the provision of a communication network backbone and this includes a significant number of base stations. GSM, which is also known as 2G, is still a popular form of mobile communication technology in many African countries. However, the only visual tagging paradigm that GMS supports is SMS messaging.

GPRS: GPRS is the most ubiquitous wireless data service in the world and it transfers data through the packet switching mechanism – that is, the data to be transferred is composed of smaller packets of data, with each carrying the destination address, usually IP for a transmission based on the TCP/IP protocol. GPRS, also called 2.5G, supports data transfer speeds of up to 170kbits/s, while users are usually billed per byte, kilobyte or megabyte of data downloaded. In contrast to GSM, GPRS supports both data and voice. The advent of GPRS made the offering of mobile data services possible and opened up new forms of communication to mobile phone users. The data services available include SMS, MMS, Instant Messaging, Web browsing, email and gaming applications. The Nokia 6280 handset that was used for this study can be used to access data over both GPRS and 3G networks.

EDGE: EDGE or 2.75G is an upgrade of GPRS (i.e. 2.5G) as it provides enhanced data transfer rates and increased capacity for bandwidth-intensive applications. Data Services such as full MMS Messaging, video and audio streaming, and high speed Internet access are possible on an EDGE network. The throughput of EDGE at optimal network conditions is 180 Kbps, a speed that is three times faster than those of GSM/GPRS networks. The cellular communication service providers, MTN and Vodacom, both provide EDGE services to their subscribers in South Africa.

3G: 3G (i.e. Third Generation) is a collection of international standards and technologies aimed at increasing efficiency and improving the performance of mobile wireless networks. At a high level, 3G networks are wide area mobile phone networks that also incorporate very high-speed internet access and video calling. The major advantages of 3G wireless services over GPRS/EDGE networks is that 3G networks offer greater data speeds and support a greater volume of bandwidth-intensive voice and data applications. 3G technologies make it possible to access data-hungry mobile data services such as live broadcasts, video clips, and mobile TV on cellular networks. Consequently, 3G networks are a vast improvement over GPRS/EDGE networks in terms of quantity, speed, reliability and security of data transfer. Although 3G technologies are composed of the six different standards: W-CDMA (often implemented with UMTS), CDMA2000, CDMA 2001, TD-CDMA/ TD-SCDMA, UWC-136, and DECT, only UMTS and CDMA2000 networks have been deployed in Africa.

UMTS/W-CDMA: UMTS (Universal Mobile Telephone System), also known as 3GSM, is the most ubiquitous 3G technology in Africa and is predicated on the Wideband Code Division Multiple Access (W-CDMA) technology. W-CDMA supports the provision of mobile multimedia and data services such as music, TV and video, high-speed Internet access in addition to SMS, MMS and IM. Technically, W-CDMA is an over-the-air technology medium for 3G services delivery. The standardization of W-CDMA is a result of collaboration between mobile phone service providers globally and the 3G Partnership Project standards organization (3GPP).

CDMA: The International Telecommunications Union (ITU) selected the Code Division Multiple Access (CDMA) 2000 technology as the standard for 3G wireless systems in 1999. Since then, many CDMA networks have been deployed in Africa and elsewhere around the world. The CDMA 2000 standard consists of the following three composite standards: CDMA 2000 1x, CDMA2000 1xEV-DO, and CDMA2000 1xEV-DV. CDMA

2000 is standardized by 3GPP2, a body that is separate from 3GPP, and is an upgrade of the 2G CDMA/IS-95 networks.

CHAPTER FOUR
USER EXPERIENCE STUDY DESIGN

4.1 Introduction

To evaluate the 2D visual tagging paradigm, five 2D visual tagging systems were selected. The systems are: BeeTagg, Connexto, Semacode, Shotcode, and UpCode. These five 2D visual tagging systems were selected because of their high visibility in the field of physical world hyperlinks and also because a Nokia 6280 handset (which was the camera phone that was used for this study) can be used to interact with any of these systems. The focus of this chapter is therefore to describe the design of the user experience study that was conducted to evaluate the usability attributes of the selected 2D visual tagging systems. In terms of structure, this chapter consists of the following sections:

- Methodology
- Sample
- Scenario-based Usability Evaluation and Testing (SUT)
- Test Environment
- Equipment

Under 'Methodology', the approaches employed for this study are explained. In 'Sample', the composition and characteristics of the study participants are detailed, while a description of the set-up and the tasks performed by the participants is presented in 'Scenario-based usability evaluation and testing'. An overview of the real life environments where the usability testing sessions occurred is given under 'Test environment'; while the materials used during the study are described in the section, 'Equipment'.

4.2 Methodology

This study was designed to answer the following research questions:

3. What mental model or perceptions do users have about how to use mobile 2D visual tagging technology?
4. What are the usability issues that arise as a result of the use of 2D visual tagging systems? This research question is further decomposed into the following sub-questions:

I. What mental model or perceptions do users have about how to use mobile 2D visual tagging technology?

II. How natural and easy is it for novice users to interact with, and use a 2D visual tagging system without explicit guidance?

III. What are the attitudes that users have towards the adoption of the 2D visual tagging paradigm?

IV. What are the strengths and weaknesses of the currently available free-for-private use 2D visual tagging systems from a usability perspective?

V. How do lighting conditions affect the performance of 2D visual tag-reading applications?

Consequently, a hybrid approach that consisted of three discrete sets of questionnaires, observations, and interviews as well as the actual usability testing sessions was adopted. The guiding rule for the adoption of this methodology was that a hybrid approach was the only pathway that was guaranteed to provide comprehensive illumination and feedback on the key usability issues that were being investigated. A summary of the evaluation techniques and survey instruments used during the user experience study is presented in this section. The instruments and techniques include the Mobile Data Services Questionnaire, the Nielsen's Attributes of Usability Questionnaire, the System Usability Scale Questionnaire, observations, interviews, and the application of the Real Access criteria.

4.3 Survey Instruments

4.3.1 Mobile Data Services Questionnaire

A Mobile Data Services Questionnaire (MDSQ1)[16] was served to 52 respondents before the commencement of the main user study to gauge the level of penetration and usage of mobile data services. A version of this instrument, the MDSQ2[17], was also served to the twenty volunteers who participated in the scenario-based usability testing sessions. In all, the MDSQ 1 and 2 instruments had 72 respondents

The purpose of the MDSQ1 and MDSQ2 was primarily to assess the current uptake and attitude to the use of data services on mobile phones. Although similar surveys have been carried out in other parts of the world, there was a need to assess what the local realities were in terms of how many people had camera phones, used mobile Internet, and how browsing costs, among other issues, impacted on the uptake of mobile services and by extension, 2D visual tagging systems. The sample of the MDSQ1 was very representative as it consisted of a balanced mix of young and old, and male and female. The instrument was served in Cape Town, South Africa to a variety of people ranging from professionals to students.

4.3.2 Nielsen's Attributes of Usability Questionnaire

The Nielsen's Attributes of Usability Questionnaire (NAUQ)[18] was served during the Main Usability Testing sessions. Each participant had to complete four NAUQ instruments for each of the Shotcode, ConnexTo, UpCode and BeeTagg visual tagging systems during a Main Usability Testing session. Participants were not required to complete a Nielsen's Questionnaire for the Semacode system in order to avoid biasing

[16] Please see Resources (at the end of the thesis) for a description of the MDSQ1 instrument
[17] Please see Resources for a description of the MDSQ2 instrument
[18] http://www.acm.org/~perlman/question.html/http://www.useit.com/alertbox/20030825.html

the results of the study. This was because the Semacode visual tags that were created for this study could not be decoded and as such, it was assumed that the comments of users about the Semacode system may not have been very positive.

4.3.3 System Usability Scale Questionnaire (SUSQ)

The System Usability Scale[19] is a 10-item LikertScale usability questionnaire that is used to measure the subjective aspects of the usability of a computer system or software during a usability evaluation procedure. Developed in 1996 by John Brooke at the UK-based Digital Equipment Company, SUS scores can range from 0 to 100. The higher the score, the greater the usability/the more usable the system being assessed is. Each participant was required to fill out two SUS questionnaires during a Main Usability Testing session to provide a subjective measure of the usability of the Shotcode, ConnexTo, UpCode and BeeTagg visual tagging systems. The first SUSQ was filled out to measure the usability of the first visual tagging system to be used for a group, while the second was completed at the end of the testing session (when all the visual tagging systems for a group had been interacted with, depending on the experimental observed for the group) to provide a subjective assessment of the overall usability of the 2D visual tagging paradigm. However, no SUSQ instruments were filled for the Semacode system due to the reason cited earlier.

4.3.4 Observations

The participants' degree of success with each task they were assigned to complete, as well as their demeanour, comments, and intangibles such as non-verbal communication clues were captured through user observation[20] during the usability testing sessions. Observations about user comfort or unease levels at completing tasks as well as the speed and efficiency at which they completed tasks during the SUT sessions were made.

[19] http://www.usabilitynet.org/trump/documents/Suschapt.doc
[20] http://www.ul.ie/~infopolis/methods/observat.html

4.3.5 Post-SUT Interviews

There was a question and answer (Q&A) session at the end of each SUT session – that is, after participants had completed the mental model, ease of learning to use, and main usability SUT sessions. The Q&A session was based on the unstructured interview[21] question format and it was designed to allow participants to give their opinions, general comments and suggestions about the five visual tagging systems investigated, as well as the 2D visual tagging paradigm in general.

4.3.6 Real Access Criteria-based Evaluation

During and after each of the Mental Model, Ease of Learning and Main Usability SUT sessions, participants were observed and also interviewed about their experiences. They were asked both structured and unstructured interview questions, with a view to capturing their views, comments, and suggestions about the applicability of 2D visual tagging systems in Africa. These questions were designed specifically to provide an understanding of how the symbol-reading systems investigated met the Real Access [BRID1] criteria for the deployment of ICT applications in the African environment. The selected 2D visual tagging systems that were employed for this study were evaluated against the following Real Access criteria [BRID1]:

- Physical access to technology
- Appropriateness of technology
- Affordability of technology and technology use
- Human capacity and training
- Locally relevant content, applications and services
- Integration into daily routines
- Socio-cultural factors

[21] http://www.ul.ie/~infopolis/methods/interv.html

4.4 Scenario-based Usability and Evaluation Testing

The Scenario-based Usability and Evaluation Testing (SUT) sessions were designed to provide feedback on the research questions, and also to measure the usability of the five free-for-private-use 2D visual tagging systems that were selected for this study. Therefore participants were given a set of tasks to perform during the SUT sessions using a Nokia 6280 camera phone pre-installed with the appropriate visual tag readers and the 2D visual tags selected for this study. The SUT consisted of four broad usability assessments or sessions. These were the Mental Model, Ease of Learning to Use, Visual Tag Decoding in Poor Lighting Conditions and Main Usability Testing phases.

4.4.1 Procedure

During a SUT evaluation session, a participant was required to use each of the BeeTagg, Shotcode, UpCode, Semacode, and ConnexTo 2D visual tagging systems that were employed for this study. In all, there were 20 SUT sessions. The Mental Model and Ease of Learning to Use testing phases were completed at the beginning of each SUT session and participants were required to use only one 2D visual tag and/or visual tagging system for these two testing phases. Participants were however required to interact with the other 2D visual tagging systems that they did not interact with during the mental model and ease of learning to use testing phases during the main usability Testing phase. The twenty participants who participated in SUT sessions were classified into four groups for the purposes of this study – see Table 1 for the experimental order observed for the SUT sessions. The SUT experimental order for Group 1, for instance, shows that participants in this group started with the Semacode application and so, both mental modelling and ease of learning to use testing phases were carried out with the Semacode visual tag.

GROUP 1: Semacode Shotcode ConnexTo UpCode BeeTagg
GROUP 2: Shotcode ConnexTo UpCode BeeTagg Semacode
GROUP 3: ConnexTo UpCode BeeTagg Semacode Shotcode
GROUP 4: UpCode BeeTagg Semacode Shotcode ConnexTo
GROUP 5: BeeTagg Semacode Shotcode ConnexTo UpCode

Table 1: The experimental order for the SUT sessions

The other four visual tags, Shotcode, ConnexTo, UpCode and BeeTagg were not tested during the mental modelling and ease of learning to use testing phases for Group 1 because this would have introduced bias into the study. Moreover, the experimental order of the SUT sessions for Groups Two, Three and Four was varied for this same reason.

4.4.1.1 Main Usability Testing

The mental modeling, ease of learning to use, and main usability testing phases were all completed using a Nokia 6280 handset that had been pre-installed with Shotcode, ConnexTo, UpCode, Semacode and BeeTagg visual tag readers. During the main usability testing phases, participants were required to capture the images of the respective 2D visual tags while holding the camera phone in the standard upright or horizontal position. Each participant was also required to capture the visual tags whilst the camera phone was oriented at different angles to the tag. The main usability testing phase was conducted at the University of Cape Town's Department of Manuscript and Archives as well as a simulation of a Baxter Theatre (see Test Environment). This evaluation stage was designed to provide answers to research questions three, four and five. Meanwhile, a detailed explanation of how the mental model, ease of learning to use and poor lighting conditions' testing phases were conducted is presented in the following sections.

4.4.1.2 Mental Model Testing

When human beings are presented with a task or situation they had not encountered before, they usually fall back on a repertoire of psychologically-archived 'mental models' of how similar tasks or situations had been handled before [Nielsen, 1993], [Johnson-Laird, 1999]. A good introduction to the concept of mental modelling in usability is available online[22] [23]. Symbol-reading technologies are new and so users were assumed to be unfamiliar with the 2D visual tagging paradigm. Consequently, the aim of the mental model testing phase was to evaluate the perceptions of users on how to use and interact with the printed 2D visual tags with the Nokia 6280 camera phone provided. Participants were not told what to do or how to proceed; but they were given an overview of the functions and application scenarios of 2D barcodes.

The major goal of the mental model testing phase was to get a verbal explanation or demonstration from users on how they were going to use or obtain information from a 2D visual tag in spite of the absence of relevant cognitive models. In addition, the feedback to the first research question, namely the determination of the mental models or perceptions that users had about how to use visual tagging systems, was dependent on the outcome of the mental model testing phase.

4.4.1.3 Ease of Learning to Use Testing

As a follow-up to the conduct of the mental model testing phase above, participants were asked to capture a 2D visual tag and try to use a visual tagging application on their own, without any provision of specific guidelines. Before participants were given the Nokia 6280 that was used for this testing phase, the menu on the Nokia phone was open to the

[22] http://www.lauradove.info/reports/mental%20models.htm
[23] http://www.interaction-design.org/encyclopedia/mental_models.html

specific visual tagging application to be used. For example, for an experiment that began with the Shotcode system, the participants had the Shotcode viewfinder/reader open and ready to take pictures of a visual tag. The purpose of this testing phase was to evaluate how easy and intuitive it was for novice users to navigate visual tag-reading systems. This testing mode was conducted to measure the ease with which a novice user may learn to use a 2D visual tagging system.

4.5 Test Environment

Two test environments, the Department of Manuscript and Archives (MSS)[24] and a simulation of the Baxter Theatre Centre[25], were selected for the usability evaluation testing sessions. These two real and simulated environments were selected because they constitute 'everyday life environments' where real life visual tagging application scenarios could be tested. They are not laboratory or artificial testing environments.

4.5.1 The MSS Centre

The Department of Manuscript and Archives (MSS) at the University of Cape Town has an extensive collection of original research material – manuscripts, photographs, et cetera - relating to the political, social, cultural and economic history of the Western Cape in South Africa. The subjects covered include art, music, education, literature and language, botany, politics and architecture. For information retrieval and archiving purposes, the subjects are classified into eight broad categories and these are:

- Architectural Collections
- Botanical Collections
- Collections featuring women
- Educational Collections
- Legal Collections

[24] http://www.lib.uct.ac.za/mss/
[25] www.baxter.co.za

- Literary Collections
- Medical Collections, and
- Musical Collections

However, most of these collections are in print form. Only a few of the collections have been digitized. The collections that can be accessed online include:

- UCT through the years: Groote Schuur Campus 1900 – Present
- The San (Bushman) photographs of Dorothea Bleek
- Erik Chisholm: snapshots of a remarkable life

The San Bushmen online photographic collection[26] was selected for this study. The San collection, which is also listed in the UNESCO's Memory of the World Register [MSS1], was created by Dorothea Bleek, who was an avid researcher of the languages and cultures of the San Bushmen of Southern Africa. For this study, visual tags that link to the URL for the San photo album were created. The visual tags were then placed next to the print equivalent of the photographs, and participants were asked to interact with the tags. Usually, only one photograph is printed per manuscript. But by using the visual tagging system, users could potentially get access to the fifty digital prints that are available online. This user experience study was conducted on the premises of the Department of Manuscript and Archives.

4.5.2 The Baxter Centre

The Baxter Theatre Centre is a leading venue in Cape Town, South Africa for theatrical productions, musical and dance events, and conferences. The Baxter opened in 1977 and it was built to "develop and cultivate the arts in Cape Town and the adjacent districts". On any given day, the Baxter hosts a variety of shows from comedies to musicals and exhibitions. To promote awareness about these shows, colourful posters (see Figure 4) are created and posted at strategic places around the city. So people become informed

[26] http://www.lib.uct.ac.za/mss/existing/DBleekXML/Bleek_test.xml

about the production, but they are not provided with any other information about the production or any other productions at the Baxter. Therefore discrete visual tags that encoded more details about the production displayed on the poster, as well as provided an online map to the Baxter, provided details about the other shows that were currently running, and a Baxter mailing list were created. The subjects were then asked to interact with these visual tags by using the Nokia 6280 phone provided (see Figures 23 and 24). The poster that was selected for this study was 'Hallelujah" as the comedy was still running during the period the study was conducted.

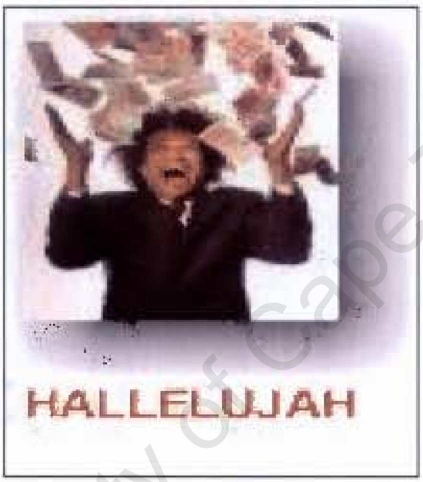

Figure 4: A poster for the 'Hallelujah' production at the Baxter Theatre

4.6 Sample

Twenty participants, comprising ten adults and ten youths volunteered for the SUT evaluation sessions. 11 of the participants were females while 9 were males. Participants who were under twenty years of age were classified as youths, while those who were twenty-one years old and above were classified as adults. All the volunteers seemed to be in good health and none had mobility, cognitive or visual impairments. All the volunteers were living in the Cape Town area at the time of the study, and were mainly drawn from the University of Cape Town community. Some were students, and the other volunteers were from the non-academic staff community. The latter group was further divided into two categories: those with a high school education, and those with some form of tertiary qualification.

Most of the participants either owned or used a cell phone regularly, but there were two participants who only used cell phone occasionally. However, not all respondents had camera phones. The camera phones owned by most of the participants had VGA resolution. Most of the participants reported that they had previously used mobile data services as well as accessed the Internet on their handsets before. But none of the volunteers had interacted with a visual tagging system before, or were familiar with 2D barcodes.

To ensure that the sample was as representative of the general population as possible, none of the participants had a computing or IT background. This was a deliberate act and explains why no Computer Science student or staff participated in the usability studies. The reasoning behind this is that computing students usually find it easier to adopt and use new technologies and applications.

4.7 Equipment

The equipment for this research project included printed 2D visual tags for the Semacode, Shotcode, ConnexTo, BeeTagg and UpCode 2D barcode systems, and a Nokia 6280 camera phone that had been pre-installed with Semacode, Shotcode, ConnexTo, BeeTagg and UpCode visual tag readers. A description of each piece of equipment utilized for the study is presented in the following section.

4.7.1 The Semacode System

The Semacode visual tagging system, a 2D barcode system that is based on the DataMatrix standard, enable the linking of the physical world to the virtual world using mobile technology. Through the Semacode Software Development Kit (SDK), 2D barcodes called Semacode visual tags may be created for different objects and contexts, with each Semacode (see Figure 5) encoding a unique URL. The codes may then be read using a cell phone that has an in-built camera. The Semacode visual tag reader that had been installed on the phone will then display the appropriate mobile content via a WAP browser. The Semacode Corporation, the organization that is responsible for the development and marketing of Semacode 2D barcodes, released the current version of the Semacode SDK, the Semacode SDK 1.6 in 2006. The SDK features a range of products that are targeted at end users, as well as PC, Web and mobile developers. The complete suite of products is available online[27].

Figure 5: A Semacode visual tag

Users have the option of creating Semacode visual tags in two different ways. A user may opt to create a Semacode on the site, Semacode.org/tag. The tags may also be created on the site[28]. Furthermore, there are two ways to install the Semacode reader on Java mobile phones such as the handset used for this study. The first option is to download the software from Semacode.org/software to a PC and then transfer the program to a mobile phone via Bluetooth or USB cable. The second way is to install the software 'over the air' (i.e. OTA) by pointing the Web browser on the cell phone to the URL, Semacode.org/ota.

[27] http://Semacode.org/weblog/2006/05/04
[28] http://sohne.net/projects/semafox/

4.7.2 The Shotcode System

The Shotcode visual tag – see Figure 6, is based on the SpotCode tagging technology [Scott, 2005] that was developed by High Energy Magic, an entity that was later acquired by OP3[29]. A Shotcode is a proprietary symbology that consists of a circular barcode with four data-rings (that is composed of three inner rings and one outermost ring) and twenty-one sectors, with a bull's eye in the centre. To encode bits in the data rings, black and white blocks are used to indicate values of 0 and 1 respectively. A 5-bit checksum is used for error correction while a sync-marker that is located in the outermost ring gives the tag orientation. The targeted encoding of the checksum facilitates the unique identification of the sync marker [Scott, 2005]. Each Shotcode encodes a specific URL and are designed to be read by cameras on devices such as mobile phones and webcams. Shotcodes can only be created by end users for non-commercial purposes after they have signed up for a free account on the site, manage.Shotcode.com. The site features some code authoring tools that optimize the Shotcode-creation process.

The Shotcode visual tag reader has a similar function to the Semacode SDK as it performs image processing, location and tag decoding in real time. There are three options for downloading the free Shotcode reader. Users may enter the URL[30] on the browser of their phone. The installation of the reader takes place automatically after the brand and model of the phone has been selected. Alternatively, users may first download the reader to their PCs and then transfer the Shotcode program to their handsets via Bluetooth connection or USB cable. Users may also email the Shotcode program to their handsets after the program had been installed on their desktops.

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[29] http://www.op3.com/

[30] http://mob.Shotcode.com

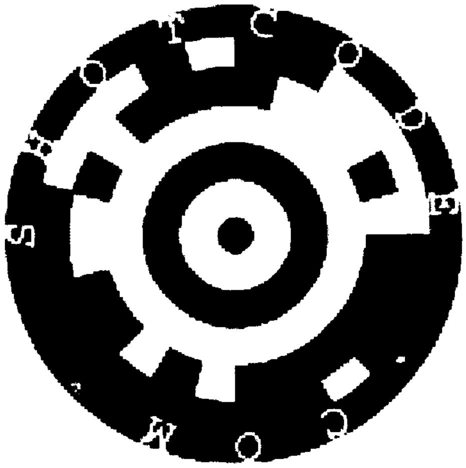

Figure 6: A shotcode visual tag

4.7.3 The ConnexTo System

ConnexTo visual tags (see Figure 7) are based on the mCode, a proprietary 2D barcode that was developed by Nextcode Corporation[31]. The mCode technology can only work on cameras with a minimum of QCIF or 176 x 144 image resolution. The mCode also has error detection and correction capabilities. ConnexTo tags come in different shapes, sizes and aesthetics, and can be embedded on products. Each ConnexTo tag can encode a URL, SMS message, contact information or auto-dial phone number. Thus the interaction model of the ConnexTo system is different from those of Semacode and UpCode as a ConnexTo visual tag can encode three different data types in addition to a URL.

ConnexTo visual tags are created through the use of the ConnexTo Code Creator, which is a web-based application. Users have to login to the ConnexTo site and then sign up for a free account before they can use the online tag creator. The Code Creator runs only on Windows systems and in addition, the PC must be on Microsoft Windows 98, Me, 2000, XP or higher. Also, only the Internet Explorer 5.5 or higher is supported and users must have ActiveX Control installed on their systems. The visual tags are created in two formats: EPS and BMP, although BMP is the default format. The tags may then be printed and affixed on objects and products in the environment.

[31] http://www.nextcodecorp.com

A ConnexTo Code Reader is required for the decoding of ConnexTo visual tags. The only way to download the Reader is by pointing a mobile Internet browser to the site, wap.ConnexTo.com.

Figure 7: A ConnexTo visual tag

4.7.4 The UpCode System

UpCode is a proprietary 2D symbology that may be embedded into products. Developed by UpCode Ltd, a subsidiary of the UPC Group in Vaasa, Finland, an UpCode is similar in structure to a Semacode or Shotcode as it only encodes a URL. The main distinctions of the UpCode system are that it also works with older Java mobile phones and phones without cameras. Moreover, the user does not always have to explicitly click on an UpCode tag for it to be captured. The UpCode system offers an image capture mode whereby image capture takes place automatically once the UpCode Reader recognizes the UpCode tag. Furthermore, each UpCode has a unique identification number. Users without camera phones but whose handsets are WAP-enabled have to enter this (that is, UpCode identification) number when prompted for it in order to decode an UpCode visual tag. But to use this tagging mode, users first have to select the 'insert code' option from the system menu.

Users do not create UpCode visual tags (see Figure 8) directly. They fill out a form on the site[32], where they can specify the URL or resource that they want to be linked to their UpCode. Once this is done, the requested or ordered UpCode visual tags are then sent to users.

There are three approaches for downloading the UpCode Reader. Upon entering the URL, `www.upcode.fi` on a WAP browser, a user is prompted to select language of preference for reader download purposes. The reader is then automatically installed after the reader download. The second approach is to download the reader (UpCode Java Version 2) from the site[33], to a desktop and then transfer the program to a mobile phone. Users of handsets without cameras may download the UpCode Basic reader application via transfer of the application from a desktop, on which it was installed, to a cell phone.

Figure 8: An UpCode visual tag

[32] http://www.UpCode.fi/computer/mycode.htm

[33] http://www.UpCode.fi/computer/download.htm

4.7.5 The BeeTagg System

The BeeTagg system was developed by Swiss-based company, Connvision; and BeeTaggs may be used to encode a URL link, plain text/PDF document, XLS, PPT, VCS or VCF files. BeeTagg visual tags may be created online at the BeeTagg site[34], which requires a user account.

Tags are usually created for any of the following five purposes:

A. Standard BeeTagg visual tag code creation[35]
B. Use of BeeTagg visual tags for the creation of mobile Web sites[36]
C. Use of BeeTagg visual tags for blogging[37]
D. Use of BeeTagg visual tags for eBay[38]
E. Use of BeeTagg visual tags as vCards, Business cards or IDs[39]

There is an online management tool for created BeeTagg visual tags and users may customize tags by embedding their logos or other identifier into standard BeeTagg visual tags. BeeTagg visual tags are created in three formats: standard, hexagonal and square (see Figure 9).

The standard BeeTagg visual tag reader may be downloaded by either sending an SMS with the text, "Bee" to the number, +44 762 480 24 86 or by directing the Web browser of a supported phone to the site[40]. Another reader, the BeeTagg Reader Lite, may be downloaded by users whose phones have no camera or camera access to scan, and this application makes use of the unique BeeTagg keywords to scan individual tags.

[34] http://generator.BeeTagg.com/
[35] http://generator.BeeTagg.com/
[36] http://mobisites.BeeTagg.com/Editor/Editor_Start.aspx
[37] http://blog.BeeTagg.com/
[38] http://ebay.BeeTagg.com/
[39] http://myid.BeeTagg.com
[40] http://get.BeeTagg.com

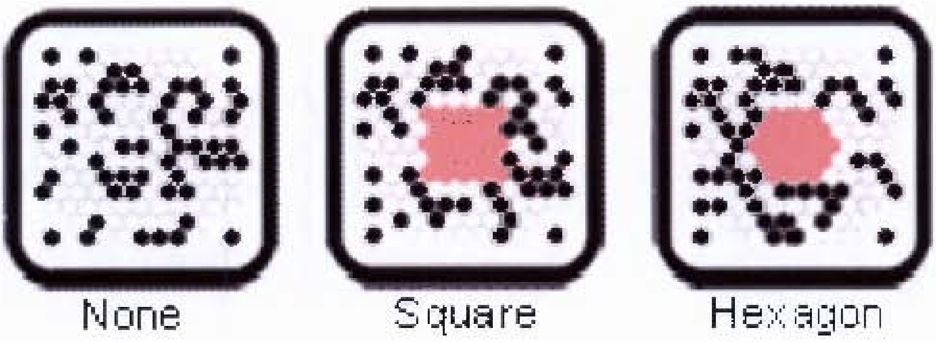

Figure 9: A BeeTagg visual tag (shown) in three different formats

4.7.6 The Nokia 6280 Phone

The Nokia 6280 is a 3G slider phone that runs on the Symbian Series 40 operating system – see Figure 10. The handset has a measurement of 100 x 46 x 21mm and is a bit chunky at 115g. It has a relatively large and high quality 262,144-colour (TFT) screen display with a resolution of 320 x 240 pixels. The phone also supports SMS, MMS, Instant Messaging, email (SMTP, POP3, and IMAP4), and push to talk. Moreover, the handset comes with 74 Mbytes of built-in memory that consists of 10MB of internal memory plus an expandable 64MB miniSD memory card. Connectivity options include Bluetooth, USB 2.0, Pop-Port™, and infra-red. In terms of network connectivity options, the phone offers simultaneous support for GPRS/EDGE and WCDMA 2100 (UMTS) i.e. Dual Mode WCDMA/GSM transmission. Thus fast Internet access is achieved via WCDMA and EDGE connections for broadband-speed browsing – that support download speeds of up to 384 kbps, and upload speeds of 128 Kbps - plus tri-band GSM with global roaming capabilities.

Figure 10: A Nokia 6280 handset

The handset has a 2 megapixel camera on the rear side of the phone for taking still images, and a front-mounted VGA camera for video calling. Moreover, the camera has an 8x digital zoom, night mode and integrated flash but lacks auto-focus. Image compression quality may be set to high, usual or basic. In addition, image resolution can be set to any of the five options: 1600x1200, 1280x960, 640x480, 320x240 and 160x120. The resolution for the video camera varies from 640x480 to 128x96 (352x258, 176x144) and is based on the 3GPP data format.

CHAPTER FIVE

DATA ON USE OF MOBILE PHONES

5.1 Use of Non-Call/SMS Services on Cell Phones (MDSQ1)

A survey instrument, the Mobile Data Services Questionnaire (MDSQ1) was served before the main visual tag usability testing phase was conducted. The purpose of the MDSQ1 was to determine how South Africans use the non-call/SMS features of their cell phones such as camera, mobile Internet, calculator, alarm, address book, et cetera. This was important to get a preliminary assessment or picture of how many people would be willing to use tag-based technologies. The hypothesis here was that those respondents who currently use their phones to take pictures, surf the Internet, and/or do calculations are more likely to be favourably disposed towards using their cell phones to interact with 2D visual tags. The MDSQ1 instrument was served to fifty-four (52) respondents living in Cape Town (Southern Suburbs) in December of 2006. A similar instrument, the MDSQ2 was also served to the 20 volunteers who participated in the scenario-based, main visual tag usability testing sessions, the results of which are to be presented in Chapter Six.

In addition, data collected from the MDSQ questionnaires helped to evaluate three hypotheses that were formulated to measure the potential of adoption of 2D visual tagging systems by current users of cell phones. These hypotheses are that:

- Hypothesis 1: Current cell phone users generally assume that it is cheaper to browse the Internet on a PC than on a mobile phone
- Hypothesis 2: Users assume that it is cheaper to send an SMS than to browse the Internet on a cell phone
- Hypothesis 3: Current usage patterns of (non-call and non-SMS) mobile phone services like address book, calculator, et cetera may be used to predict potential adoption of 2D visual tagging technologies.

The first two hypotheses are a measure of how user perception of the cost of using the mobile Web would affect the uptake of tagging systems. It should be noted however that the second hypothesis was not included in MDSQ1. The rest of this chapter is consequently devoted to the presentation and analyses of data collected from the MSDQ1 and MSDQ2 questionnaires.

5.1.1 Volunteer Ages (MDSQ1)

Data collected from the MDSQ1 instrument revealed that only 39 respondents disclosed their ages. A breakdown of the sample (i.e. respondents) for the study by age group shows that about a quarter (26%) of the 52 respondents belongs to the 20-24 year olds demographic, which is also the group that is most represented in the study – see Figure 11. The 14-19 year olds age group is the least represented (11%) group in the study, while 13 respondents (i.e. 24%) belonged to the 30-61 years old demographic. The age distribution for the 30-61 years old demographic also showed that only 2 respondents are above 35. In terms of the age limits, the youngest respondent was 14 years old while the oldest was 61. However 13 respondents declined to give their ages.

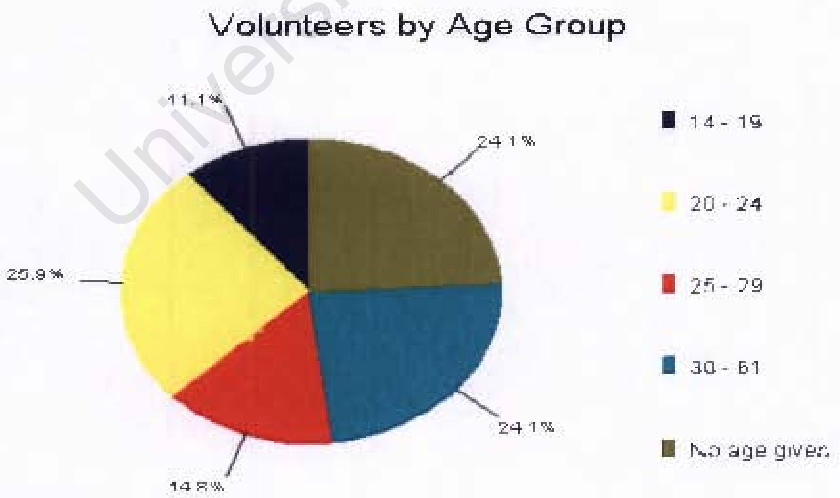

Figure 11: Volunteers by Age Group

5.1.2 Camera Phone Ownership and Usage (MDSQ1)

The chart in Figure 12 shows camera phone ownership by age group. The plot indicates that the 30 – 61 demographic own or use more camera phones than any other group – that is, 83% of respondents from this age group or 11 volunteers have camera phones. On the contrary, of the 20 – 24 age group, only 57% of respondents or 8 volunteers have camera phones. Thus this group has the least number of camera phones. It is pertinent to point out at this juncture that the differences in camera ownership among the various age groups are more of a reflection of purchasing power rather than individual choice or preference. For instance, a high percentage of 30-61 year olds have camera phones but this is mainly due to the fact that these individuals can afford these phones which are usually out of the reach of the 14- 19 demographic (the phones used by 14 – 19 year olds are usually bought for them by their parents or guardians). In addition, some individuals in the 20-24 age group cannot afford camera phones. Moreover, individuals in the 30–61 age group do not seem to use the photo-taking function of their camera phones frequently.

The chart in Figure 13 gives the number of volunteers that have access to, or own a camera phone as well as how frequently they use their camera phones for imaging purposes. For instance, 17 respondents do not have access to camera phones, while only 9 volunteers use their camera phones to take photographs regularly. Furthermore, 6 volunteers have never used their phone to take pictures. In summary, four out of five (83.78%) respondents of those who have camera phones use their phones to take pictures either regularly or occasionally.

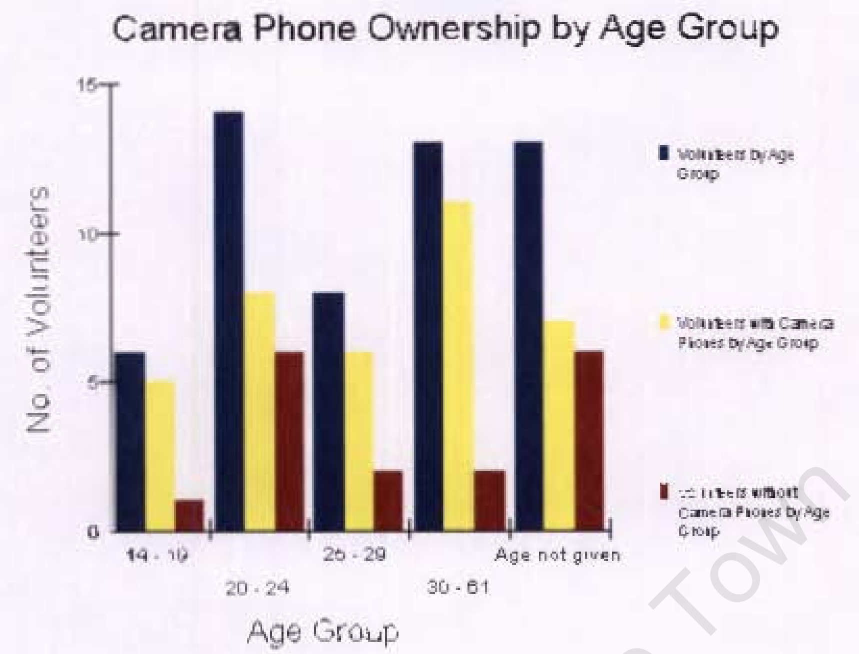

Figure 12: Camera phone ownership by age group

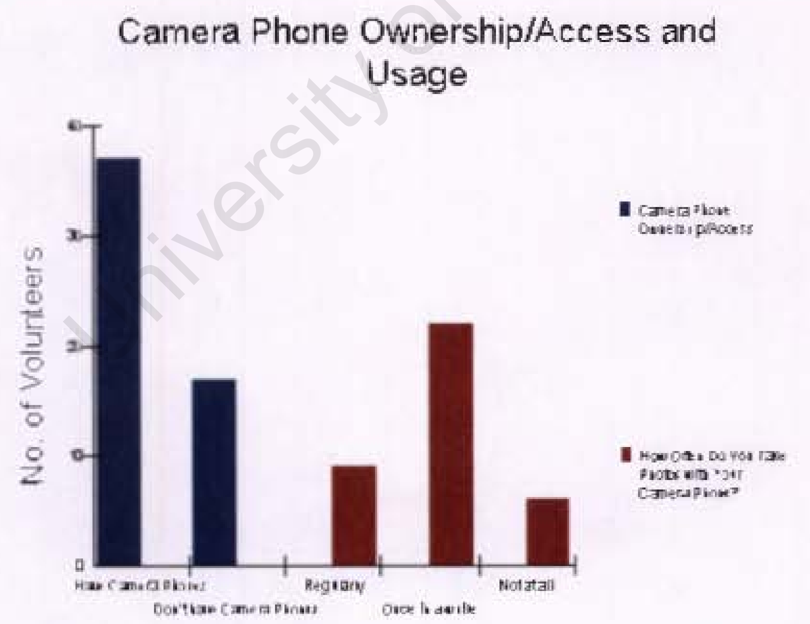

Figure 13: Camera phone ownership/access and usage

5.1.3 Mobile Internet Access and Usage (MDSQ1)

As the chart in Figures 14 shows, a staggering 72% of (nearly three out of four) respondents – that is, 39 individuals of all 52 respondents - either do not have Internet-capable cell phones or have not used their phones to browse the Internet before. The reasons for this disturbing trend vary from mobile Internet browsing costs to usability issues associated with browsing on cell phones (see Figure 14). The chart also shows that only a third of the volunteers (i.e. 5 respondents) who do browse the Web on their cell phones (15 respondents use their cell phones for Internet surfing) browse regularly as opposed to the 10 respondents who browse only once in a while. In general, respondents seem to have an aversion for mobile Web browsing as only 38.5% of respondents who have Internet-capable cell phones have ever accessed online content on their phones. This finding correlates with previous studies that show a slow uptake of, or reluctance to use mobile Internet [Viehland, 2002].

Further analysis of MDSQ1 data shows that the main objection that respondents who use their cell phones for Internet browsing have against the frequent use of the mobile Web is that they do not like the browsing experience afforded by a cell phone. Other respondents cited the cost of browsing and the difficulty of using cell phones for browsing (due to limited screen display and input facilities) as obstacles towards a more regular use of their phones for surfing the Internet.

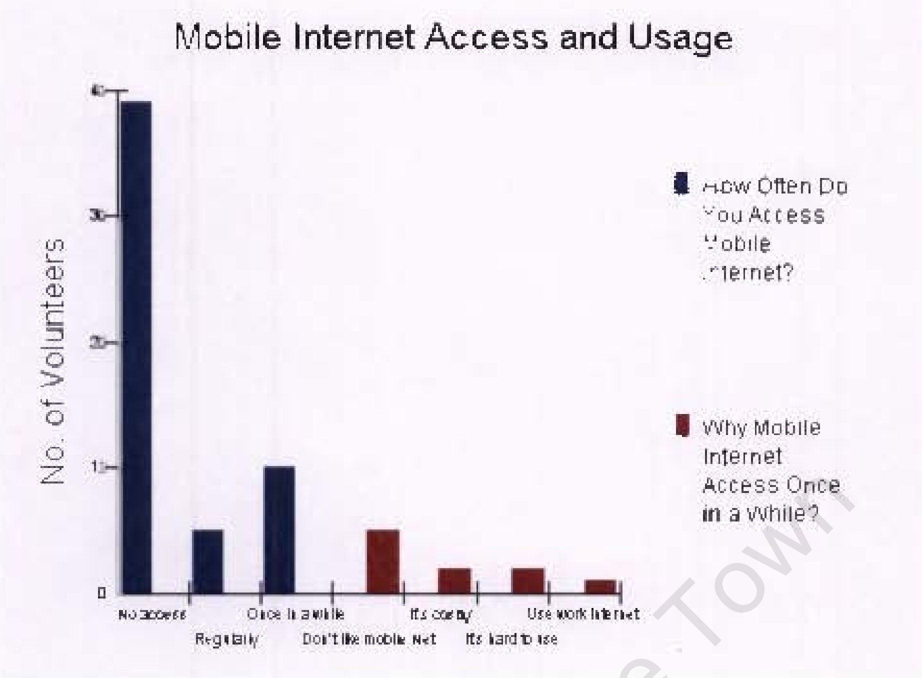

Figure 14: Mobile Internet Access and Usage

5.1.4 Perception of Browsing Costs (MDSQ1)

This questionnaire item was designed to provide feedback on the hypothesis that most Internet users think that Internet browsing on a cell phone *always* costs more than browsing on a desktop computer (irrespective of the pricing plan). The questionnaire item is also a measure of how this phenomenon contributes towards the reluctance by users to access Mobile Internet more frequently. This hypothesis is based on the observation that users are generally unaware of mobile Internet browsing rates; and also often do not know that there is a difference between the billing rates for calls made on mobile phones, and accessing the mobile Web. The chart in Figure 15 indicates that at least three out of four volunteers (i.e. 77.3%) of all 43 volunteers who responded to this MDSQ1 item think that it is more expensive to browse on a cell phone than to browse on a PC in an Internet café. For the purposes of this study, browsing cost on a PC is assumed to be that charged for using an Internet café in any of the suburbs in Cape Town (The cheapest rate that users are offered for browsing at an Internet café is R5 an hour). Thus the hypothesis that users think it is always cheaper to browse on a PC than on a cell phone was validated. There is therefore a strong indication that the perception that mobile Internet browsing is expensive is a major obstacle to the wider and regular use of cell phones for Web surfing. This phenomenon and its potential to influence the adoption and usage of 2D visual tagging technologies will be discussed further in Chapters Six and Seven (Sections 6.8.2 and 7.5).

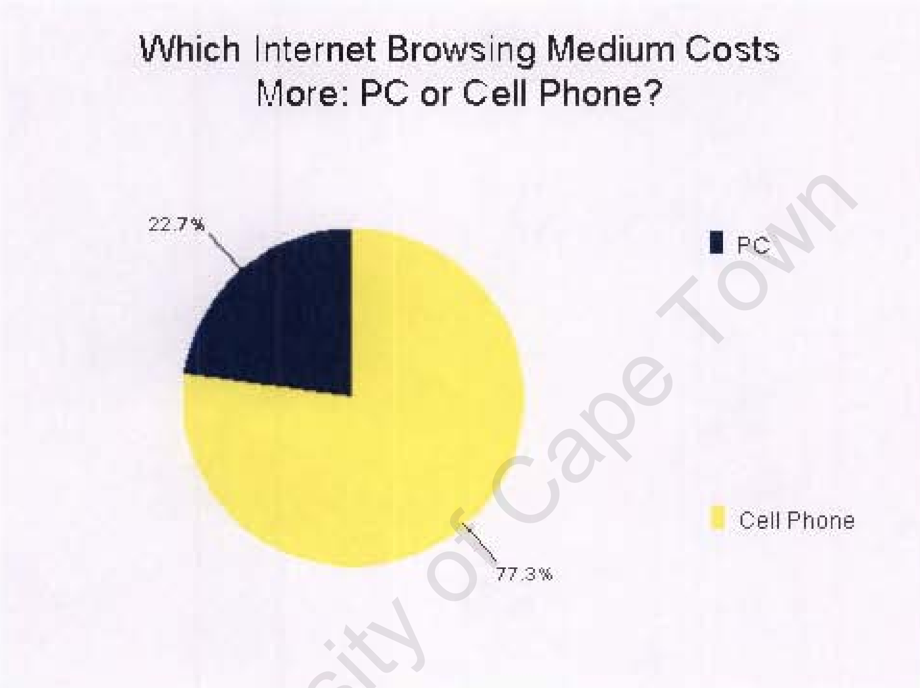

Figure 15: Which Internet Browing Medium Costs More: PC or Cell Phone

5.1.5 The Non-Call/SMS Services' Usage Index (MDSQ1)

The MDSQ1 item, "Do You Use Non-Call/SMS services (e.g. Calculator, Alarm, Calendar, etc)?" was designed to test the hypothesis that individuals who use non-call/SMS services such as calculator or calendar are more likely to use their phones to take pictures or surf the Internet . It is also assumed that these individuals will be more inclined towards using their cell phones to interact with 2D visual tags. The plot in Figure 16 shows that four out of five (i.e. 80%) or 43 respondents access non-call/SMS services on their phones. These volunteers were put in a separate category called the non-call/SMS group. Of this non-call/SMS group, that is the respondents who reported that they frequently use non-call/SMS services, 25 of the 32 (i.e. 78%) respondents who have camera phones use them (regularly or occasionally) to take photographs, while 7 respondents have not used their camera phones to capture images before.

Analysis of mobile Internet usage data shows that of the 14 volunteers from the non-call/SMS group who also have Internet–capable phones, only one has never used a cell phone to access the Internet (see Figure 16). Data from MDSQ1 also shows that 4 respondents use their phones to browse regularly while 9 respondents only browse occasionally.

Analysis of MDSQ1 data shows that 78% of respondents who belong to the non-call/SMS group use their phones to take pictures. In addition, 92.9% of these same (non-call/SMS group of) respondents use their cell phones to access online content. Significantly, this shows that the hypothesis that the frequency of use of non-call/SMS services could be used as an indicator of inclination towards the use of mobile Internet browsing and camera phone for taking photographs is valid.

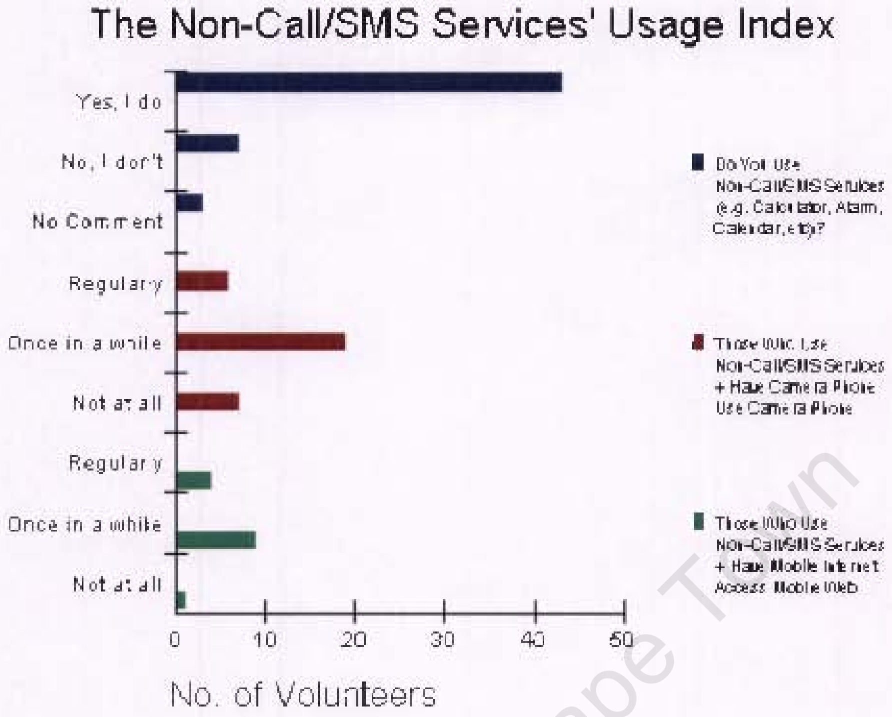

Figure 16: The non-call/SMS services' usage index

5.2 Mobile Data Services Questionnaire (MDSQ2)

The purpose of the MDSQ2 was to determine how the 20 volunteers that were recruited for the Scenario-based Usability Testing phase of this research project use the non-call/SMS features of their cell phones such as camera, mobile Internet, calculator, alarm, et cetera. The use of MDSQ2 made possible the testing of the hypothesis that respondents who currently use their phones to capture images or browse the Web will be more inclined towards adopting the 2D visual tagging paradigm. The MDSQ2 instrument was served to twenty (20) respondents at the University of Cape Town in January of 2007.

5.2.1 Camera Phone Ownership/Access and Usage

The chart in Figure 17 shows that 12 volunteers (i.e. 60% of respondents) either own or have access to camera phones. One-half of these 12 volunteers frequently use their camera phones to capture images while the other half do not. Meanwhile, eight volunteers do not have camera phones. Figure 18 shows the types of phones used or owned by volunteers who participated in the study. The chart shows that Nokia phones are the most commonly used although some respondents (i.e. 9.1% of respondents) did not specify the type of phone they use.

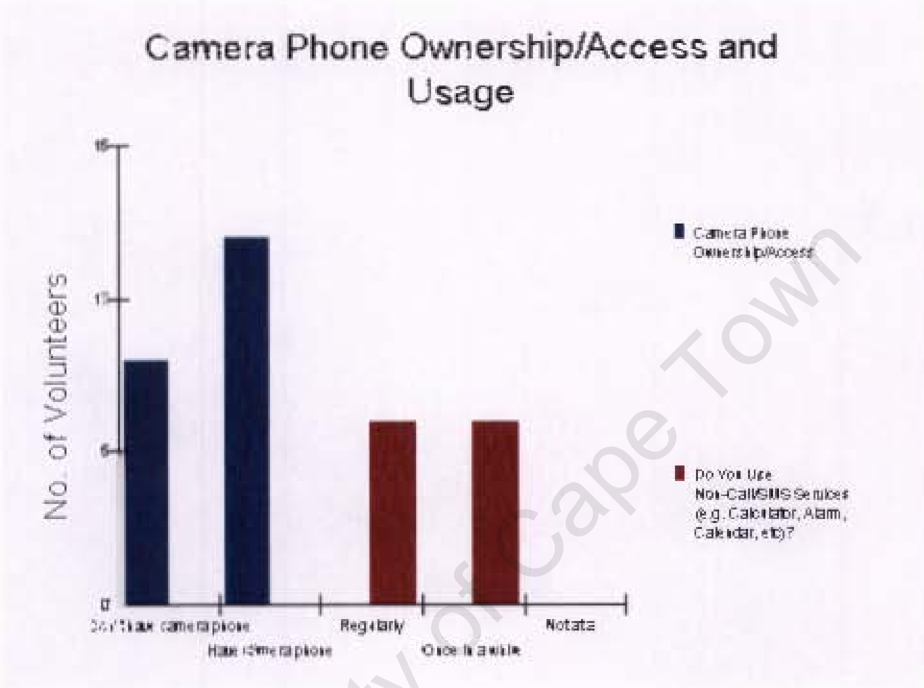

Figure 17: Camera phone ownership/access and usage

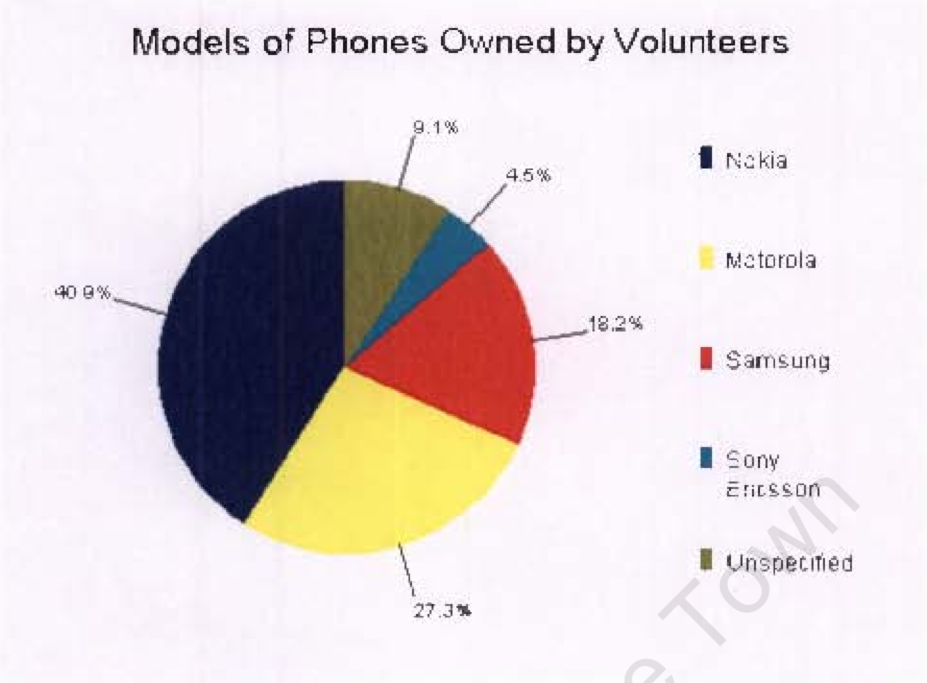

Figure 18: Models of phones owned by volunteers

5.2.2 Mobile Internet Access and Usage

As the chart in Figure 19 shows, 8 respondents (40% of respondents) do not have Internet-capable cell phones, and thus have no experience with using their cell phones for Internet browsing purposes. In addition, 3 respondents or (15% of respondents) have also not used their phones for Web surfing before due to perceived costs and ease of use issues (see Figure 19). The chart in Figure 19 also shows that only 2 of the 9 volunteers who do browse the Web on their cell phones browse regularly, while the rest only browse occasionally.

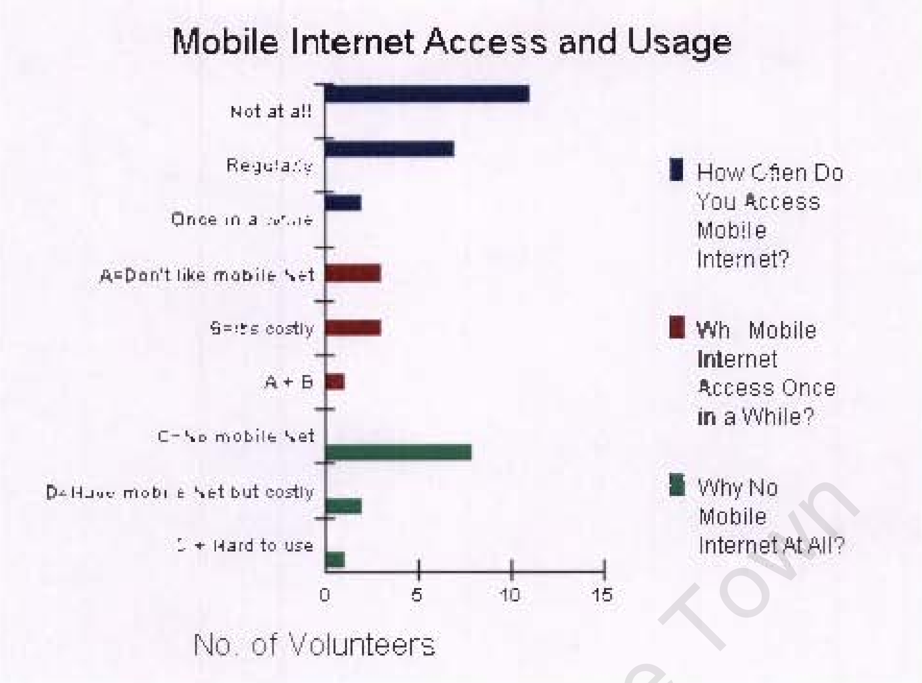

Figure 19: Mobile Internet access and usage

5.2.3 The Non-Call/SMS Services' Usage Index

Again, the MDSQ2 item, "Do You Use Non-Call/SMS services (e.g. Calculator, Alarm, Calendar, etc)?" was designed to test the hypothesis that individuals who use non-call/SMS services such as calculator or calendar are not only more likely to be inclined towards using their cell phones to interact with 2D visual tags, but also to take pictures or browse the Internet. The plot in Figure 20 shows that 18 (90%) respondents access non-call/SMS services on their phones. These respondents were designated as belonging to the non-call/SMS group. Of this non-call/SMS group, that is the 18 respondents who reported that they frequently use non-call/SMS services, all of the 12 respondents who have camera phones use them (regularly or occasionally) to take photographs. In contrast, 3 of the 12 respondents (i.e. 25%) from the non-call/SMS group who also have Internet–capable phones have never browsed the Internet on their cell phones while the remaining 9 volunteers either browse regularly or once in a while.

Analysis of MDSQ2 data shows that all 12 respondents who belong to the non-call/SMS group (and have camera phones) use their phones to take pictures. Similarly, 9 of 12 respondents (or 75%) who belong to the non-call/SMS group and have Internet-capable cell phones use their phones to browse the Internet. Thus the hypothesis that the frequency of use of non-call/SMS services could be used as an indicator of inclination towards the use of mobile Internet browsing and camera phone for taking photographs is once again validated.

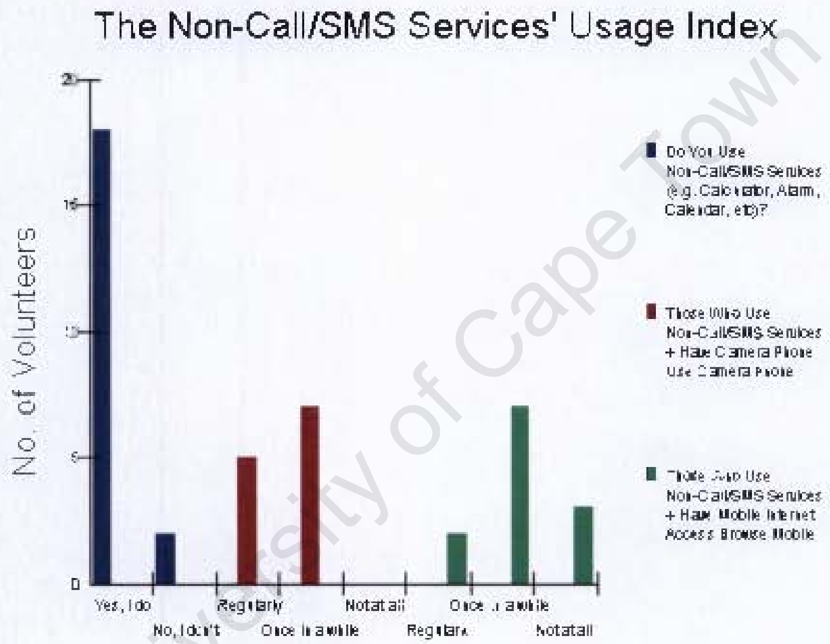

Figure 20: The non-call/SMS services' usage index

5.2.4 Perception of Browsing Costs

The two questionnaire items: "Which Internet Browsing Medium Costs More: PC or Cell Phone?" and "Which is Cheaper: SMS or Mobile Internet?" were designed to provide feedback on the hypothesis that most Internet users associate the use of mobile phones for Web browsing with relatively high costs compared to browsing on a PC in an Internet café or sending a text message. Moreover it is assumed that this high cost of use associated with mobile Internet surfing partly explains user reticence towards accessing Mobile Internet more regularly. This hypothesis is based on the observation that users do not know that there is a difference between the billing rates for calls made on mobile phones and accessing mobile Web. The chart in Figure 21 indicates that nearly two-thirds of all volunteers (64.71%) who responded to this MDSQ2 item think that it is more expensive to browse on a cell phone than on a PC in an Internet café. Similarly, three out of four (76.47%) volunteers assume that it is cheaper to send an SMS than to access Mobile Internet.

Thus the hypothesis that users associate higher costs with mobile Web browsing than either PC-based Internet surfing or text messaging is proven valid. Hence this outcome strongly indicates that the assumption that it is costly to browse the Internet on a cell phone could negatively impact the use of phones frequent Internet browsing. This observation/phenomenon will be given more attention in Chapter 7. Browsing cost on a PC is assumed to be that charged for using an Internet café for the purposes of this study (The cheapest rate that users are offered for browsing at an Internet café is R5 an hour). However, browsing cost on a cell phone is taken as that charged by Vodacom, a South Africa-based service provider.

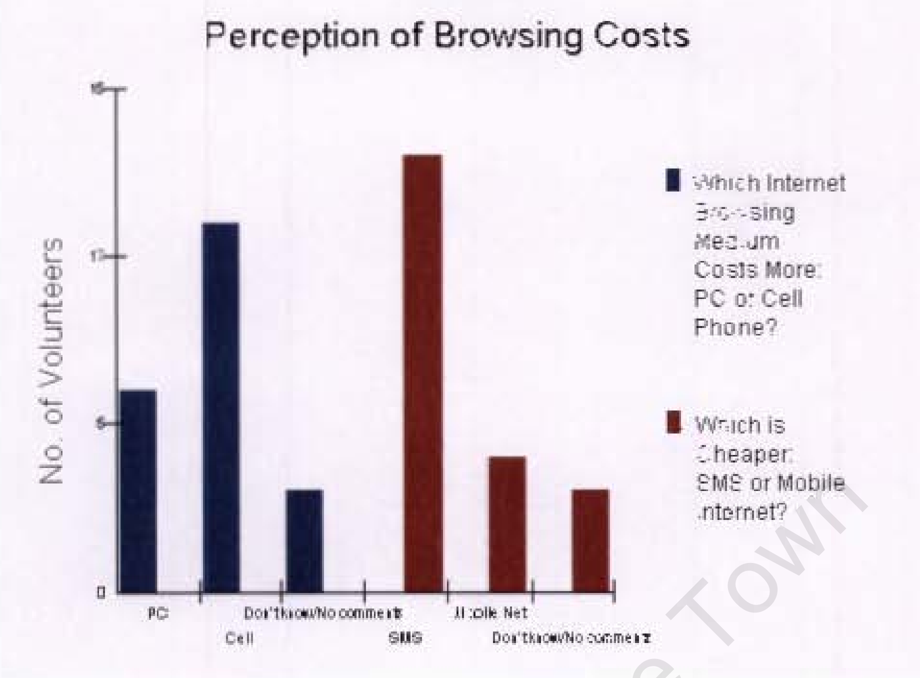

Figure 21: Perception of browsing costs

CHAPTER SIX

PRESENTATION OF USABILITY TESTING RESULTS

6.1 Introduction

2D Visual tagging technologies are enablers of new forms of social and educational interaction. By encoding 2D bar codes that store URL links, SMS or plain text, visual tags link information about objects in the physical world to online or offline content. Although visual tagging technology has much potential to positively influence the way people, and Africans in particular, interact with the natural environment, current research indicates that its use has not been comprehensively tested in Africa. Thus Chapter Four outlined a methodology for the testing of five selected free-for-private-use 2D visual tagging systems. The procedure was based on a hybrid approach that consisted of the following seven elements:

- Two Mobile Data Services Questionnaires (MDSQ1 and MDSQ2)
- Nielsen's Five Attributes of Usability Questionnaire (NAUQ)
- System Usability Scale Questionnaire (SUSQ)
- Scenario-based Usability Testing (SUT): The SUT in turn consists of the following:
    - I. Mental Model Testing
    - II. Ease of Learning to Use Testing, and
    - III. Visual Tag Decoding in Poor Lighting Conditions Testing
    - IV. Main Usability Testing
- Observations (based on user interaction with visual tagging systems)
- Interviews after task completions by users
- Assessment – via the bridges.org Real Access criteria - of the readiness of tagging technologies for the African environment.

While Chapter Five was devoted to the presentation of data collected from MDSQ1 and MDSQ2, this chapter will focus on the presentation of SUT data together with data collected from the NAUQ, SUSQ, user observations and post-SUT interviews.

6.2 Mental Model Testing

During the mental model testing stage, participants were required to carry out three tasks. The tasks are 2D visual tag recognition, inference of information stored in visual tags, and mode of obtaining information stored in the visual tags. The next section details the results of the mental model testing phase.

6.2.1 Visual Tag Recognition

At the beginning of each of the 20 usability testing sessions, all 20 participants were shown a visual tag. The visual tag (that is, Shotcode, Semacode, ConnexTo, BeeTagg or UpCode visual tag) a participant was shown was dependent on the experimental order observed for that particular usability testing session. They were then asked whether they were familiar with, or could recognize the tag they were shown. Most participants (15 participants or 75% of respondents) were not familiar with the 2D visual tags – see Figure 22. A few participants did however say that the tags looked like crossword puzzles or mathematical symbols.

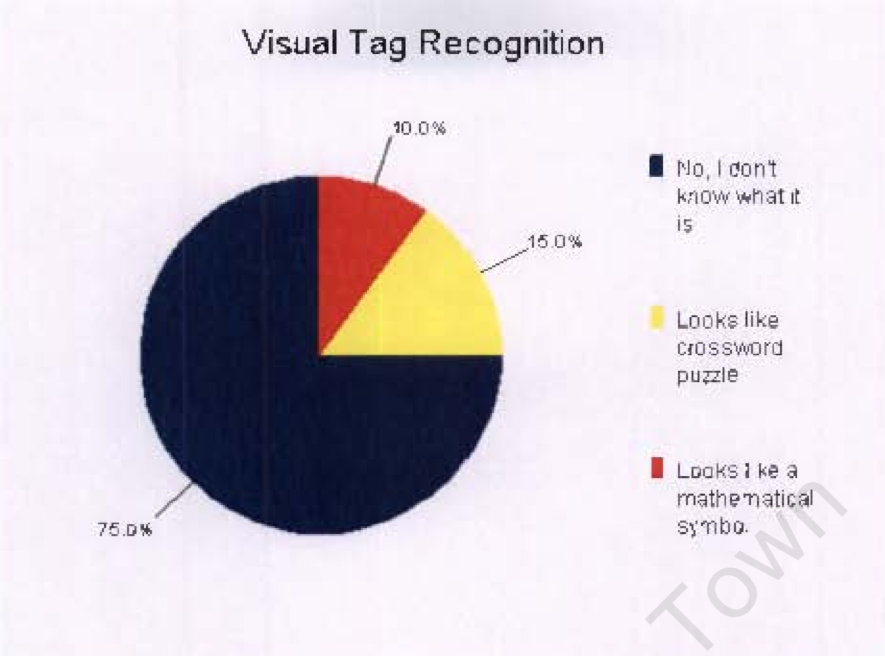

Figure 22: Visual tag recognition

6.2.2 Inferring Data Stored in Visual Tags

The second task that participants were required to carry out was the inference of information stored in the visual tags. There were two groups of visual tags for this task. One group encoded URL links to the San photo album in the UCT MSS library while the other contained links to the Baxter Theatre and information about the comedy, Hallelujah. Thus each of the visual tags used in the study encoded a URL link but participants were unaware of this. The responses of participants to this activity were varied. Most participants guessed accurately that the visual tags encoded either resources in the UCT MSS library or information about the Hallelujah show at the Baxter Theatre. A selection of the typical responses from participants about the kind of data that could be stored in tags is presented below:

Use for photos / store photos

Where the books are

The content and authors of books

Books, brief content, summary of photos, authors
Text, pictures, sound, programming code, cataloguing system,
[Responses for the UCT MSS Library group]

Show price, what the show is about, venue, time, how long
Show time, cost, venue, summary of what the show is about
Date and times of show, cost, crew info, show details (what the show is about), images for posters
Venue, time, cost, audience, who the show is for, online booking info
[Responses for the Baxter Theatre group]

6.2.3 How to Get Information from Visual Tags

Once participants had stated the kind of information they think could be stored in visual tags, they were then asked to show how they would retrieve the data stored in the tags. The responses to this activity were also varied. While some participants had either accurate or close guesses as to how tags may be decoded, others were completely off the mark in their responses. Some of the comments from the former group include:

If the cell phone is a recorder, take a photo – zoom in with built in camera
Take a picture of the barcode
Use special application to decipher code dots or info
A program on phone that will decode tag

Analysis of the comments from participants - as typified by the responses below - also indicate that some participants (5 responses) thought that tags could be decoded via Bluetooth, Infra red technology and/or the Internet:

Through Bluetooth, Infra red technology
Infra red technology scanning
email image to someone/org for analysis

Type in some URLs/ message on code and look it up on the Internet
Also, go to Shotcode.com that's printed on the tag
SMS the code no to a dedicated cell phone number, and they will send a Web link. Click on the phone and gets you to the Web site
If the tag has code no, google it.

6.3 Ease of Learning to Use Testing

This testing phase was a measure of how quickly and efficiently novice users could learn to use a visual tagging system. Based on the experimental order explained in Chapter Four, each participant was given a Nokia 6280 and asked to interact with a specific 2D visual tagging system using the visual tagging system-specific decoding software pre-installed on the phone. The results of this task show that most volunteers were able to figure out how to use the Nokia 6280 phone to read the tags within 3 minutes. Some however had to learn to capture all the borders of a tag before the tag could be accurately decoded while a few had to be told to remove their hands from obstructing the view of the camera phone lens. Observation of users also revealed that users had more difficulty interacting with the UpCode tags than with any other system. This was due to the sluggish decoding latency and general user discomfort with the default automatic capture mode of the UpCode system. The conclusion from this testing phase was that it is generally easy and intuitive for novice users to use a tagging system on their own with minimal instruction and without the help of a manual and/or instructor.

6.4 Scenario-based Usability Testing

After the ease of learning to use test where volunteers interacted with one visual tagging system, volunteers proceeded to use the other visual tagging systems (see Figure 23) during a main usability testing session. In all, there were twenty of such sessions. The purpose of these testing sessions was to assess – via observations, interviews and data collected from questionnaires that were filled out after the use of the tagging systems by volunteers - the decoding latency, ease of use, intuitiveness of interface, and other usability issues/features of the Shotcode, ConnexTo, BeeTagg, UpCode and Semacode systems. This section will focus on the review of the performance of the five tagging systems during the usability testing sessions (There was limited usability testing of the Semacode system).

Figure 23: An illustration of the experimental set-up for the scenario-based usability testing sessions

6.4.1 Usability Assessment of the Semacode System

The Semacode reader (version 1.6) was used during this study for the assessment of the Semacode platform, and the application takes about 3 seconds to load on the Nokia 6280. First, it should be pointed out that none of the Semacode visual tags that were created for usability study purposes could be decoded. Consequently, volunteers were not required to fill out NAUQ and SUSQ on the Semacode system since this would have biased their responses. However, they were still required to use the system to try and decode the

Semacode tags. What users found most disconcerting about the use of the system – see the italicized comments in parentheses - was the placement of the 'Recruit' button in place where the 'capture' button should have been ("*Recruit should have been in options instead of the main screen*"; "*...recruiting friends and actually getting through to the Web site should be kept separately*"; *"Centre button: expect to be able to connect to Web, but instead invited to Recruit"*). To complicate matters, information in the help menu directs users to push the "centre joystick button" to be able to decode tags. (*"Inconsistency between what it says in help function and what you have to do i.e. help says push the centre button but doing this doesn't capture the image")* To capture the Semacode visual tags, users have to go to the help menu and select the "Capture" option. Another drawback of the system is that users cannot see the visual tag they are about to decode after pressing the Capture/Viewfinder button (*"Can't see what is being captured when capture button is clicked""; No View: Need to click viewfinder").* Thus the interface displays some inconsistency regarding the use and placement of menu icons and buttons. An additional deficiency of the Semacode system is that users found the help menu on how to decode Semacode tags unhelpful as the instructions featured only text and no diagrams (*"Help: only text, no diagrams or pics")* – participants preferred instructional pictorials because they are more intuitive and easier to follow. However, both the "Recruit" menu option (for promoting awareness about the Semacode platform) and error feedback message were strong points of the Semacode system. It is also easy to create Semacode tags using online tools on the Semacode or semafox Web site.

6.4.2 Usability Assessment of the Shotcode System

The Shotcode reader version 3.02 was used for this study and it takes about 2 seconds for the application to load on the Nokia 6280. Participants were able to decode Shotcode tags (see Figure 24) relatively quickly and confidently. Visual tags could be decoded in upright, horizontal or angular positions. Moreover, the tags could be captured and read at different camera angles including vertical, horizontal and slanting positions. In addition, visual tags of smaller dimensions (i.e. smaller than A4/A3 paper and up to the size of a standard business card) could be decoded; and the system had good error feedback for decode failure ("Please try again"). In contrast to the Semacode system, the capture button is appropriately labelled "Capture" and positioned (in the centre of the screen). Furthermore, instruction within the 'Help' menu on how to use the system features only diagrams, and it takes only four scrolls to view the entire page. Shotcode tags could also be decoded under partial lighting or in poorly lit rooms.

In summary, users generally found the features and the functioning of the Shotcode system efficient and satisfactory. A sample of the typical responses from participants, which show general user satisfaction after using the Shotcode system, is reproduced below:

"Easier to capture code as it is circular not a circular code"
"Even if you took the picture at an odd angle it still worked"
"I like the help function... have pics rather than text"
"It showed you how the picture must be, so gives you some idea of the distance between camera and pic"
"The help function was great"
Very quick and efficient"
"Efficient to use when needed"
"Good updates of process occurring"
"Easy to use and there's no help needed to operate it"

A peculiar feature of the Shotcode system is the circular shape of the tags. Observation of user interaction with the five tagging systems showed that users found Shotcode visual tags the easiest to capture within the camera phone view due to their roundness. Another system highlight is that tagged Web sites are optimized for viewing on mobile devices. Thus Shotcodes offers the best Mobile Web site viewing experience of the five systems investigated. The drawbacks of the Shotcode system are that the 'Send to a friend' menu option does not work in South Africa, and Shotcode tags cannot be decoded in partial lighting conditions when and where there are shadow interferences.

6.4.3 Usability Assessment of the UpCode System

This study employed the use of the UpCode tag reading software (version 3.50.0) and the application takes about 2 seconds to load on the Nokia 6280. The most distinguishing feature of the UpCode visual tagging system is that UpCode visual tags can be captured in three ways. In the automatic mode of capture, the application takes a picture of the tag on its own, while for the manual mode, a user has to manually push the capture button to take a picture of the tag. Users with or without camera phones may also manually type in the unique code number on an UpCode tag to be able to decode the tag. Observation of users recruited for the study showed that they experienced the most frustration with the automatic capture mode, especially if they had started the testing session with any of the other visual tagging systems that featured mainly manual modes of capture. User frustration was mainly due to the fact that they felt out of control, and unsure of what was happening within the system (*"I was totally lost, just heard 'clicks'; "The automatic capture is not good as one would not be focused on the photo but it would capture thus causing confusion"; "Automatic mode is too fast, you don't really know what's happening"; "I didn't like the automatic one because as soon as you change position it takes another photo, I personally found it irritating").* But the frustration levels expressed by users were lower when the UpCode system was the first tagging system to be used by the users (see Figure 24) during a usability testing session. This was because they could not compare the default automatic mode of capture of the UpCode system with the mainly manual mode capture of the systems they had previously used.

A second downside of the system was that users had to keep varying their physical distance away from the UpCode visual tag in order to find the right distance from which UpCode tags may be accurately decoded. A third drawback of the system was the unimpressive decoding times recorded through the use of the automatic and manual capture modes. Users had to wait long for the tags to be accurately decoded, and sometimes the tags could not just be read. The high decoding latency further compounded user frustration with the UpCode system (*"If it wasn't an experiment, I would have given up a long time ago"; "Manual takes time to capture and you need to find the right* *distance which consumes time"; "Takes too much time to recognize the code").* The UpCode technical team explained that the high decoding latency is due to the fact that the UpCode reader does not have direct access to the camera (or imaging module) in the Nokia 6280.

Figure 24: A participant interacting with a 2D visual tag

Another system deficiency is the appropriateness of some of the feedback messages from the UpCode system. For instance when an UpCode tag is accurately decoded, the following confusing message appears on the screen, "Your device doesn't support concurrent processing, exit...". This message is supposed to indicate that the tag has been accurately decoded, but this is not the information that is conveyed to the end user if the feedback (message) is interpreted literally. So users keep on clicking the wrong response buttons (in this case, "No") because of the unintuitive nature of the system feedback. [The explanation from UpCode about this was that the message in question is a default error message/feedback from Nokia that appears on applications running on both the Nokia 6280 and 6282 phones.] Users also found fault with the help menu on how to use the UpCode system as the instruction was limited to text only and did not make use of diagrams. Finally, UpCode visual tags could not be decoded under poor or partial room lighting conditions via the use of the automatic and manual capture modes.

However, users generally found the "Insert Code" capture mode option easier to use because they could control the process and also because decode times were relatively faster. *("The enter code is very efficient and one does not make much error with; it even if one does, it would be easy to check against the code to see if numbers were inserted correctly"; "Ease of entering the code"; "Insert mode helpful, not complicated" "Insert mode is easier to use"; "The insert code option was easier"; "The insert code option is quite better").* Some users were also pleased with the fact that there was more than one option to capture UpCode tags *("It gives you different options"; "Offers three modes of operation"; "Good to have different options in case camera is not working").*

Users have to sign up for an account in order to be able to create UpCode visual tags. The UpCode Web site has an online tag management tool, and UpCode visual tags are created as PDF documents and cannot be altered or resized after download; although the URL link may be changed.

6.4.4 Usability Assessment of the BeeTagg System

The BeeTagg tag-reading application version 1.2.2 was used during this study and the application takes about 4 seconds to load on the Nokia 6280. The decoding latency for the BeeTagg visual tagging system was very impressive as tag decode times was short and tags could be decoded even whilst orientated angularly or upside down. Tags could also be decoded in different camera positions including when the camera is facing down or in a slanting position (i.e. at an angle relative to a BeeTagg). More impressively, very small BeeTaggs could be decoded as well. Some of the options available on the BeeTagg system are 'History' (a folder where all scanned beetags are saved in a chronological order) and 'Bookmarks' (a log of BeeTaggs that have been created and decoded). For a BeeTagg to be bookmarked, it needs to be saved using the 'Save BeeTagg' menu option.

The BeeTagg visual tagging system has an effective and efficient feedback mechanism. A unique sound as well as a green light (crosshairs) with a tick symbol informs users that a BeeTagg has been successfully decoded. On the other hand, a red light with an 'X' symbol as well as another beep tone is an indication that a BeeTagg decode attempt was unsuccessful. A flying bee is also displayed when the application is busy reading a BeeTagg. Moreover, the "Send Reader" option feature for creating awareness about the BeeTagg system is also functional. The instruction page in the 'Help' menu on how to use the BeeTagg system makes use of pictorials and like the Shotcode system, it takes only four scrolls to get to the end of the page. Apart from the standard use of BeeTaggs for linking of physical objects to online content, BeeTaggs may also be used for the creation of mobile Web sites, blogging, eBay, and as vCards. Furthermore, users can customize their BeeTaggs by making use of an online tool[41]. BeeTaggs, like UpCode tags, may be decoded by entering the unique BeeTagg number on individual BeeTaggs via the use of the 'Insert BeeTagg Number' menu option. BeeTagg visual tags may thus be used with phones which have no cameras.

However, BeeTaggs could not be decoded in poor illumination or partial lighting conditions. Moreover, the BeeTagg visual tag (online) creation and management Web page which requires users to sign up for an account, is in German. Furthermore, the on-screen message after a successful decode ("Go to w..."), a prompt for the user to indicate whether the application should proceed to the Web site of interest, is not easily decipherable by the average user. A user commented on this feature thus: *"Lack of full wording when telling me to go to Web – had to assume"*. The capture button label ('Search') could have been given a more suitable name to better reflect its function. In summary, the comments below reflect the levels of user satisfaction and feelings about interacting with the BeeTagg visual tagging system:

[41] http://designer.BeeTagg.com/

"The accompanying sound, the sound when you fail to capture image"

"Speed of linking to the Net"

"Good to capture even if your hand is unsteady"

"very easy to use"

"Nice sounds to tell you, you took the picture right or wrong"

"finds the image 1st time nearly every time

"Interesting sounds…"

"It's actually quite easy"

"It was fast in recognizing the code"

"Sound effects: green lights shows the process; compared to previous systems much better"

"The noise feedback is nice" / "The sounds are more interactive"

"Process was fast"

"Simple to use – Help function great"

"Beep sound tells you if you are successful / less fiddling around"

"Noise – good feedback especially for the visually impaired"

"Shows picture of the tag taken"

6.4.5 Usability Assessment of the ConnexTo System

The mCode-reading application software (version 1.14) was used for reading ConnexTo visual tags and it took about 2 seconds to load on the Nokia 6280. ConnexTo visual tags may be decoded in upright, downward, horizontal, or angular positions. The tags may also be decoded with the camera (i.e. camera on the Nokia 6280) orientated at different angles to the ConnexTo tag. User observation showed that ConnexTo tags were relatively easy and quick to decode. All the interface elements and icons are suitably and intuitively named. Another good element of the system was that it had the fastest Internet download times of all visual tagging systems investigated (*"UpCode real fast"; "Downloading was much faster""; "very quick to connect""; "Upload faster")*. Although ConnexTo visual tags may be read in partial lighting, tags cannot be decoded in poorly lit rooms or areas when and where there are shadows. In addition, tags cannot be decoded under very poor lighting conditions.

Some of the drawbacks of the ConnexTo visual tagging system include the absence of feedback or error message(s) for decoding failure (*"If you were not successful, it doesn't tell you that you were not successful"),* and the failure of the application to be able to read tags with smaller dimensions (i.e. smaller than A4 size paper). Moreover, users were not impressed with the 'Help' menu on how to use the ConnexTo system. The instruction page consists of text only and scrolling down to the end of the page is tedious. More significantly, the instruction page has no details about how to use the system per se – the page basically contains a description and background of the ConnexTo platform (*"I don't like help function at all – it's probably got the worst help function"; "help was not efficient"; "The help function needs work"; "Help function was not very helpful in terms of use of actual system"; "Help function talked more about the program than how to use it").* The "Send to a friend' menu option is also not functional.
To create tags, users need to sign up for an account and the online tag creation tool requires Active X control. But overall, users found the system easy and pleasant to use (*"Easy to use"; "Easy to use and very straight forward"; "Easy to use once you get used to functions"; "Saves time & convenient").*

6.5 Evaluation of the Nielsen's Attributes of Usability

The Nielsen's Attributes of Usability Questionnaire (NAUQ), whose validity and reliability have been established, is a tool for the evaluation of the subjective aspects of the usability of a software system. The NAUQ is a survey instrument on which respondents may specify any value from 1 to 7 to indicate their assessment of any of the five attributes being evaluated. The lower limit on the NAUQ is '1' and this Scale means 'bad'; and the upper limit, '7' means 'good'. A Scale rating of '4' for a system by a respondent usually means the respondent is unsure of the specific attribute being measured. The NAUQ scores for the four visual tagging systems (BeeTagg, ConnexTo, Shotcode, UpCode) will be presented as a plot of the number of the 1s, 2s, 3s, 4, 5s, 6, and 7s that respondents gave each tagging system under the following five Nielsen's usability attributes categories: Learnability, Efficiency, Memorability, Errors, and Satisfaction.

Consequently, the NAUQ was used during this study to evaluate the following five key usability aspects (also known as the Nielsen's Five Attributes of Usability) of the 2D visual tagging systems investigated:

1. **Learnability**: A measure of the ease with which users can learn to use a visual tagging system

2. **Efficiency**: A measure of how efficiently a visual tagging system can be used to complete tasks. The single most important component that influences the outcome of the evaluation of the Efficiency usability attribute is the decoding latency of the visual tagging system being evaluated

3. **Memorability**: A measure of how easy it is for users to recall the function and use of the interface elements (e.g. menus, icons, et cetera) of a visual tagging system

4. **Errors**: A measure of the error rate and/or ease of recovering from errors associated with the use of a visual tagging system

5. **Satisfaction**: A measure of user satisfaction or pleasantness of use of a visual tagging system

Each of the 20 volunteers filled out a NAUQ for the Shotcode, BeeTagg, ConnexTo, and UpCode tagging systems. As has been explained earlier, volunteers did not fill out a NAUQ for the Semacode system because this would have introduced bias into the evaluation feedback for the Semacode system. The data collected from the NAUQ is presented under the sections for the respective visual tagging systems.

6.5.1 NAUQ Scores for the UpCode System

Learnability: The mean of the 20 Learnability scores for the UpCode system is 3.85 (see Table 2), and this is an indication that users did not feel that it was easy to learn to use the UpCode system. This score is due to the features of the UpCode system highlighted earlier in this chapter. A plot of the Learnability scores (see Figure 25) shows that most (about 65%) of the scores fall into the Scales 4, 5 and 1 categories.

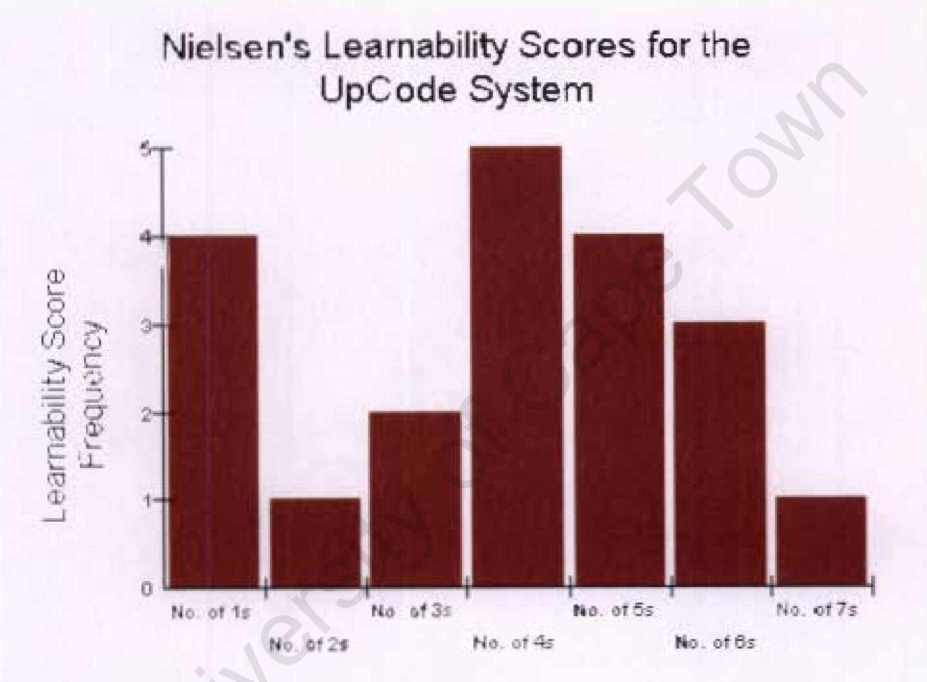

Figure 25: Nielsen's learnability scores for the UpCode system

Statistical Measures	Learnability	Efficiency	Memorability	Errors	Satisfaction
Mean	3.85	4.00	4.35	3.25	4.30
95% Confidence Interval	2.974 to 4.726	3.004 to 4.996	3.557 to 5.143	2.366 to 4.134	3.467 to 5.133
Standard Deviation	1.87	2.13	1.69	1.89	1.78
Average Absolute Deviation	1.45	1.80	1.25	1.45	1.40
Median	4.00	4.5	5.00	3.00	4.50
(Normal) Distribution	[42]p= 0.50	p= 0.55	p= 0.39	[43]**p= 0.14	p= 0.33

Table 2: Descriptive Statistical data for the UpCode System

Efficiency: The mean (see Table 2) of the 20 Efficiency scores for the UpCode system is 4.00. This mean score shows that users (i.e. volunteers) were unsure about whether the UpCode system could be used to efficiently complete tasks. A plot (Figure 26) of the Efficiency scores also shows that nearly one-half of the scores fall within Scales 1 and 5. Moreover, the score distribution shows that there are an equal number of Efficiency scores on the 'low' Efficiency (i.e. Scales 1 – 4) and 'high' Efficiency sides (i.e. Scales 5 – 7).

[42] The statistical data presented in Tables 2 – 5 were generated using the online tool at at http://www.physics.csbsju.edu/stats/cstats_paste_form.html.

[43] * indicates data is not normally distributed. ** indicates data is not particularly well/normally distributed

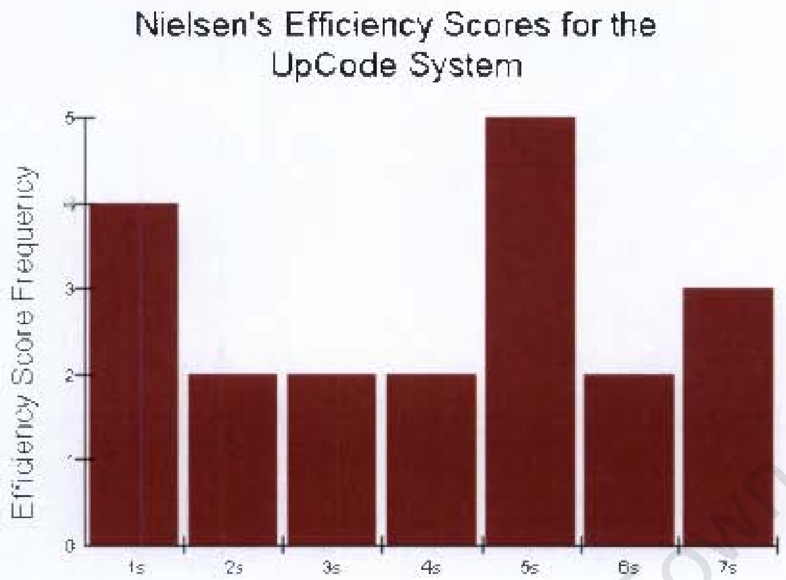

Figure 26: Nielsen's efficiency scores for the UpCode system

Memorability: The mean of the Memorability scores for the UpCode system is 4.35 and again, this score indicates that users were uncertain about whether it was easy to recall the functions and use of the interface elements of the system. Similar, the distribution of the scores in bar chart in Figure 27 corroborates the conclusion that volunteers did not find the features of the UpCode system memorable as 9 (or 45%) of the Memorability scores are on the low Memorability end.

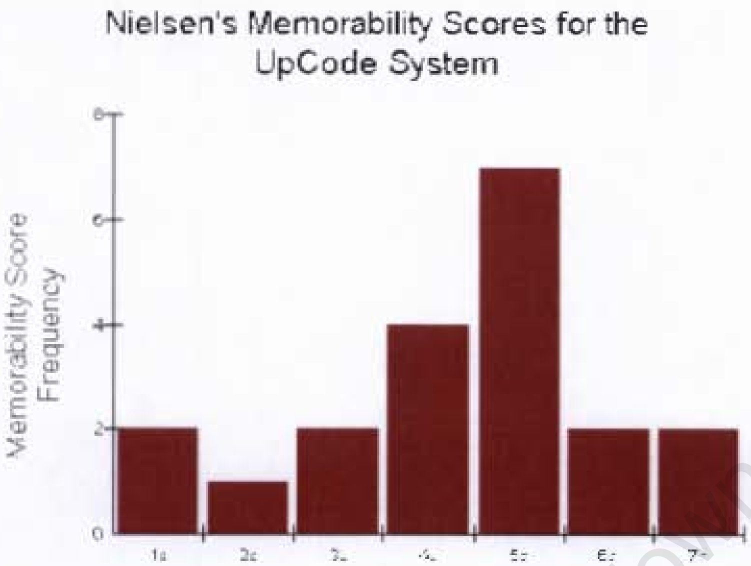

Figure 27: Nielsen's memorability scores for the UpCode system

Errors: The mean of the Errors scores is 3.25 and this score is a strong indication that users associated the use of the system with a relatively high error rate. The distribution of the Errors scores (see Figure 28) also supports this conclusion as 85% of the Errors scores falls within Scales 1 – 4.

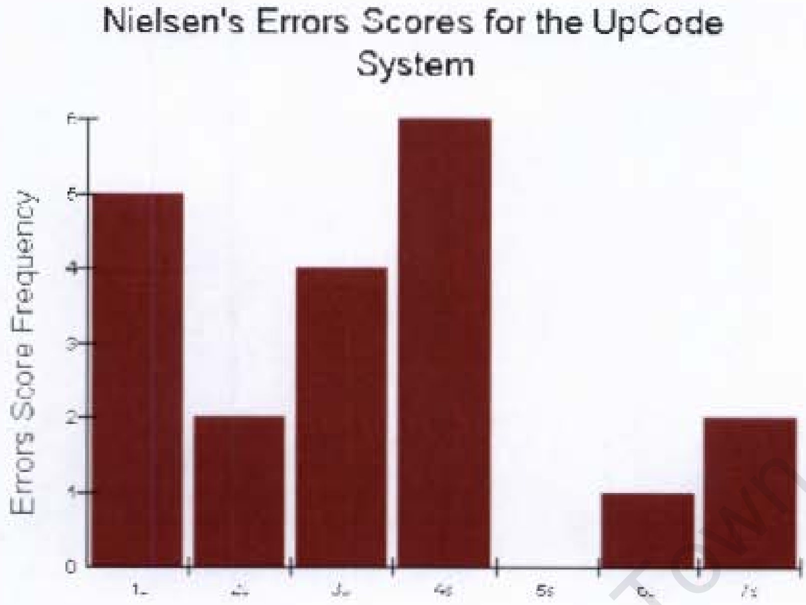

Figure 28: Nielsen's errors scores for the UpCode system

Satisfaction: The mean of the 20 Satisfaction scores is 4.30, and this score represents a mixed response to the 'Pleasantness of Use Ratings' for the UpCode system. Figure 29 show that half of the Satisfaction scores are on the Scale 1- 4 (poor Satisfaction) end of the NAUQ while the other half are on the Scale 5 – 7 (high Satisfaction) end, with the highest scores falling within Scales 4 and 5.

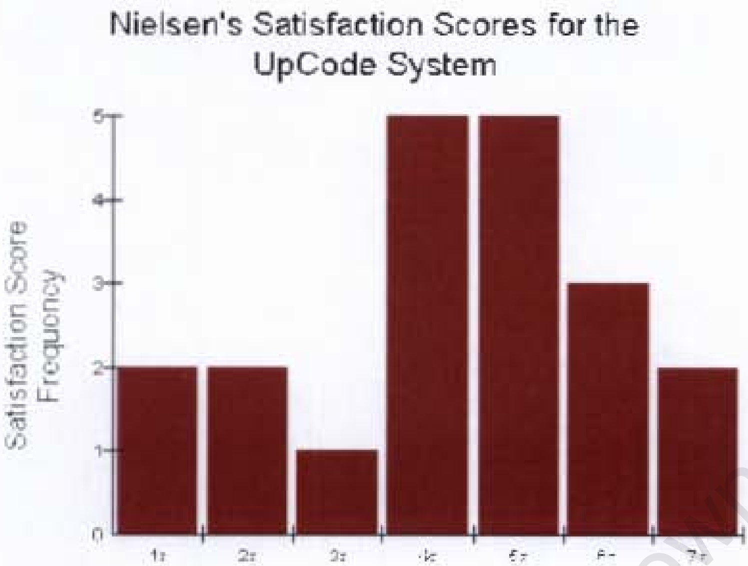

Figure 29: Nielsen's satisfaction scores for the UpCode system

6.5.2 NAUQ Scores for the BeeTagg System

Learnability: The high mean Learnability score of 6.10 (see Table 3) strongly indicates that users felt it was very easy to learn to use the BeeTagg system. A plot (Figure 30) of the Learnability scores shows that 85% of the scores are within Scales 6 and 7.

Statistical Measures	Learnability	Efficiency	Memorability	Errors	Satisfaction
Mean	6.10	6.35	6.40	5.722	6.30
95% Confidence Interval	5.555 to 6.645	5.940 to 6.760	5.987 to 6.813	5.188 to 6.256	5.842 to 6.758
Standard Deviation	1.17	0.875	0.883	1.07	0.979
Average Absolute Deviation	0.80	0.65	0.60	0.833	0.70
Median	6.00	7.00	7.00	6.00	7.00
(Normal) Distribution	[44]*p= 0.01	*p = 0.05	*p= 0.02	p= 0.32	*p= 0.05

Table 3: Descriptive Statistical data for the BeeTagg System

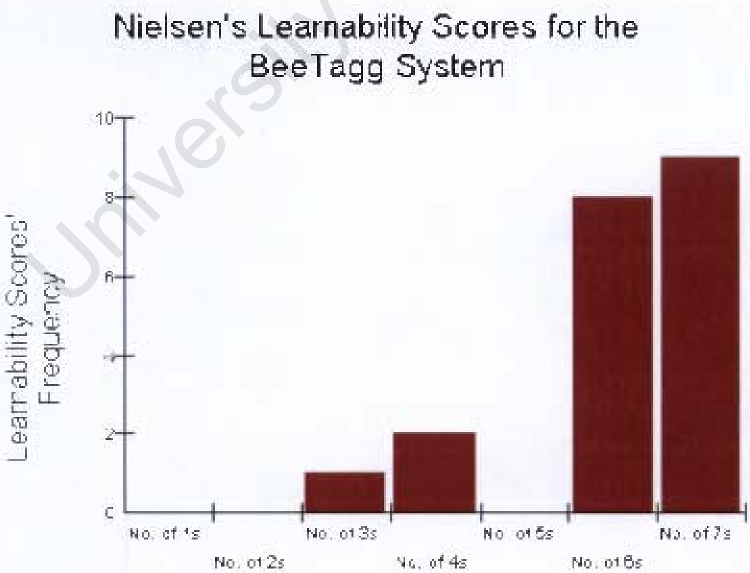

Figure 30: Nielsen's learnability scores for the BeeTagg system

[44] * indicates data is not normally distributed. ** indicates data is not particularly well/normally distributed

Efficiency: Again, the high mean (Table 3) Efficiency score of 6.35 is a very strong indication that users found the BeeTagg system very efficient to use to complete assigned tasks. A chart of the Efficiency scores (Figure 31) reveals that there were no scores within Scales 1, 2 and 3 for this category, and only 1 respondent was unsure about how to rate the efficiency of the BeeTagg system. So most of the scores are on the high Efficiency end.

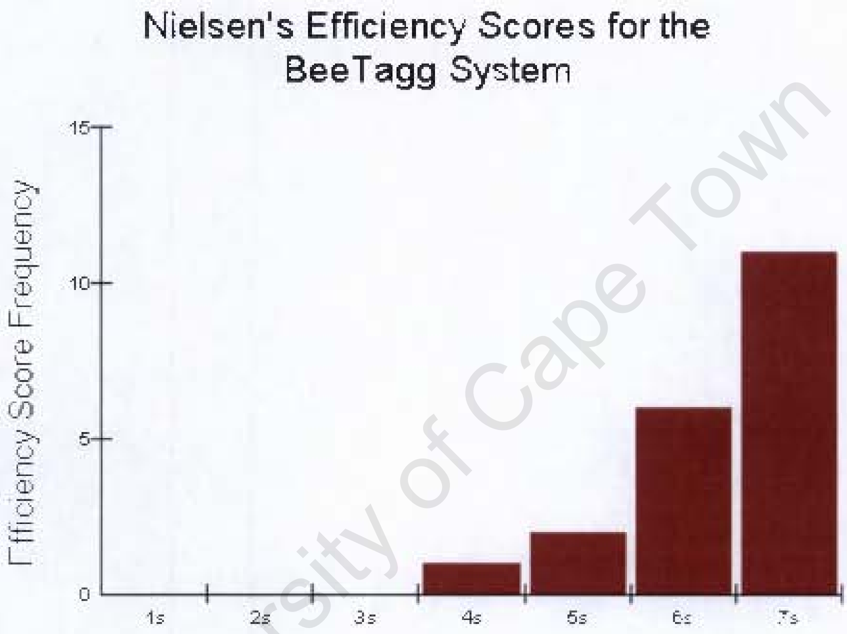

Figure 31: Nielsen's efficiency scores for the BeeTagg system

Memorability: The high mean (Table 3) Memorability score of 6.40 is a strong indication that users found it quite easy to recall the functions and use of the interface elements of the BeeTagg system. A chart of the Memorability scores for the BeeTagg system (Figure 32) shows a strong correlation with this conclusion as 95% of the Memorability scores are within Scales 5, 6 and 7.

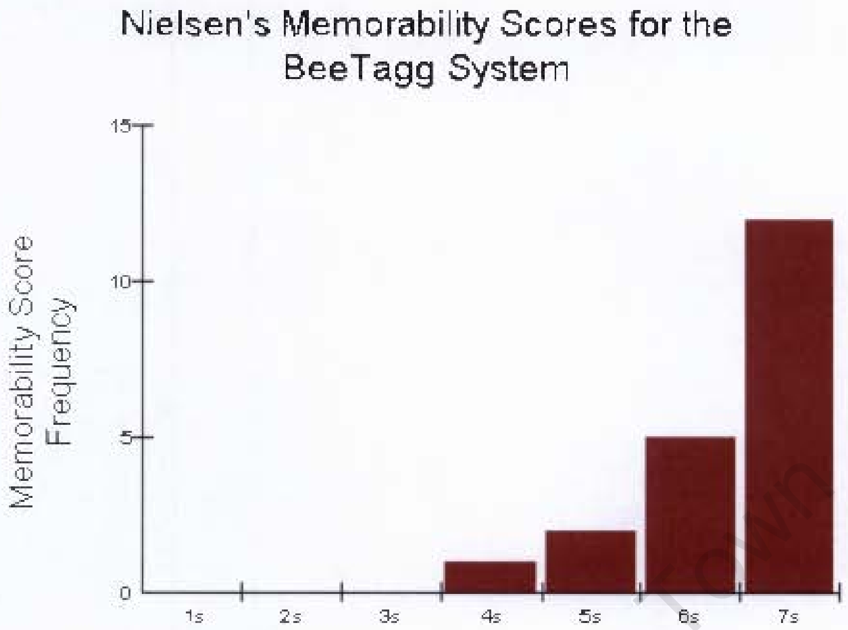

Figure 32: Nielsen's memorability scores for the BeeTagg system

<u>**Errors:**</u> The mean score for the Errors Usability Attribute is 5.72. Although this score is relatively less than the Learnability, Efficiency, Memorability and Satisfaction scores for the BeeTagg system, this is not necessarily a reflection of the error rate associated with the use of the system. The score is more of a reflection of the fact that a slightly higher number of respondents were uncertain about how to rate the BeeTagg system on the Error attribute (see Figure 33). In any case, the mean score and score distribution (Figure 33 shows that 85% of the scores are on the low Errors rate end) strongly indicate that most users felt the system had a low error rate.

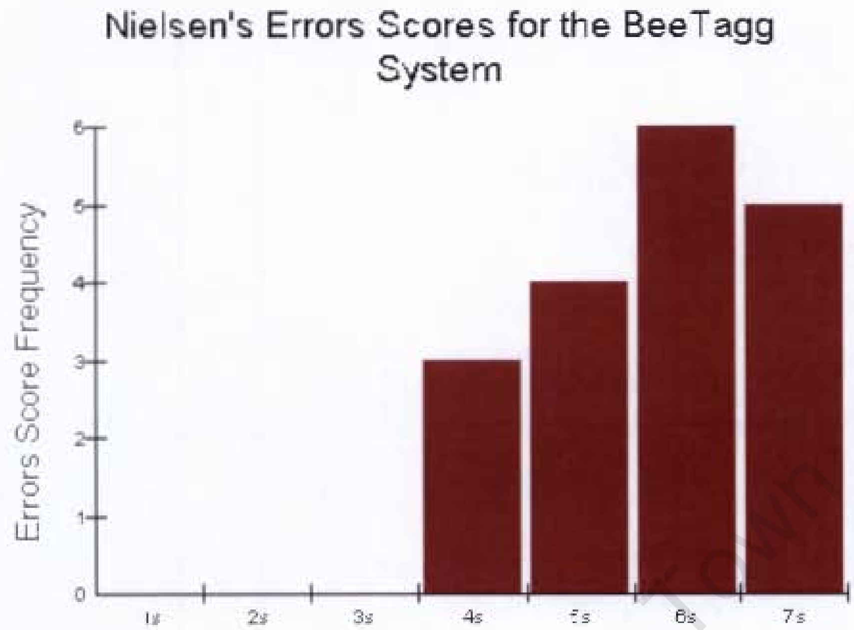

Figure 33: Nielsen's errors scores for the BeeTagg system

Satisfaction: The high mean (Table 3) Satisfaction score of 6.30 is a strong indication that users were very satisfied with the look, feel and function of the BeeTagg system. A chart of the Satisfaction scores for the BeeTagg system (Figure 34) shows that 85% of the Satisfaction scores are within Scales 5, 6 and 7.

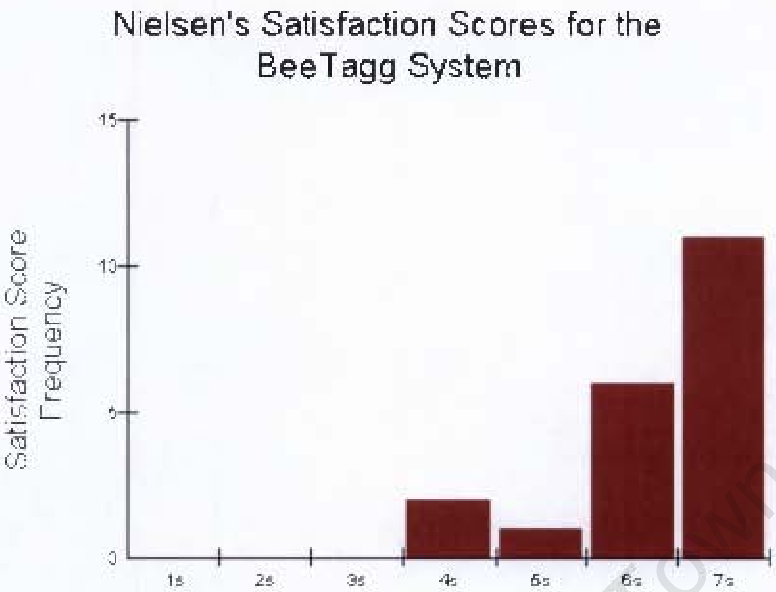

Figure 34: Nielsen's satisfaction scores for the BeeTagg system

6.5.3 NAUQ Scores for the Shotcode System

Learnability: The average of the 20 Learnability scores for the Shotcode system is 6.35 (see Table 4) – and this indicates that users found the system very easy to learn to use. From the plot in Figure 35, it can be seen that users were clearly impressed with how it was easy it was learn to use the Shotcode system as all the Learnability scores are within Scales 5, 6 and 7. Moreover, at least half of all users gave the system a Learnability score of 7.

Statistical Measures	Learnability	Efficiency	Memorability	Errors	Satisfaction
Mean	6.35	6.40	6.75	6.5263	6.450
95% Confidence Interval	5.970 to 6.730	5.844 to 6.956	6.542 to 6.958	6.191 to 6.862	6.129 to 6.771
Standard Deviation	0.813	1.19	0.444	0.697	0.686
Average Absolute Deviation	0.65	0.60	0.250	0.474	0.550
Median	7.00	7.00	7.00	7.00	7.00
(Normal) Distribution	[45] *p= 0.02	*p= 0.00	*p= 0.00	*p= 0.01	*p= 0.02

Table 4: Descriptive Statistical data for the Shotcode System

[45] * indicates data is not normally distributed, ** indicates data is not particularly well/normally distributed

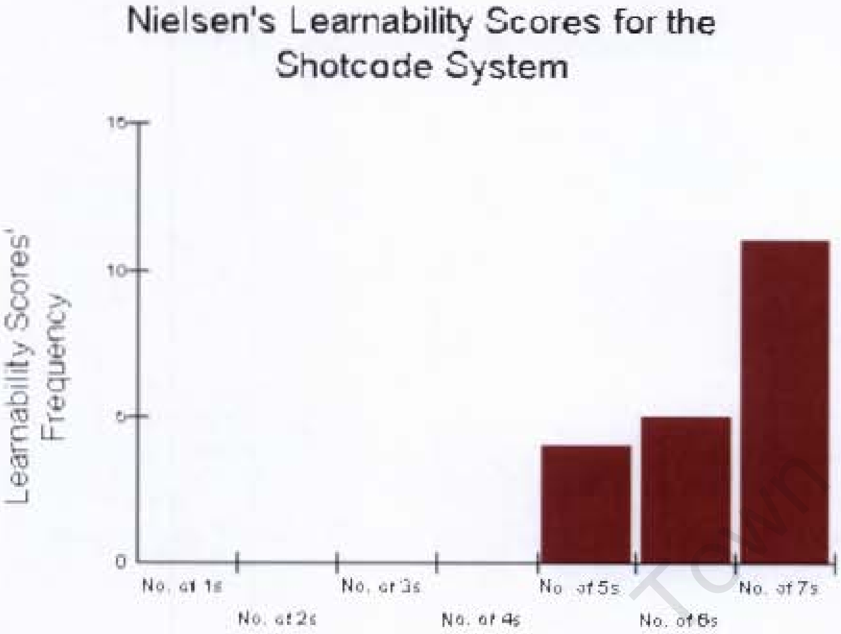

Figure 35: Nielsen's learnability scores for the Shotcode system

<u>**Efficiency**</u>: A mean Efficiency score of 6.40 (Table 4) shows that users found the Shotcode system highly efficient to use to complete tasks. This is reinforced by a plot (Figure 36) of the distribution of the Efficiency scores as 65% of the scores are a 7.

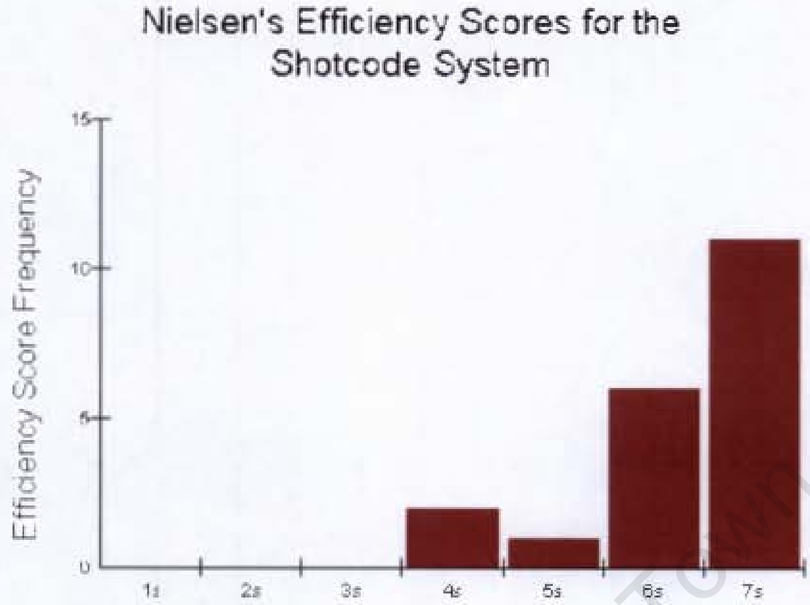

Figure 36: Nielsen's efficiency scores for the Shotcode system

Memorability: The relatively high mean value of the Nielsen's Memorability score of 6.75 (see Table 4) shows that the components of the Shotcode system are very easy to remember. The high Memorability value of the Shotcode system is better explained by the chart in Figure 37 which shows that 75% of the Memorability scores are a 7, while the remaining scores are a 6.

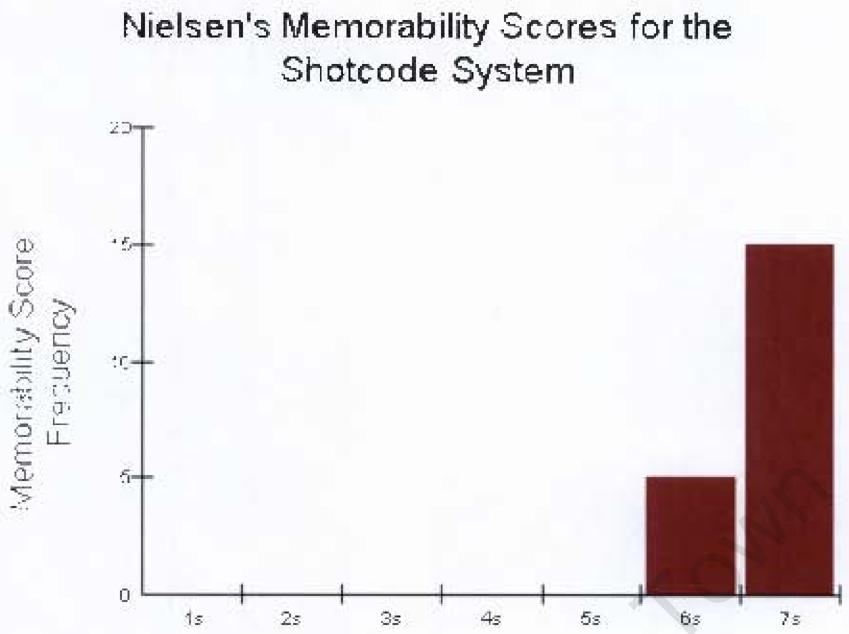

Figure 37: Nielsen's memorability scores for the Shotcode system

<u>**Errors**</u>: The mean Errors rate of 6.53 (Table 4) indicates that users either did not make any errors or made very few errors during the use of the Shotcode system. It can thus be inferred that use of the system is almost error-free. This conclusion is given weight by the plot of the distribution of the Errors scores in Figure 38.

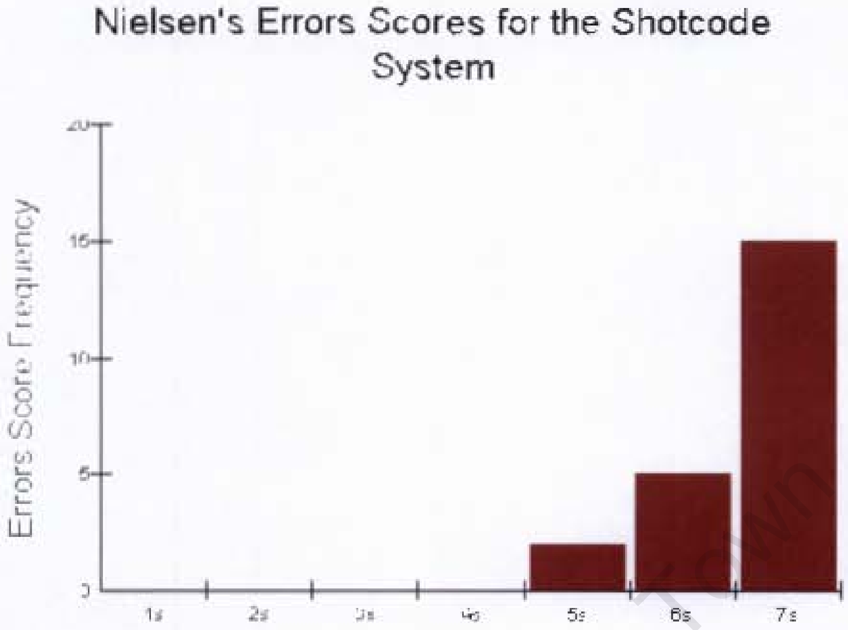

Figure 38: Nielsen's errors scores for the Shotcode system

Satisfaction: Again, the high mean value of 6.45 for the Satisfaction measure (Table 4) shows that users rated the Shotcode system very highly on the 'Pleasantness' factor. This is corroborated by the plot (Figure 39) of the distribution of the Satisfaction scores – 90% of the scores are within Scales 6 and 7.

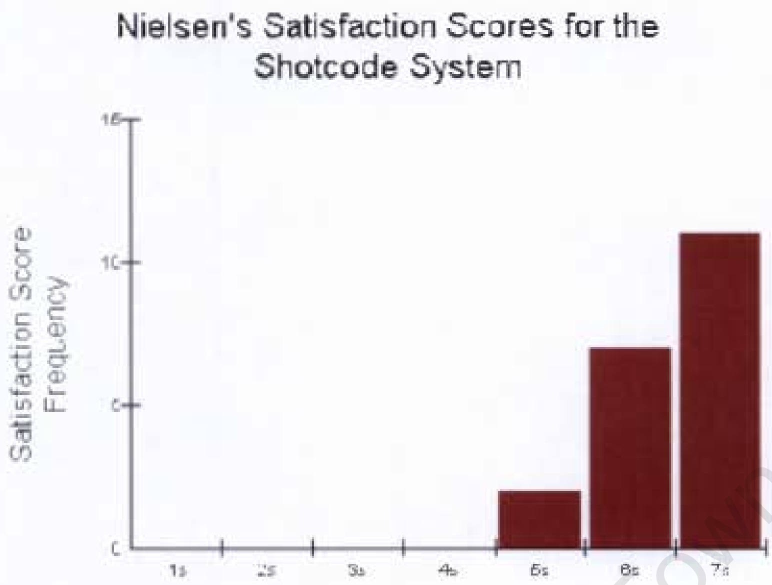

Figure 39: Nielsen's satisfaction scores for the Shotcode system

6.5.4 NAUQ Scores for the ConnexTo System

__Learnability__: The high mean score of 6.45 (see Table 5) shows that the ConnexTo platform is an easy to learn to use system. The high score can be explained by the high number of Scale 7 scores (see Figure 40).

Statistical Measures	Learnability	Efficiency	Memorability	Errors	Satisfaction
Mean	6.45	6.20	6.50	5.8947	6.20
95% Confidence Interval	6.129 to 6.771	5.781 to 6.619	6.178 to 6.822	5.254 to 6.535	5.706 to 6.694
Standard Deviation	0.686	0.894	0.688	1.33	1.06
Average Absolute Deviation	0.550	0.70	0.50	0.947	0.80
Median	7.00	6.00	7.00	6.00	6.50
(Normal) Distribution	[46]*p= 0.02	**p= 0.10	*p= 0.01	*p= 0.05	*p= 0.07

Table 5: Descriptive Statistical data for the ConnexTo System

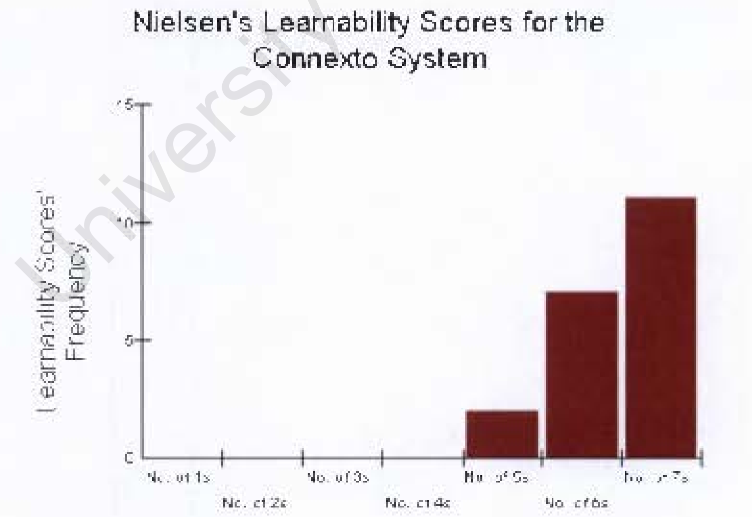

Figure 40: Nielsen's learnability scores for the Connexto system

[46] * indicates data is not normally distributed. ** indicates data is not particularly well/normally distributed

Efficiency: A mean Efficiency score of 6.20 (Table 5) indicates that the ConnexTo visual tagging system is a very efficient system to use. Moreover, 19 of the 20 Efficiency scores are within Scales 5, 6 and 7 (see Figure 41)

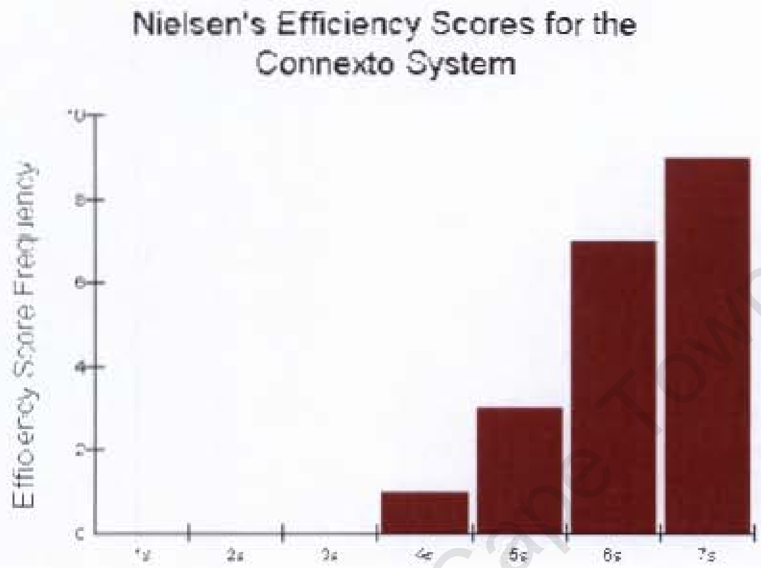

Figure 41: Nielsen's efficiency scores for the Connexto system

Memorability: The very high Memorability mean score of 6.50 is a strong pointer to the ease of recall and memorization of the interface elements of the ConnexTo system. The chart in Figure 42 shows the distribution of the 20 Memorability scores.

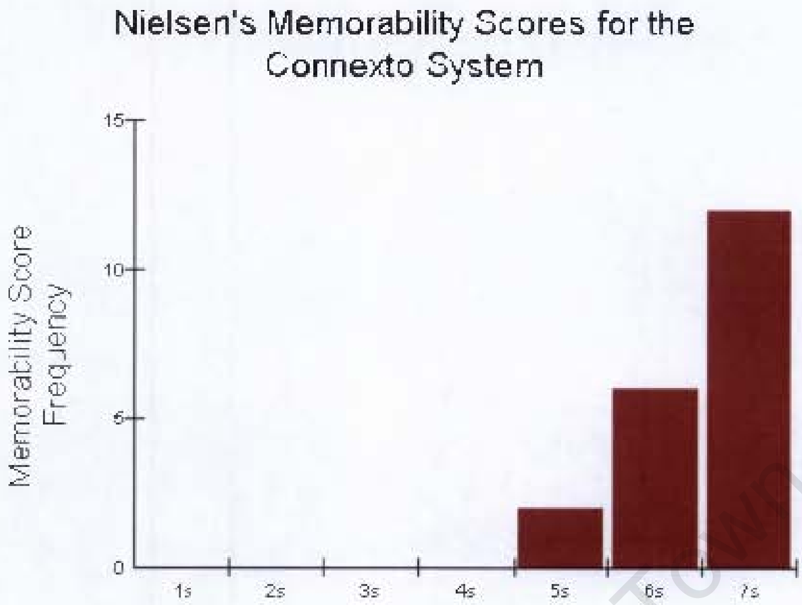

Figure 42: Nielsen's memorability scores for the Connexto system

Errors: The ConnexTo system has a mean Errors rate of 5.89, which means that the use of the system is generally associated with a low error rate. The distribution of the Errors scores shows that 80% of the scores are in the Scales 5, 6 and 7 ranges (see Figure 43).

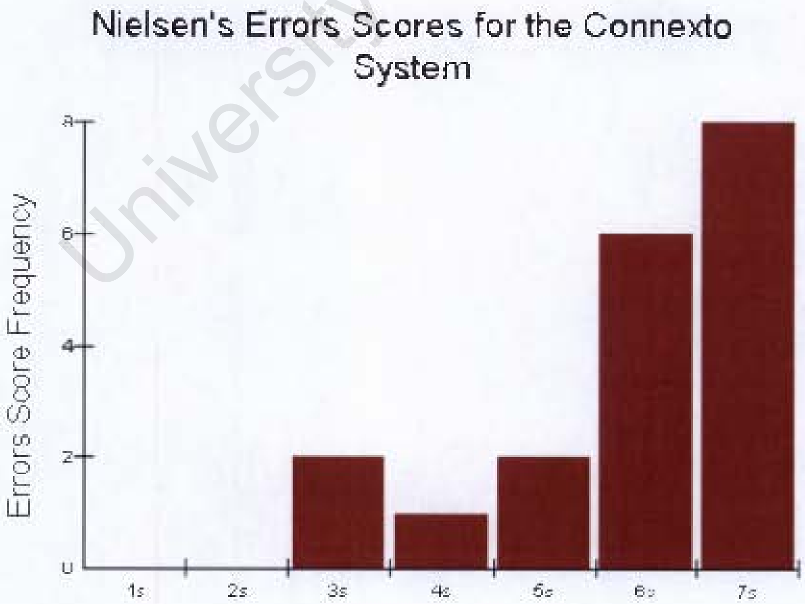

Figure 43: Nielsen's errors scores for the Connexto system

Satisfaction: The high Satisfaction mean score of 6.20 means users were significantly pleased with the overall functioning and pleasantness of the ConnexTo system. The chart in Figure 44 shows the distribution of the Satisfaction scores.

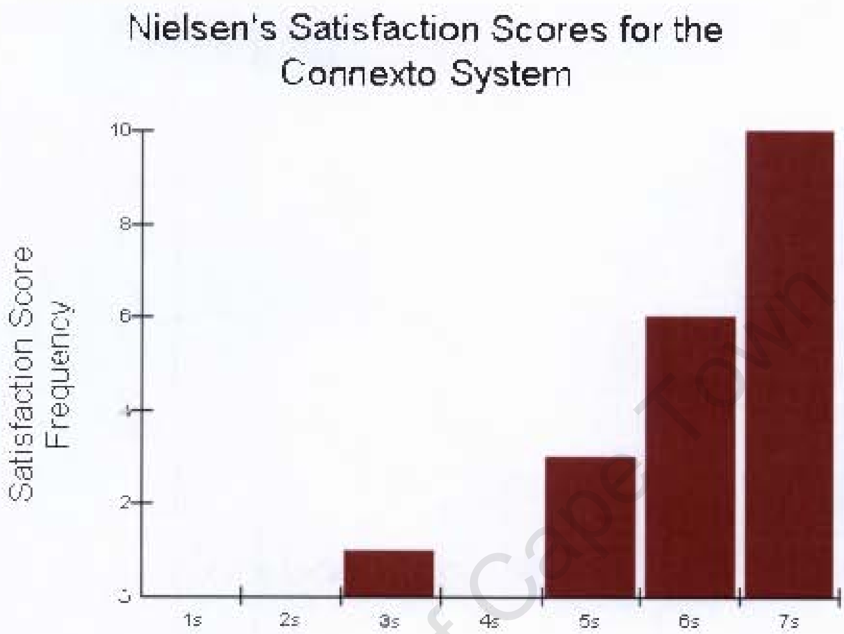

Figure 44: Nielsen's satisfaction scores for the Connexto system

6.6 System Usability Scale Data

The System Usability Scale Questionnaire (SUSQ) [SUSQ] is a robust and reliable, 10-item Likert-scale instrument that can be used for the usability assessment of software systems. All volunteers for this study (apart from the first two participants) filled out two SUS questionnaires during a usability testing session. In all, 34 questionnaires were filled out to provide subjective feedback on the usability of the four visual tagging systems investigated – the Semacode system was left out of this data collection process due to reasons explained earlier under the section on NAUQ data collection. 16 questionnaires - four each for the BeeTagg, ConnexTo, UpCode and Shotcode systems were completed to provide specific usability assessment of the four tagging systems above, while 18 questionnaires were filled out by participants to provide a usability evaluation of the 2D visual tagging paradigm based on interaction with the four visual tagging systems above.

The SUSQ scale has values that range from 1 ("strongly disagrees") to 5 ("strongly agrees") and participants have to fill out all ten items on the SUSQ. Although the SUSQ is simple to use, some volunteers did not know the meaning of the word "cumbersome" under Item 8. Such volunteers were therefore asked to substitute "awkward" in place of cumbersome. After the completion of a SUSQ by a participant, the overall SUSQ score is then computed based on a formula provided in [SUSQ]. SUSQ scores have a range of 0 – 100, and generally, the higher the score, the greater the usability of the system being assessed. A mean SUSQ score of 60 was adopted for this research project as the minimum SUSQ score a system has to obtain in order for it to be considered reasonably useable – that is, easy to learn, easy to use and efficient. A SUSQ score of 80 and above for a system suggests that the system has a high usability rating. The SUSQ scores for the BeeTagg, ConnexTo, UpCode and Shotcode systems as well as the general scores for the visual tagging systems as a whole are presented in the next section.

SUSQ Scores (UpCode): The distribution of the SUSQ scores (see Figure 45) shows that two of the scores are below 60. The average SUSQ score is 63.75 and this indicates that participants were not very satisfied with the usability of the UpCode system.

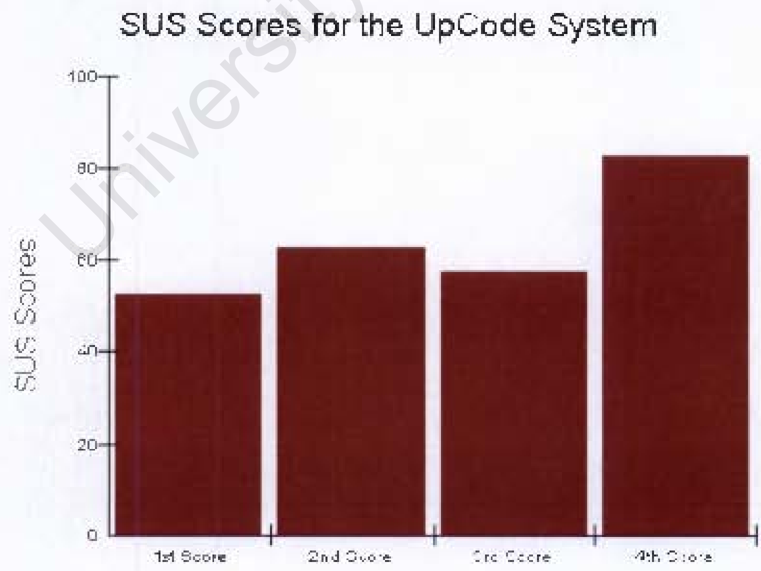

Figure 45: SUS scores for the UpCode system

SUSQ Scores (BeeTagg): The range of the SUSQ scores (Figure 46) for the BeeTagg system and the mean SUSQ score of 83.75 clearly show that participants rated the system very highly on usability.

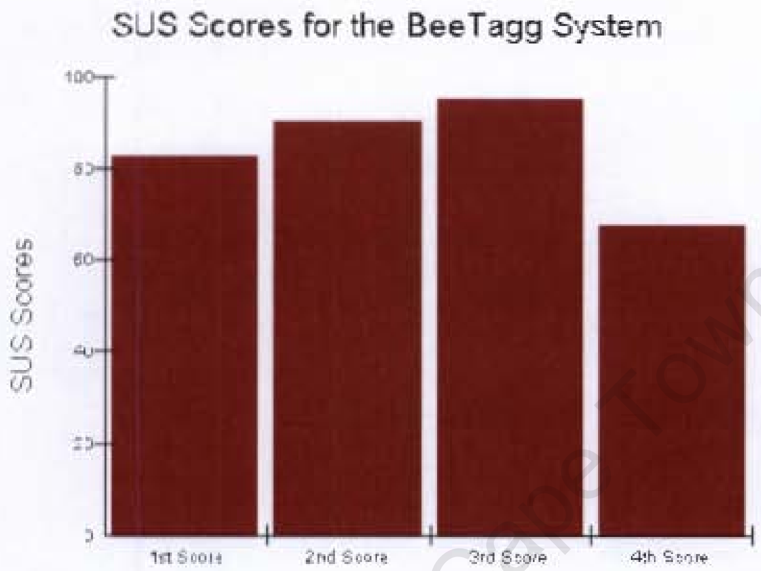

Figure 46: SUS scores for the BeeTagg system

SUSQ Scores (ConnexTo): The high mean SUSQ score of 76.88 together with the distribution of the SUSQ scores (Figure 47) indicates that participants found the usability of the ConnexTo system impressive.

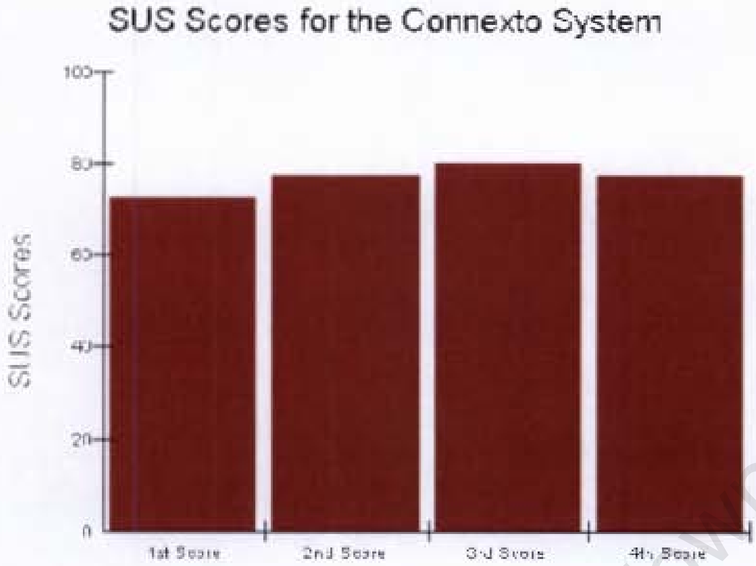

Figure 47: SUS scores for the Connexto system

SUSQ Scores (Shotcode): The range of the SUSQ scores for the Shotcode system (Figure 48) and the mean SUSQ score of 80 together indicate that it is easy and pleasant to use the system.

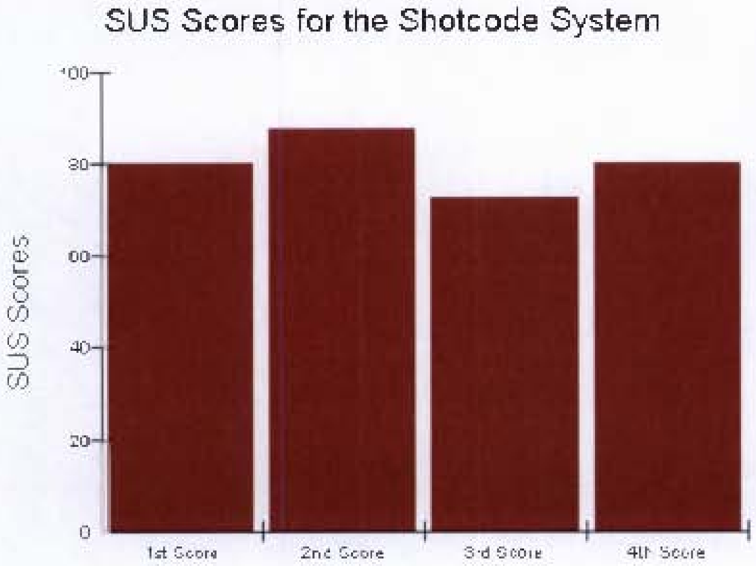

Figure 48: SUS scores for the Shotcode system

<u>SUSQ Scores (2D Visual Tagging Paradigm)</u>: The range of the SUSQ scores (Figure 49) as well as the average SUSQ score of 78.5 together strongly suggest that participants were clearly satisfied with the 2D visual tagging paradigm from a usability perspective.

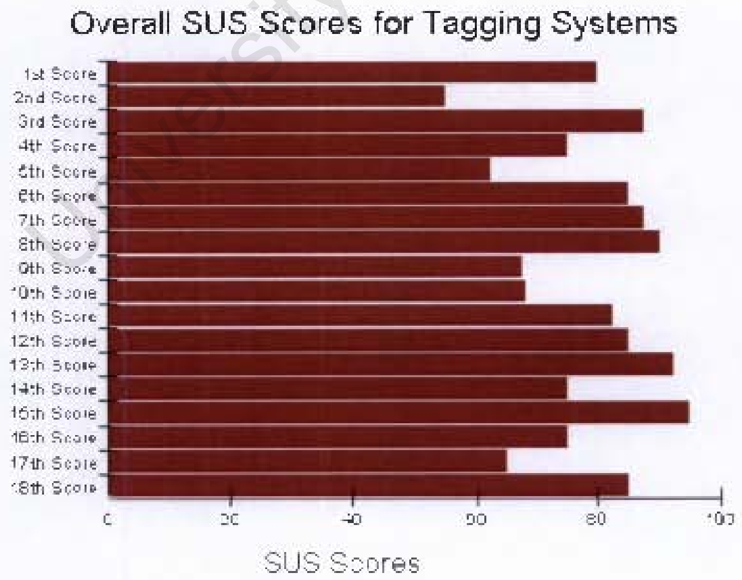

Figure 49: Overall SUS scores for the 2D visual tagging paradigm

6.7 Visual Tag Design Appeal and Ease of Use Ratings

6.7.1 Design Appeal

As part of the interview questions at the end of a usability testing session, participants were asked to rank the five visual tags (BeeTagg, Semacode, ConnexTo, UpCode and Shotcode) used in this study in terms of design and visual appeal. This exercise was carried out because visual tags serve a dual purpose: they encode information, but they also advertise a service. Consequently, the visual appeal of tags must be such that their presence in the physical environment should be able to attract both those who are familiar with their use, and more importantly, curious passersby drawn by the aesthetic or design appeal of the tags. The results show that participants consistently rated the Shotcode visual tag as having the best design in terms of visual appeal and brand recognition. It seems the circular shape of the Shotcode tag made it stand out ("*Interesting picture"; "Nice image or barcode to capture"; "Easier to capture code as it is circular…*"). Participants also rated both Shotcode and UpCode visual tags highly for their instant tag recognition feature - both tags have their brand names imprinted on them *("UpCode and Shotcode have text/brand names – easier to recognize and relate to"; "The Shotcode and UpCode have good graphics. The fit in the norm and would blend in with other posters")*. Some participants were also impressed with the BeeTagg visual tag due to its distinctive beehive-like design. In contrast, participants were generally not impressed with the ConnexTo and Semacode visual tags ("*ConnexTo and Semacode look like technical computer code – difficult to understand*").

The ranking of the visual tags by participants based on design appeal (see Figure 50) shows that 47.1% (or nearly half) of participants ranked Shotcode as having the best visual tag design, while just under 3% of participants thought that Semacode visual tags have a high visual appeal.

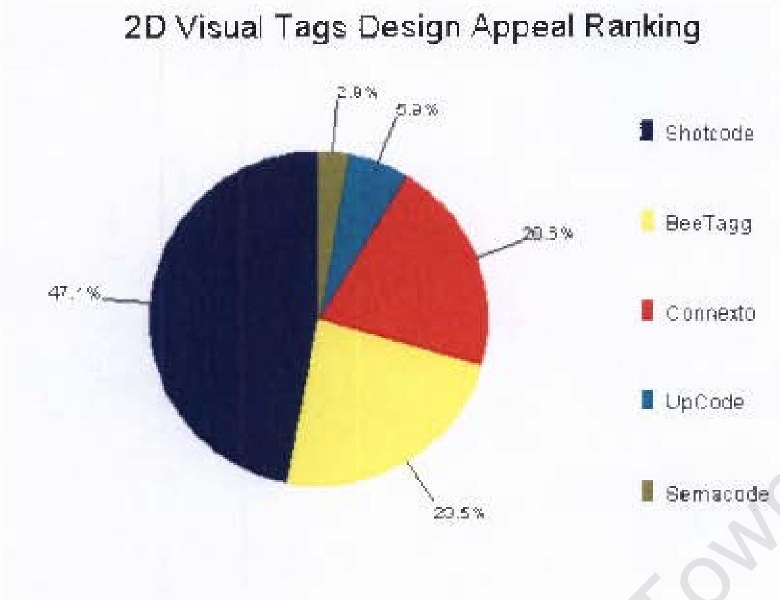

Figure 50: 2D visual tags' design appeal and ranking

6.7.2 Ease of Use

Participants were also asked after the conclusion of the usability testing session to name the 2D visual tag system (i.e. Shotcode, BeeTagg, ConnexTo, or UpCode) they found easiest to use. The Semacode system was not included in this phase because participants did not use the system for direct 2D visual tag decoding purposes. The results of this ranking exercise (presented in Figure 51) shows that 71.8% of all participants felt that the Shotcode and BeeTagg visual tagging systems were the easiest to use.

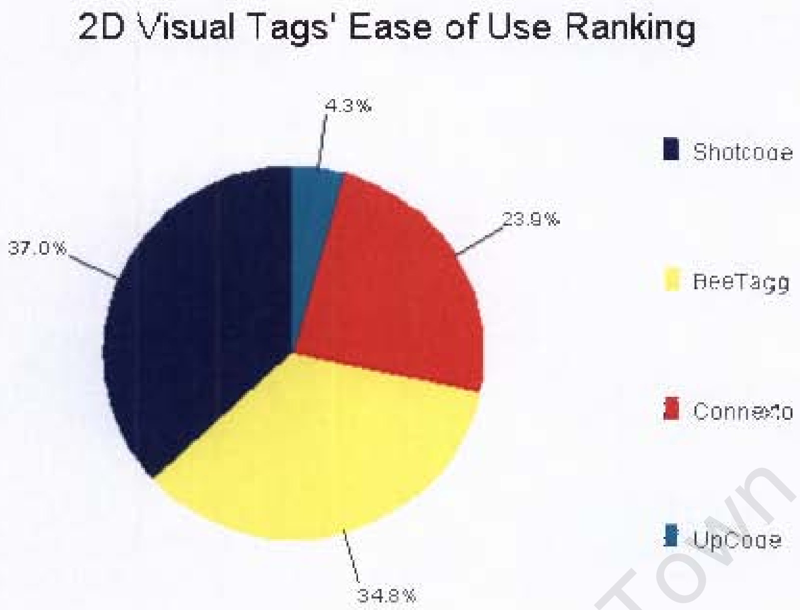

Figure 51: 2D visual tags' ease of use ranking

6.8 Visual Tagging Technology Adoption

In this section, the feedback from participants - after using the systems during the usability testing sessions – about their attitudes towards the adoption of visual tagging systems, is presented. The barriers that could limit the frequency of use and/or adoption of visual tagging systems are also highlighted.

6.8.1 Attitudes towards Adoption

The comments from participants after interacting with the visual tagging systems used during this study and their responses to the post-testing interviews clearly show that participants are overwhelmingly in favour of the regular use of tagging systems. A participant who was very much impressed with the potential of 2D visual tagging systems to connect the physical and virtual worlds commented after using a visual tagging system, "Is it for real? It will take me a while to get over it." In general, the 'Wow Factor' surrounding the potential and use of tagging systems was expressed in several ways. Some participants were excited about the novelty of tagging applications ("*the system is very mind challenging, it opens up your mind, you become aware that there is plenty of info hidden behind a set of 'picture' which makes no sense at all at first glance"; "An interesting experience, something different and unique"; "Was interesting for me using technology in this way. Only really thought of cell phones as personal (one to one) communicating tool not as a source of info"; "It's an exciting new concept – yet another way of delivering fast information*"), while others were impressed with the efficiency of the systems ("*Very useful because it saves time when you are in a rush"; "Easy, saves time, can be done anywhere, can be done in the moment"; "The more you use the system, the easier it becomes*"; "*It was convenient in using, due to having access in an instant";*) and how the use of visual tagging systems makes the entering of (long) URLs on the inconvenient cell phone keypad unnecessary ("*I can see myself using these systems regularly as Web addresses become longer and more difficult to remember…Can't use predictive text [for entering URLs] – one letter wrong and can't have access*").

Some participants also commented positively on specific features of tagging systems that they found beneficial and/or interesting ("*Its different functions such as 'Recruiting a friend' were interesting"; "Program doesn't take lots of memory on the phone which is quite nice"; "The experience was incredible, it makes life more easier and is easy to use. And you can book your ticket anywhere. You don't have to wait in long lines"; "Amazing, never thought that one could get a map from a cell phone. Surely life will be easier with the system. Quicker than getting directions from the garage or reading a map*").

Although feedback from participants suggests that most would consider using tagging systems on a regular basis ("*These programs were really good and I would like to have access to them"; I could definitely use the system to upload information"; "All in all, the system is fantastic & will be convenient to use anywhere"; "Yes, definitely – I see myself using this system regularly; "I see myself using the system regularly for entertainment or any other use*") as well as 'upgrade' their cell phones to models that could be used with visual tagging systems ("*Will upgrade to/ buy a cell phone that can use these features"; "Yes I think I would upgrade")*, they indicated that would only do so in limited circumstances or relevant scenarios ("*Convenient when venues are closed" [i.e. for specific scenarios]; "It's a helpful tool for students because its application help them to have unlimited information to the library and have the information easily stored"; "Not regularly when it [i.e. library] is open, at times when library is closed & I need to see the [San Bushman] photographs"; "The system is great, but how regularly I'll use it depends on the type of info I could get from it*"; "*System could be used to give directions to Tourists, studying information to students"; "Looking for something specific in a shop and want to know which shop to go to, the system could prove useful*").

In summary, the attitudes of participants towards incorporating the use of visual tagging systems into their lifestyles were hugely positive. Their comments indicate that they view visual tagging systems as convenient and efficient tools that may be used for either work or play.

6.8.2 Barriers towards Adoption

The primary and single most important barrier that was cited by participants as a barrier towards the adoption and regular use of visual tagging systems was cost. Cost is seen as a huge barrier because camera phones, the only kind of phones that can be used with most visual tagging systems, are far more expensive than basic phones which have no cameras ("*Cost would be a problem to me"; "Not all phones can support the program"; "Not having cell phones & not all phones have browsers and cameras*"). Participants also associated mobile Internet browsing with considerably higher billing rates ("*Cost to download"; "Yes, I think browsing with this system could become expensive*") than desktop-based Web browsing or text-messaging as data from MSDQ1 and MSDQ2 (see Chapter Five) clearly shows. Apart from cost, some participants were concerned that only highly educated, affluent, and English-speaking individuals may get to use 2D visual tagging systems due to the unavailability of the systems in local languages. This group of participants also felt that the use of the systems needed to be adapted to incorporate local content that would appeal to individuals living in townships (i.e. less affluent areas).

Some participants also pointed out that visual tags need to be put up at locations where they will be physically accessible; otherwise users will not be able to physically access them ("*Depends on where posters are... won't traffic be in your way and will parking be readily available*"). Moreover, a participant commented that users should be made aware of the presence of visual tagging systems at a location ("*The system needs to be well advertised and people need to become familiar with it – maybe putting a few instructional posters up would help*"). However, some participants were concerned about the potential of locations with 2D visual tag presence to attract criminal elements in the society. Phone theft is common in South Africa, and criminals may become aware – either through chance or experience – that a visual tag will usually need to be interacted with through a camera phone. This means that areas where visual tags are hosted may attract criminals who are on the prowl for victims that they may steal camera phones from.

The experiences participants had browsing the Internet also impacted their views about the limitations of using visual tagging systems to decode URL links. The unavailability of some Internet sites (mostly due to network unavailability) and the often slow download times curbed the enthusiasm some participants had for the 2D visual tagging paradigm ("*People don't/will not want to use because they think it is expensive! If Internet is not reliable, again people will not want to use*"). Last, some participants felt using the system would require a steep learning curve for older users and individuals who are not familiar with computers and cellular technology in general ("*People will have to adjust to new system... won't understand at first*").

CHAPTER SEVEN
ANALYSIS OF RESEARCH DATA

Based on the research methodology outlined in Chapter Four, Chapters Five and Six were devoted to the presentation of data from the Mobile Services Data Questionnaires MSDQ1 and MSDQ2, and the Scenario-based Usability Testing (SUT) sessions. In this chapter, the correlations, interpretations and conclusions that may be inferred from the SUT and MSDQ1 and MSDQ2 data will be discussed. Therefore, this chapter will quintessentially be a summary of the usability attributes of the 2D visual tagging systems investigated for this study; influence of the visual appeal and design of 2D visual tags; and factors that may influence the adoption of the 2D visual tagging paradigm. The categorization of mobile phone users with respect to the use of 2D visual tagging systems and the Real Access criteria-based evaluation of the readiness of 2D visual tagging systems for deployment in the African environment will also be discussed.

7.1 Analysis of the Usability Attributes of 2D Visual Tagging Systems

One of the main outcomes of the interaction of participants with the 2D visual tagging systems in the usability testing sessions is the observation that the most critical factor influencing user perceptions about the ease of learning to use a system is the decoding latency of the system. Users are more likely to rate a visual tagging system very highly on how easy it is to learn how to use it if the visual tag reader of the system can be used to quickly and accurately decode visual tags. The 2D visual tagging systems (that is, Shotcode, BeeTagg, and Connexto) that were rated highly on the 'Ease of Use' criterion (Figure 51) are the systems whose visual tags participants were able to decode quickly, once they figured out how to use the Nokia 6280 to capture the whole barcode.

Visual Tagging System	Learnability	Efficiency	Memorability	Errors	Satisfaction	System Usability Scale Score
UpCode	3.85	4.00	4.35	3.25	4.30	63.75
Connexto	6.45	6.20	6.50	5.8947	6.20	76.88
BeeTagg	6.10	6.35	6.40	5.722	6.30	83.75
Shotcode	6.35	6.40	6.75	6.5263	6.450	80.00
2DVisual Tagging Paradigm	[47]N/A	N/A	N/A	N/A	N/A	78.5

Table 6: Summary of the Mean NAUQ and SUSQ Scores for the UpCode, ConnexTo, BeeTagg and Shotcode Systems

Moreover, the 2D visual tagging systems that were rated highly on the 'Ease of Use' criterion are the same systems - that is, Shotcode, BeeTagg, and Connexto - that consistently got high mean NAUQ Learnability scores (see Table 6). The UpCode system was rated poorly on Learnability mainly because the decoding latency of the system is low when the UpCode reader is run from a Nokia 6280 phone. If the decoding latency of the UpCode visual tagging system had been low enough, users would either have been able to overcome the temporarily unsettling experience of coming to terms with the functioning of the automatic capture mode or switched to the manual capture approach.

Similarly, the NAUQ Efficiency scores are a reflection of the decoding latency of the 2D visual tagging systems. This is why the UpCode system, whose visual tags users found hard to decode via the automatic and manual capture modes, had the lowest score while the Shotcode system had a nearly perfect score (Table 6). In contrast, the NAUQ Errors usability attribute is a measure of user frustration (or otherwise) with a 2D Visual tagging system - the lower the score, the higher the frustration levels. The very low mean Errors score of 3.25 for the UpCode system (see Table 6) suggests that participants were considerably flustered and frustrated with the use of the system. Meanwhile, the relatively high mean Errors scores for the Shotcode, BeeTagg, and Connexto systems

[47] N/A = Not Applicable

(Table 6) are a strong indication that the use of these 2D visual tagging systems, especially Shotcode, is largely a pleasant, error-free experience.

Observation of user interaction with tagging systems and post-usability testing interviews show that, on the one hand, participants had a high recall of the 2D visual tagging system(s) that they found difficult to use. On the other hand, they could also easily recall the name(s) of the system(s) they found pleasant to use. This recall attribute is simply a reflection of the levels of user satisfaction or dissatisfaction with the respective 2D visual tagging systems – it is human nature to remember particularly negative or positive experiences. In real terms, however, the Memorability of a visual tagging system is enhanced by how efficient the system is (efficiency is measured by the decoding latency) and the intuitiveness of the interface. For instance, a system whose feedback mechanism is unique (e.g. the unique sounds to indicate decode status in the BeeTagg system) is easier to remember than one whose features are bland even if competent.

It can also be argued that the NAUQ Satisfaction scores reflect levels of user comfort and contentment with the overall functioning, look and feel of the 2D visual tagging systems that were investigated. For instance, a participant that rates a visual tagging system higher than the others is indicating that given a choice to pick the tagging system to use to perform a given task, the individual would choose the visual tagging system that was given the highest Satisfaction rating. The mean Satisfaction ratings for the Shotcode, BeeTagg, Connexto and UpCode visual tagging systems (based on argument that Satisfaction ratings reflect user perception of the overall performance and functioning of a 2D visual tagging system) show significant correlation with the mean SUS scores (Table 6) and the Ease of Use ratings (shown in Section 6.7, Chapter 6) for these four visual tagging systems.

It is clearly evident from a usability perspective that the most important component of a 2D visual tagging system is its decoding latency. The design lesson therefore is that 2D visual tagging system providers must ensure that the decoding powers of their platforms must be low; low enough to ensure the first time decode of a captured visual tag.

Repeated attempts at decoding the same visual tag lead to user frustration and subsequently, either unwillingness to continue with the interaction process or frustration with the visual tagging system being used.

The other features that 2D visual tagging system vendors must provide in their platforms to reduce the learning curve for the use of their systems by novice users are:

- Intuitive labelling and positioning of system components and the inclusion of appropriate instruction manuals in the Help menu. For instance, users expect the capture button to be the middle button or icon on a 2D visual tagging system application interface. Users become confused when they click the centre button and are taken to another function, instead of the image capture function utility

- Moreover, the name of an icon should reflect its function. A button that is designed to capture images, for example, should be given a name that reflects this function. Naming such a button "Find" is not very intuitive, and is definitely not helpful for novice

- In addition, the Help menu should not be crowded with items - only the most relevant items should be included as mobile users usually do not have the time or patience to browse through an overwhelming number of menu choices

- A maximum number of five Help items should be sufficient to facilitate a more pleasurable visual tagging experience

A summary of some of the features of the 2D visual tagging systems that were investigated is presented in Table 7.

7.2 Summary of the Usability of Individual Platforms

During the SUT sessions which consisted of the Mental Model, Ease of Learning to Use, and the Main (Visual Tag) Usability Testing sessions, participants interacted with, and participated in the evaluation of the Semacode, UpCode, BeeTagg, Connexto and Shotcode 2D visual tagging systems. The comprehensive results from this evaluation process have been presented in Chapter Six. However, in this section, a summary of the usability attributes and features of the 2D visual tagging systems that were investigated is outlined.

Semacode Platform: A main deficiency of the Semacode 2D visual tagging platform is the high decoding latency – a feature of the system that has been pointed out before [Toye, 2005]. So in spite of the high visibility of the Semacode platform in the 2D visual tagging field, the image recognition performance and decoding latency of the Semacode visual tag-reading application are under par compared to visual tagging systems such as Shotcode or BeeTagg. The Semacode reader could not read the tags that were created for this study for instance. In addition, the structuring of the interface and menus make it difficult for novice users to conveniently capture images. The instruction card on how to decode Semacode visual tags together with the design of the tags needs an upgrade. However, the Semacode platform probably has the most convenient and accessible tools for visual tag creation.

UpCode Platform: Participants did not rate the UpCode platform highly on decoding latency, ease of learning to use and general satisfaction levels. The platform providers have explained that the low decoding latency is device-specific – the UpCode reader does not have direct access to the camera in a Nokia 6280 cell phone. Moreover, the other main deficiency of the system that was pointed out by participants, the misleading message (that is, "Your device doesn't support concurrent processing, exit…") that appears after a barcode has been successfully recognized, is also (Nokia 6280) device-specific. However, the UpCode system could not be tested with other camera phones to validate this explanation. There is a strong indication however that participants would have rated the UpCode system better on 'ease of learning to use' if the decoding latency of the system had been low. Finally, the overall usability (as indicated by the mean SUSQ score – see Table 6) and satisfaction levels for the use of the UpCode system would have received a higher rating if participants had found the decoding latency and the ease of learning to use the UpCode system satisfactory.

Features	**Shotcode**	**BeeTagg**	**Connexto**	**UpCode**	**Semacode**
Reader version	3.02	1.2.2	1.14	3.50.0	1.6
File size	46.7kB	102.7kB	49.3kB	94.9kB	74.2kB
Time to open application	2 seconds	4 seconds	2 seconds	2 seconds	3 seconds
Decoding Latency	Low	Low	Low	High	High
Supported handsets (from list of phones currently owned/used by participants)	2 Handsets: Motorola V3x Razr Sony Ericsson W810i	1 handset: Sony Ericsson W810i Motorola V3 Razr	1 Handset: Sony Ericsson W810i (Beta)	7 Handsets: Nokia 6230i, 6101, 6230 Motorola V3 Razr, C650 Sony Ericsson W810i Samsung D600	2 Handsets: Motorola V3x Razr Sony Ericsson W810i
No. of items in Help menu	3	7	5	7	4
Usability Rating Summary	High	High	High	Average	Not Rated

Table 7: A summary of some of the features of the Shotcode, BeeTagg, Connexto, UpCode and Semacode 2D visual tagging systems

Connexto Platform: The Connexto system is competent and efficient with a low decoding latency. The main feature of the system that requires an upgrade – based on feedback from participants – is the visual appeal of Connexto tags. Overall, participants rated the Connexto platform highly on usability (see SUSQ score in Table 6).

<u>BeeTagg Platform</u>: Apart from its very low decoding latency, the BeeTagg system has the best feedback mechanism for the presentation of the status of the system during use. Features of the system such as the bee-inspired design of the visual tag, 'History' and 'Bookmarks' are also elements that make the BeeTagg platform stand out. However, the capture button and system feedback statement after tag capture require reworking. Overall, the BeeTagg platform was scored high on usability (Table 6).

<u>Shotcode Platform</u>: The feedback from the evaluation of the Shotcode system suggests that the Shotcode system is almost flawless. Participants were impressed with the visual appeal of Shotcode visual tags, the decoding latency, system feedback messages and the general look and feel of the system. Furthermore, the system had the best performance under partial or poor lighting conditions and it also provides users with the best mobile Internet browsing experience. Overall, the Shotcode platform received a high score on usability (Table 6).

7.3 Influence of the Physical Design and Visual Appeal of 2D Visual Tags

The feedback from participants (see Section 6.7, Chapter 6) shows that users are drawn to tags that are distinctive and thus have a 'come hither' appeal. But since almost all participants could either not recognize visual tags or accurately state their purpose, it becomes imperative then that attention be given to promoting the visual tagging paradigm platform to novice users or those who are unfamiliar with the concept and use of visual tags. There are three possible approaches to promoting awareness and enhancing the visual appeal and design of 2D visual tags.

First, visual tags must be designed in such a way that they must be able to 'stand out' in the physical environment. One reason why this is necessary is that the natural environment is saturated with images such as colourful posters and billboards; and so only distinctive 2D visual tags will be able to stand out from the motley of posters and adverts that are all vying for human attention. This means that visual tags should be available in multiple colours. This means also that the performance of the imaging modules or image recognition component of the current generation of 2D visual tagging systems will have to be enhanced to facilitate the decoding of multi-coloured visual tags. This is because 2D visual tag readers are currently either designed to read, or are only efficient in decoding black and white visual tags.

Second, input from participants indicates that having a name (such as name of 2D visual tagging system provider) or some form of identifier on a visual tag enhances tag recognition and/or recall. This is probably based on the fact that at a psychological level, individuals can relate better to a named entity than a nameless brand. A named brand feels familiar, convenient and safe, while a nameless brand or technology is equated with inferior quality or status.

Third, it will be good practice to have some form of descriptive text beside a 2D visual tag. The descriptive text should describe what the visual tag stores and how users may interact with it. This practice (having descriptive text beside visual tags) will help novice users who are unfamiliar with tagging technology. It will also help those individuals who are already familiar with visual tagging systems as the descriptive text will help them to accurately and more quickly decode a visual tag. Although novice users may be drawn to a visual tag because of its distinctive design and name recognition, they may not know how to interact with the tag when they are near it, unless information about the interaction procedure is provided.

7.4 Categories of Mobile Phones Users

Analysis of the results of the 'Ease of Learning to Use' and 'Main Visual Tag Usability' testing phases as well as MSDQ1 and MSDQ2 data suggest that mobile phone users can be placed into three categories. The three identified groups of users are namely:

1. **Advanced Users**: These users have advanced (features-rich) cell phones, regularly use other mobile data services on cell phones such as calculator, calendar, et cetera, and are generally aware and eager to use new (cellular) technologies. Under the ease of learning to use testing phase, this group of participants learned how to use the system on their own at a relatively quicker pace. The average decode time was (within) 2 minutes - with most participants decoding the tags within 90s.

2. **Intermediate Users**: Those who have camera or cameraless cell phones but either use their phones only for calling and texting purposes, or for limited mobile data services or other functions e.g. use of the calculator. Intermediate users required more time (than advanced users) to figure out how to use a 2D visual tagging system under the ease of learning to use testing phase. The mean visual tag decode time for this group was 2 - 4 minutes.

3. **Basic Users**: Most individuals in this group have basic cell phones - although a few had phones with cameras and other advanced features. The main characteristic of this group is that they (i.e. basic users) see the cell phone as strictly a calling device. The users in this group generally prefer mobile devices that are simple in function and uncluttered with advanced features, while some are also technologically challenged (either because they do not like or are not exposed to cellular technologies). The basic users group largely comprises older people, those from previously disadvantaged communities or those with limited education. This group of users tended to require some form of guidance or prodding in the right direction to be able to decode the visual tags. The average

decode time for this group under the ease of learning to use testing phase was 4 minutes or more (i.e. >4 minutes).

It should be noted that the average visual tag decode times for all three groups (under the main usability testing phase) generally decreased as participants proceeded to interact with the other 2D visual tagging systems, after initially interacting with only one tagging system under the ease of learning to use (mental model) testing phase.

7.5 Visual Tagging Technology Adoption Considerations

Although participants demonstrated a marked enthusiasm for the incorporation of the use of 2D visual tagging systems into their lives, the adoption of the technology may be limited by some constraints. First, a significant percentage of the mobile phone using population do not own or have access to camera phones which are essential for interacting with 2D visual tagging systems. Data from the MSDQ1 and MSDQ2 (see Figure 13, Section 5.1.2 and Figure 17, Section 5.2.1) shows that only 66.22% of all 72 respondents (or 49 participants) have camera phones. This means that only about 6 out of 10 individuals have the potential or capacity to adopt 2D visual tagging technology. Similarly, 63.51% of all respondents (or 47 participants) either do not have Internet-capable cell phones or have not browsed the Internet on a cell phone before (Figure 14, Section 5.1.3 and Figure 19, Section 5.2.2).

Of the 12 respondents for the MSDQ2 who do have camera phones (there were 20 respondents in total for the MSDQ2), only 6 individuals (with 7 handsets between them) or 30% of the 20 respondents have a cell phone that is currently supported by any of the five 2D visual tagging platforms that were evaluated in this study. Similarly, only 36.49% of all 72 respondents (or 27 participants) either have Internet-capable cell phones or have browsed the Internet on a cell phone before. The camera phone ownership and mobile Internet access statistics together indicate that the target population or potential market that may be reached for the adoption of 2D visual tagging systems for the linking of physical objects to Internet sites is less than 4 out of 10 individuals, or less than 40% of the mobile phone using population.

However, the number of individuals with camera phones and/or mobile Internet access is set to increase significantly as the share of camera phones being produced outstrip that of basic phones without cameras, and as more consumers with basic phones upgrade to phones with more advanced features. But 2D visual tagging system providers can in the interim help enhance access to 2D visual tagging technologies by broadening the range of phones that can be supported by their respective platforms. Providers should also have more support for cameraless phones by providing a visual tag decoding mechanism that will work on phones without cameras. An example is the provision of unique visual tag code identification numbers on both the BeeTagg and UpCode platforms that users may enter on their (cameraless) phones to decode BeeTagg and UpCode visual tags. The limited camera phone ownership and mobile Internet access by the cell phone-using population also means that 2D visual tagging system providers may have to move from the current fixation on the encoding of URL links to non-Internet related content such as text or offline images.

Another major constraint to the adoption of 2D visual tagging system is the high cost of camera phones and the user perception that browsing the Web on a mobile phone is expensive. Data from the MSDQ1 and MSDQ2 (see Chapter Five) shows that most participants have a perception that browsing the Internet on cell phones is expensive. To verify the charges for browsing the Web on a cell phone, participants were shown the account statement at the beginning of a main usability testing session, before any Internet surfing activity had taken place. They were also shown the account statement after all Web-related visual tagging tasks had been completed. The account statements showed that on average, it cost about 5 cents to browse (without any major data e.g. images download involved) the Web on a cell phone based on the Vodacom service provider Internet billing rates (see Table 8 for Internet billing rates). Mobile Web browsing involving significant data downloads (for instance, download of a map to the Baxter Theatre) cost more – about 35 cents per browsing session. When participants were shown these billing charges for mobile Internet use, they were incredulous when, contrary to their expectations, they realized that it was actually cheaper to use the mobile Internet than it is to browse on a PC in an Internet café (the average rate for an hour of Internet browsing in an Internet café in cape Town is R7) or to send an SMS at peak or off-peak hours (it costs on average about 74 cents to send an SMS during peak hours and at least 30 cents to send an SMS during off-peak hours – see Table 8).

Service Provider	**SMS (Off-Peak) per message**	**SMS (Peak) per message**	**Mobile Internet Use (GPRS/EDGE)**
Vodacom	R0.35	R0.80	Pay for amount of data downloaded
MTN	R0.35	R0.75	Pay for amount of data downloaded
Cell C	R0.34	R0.80	Pay for amount of data downloaded
Virgin Mobile	R0.35	R0.60	R0.50 (GPRS/EDGE Data per MB)

Table 8: Data Tariffs for Mobile Internet Usage - Billing rates for use of mobile Internet on the GPRS/EDGE networks provided by the four cellular communication service providers in South Africa.

The perception that it is costly to use the mobile Web may be partly due to the unavailability of clear information about the pricing plan for mobile Web use on any of the networks from South Africa's four service providers. For instance, pay-as-you-go subscribers to the Vodacom, MTN and Cell C (GPRS/EDGE) networks are only billed for the amount of data they send or receive while browsing the Web on a GPRS-capable mobile device (see Table 8), and not for time spent on the Internet. But most subscribers are unaware of this pricing plan possibly because the service providers prefer to put a premium on advertising 3G services and other data plans which are more expensive but generate more revenue for the service providers.

In general, two theories may be advanced for the explanation of the user perception or mental association of mobile Web browsing (and by extension, the use of 2D visual tagging systems) with high billing charges. First, South Africa[48] has one of the highest phone call rates in the world. Moreover, cellular communication providers do not have transparently communicated or uniform billing systems for either standard calling or Internet browsing. It is therefore only natural for mobile phone users to equate the use of the cell phone and any associated features with high costs. Second, it is fairly established that new technologies are usually expensive at first to use. Savvy technology users, for instance, usually delay the purchase and use of new technologies until acquisition costs for the technology have come down. Meanwhile, individuals who are the first to embrace a new technology usually do so at a price of high initial costs. Since participants and by extension, users think that 2D visual tagging systems are a new form of technology, they might have been understandably wary of the initial high costs that they would incur if they decided to adopt a regular use of the technology.

The best way to disabuse users of the notion that it is expensive to browse the Internet on a cell phone (and therefore expensive to use 2D visual tagging systems for Web-related object tagging) is to create awareness about the billing rates for mobile Web use. The onus will be on the 2D visual tagging system providers to provide this awareness. Cost issues should also serve as a motivation for 2D visual tagging system providers to put more emphasis on the tagging of offline content via their platforms.

7.6 Real Access Criteria

The Real Access criteria were developed by bridges.org and consists of a twelve-criteria framework through which ICT applications and solutions developed outside of a Third World context (usually in industrialized nations) may be assessed for efficient and effective deployment in a developing country context. The seven criteria that will be employed to assess the readiness of 2D visual tagging systems for deployment in South Africa are:

[48] http://news.bbc.co.uk/2/hi/africa/4918460.stm

1. Physical access to technology
2. Appropriateness of technology
3. Affordability of technology and technology use
4. Human capacity and training
5. Locally relevant content, applications and services
6. Integration into daily routines
7. Socio-cultural factors

7.6.1 Physical Access to Technology

The physical Access to Technology is a measure of "...whether ICT is available and physically accessible to the people and organizations involved with or affected by the project or policy" [BRID1]. One of the main highlights of the 2D visual tagging paradigm, in this regard is its ability to build on the ubiquity of mobile phones to facilitate anytime, anywhere access. The primary requirement for access to visual tagging systems is the possession or use of a cell phone. But the cell phone must have a camera – this type of phone is also called a camera phone – as well as a Web browser. It should be pointed out however that some 2D visual tagging systems may work with phones which have no cameras. But the phones must have micro-browsers for Internet-related visual tagging purposes. In addition, the phone (model) must be supported by the 2D visual tagging platform a user wants to interact with – that is, it should be possible for the visual tag reader to be downloaded to the phone and for it to be able to work on the phone. Each of the 2D visual tagging systems employed for this study has a list of supported phones but the individual lists are by no means exhaustive. Furthermore, there must be availability of printed/posted 2D visual tags with which users may interact. In summary, for the technology to be available to people and organizations, the following requirements must be met:

- Possession of a camera phone which has a Web browser (almost all camera phones have browsers by default)

- The camera phone must be supported by the 2D visual tagging system that user wants to interact with
- There must be 2D visual tags created by individual users or third parties in the (physical) environment

Thus the 2D visual tagging paradigm, in terms of physical accessibility, is potentially available to most people within the South African context. This is because most South Africans, including a majority of individuals from low-income households, have a cell phone [Samuel, 2005]. The main challenge, however, is that only a few people have the kind of phones (see Section 6.5) that are supported by visual tagging systems. Some users, especially those living in townships, may also not live in an environment with a preponderance of 2D visual tag posters. This is because 2D visual tags tend to be created and posted around metropolitan and more affluent suburbs.

There are many ways that 2D visual tagging systems may become more available and physically accessible to the average South African. First, users may upgrade their cell phones to a more advanced model that is supported by at least one 2D visual tagging platform. The range of phones that is currently supported by visual tagging systems tends to fall within the features-rich and smart phones categories that were discussed in Chapter Three.

Second, the 2D visual tagging system providers could provide more support for cameraless phones that are WAP-enabled so users can still interact with visual tags that encode URL links without having camera phones. This is because some of the phones in the Basic Phones category discussed in Chapter Three have WAP browsers. Moreover, analysis of the MSDQ1 and MSDQ2 data reveals that a significant percentage of respondents either use or own a basic phone. In the same vein, 2D visual tagging platform providers could increase support beyond the current exclusive focus on features-rich and smart phones so as to include coverage of more basic phones.

Third, there could be a concerted effort to target less affluent areas such as townships to create awareness and promote 2D visual tagging services. One of the ways to create this awareness is to conduct trails of visual tagging systems in selected townships. The feedback from participants in this study who live in a township shows that the 2D visual tagging paradigm will be well received within the average township community, especially among young people.

In conclusion, 2D visual tagging technology is potentially available to all mobile phone users, but is (currently) only physically accessible to those in possession of a camera phone with Internet browsing capabilities and who probably live in a metropolitan area.

7.6.2 Appropriateness of Technology

The appropriateness of technology criterion is "gauged in terms of power requirements, security, environmental conditions, and other aspects of the local situation". The average South African and by extension, African is accustomed to having or using a cell phone. Moreover, the use of 2D visual tagging systems requires no power supply backups or storage space facilities. All a user of 2D visual tagging system needs is a supported cell phone. Hence 2D visual tagging technology is an example of (the use of) a technology that is appropriate to the local needs of and conditions of the target population as the use of the technology does not impose any additional burdens on users.

7.6.3 Affordability of Technology and Technology Use

Most study participants cited cost as a major concern and possible barrier towards the adoption and regular use of 2D visual tagging systems. However, this was based on the erroneous assumption that mobile Internet costs were prohibitive. But once they were shown that simple Web browsing (with no sizeable data/image download) was much cheaper than sending an SMS or browsing in an Internet café, and also far cheaper than they had expected, they decided Internet browsing cost was not a limiting factor to the regular use of 2D visual tagging systems. In addition, there are other ways that 2D visual tagging systems may be made more affordable. For instance, the use of visual tagging systems for Web-related tagging activities could be limited to simple browsing (e.g. reading news online) that will not involve any major data (especially audio and video) downloads. Furthermore, 2D visual tags may be used to encode data that upon decoding will yield only text – that is, Internet browsing is not involved at all. This is particularly relevant for mobile phone users who are on the pay-as-you-go system, and for whom every cent spent on telecommunication bills counts. However, those who do not use a suitable or supported cell phone may still have to pay for the upgrade of their cell phones to models that may be used with 2D visual tagging systems.

7.6.4 Human Capacity and Training

All the participants in the study practically had no previous experience interacting with 2D visual tags or tagging technologies in general. However, results of the Ease of learning to use testing phase (an assessment of how quickly novice users could figure out how to use a 2D visual tagging system) showed that most users deciphered how to use the visual tagging systems provided within 3 minutes, and without external help. Thus in terms of human capacity and training, 2D visual tagging technologies have low entry barriers as novice users as well as people with limited formal education could interact with the visual tagging systems provided with minimal supervision or technical help. Moreover, because this is an image-based technology, there is very limited reading and writing at all involved in interacting with a visual tag. Moreover, some of the help menus of the different 2D visual tagging systems feature easy-to-follow diagrams that most people with limited or no formal education at all can easily follow.

7.6.5 Locally Relevant Content, Applications and Services

There was a wide acceptance of the 2D visual tagging systems that were created within the local context of using the systems to browse for photographs at a local library and to obtain information about a comedy production at a local theatre (see Chapter Four). The acceptance of 2D visual tagging systems when deployed in a locally relevant manner emphasizes the Real Access criterion that the availability of locally relevant content and services greatly enhance the attractiveness and desirability of an ICT application to a local population. However, the non-availability of the 2D visual tagging system applications in local South African languages is a potential obstacle to the adoption of the 2D visual tagging paradigm by South Africans whose first language is not English. This is because a significant percentage of the population is either not fully proficient in English, or is not comfortable reading technical material in a language other than their own (native language). An easy way to get around this problem is to create help menus (for the visual tagging systems) that will be composed exclusively of how-to diagrams of how to interact with visual tags. As a follow-up, any related Internet or text-only content should also be available in the target local language.

7.6.6 Integration into Daily Routines

A main attractiveness of the 2D visual tagging paradigm is that the platform benefits from, and is enhanced by the features that make cellular communication devices a convenient and permanent fixture of life in the 21st century. In essence, 2D visual tagging systems share features such as portability, ubiquity and mobility with cell phones and may consequently be used to tag objects anytime and anywhere. Thus visual tagging systems can be easily integrated into daily routines not only because of their mobile device-like features (highlighted above), but also because they are a form of unobtrusive technology and have practically zero maintenance costs. An example of the perfect harmony that exists between the use of 2D visual tags and integration into daily routines is illustrated in the use of visuals tags to interact with the Baxter Theatre comedy, Hallelujah. In one of the possible scenarios, an individual sees a Hallelujah poster with a 2D visual tag beside it as she exits a mall. She moves closer to read the poster and the visual tag, and then decides she would like to see the show. All she has to do next is to click on the visual tag and she will be taken to the CompuTicket Web site where she can enter her credit card details to book a ticket for the comedy. Moreover, the whole process may take her less than five minutes.

7.6.7 Socio-cultural Factors

It has been observed that some socio-cultural factors may place limitations on the adoption of the 2D visual tagging paradigm. For instance, older populations in South Africa tend to be not as technology-savvy as young people. Adults above the age of forty are more likely to use basic phones – that is, phones without cameras and (also sometimes without) Internet browsers. And if they do have camera phones, they are more likely not to have used the imaging capability of the phone at all. Second, social status is another factor that has the potential to influence the adoption of the 2D visual tagging paradigm. Affluent individuals, old or young, from high income households are more likely to have access to 2D visual tagging systems and live in areas with availability of posted visual tags than people from townships, economically deprived areas. Similarly, people with at least a high school education would be far more inclined to learn about, and use visual tagging systems than people without a 'Matric' (i.e. South African high school diploma) qualification. However, no noticeable differences in the use and attitude towards visual tagging systems were observed in terms of gender and race.

The other significant socio-cultural obstacle towards the use of tagging systems is disability. Interacting with a visual tag requires good eye to hand coordination as well as nerve coordination. Consequently, visual tagging technology is an inaccessible technology for those with vision or motor impairment. Therefore, the socio-cultural factors that may limit the use of 2D visual tagging systems are age, literacy or educational status, age, income group and living environment. However, literary and educational status barriers - as has been stated earlier - may be overcome by the provision of the application interface, menus and help functions of 2D visual tagging systems in relevant local languages.

7.7 Limitations of Study

This study was designed so that the data collected and subsequent data analysis and conclusions would be reliable and valid. Consequently, meticulous attention was paid to aspects of the study such as the adoption of a hybrid methodological approach to safeguard the study against biased investigation and introduction of errors into the data collection process. The experimental order of the SUT evaluation sessions were also designed to avoid the introduction of false positives or biases into the usability evaluation process. However, this study still had some limitations.

- First, it would have been expedient to test the performance of the 2D visual tagging systems investigated during this study on other camera phones, apart from a Nokia 6280 cell phone. Usability testing with other phones is necessary to evaluate whether the cell phone model and associated camera phone technology affect the performance of a 2D visual tagging application

- Second, it would have been desirable to test and evaluate many more 2D visual tagging systems, but the testing of these other systems could not be conducted due to time constraints

- Third, a more in-depth assessment of the influence of Internet browsing costs on the adoption of 2D visual tagging systems as well as a thorough field assessment of the mean browsing rates in Internet cafes in Cape Town together with camera phone prices could have been conducted. But again, these assessments could not be conducted due to time constraints

- Last, the sample for the MSDQ1 and MSDQ2 instruments could have been more geographically representative of the South African (mobile phone using) population as data collection for the MSDQ1 and MSDQ2 instruments was conducted in Cape Town only

CHAPTER EIGHT
CONCLUSION

8.1 Thesis Review

This study principally focuses on the cross-platform usability evaluation of the BeeTagg, ConnexTo, Shotcode, Semacode, and UpCode 2D visual tagging systems. The use of 2D visual tagging systems enables information about objects of interest to be linked to online or offline content. A 2D visual tagging system consists of a 2D visual tag and 2D visual tag reader which is downloaded onto (usually a camera) phone which has the capability to run the application. A 2D visual tag may encode a URL link, text, images or personal information. A 2D visual tag reader may then be used to decode a visual tag for it to yield the information that is stored in it. All the five, free-for-private-use 2D visual tagging systems that were selected for this study share the attribute that their individual platforms offer support for using the Nokia 6280 phone to interact with the respective 2D visual tagging platforms.

In Chapter One, the subject of this study, the cross-platform usability evaluation of 2D visual tagging systems, is introduced. The structure and outline of this thesis is also presented. Chapter Two is a review of the pertinent literature and major publications in the fields of 2D visual tagging, mobile computing, ubiquitous computing and Human Computer Interaction. Chapter Three, on the other hand, focuses on the description of the underlying architecture that makes the 2D visual tagging paradigm possible.

To evaluate the BeeTagg, ConnexTo, Shotcode, Semacode, and UpCode 2D visual tagging systems that were investigated for this study, a hybrid procedural approach was adopted. In Chapter Four, this hybrid methodology is outlined. The methodology consists of questionnaires (the Mobile Data Services Questionnaires, MSDQ1 and MSDQ2; the Nielsen's Attributes of Usability Questionnaire, NAUQ; and the System Usability Scale Questionnaire, SUSQ), observations, interviews and the Scenario-based Usability Testing (which comprises the Mental Model, Ease of Learning to Use, and Main Visual Tag Usability Testing phases).

In Chapter Five, the data collected from the 72 respondents for the MSDQ1 and MSDQ2 survey instruments is presented. The data shows how the mobile phone using population in Cape Town (South Africa) use their cell phones with respect to taking photographs, accessing mobile Internet, and using other non-call/text mobile data services such as calculator, calendar, alarm, et cetera. The focus of Chapter Six is the presentation of the valuable feedback from the twenty participants who volunteered for the SUT sessions about the performance and pertinent usability issues surrounding the use of 2D visual tagging systems. The feedback from participants was obtained through observations, interviews and the interaction of participants with the selected 2D visual tagging systems during the SUT sessions. In Chapter Seven, an analysis of the all the research data that was collected for this study is presented.

This chapter will highlight the key usability findings from the cross-platform evaluation, the contributions of this study towards enhancing the body of knowledge on visual tagging, and the resolution of the research questions that were the focus of this study. In addition to the suggestions for future research that can extend or build on this study, this chapter will also outline a list of recommendations that 2D visual tagging system providers need to adopt to make the 2D visual tagging paradigm more efficient and accessible.

8.2 Summary of Evaluation Findings

The observations from the interaction of participants with the 2D visual tagging systems during the SUT sessions clearly suggests that mobile phone users may be classified into three broad groups:

- Basic Users
- Intermediate users

- Advanced Users

Most participants in the advanced users' category could decode 2D visual tags on their own and with minimal guidance within 90 seconds. In contrast, most participants in the intermediate and basic users' categories needed close to four minutes and some form of external help to be able to decode 2D visual tags at their first attempt.

The usability testing sessions also revealed that participants were generally high satisfied with the performance of the Shotcode, BeeTagg and ConnexTo visual tagging platforms. The features of these three 2D visual tagging systems that were highly commended include the low decoding latency, the visual appeal and design of visual tags (particularly for Shotcode and BeeTagg), the feedback messages and the intuitive interface. On the contrary, participants found some aspects of the Semacode and UpCode visual tagging systems unpleasant. The Semacode platform has a high decoding latency and the button for visual tag capture is not positioned appropriately. Similarly the UpCode visual tagging system also has a relatively high decoding latency when the visual tag reader is run from a Nokia 6280 phone. In addition, it took participants time to get used to the automatic capture mode of the UpCode system. However, the UpCode visual tagging platform offers users more options for decoding visual tags than any other platform. In addition, the 'Insert Code' visual tag capture option of the UpCode system has a low decoding latency and may be used by users without camera phones and/or Internet browsers. It is important to note that only the BeeTagg system has a similar feature.

8.3 Recommendations for Best Practices

The 2D visual tagging paradigm basically consists of the interaction of people with 2D visual tagging systems, and the use of visual tagging applications offers many benefits. First, the use of 2D visual tagging systems enable a new form of social interaction as users can interact with physical objects in the environment through the use of the systems. Another benefit of using 2D visual tagging systems is that 2D visual tags that encode URL links make redundant the typing of (the often long) URL characters on the keypad of a cell phone. This is because users are taken directly to a tagged Web site. Third, it is relatively easy to learn to how to use a 2D visual tagging system. The 2D visual tagging paradigm therefore has a low entry barrier. Fourth, 2D visual tagging systems facilitate anytime, anywhere access and are easy and convenient to use. Fifth, the systems may be deployed for use in diverse fields ranging from education and learning to entertainment, commerce, advertising, and tourism.

But the benefits of using 2D visual tagging systems are not fully available to users because some aspects of the 2D visual tagging paradigm still need to be enhanced. The interaction of users with, and the evaluation of the 2D visual tagging systems that were investigated for this study highlighted some of these aspects and features of 2D visual tagging systems that 2D visual tagging system providers need to address to significantly improve the overall functioning and acceptance of the systems by the general (mobile phone using) population. A list of 20 recommendations has consequently been developed from the feedback from the evaluation process and user interaction with the visual tagging systems evaluated. The recommendations are intended to serve as a reference or guide to the best practices that 2D visual tagging system providers need to adopt to make the 2D visual tagging paradigm more efficient, attractive and accessible to users. The 20 recommendations are grouped into five categories namely:

- **2D *Visual Tag Reader***: The recommendations under this category address the efficiency of the visual tag reader and/or the decoding latency of a 2D visual tagging system

- ***Cost***: These measures address user perceptions about mobile Web browsing costs and (means for reducing) actual browsing costs

- ***Interface***: These measures address the intuitiveness and usability of the interface elements of 2D visual tagging applications

- ***Accessibility***: These recommendations are measures that can facilitate broader access to the 2D visual tagging paradigm

- ***Design***: These recommendations address the physical design and visual appeal of 2D visual tags

The 20 recommendations are listed below under the appropriate categories:

2D Visual Tag Reader

1. The most important 'Best Practice' that System providers need to absolutely follow is that the decoding latency of their individual tagging systems must be (very) low. There is no need to market a 2D visual tagging system whose decoding latency is high as users will not use such a system regularly or consistently

2. 2D visual tagging system providers should provide more support for cameraless phones and phones without micro-browsers to make it possible for these phones to be used also for interacting with 2D visual tags. This measure can be implemented through the provision of a visual tag decoding mechanism that will work on phones without cameras (and/or Internet browsers)

3. The System providers could focus their energies on the development of a universal visual tag reading software that will be able to decode all (or most of) the 2D visual tags that are currently available. This measure is not impossible to achieve as a software company is already developing such a kind of universal software [Smith, 2004]

4. System providers should improve the image recognition capabilities of their individual platforms to make it possible for 2D visual tags to be decoded in partial or poor lighting conditions

Cost

5. To reduce and address user perception about internet browsing costs, system providers could emphasize the use of 2D visual tagging systems for Web-related tagging activities that will be limited to simple browsing (e.g. reading news online) activities and will consequently not involve huge data downloads. To implement this recommendation, content providers can collaborate with system providers to offer users alternative 'light' content

6. Similarly, there is a need for system providers to engineer a paradigm shift from an (almost overriding) emphasis on the encoding of URL links to non-Internet related content such as plain text or offline images

7. In addition, the onus is on system providers to create awareness about the billing rates for mobile Web use (facilitated) through interaction with a 2D visual tagging system in order to address invalid user perceptions about browsing costs

Interface

8. System providers should ensure that the item under the Help menu that explains how users may interact with 2D visual tags feature easy-to-follow diagrams (with or without text)

9. System providers should ensure that buttons, menu icons and functions are appropriately positioned and intuitively labelled

10. It is recommended that the maximum number of items in the Help menu be limited to five

11. The feedback mechanism of a 2D visual tagging system should be robust, efficient and reliable

12. The menu option that allows users to inform others about the use of a 2D visual tagging system should be functional internationally to promote awareness of the 2D visual tagging platform concerned and the 2D visual tagging paradigm in general

Accessibility

13. System providers should make the creation of visual tags easy, accessible and convenient

14. System providers should increase support for phones beyond the current exclusive focus on features-rich and smart phones so as to include coverage of more basic phones. One way to implement this measure is for the respective 2D visual tagging platforms to broaden the list of currently supported phones. For instance, only a minor percentage of camera phones that can be used with 2D visual tagging systems are currently supported by any of the 2D visual tagging platforms

15. 2D visual tagging system providers could form partnerships with the major phone manufacturers to ensure that some phone models come equipped or pre-installed with 2D visual tag readers. This measure will enhance accessibility by saving users the burden of having to download the visual tag reading software unto their phones themselves. For instance, most phones in Japan come equipped with QR 2D barcode readers

16. To ensure local acceptance and accessibility to 2D visual tagging services, system providers should make their platforms conducive for the deployment of locally relevant content and services

17. To further ensure local acceptance and accessibility to 2D visual tagging services, system providers could make possible or facilitate the localization of certain

system features such as menus and the visual tag creation pages. These features could for instance incorporate local language and content

Design

18. System providers should ensure that the physical design or appearance of 2D visual tags is distinctive, visually appealing and attractive

19. It is recommended that system providers provide a name or (some form of) identifier on their 2D visual tags to enhance visual tag recognition and/or recall

20. It is recommended that some form of explanation or descriptive text be placed near a 2D visual host site or location to explain the purpose of the visual tag placed at the location

8.4 Resolution of Research Questions

The aim of this research project was to provide answers to the research questions that were posed at the beginning of this study (see Chapters One and Four). Consequently, the survey instruments and the other procedures that were employed for this study were adopted because the procedures constitute a valid and satisfactory approach to yielding or providing comprehensive and reliable solutions to the research questions. Based on the analyses of the data, observations and interviews from the MSDQ1 and MSDQ2, NAUQ, and SUSQ instruments, and the Scenario-based Usability Testing (SUT) sessions, the research questions for this study may now be conclusively resolved. The following section details the responses to the research questions.

What mental model or perceptions do users have about how to use mobile 2D visual tagging technology?

None of the participants in this study had any prior experience with 2D visual tagging systems. Yet the results of the Mental Model testing phase reveals that most participants were able to accurately predict the type of data that would be encoded in a visual tag when shown one. Furthermore, about a third of participants were near accurate in specifying the mode of getting information from, or decoding the 2D visual tags. Therefore, from a mental modeling or perception perspective, novice users will be able to accurately infer the function of 2D visual tags when they encounter such tags in their neighbourhoods or physical environment. However, it will still be helpful for some form of printed information describing the purpose(s) of a 2D visual tag to be placed near the tag.

How natural and easy is it for novice users to interact with and use a 2D visual tagging system without explicit guidance?

The outcome of the Ease of Learning to Use testing phase shows that most participants were able to decode the 2D visual tags provided within 3 minutes – in spite of the fact that participants had no prior experience using a 2D visual tagging system. Only basic users generally had to receive considerable guidance to figure out how to use a 2D visual tagging system. But even this group of users found it easy to decode the visual tags once they had interacted with more than one visual tagging system. It may consequently be inferred that it is easy for novice users to interact with and use a 2D visual tagging system without explicit guidance.

What are the attitudes that users have towards the adoption of the 2D visual tagging paradigm?

The data from the three questionnaires served during the study and the feedback from the usability testing sessions clearly shows that participants were highly impressed with the use and purpose of 2D visual tagging systems. A significant number of participants also indicated interest in using visual tagging systems on a regular basis, even if that means buying new and advanced cell phones. However, most cited cost as a possible major deterrent to the frequent use of visual tagging systems. Overall, it can be concluded that the attitudes of users towards the adoption of the 2D visual tagging paradigm are hugely positive.

What is the contextual application and deployment of this technology in the African environment? Are 2D visual tagging applications appropriate for deployment in the African environment?

An evaluation of the 2D visual tagging paradigm against the Real Access criteria framework shows that 2D visual tagging systems surpass the minimal criteria threshold for effective and efficient deployment within an African context. The results of the Real Access-based evaluation reveal that 2D visual tagging systems are potentially available and largely physically accessible available to all mobile phone users. Moreover, the adoption of the paradigm imposes no additional burdens, in terms of training requirements or maintenance costs, on users. Furthermore, the technology is affordable to use (if Internet browsing is minimized and non-Web tagging is emphasized) and can be easily integrated into daily routines. But the visual tagging platform still needs to be localized for its services to be available and accessible to a wider (South African and by extension, African) population. Similarly, individuals from low-income households and neighbourhoods as well as the physically challenged face barriers that may prevent them from accessing 2D visual tagging services. It may be concluded that 2D visual tagging applications are not only appropriate for deployment in the African environment, but that they can also be effectively and efficiently deployed for use by Africans.

What are the strengths and weaknesses of the currently available free-for-private use 2D visual tagging systems from a usability perspective?

The outcome of the various evaluations and analyses carried out for this study indicates that the most important component of a 2D visual tagging system from a user perspective is the decoding latency of the system. The BeeTagg, Shotcode and ConnexTo systems have low decoding latency while the performance of the visual tag reading powers of the UpCode (on a Nokia 6280 phone) and Semacode systems needs to be improved. To a lesser extent, the visual appeal of the Semacode and Connexto visual tags need to be enhanced. The decoding latency of a 2D visual tagging system is critical because the results of the usability testing sessions clearly show that the use of a system with a high decoding latency can leave users frustrated and disenfranchised. It can also be assumed that in a 2D visual tagging field that is increasingly becoming more crowded, visual tagging platforms with a high decoding latency will experience a significant loss in market share. In conclusion, although the five visual tagging systems evaluated during this study have varying strengths and weaknesses, the single most important strength or weakness of a 2D visual tagging system is its decoding latency.

How do lighting conditions affect the performance of 2D visual tag-reading applications?

The current generation of 2D visual tagging systems (judging by the performance of the systems investigated for this study) seems not to be designed to work under poor lighting conditions. Of the five visual tagging systems that were evaluated during this study, only the shotcode visual tag reader may be used to decode shotcode visual tags in partial lighting conditions. But the shotcode reader cannot be used to decode visual tags when there are shadows in the vicinity of the visual tag to be captured. Like all the other visual tagging systems, the shotcode visual tag reader cannot also be used to read visual tags in poor lighting conditions (for example in unlit rooms or enclosures with very poor light sources) or in areas with no illumination. In summary, the BeeTagg, ConnexTo, Shotcode, UpCode, and Semacode (and by extension, the current generation of) 2D visual tagging systems perform dismally under poor lighting conditions. However, the dismal performance may be a function of camera phone technology rather than a flaw in (any of) the visual tag reading software.

8.5 Contributions

The main contributions of this study towards enhancing the body of knowledge on the subject of visual tagging systems include:

- This study is possibly the first to focus (a review of current literature does not yield a study with a similar focus) on a cross-platform usability evaluation of (five) currently available 2D visual tagging systems

- This study is possibly the first to address the readiness of 2D visual tagging applications for deployment within an African setting

- This study is possibly the first to map the non-call/text cell phone usage patterns of the South African mobile phone using population with respect to predicting the (potential for the) adoption of the 2D visual tagging paradigm

- This study is possibly the first to detail a comprehensive list of recommendations or best practices that 2D visual tagging system providers need to adopt to make the 2D visual tagging paradigm more efficient, attractive and accessible

- This work study is one of the few studies to focus on the usability evaluation of a 2D visual tagging system as opposed to presenting and describing the functions of a new 2D visual tagging application

8.6 Future Work

This study focused mainly on the cross-platform usability evaluation of the BeeTagg, UpCode, ConnexTo, Shotcode and Semacode 2D visual tagging systems. But there are currently more than fifteen 2D visual tagging systems. Therefore, future work could focus on the testing and evaluation of any of the other visual tagging platforms (see Appendix 1) like Semapedia, Windows Live Barcode, Mobile Tag, etc as well as proprietary applications such as Mobot and Mobicode. It will also be expedient to carry out the evaluation of these visual tagging systems using an assortment of camera phones. The use of different camera phones may highlight any influence(s) that phone specification and functioning have on the performance of visual tagging applications. Moreover, any future studies should be more diverse from both a human and geographical perspectives. Evaluations of the visual tagging systems should be conducted in cities and non- university environments around South Africa. The sample of such evaluation exercises should also include physically challenged individuals. A possible future project is the development of a 2D visual tagging system whose design and functioning will be guided by the 20 recommendations provided in this chapter.

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RESOURCES

A. OTHER VISUAL TAGGING SYSTEMS

Due to time, equipment and capital constraints, only five visual tagging systems were selected for usability evaluation in this study. A key criterion for the selection of the five tagging systems (BeeTagg, Semacode, UpCode, Shotcode, and Connexto) that were used for this study is that they all can be interacted with through the use of a Nokia 6260 phone, the phone that was used for this study. In addition, the five systems have robust decoding latency and significant market (including mind) share in the 2D visual tagging or physical hyperlinks world. However, there are over fifteen visual tagging systems currently in use – a complete listing can be found on the site, http://theponderingprimate.blogspot.com/2005/06/physical-world-connection-companies.html. Therefore a brief introduction to some of the tagging systems that could not be tested or profiled for this study is presented in this section.

Mobile Tag: The Mobile Tag (http://www.mobiletag.com/beta/en/) visual tag from France-based Abaxia (http://www.abaxia.com/index.php may be used with camera phones and phones without cameras. Users with camera phones need to download the Mobile Tag reader to be able to scan Mobile Tag visual tags. Users may download the Mobile Tag reader in three ways:

1. By downloading to a desktop computer and transferring the application file to a cell phone
2. By downloading directly from a mobile Web browser
3. By sending an SMS with the keyword "TAG" to the number +33661714961

Mobile tags may also be decoded with cameraless phones via the user typing in the number on the mobile tag on the phone's keyboard and clicking the right button in order to access the information encoded in the tag. The Mobile Tag system is free for private use but users have to sign up for an account to be able to access the service.

The Mobile Tag application supports a large range of phones – currently about 141 phones (as at February 9th, 2007), but with more than two-thirds of supported phones being Nokia or Motorola handsets. Seven handsets used by six of the volunteers who participated in the study are currently supported. These phones are: Motorola V360, V3Razr, C650, C261; and Nokia 6230i, 6230, 6101. A main disadvantage of the application is that the options page on the phone as well as the support page on the application Web site (including the FAQ and Help functions) is currently available in French only.

Smartpox: is a free-for-private use 2D visual tagging system that requires users to sign up for a free account on the site, http://www.smartpox.com/index.asp. The information on the Smartpox application Web site (http://www.smartpox.com/support.asp) suggests that all Nokia, Samsung, LG, Siemens and Sony Ericsson phones will work with the Smartpox J2ME reader. However, this information may not be valid as the Smartpox reader could not be downloaded onto the Nokia 6280 phone that was used for this study. Smartpox tags may encode a URL link, phone number, email address, or plain text.

KoolTag: The KoolTag visual tagging system (http://kooltag.com/tagit/start.jsp and http://www.tagit.tv/index.htm) is similar in design and function to Smartpox. KoolTags may be used to encode Web sites, text or multimedia images. Although the KoolTag reader was downloaded to the Nokia 6280 phone that was used for this study, the KoolTag visual tags that were created for usability evaluation purposes could not be decoded.

XxScan: The functioning of the Xxtreme Measure XxScan (http://www.xxtrememeasures.com/Joomla/index.php?option=com_content&task=view&id=13&Itemid=2) is similar to that of the Smartpox and KoolTag systems. XxSCan visual tags may be used to encode music, graphic, and text links. However, the XxScan system could not be tested because the platform currently offers no support for Nokia 6280 phones.

Microsoft: AURA/Windows Live: The two Microsoft Research tagging systems - the Advanced User Resource Annotation (AURA) and Windows Live visual tagging systems could not be tested for this study. AURA requires the use of a smart phone that runs on the Windows Mobile system, while a tag-reader application that could accurately decode a Windows Live barcode (which is based on the QR symbology) could not be located for the Nokia 6280 phone.

Semapedia: Although the Semapedia tagging platform (http://www.semapedia.org/) has significant visibility, the Semapedia system could not be tested for this study because the Semapedia tag-reading application, the Kaywa reader, could not be used on the Nokia 6280 phone that was used for this study.

Active Print: This visual tagging system was developed by researchers at Hewlett-Packard in Bristol, UK. However, the Active Print system could not be tested because the application currently supports only 11 handsets, ten of which are Nokia phones. However, the Nokia 6280 which was the phone used for this research is not one of the Nokia handsets that are supported. Information about the Active Print Project and 2D barcode reading system can be found on the site, http://www.activeprint.org/index.html. The visual tag reader for the Active Print system makes use of Lavasphere (http://www.lavasphere.de/)

3G Vision: The 2D barcode Reader by Yehuda, Israel-based 3G Vision "is a software-only utility that turns any camera phone into a handy one-dimensional and two-dimensional barcode scanner." According to the information on the 3G Web site, the barcode reader can scan the following 1D symbologies: EAN13, EAN8, EAN128, UPC-A, UPC-E, Code39. The reader can also decode the QR, DataMatrix, and PDF417 2D barcodes. There is more information about the 3G Vision's barcode reader on the site, http://www.3gvision.com/prod-bar.htm. But since the 3G Vision barcode reader is proprietary software that is not free for private use, the application could not be tested.

AirClic: AirClic is a proprietary scanning device that works with Motorola iDEN phones such as the Motorola 1355 and i605. Although the application could not be tested, information about the device may be found on the site, http://www.airclic.com/scanners.asp.

Pixecode: The site, http://www.pixecode.com/ describes what pixecodes can do, but there are no links on the site on how pixecodes may be created, and how to access the pixecode reader.

Mobot: The Mobot application (see http://www.mobot.com/) does not require 2D barcodes or visual tag posters. All a user has to do is take a picture of suitable media and the right content will be served up. For instance, a user may take a picture of a movie poster (e.g. Kill Bill) and send it to Mobot via SMS. Depending on user requirements, users may be sent ring tones, show times or ticket(s) to view the Kill Bill movie.

Mobicode: The Mobicode platform (http://www.mobicode.co.za/) functions in a fashion similar to that of the Mobot system, and may be used (based on information on the Mobicode site) as a barcoded ticket, coupon, or e-voucher. The Mobicode application could not be tested for this study because it is proprietary software.

Mytago: Although Mytago tags may be decoded in four different ways (see http://www.mytago.com/decode/), users need to sign up for a free account to be able to create and decode tags. A major limitation of the Mytago platform is that users cannot decode the tags on their mobile phones. Users need to either go online to the Mytago decode site (although the site may be accessed on a mobile browser via http://www.mytago.com/m) or email the Mytago visual tag(s) to their Mytago accounts for the tags to be decoded.

B. ONLINE TOOLS AND REFERENCES

I. The Web (Home) pages of the 2D visual tagging systems investigated in this study are presented below:

Semacode: www.Semacode.org

UpCode: www.upcode.fi

Shotcode: www.shotcode.com

ConnexTo: www.connexto.com

BeeTagg: www.beetagg.com

II. The Web site below contains comprehensive listing and description of 1D and 2D barcodes

http://www.adams1.com/pub/russadam/barcode1.html

III. URLs for some of the projects mentioned in the main body of this research

The 12 Real Access criteria, developed by bridges.org, for the evaluation of ICTs meant for deployment in a developing country context can be found on the site, http://www.bridges.org/Real_Access

Contemporary African Music and Art Archive, CAMA: www.cama.org.za

District Six Museum: http://www.districtsix.co.za/frames.htm

Greenstone Digital Library software suite: http://nzdl.sadl.uleth.ca/cgi-bin/library

DENSO (QR Code Creator): http://www.denso-wave.com/qrcode/qrfeature-e.html

IV. Mobile Web-related Resources

The Open Mobile Alliance: www.**openmobilealliance**.org/

3GPP - The 3G Partnership Project: http://www.3gpp.org/

3GPP2 - The 3rd Generation Partnership Project 2: http://www.3gpp2.org/

W3C Mobile Web Practices Proposed Recommendation, 2 November 2006: http://www.w3.org/TR/2006/PR-mobile-bp-20061102/

V. Graph/Statistical Data Creation Tools and Evaluation Techniques

Statistics Canada: http://www.statcan.ca/english/edu/power/ch9/using/using.htm

Descriptive Statistics: http://www.physics.csbsju.edu/stats/cstats_paste_form.html

CHARM: http://www.otal.umd.edu/charm/

VI. Cellular Communication Service Providers in South Africa and Associated Data Transfer Tariffs for Mobile Internet Usage

Cell C (Service Provider): www.cellc.co.za
Cell C subscribers may send data wirelessly over both GPRS and EDGE networks. The data tariffs may be accessed on the Web pages below: EDGE and GPRS Tariff: http://www.cellc.co.za/content/services/smartdatagprs.asp

Vodacom (Service Provider): www.vodacom.co.za
Vodacom subscribers may send data wirelessly over both GPRS and 3G networks. The data tariffs may be accessed on the Web pages below: GPRS Tariff: http://www.vodacom.co.za/services/gprs/overview.jsp 3G Tariff: http://www.vodacom.co.za/services/3g/overview.jsp

Virgin Mobile (Service Provider): www.virginmobile.co.za
Virgin Mobile subscribers may send data wirelessly over both GPRS and 3G networks. The data tariffs accessed on the Web page below: Data Transfer Tariff: https://www.virginmobile.co.za/virgin-portal-customer/PrepaidPostpaid.do;jsessionid=8787844199E734243BF7B7FD1FE16789?method=initPrepaidP

MTN (Service Provider): www.mtn.co.za
MTN subscribers may send data wirelessly over GPRS, CSD, HSCSD, and HSPDA networks. The data may be accessed on the Web pages below: MTN has 4 options (http://www.mtn.co.za/?pid=6382#) CSD (MTNdataLINK) Tariff: http://www.mtn.co.za/?pid=11444 HSCSD (MTNdataFAST) Tariff: http://www.mtn.co.za/?pid=11483 GPRS (MTNdataLIVE) Tariff: http://www.mtn.co.za/?pid=11468 HSDPA Tariff: http://www.mtn.co.za/?pid=272898

C. SCENARIO-BASED USABILITY TESTING MATERIALS

C.1 Task Outline for the Scenario-based Usability Testing of 2D Visual Tagging Systems

This user experience study is part of a postgraduate research being conducted at the Department of Computer Science, University of Cape Town, South Africa into the use of visual tags on mobile phones. The exercises that you will be participating in as a volunteer consist of a series of scenario-based tasks that are part of a cross-platform usability evaluation of 2D visual tagging systems. You will be given a cell phone, a Nokia 6280 that you will use to interact with, and complete a number of tasks with the 2D visual tags provided.

The tasks you will be required to attempt are:

1. Establishing interaction paradigm for 2D visual tagging systems
2. Ease of learning to use the system
3. Using the features of the system

Please note that we will be making observations as you complete the assigned tasks and interact with the tags provided. We will also want you to complete the attached questionnaires as well as provide general comments and feedback about your experience with the systems being tested.

Thank you very much for your time and inputs.

C.2 Mobile Data Services Questionnaire (MDSQ1)

This questionnaire is part of a postgraduate research at the Department of Computer Science, University of Cape Town, South Africa into the use of visual tags on mobile phones. ***For each of the questions 2 –10 below, please circle the most appropriate answer.***

1A. Age: 1B. Sex: 1C. Profession:

2. Do you own or use a cell phone? Yes No

Cell Phone Type:

3. Does your cell phone have a camera? Yes No

4. If your cell phone has a camera, how often do you use it?

Regularly Once in a while Not at all

5. Have you browsed the Internet on your cell phone before e.g. checked your email, used google? Yes No

6. If yes, how often do you browse?

Regularly Once in a while Not at all

7. Why don't you browse more regularly on your phone?

It's hard to use   It's costly   I don't like phone Internet

8. Which is costlier: browsing the Internet on a PC or on a cell phone?

PC   Cell phone

9. Apart from sending SMS and making calls, do you use other phone functions like MMS, IM, Bluetooth, Calculator, Calendar, etc   Yes   No

[49]10. Do you use MXit?   Regularly   Once in a while   Not at all

For any queries or comments, please email sking@cs.uct.ac.za. For more info about how to use visual tags on your cell phone, please email the address above or visit the sites, www.semacode.org or www.shotcode.com. Thank you very much for filling out this questionnaire - your responses are invaluable to us.

[49] Item 10 in MDSQ1 is not in MDSQ2. There were 52 respondents for MDSQ1, while 20 SUT participants filled out MDSQ2

C.3 Mobile Data Services Questionnaire (MDSQ2)

This questionnaire is part of a postgraduate research at the Department of Computer Science, University of Cape Town, South Africa into the use of visual tags on mobile phones. ***For each of the questions 2 -9 below, please circle the most appropriate answer.***

1A. Age: 1B. Sex: 1C. Profession:

2. Do you own or use a cell phone? Yes No

Cell Phone Type:

3. Does your cell phone have a camera? Yes No

4. If your cell phone has a camera, how often do you use it?

Regularly Once in a while Not at all

5. Have you browsed the Internet on your cell phone before e.g. checked your email, used google? Yes No

6. If yes, how often do you browse?

Regularly Once in a while Not at all

7. Why don't you browse more regularly on your phone?

It's hard to use It's costly I don't like phone Internet

8. Which is costlier: browsing the Internet on a PC or on a cell phone?

PC | Cell phone

9. Apart from sending SMS and making calls, do you use other phone functions like MMS, IM, Bluetooth, Calculator, Calendar, etc | Yes | No

For any queries or comments, please email sking@cs.uct.ac.za. For more info about how to use visual tags on your cell phone, please email the address above or visit the sites, www.semacode.org or www.shotcode.com. Thank you very much for filling out this questionnaire - your responses are invaluable to us.

C.4 Nielsen's Attributes of Usability Questionnaire (NAUQ)

Please rate the system according to Nielsen's[50] attributes of usability by responding to items numbered 1 to 5 below. Also, try to respond to all the items and for items that are not applicable, please write: NA i.e. Not Applicable.

		1	2	3	4	5	6	7		NA
1. **Learnability** (How easy was it to learn to use the system?)	bad	☐	☐	☐	☐	☐	☐	☐	good	☐
2. **Efficiency** (How efficient was the system in performing set tasks?)	bad	☐	☐	☐	☐	☐	☐	☐	good	☐
3. **Memorability** (How easy was it to remember or memorize the features of the system?)	bad	☐	☐	☐	☐	☐	☐	☐	good	☐
4. **Errors/Accuracy** (During the use of the system, did you make few or many errors; and how easy or hard was it to remedy the errors?)	bad	☐	☐	☐	☐	☐	☐	☐	good	☐
5. **Satisfaction** (How interesting, exciting, or pleasant was the system to use?)	bad	☐	☐	☐	☐	☐	☐	☐	good	☐
		1	2	3	4	5	6	7		NA

[50] Based on: Nielsen, J. (1993) Usability Engineering. Academic Press. Chapter 2.2, p. 26.

List the most **negative** aspect(s) of the system:

1.
2.
3.

List the most **positive** aspect(s) of the system:

1.
2.
3.

C.5 System Usability Scale Questionnaire (SUSQ)[51]

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5

7. I would imagine that most people would learn to use this system very quickly

8. I found the system very cumbersome to use

9. I felt very confident using the system

10. I needed to learn a lot of things before I could get going with this system

Using SUS

The SUS[52] scale is generally used after the respondent has had an opportunity to use the system being evaluated, but before any debriefing or discussion takes place. Respondents should be asked to record their immediate response to each item, rather than thinking about items for a long time.

All items should be checked. If a respondent feels that they cannot respond to a particular item, they should mark the centre point of the scale.

Scoring SUS

SUS yields a single number representing a composite measure of the overall usability of the system being studied. Note that scores for individual items are not meaningful on their own.

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52 [SUSQ] Brooke, John. SUS - A quick and dirty usability scale. Available online: http://www.usabilitynet.org/trump/documents/Suschapt.doc

To calculate the SUS score, first sum the score contributions from each item. Each item's score contribution will range from 0 to 4. For items 1,3,5,7,and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Multiply the sum of the scores by 2.5 to obtain the overall value of SU.

SUS scores have a range of 0 to 100.

The following section gives an example of a scored SU scale.

C.6 Post-SUT Interview Questions

1. Which visual tags did you find the most aesthetically pleasing in terns of the physical design and visual appeal?

2. Which is costlier to use: SMS or Mobile Internet?

3. Will you upgrade your cell phone so you can have a phone that you can use with 2D visual tagging systems?

4. Do you see mobile Internet browsing cost as a barrier towards the regular use of 2D visual tagging systems?

5. How do you feel about the visual tagging systems you just used? Do you see yourself using these systems regularly?

6. What are the possible barriers and limitations that you foresee could hamper the adoption and/or regular use of 2D visual tagging systems?

7. Which 2D visual tagging system did you find the most comfortable or easiest to use?

8. Do you have any suggestions for visual tag use application scenarios, deployment, etc?

9. How beneficial or useful did you find the 'Help' menu?

10. Which visual tagging system will you recommend and why?

C.7 Mental Modelling Interview Questions

11. What kind of data or information do you expect from the visual tags or expect the visual tags to store?

12. Are you familiar with visual tags?

C.8 Real Access Criteria

(1) Physical access to technology

Example questions for applying this criterion: Is technology available and physically accessible to people and organizations? What technology is available? What factors affect physical access to technology in general? What factors affect the physical access to technology in the context of this project/policy? What can the ICT project/policy do to help ensure that technology is available and physically accessible to people and organizations?

(2) Appropriateness of technology

Example questions for applying this criterion: Is the technology appropriate to the local needs and conditions of the community? How do people need and want to put technology to use? What can the project/policy do to help ensure that ICT is appropriate to these needs and conditions of the communities involved in or affected by it? What can the ICT project/policy do to help ensure that technology is appropriate to local needs and conditions of the community? How could technology that works well in developed countries be modified to be more suitable in developing countries? Have all existing technology options been assessed and has the most appropriate solution for the specific policy/project objective been selected?

(3) Affordability of technology and technology use

Example questions for applying this criterion: Are the technologies and ICT services affordable for local people to obtain, access and use? What does "affordable" mean in the context of the community or target group? What can the ICT project/policy do to help ensure that technologies and technology use are affordable for local people and organizations? Is the project/policy planning for technology affordability in the short-term, and sustainability in the long-term?

(4) Human capacity and training

Example questions for applying this criterion: Do people have the training and skills necessary to use technology effectively? Do they understand how to use technology? Can they envision other potential uses for the technology in their lives or work? What training is already available in the community or target groups involved? Is the available training well suited to the needs of the project/policy? What can the ICT project/policy do to help ensure that people and organizations understand technology and its potential uses? What can the ICT project/policy do to help ensure that people and organizations get the training they need to use technology effectively, especially where no training is currently available?

(5) Locally relevant content, applications, and services

Example questions for applying this criterion: Are there locally relevant content, applications, and services that people and organizations can access and use through ICT? Are content, applications, and services available in local languages? What content, applications, and services are "locally relevant" in the context of the communities or target groups affected by the ICT project/policy? What can the ICT project/policy do to ensure that locally relevant content, applications, and services are available to people and organizations? Is the project/policy creating or improving locally relevant content, applications, and services?

(6) Integration into daily routines

Example questions for applying this criterion: Is technology use an additional burden to the lives and work of people and organizations already burdened by daily tasks, or is it integrated into their daily routines? What are the realities of daily life and work in the communities and groups targeted by the ICT project/policy? How can ICT use be adapted within these local realities? What can the ICT project/policy do to help ensure that technology use is integrated into daily routines and does not become an additional burden to people's lives and work?

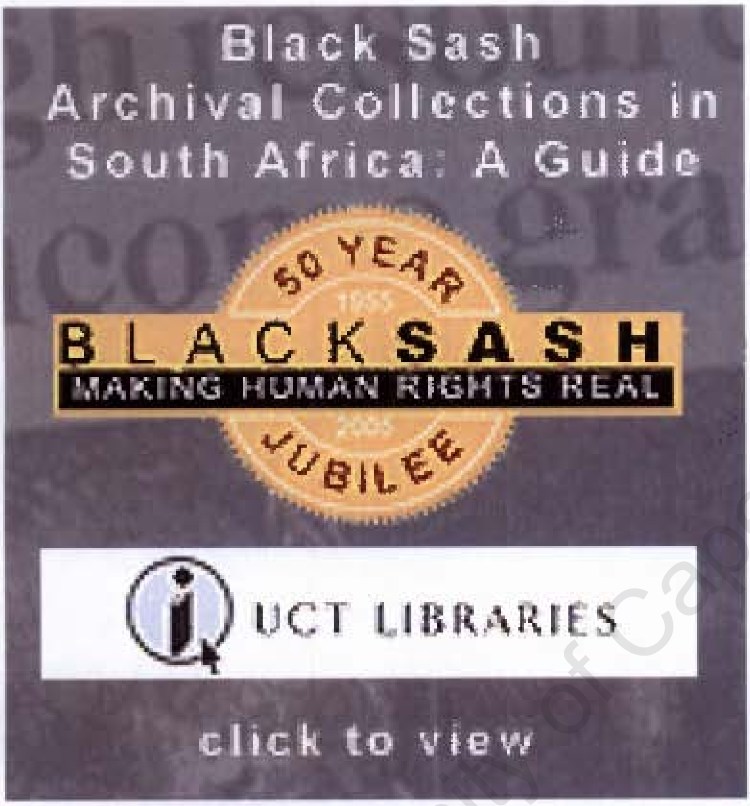
(7) Socio-cultural factors

Example questions for applying this criterion[53]: Are people limited in their use of technology because of their gender, race, disability, age, or other socio-cultural factors? What kinds of socio-cultural issues could impact on the ICT project/policy in the community involved? What can the ICT project/policy do to help ensure that people and organizations are not limited in their technology use due to gender, race, disability, age, or other socio-cultural factors?

[53] The Real Access criteria are from the site: http://www.bridges.org/Real_Access.

C.9 Test Environment 1: The MSS Centre

DEPARTMENT OF MANUSCRIPT AND ARCHIVES, UCT



WE ARE CLOSED FOR THE HOLIDAYS BUT YOU MAY CLICK ANY OF THE 2D BARCODES BELOW TO BROWSE THE SAN (BUSHMAN) PHOTOGRAPHIC COLLECTION.

THANK YOU.

C.10 Test Environment 2: Simulation of Baxter Theatre Centre Environment

HALLELUJAH

13 December – 20 January (Baxter Concert Hall)

The comedy, Hallelujah, is currently running at the Baxter Theatre. To obtain show details, book a ticket (via CompuTicket), get a map to the Baxter, view other productions that are currently running, or join the Baxter mailing list, please click any of the visual tags on this display board.