HARDWARE, SOFTWARE AND PEOPLEWARE

UNISA

SAICSIT 2001

Edited by
Karen Renaud
Paula Kotzé
Andries Barnard

HARDWARE, SOFTWARE AND PEOPLEWARE

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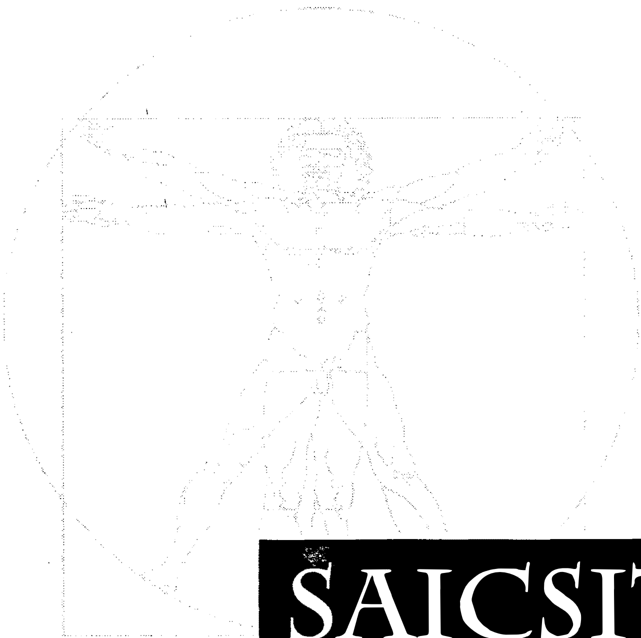

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Table of Contents

Message from the SAICSIT President iv
Message from the Chairs vi
Conference Organisation vii
Referees viii

Keynote Speakers

Cyber-economies and the Real World .... *xi*
Alan Dix
Computer-aided Instruction with Emphasis on Language Learning .... *xiv*
Lut Baten
Internet and Security Trends... *xv*
Arthur Goldstuck
The Future of Data Compression in E-technology .... *xvi*
Nigel Horspool
Strategic Planning for E-Commerce Systems: Towards an Inspirational Focus .... *xvii*
Raymond Hackney

Research Papers

Human-Computer Interaction / Virtual Reality

The Development of a User Classification Model for a Multi-cultural Society............ *1*
M Streicher, J Wesson & A Calitz
Real-Time Facial Animation for Virtual Characters.. *11*
D Burford & E Blake
The Effects of Avatars on Co-presence in a Collaborative Virtual Environment......... *19*
J Casanueva & E Blake

Education

Structured Mapping of Digital Learning Systems.. *29*
E Cloete & L Miller

Formal Methods

The specification of a multi-level marketing business *35*
A van der Poll & P Kotzé
Finite state computational morphology - the case of the Zulu noun *45*
L Pretorius & S Bosch
Combining context provisions with graph grammar rewriting rules: the three-dimensional case *54*
A Barnard & E Ehlers

Human-Computer Interaction / Web Usability

Web Site Readability and Navigation Techniques: An Empirical Study.................... *64*
P Licker, R Anderson, C Macintosh & A van Kets
Jiminy: Helping Users to Remember Their Passwords *73*
K Renaud & E Smith

Information Security

Computer Security: Hacking Tendencies, Criteria and Solutions........................... *81*
M Botha & R von Solms
An access control architecture for XML documents in workflow environments *88*
R Botha & J Eloff

Graphics and Ethics
Model-based Segmentation of CT Images 96
O Marte & P Marais
Towards Teaching Computer Ethics 102
C de Ridder, L Pretorius & A Barnard

Human-Computer Interaction / Mobile Devices
Ubiquitous Computing and Cellular Handset Interfaces – are menus the best way forward? 111
G Marsden & M Jones
A Comparison of the Interface Effect on the Use of Mobile Devices 120
J Franken, A Stander, Z Booley, Z Isaacs & R Rose
The Effect of Colour, Luminance, Contrast, Icons, Forgiveness and Closure on ATM Interface Efficiency 129
A Stander, P van der Zee, & Y Wang

Object Orientation
JavaCloak - Considering the Limitations of Proxies for Facilitating Java Runtime Specialisation 139
K Renaud

Hardware
Hierarchical Level of Detail Optimization for Constant Frame Rate Rendering 147
S Nirenstein, E Blake, S Windberg & A Mason
A Proposal for Dynamic Access Lists for TCP/IP Packet Filtering 156
S Hazelhurst

Information Systems
The Use of Technology to Support Group Decision-Making in South Africa 165
J Nash, D Gwilt, A Ludwig & K Shaw
Creating high Performance I.S. Teams 172
D C Smith, M Becker, J Burns-Howell & J Kyriakides
Issues Affecting the Adoption of Data Mining in South Africa 182
M Hart, E Barker-Goldie, K Davies & A Theron

Information Systems / Management
Knowledge management: do we do what we preach? 191
M Handzic, C Van Toorn, & P Parkin
Information Systems Strategic Planning and IS Function Performance: An Empirical Study 197
J Cohen

Formal Methods
Implication in three-valued logics of partial information 207
A Britz
Optimal Multi-splitting of Numeric value ranges for Decision Tree Induction 212
P Lutu

Abstracts of Electronic Papers

Lessons learnt from an action research project running groupwork activities on the Internet: Lecturers' experiences 221
T Thomas & S Brown

A conceptual model for tracking a learners' progress in an outcomes-based environment 221
R Harmse & T Thomas

Introductory IT at a Tertiary Level – Is ICDL the Answer? 222
C Dixie & J Wesson

Formal usability testing – Informing design 222
D van Greunen & J Wesson

Effectively Exploiting Server Log Information for Large Scale Web Sites 223
B Wong & G Marsden

Best Practices: An Information Security Development Trend 223
E von Solms & J Eloff

A Pattern Architecture, Using patterns to define an overall systems architecture 224
J van Zyl & A Walker

Real-time performance of OPC 224
S Kew, & B Dwolatzky

The Case for a Multiprocessor on a Die: MoaD 225
P Machanick

Further Cache and TLB Investigation of the RAMpage Memory Hierarchy 225
P Machanick & Z Patel

The Influence of Facilitation in a Group Decision Support Systems Environment 226
T Nepal & D Petkov

Managing the operational implications of Information Systems 226
B Potgieter

Finding Adjacencies in Non-Overlapping Polygons 226
J Adler, GD Christelis, JA Deneys, GD Konidaris, G Lewis, AG Lipson, RL Phillips, DK Scott-Dawkins, DA Shell, BV Strydom, WM Trakman & LD Van Gool

Message from the SAICSIT President

The South African Institute of Computer Scientists and Information Technologists (SAICSIT) was formed in 1982 and focuses on research and development in all fields of computing and information technology in South Africa. Now in the 20th year of its existence, SAICSIT has come of age, and through its flagship series of annual conferences provides a showcase of not only the best research from the Southern-African region, but also of international research, attracting contributions from far afield. SAICSIT does, however, not exist or operate in isolation.

More than 50 years have passed since the first electronic computer appeared in our society. In the intervening years technological development has been exponential. Over the last 20 years there has been a vast growth and pervasiveness of computing and information technology throughout the world. This has led into the expansion and consolidation of research into a diversity of new technologies and applications in diverse cultural environments. During this period huge strides have also been made in the development of computing devices. The processing speed of computers has increased thousand-fold and memory capacity from megabytes to gigabytes in the last decade alone. The Southern African region did not miss out on these developments.

It is hardly possible for such quantitative expansion not to bring a change in quality. Initially computers had been developed mainly for purposes such as automation for the improvement of processing, labour-reduction in production and automation control of machinery, with artificial intelligence, which made great strides in the 1980s, seen as the ultimate field to which computers could be applied. As we moved into the 1990s it was recognized that such an automation route was not the only direction in the improvement of computers. The expansion of processing power has enabled image data to be incorporated into computer systems, mainly for the purpose of improving human utilisation. For most computer technologies of the 1990s, including the Internet and virtual reality, automation was not the ultimate purpose. Humans were increasingly actively involved in the information-processing loop. This involvement has gradually increased as we move into the 21st century. Development of computer technology based not on automation, but on interaction, is now fully established.

The method of interaction has significantly changed as well. The expansion of computer ability means that the same function can be performed far more cheaply and on smaller computers than ever before. The advent of portable and mobile computers and pervasive computing devices is ample evidence of this. The need for users to be at the same location as a computer in order to reap the benefits of software installed on that computer is becoming an obsolete notion. Time and space are no longer constraints. One of the most discussed impacts of computing and information technology is *communication* and the easy accessibility of information. This changes the emphasis for research and development – issues such as cultural, political, and economic differences must, for example, be accommodated in ways that researchers have not previously considered. Our goal should be to enable users to benefit from technological advances, hence matching the skills, needs, and expectations of users of available technologies to their immense possibilities.

The conference theme for the SAICSIT 2001 Conference – *Hardware, Software and Peopleware: The Reality in the Real Millennium* – aims to reflect technological developments in all aspects related to computerised systems or computing devices, and especially reflect the fact that each influences the others.

Not only has SAICSIT come of age in the 21st century, but so has the research and development community in Southern Africa. The outstanding quality of papers submitted to SAICSIT 2001, of which only a small selection is published in this collection, illustrates both the exciting and developing nature of the field in our region. I hope that you will enjoy SAICSIT 2001 and that it will provide opportunities to cultivate and grow the seeds of discussion on innovative and new developments in computing and information technology.

Paula Kotzé
SAICSIT President

Message from the Chairs

Running this conference has been rewarding, exciting and exhausting. The response to the call for papers we sent out in March was overwhelming. We received 64 paper submissions for our main conference and twelve for the postgraduate symposium. We had a panel of internationally recognized reviewers, both local and international. The response from the reviewers was impressive – accepting a variety of papers and *mostly* returning the reviews long before the due date. We were struck, once again, by the sheer magnanimity of academia – as busy as we all are, we still manage to contribute fully to a conference such as SAICSIT.

After an exhaustive review process, where each paper was reviewed by at least three reviewers, the program committee accepted 26 full research papers and 14 electronic papers. Five papers were referred to the postgraduate symposium, since they represented work in progress – not yet ready for presentation to a full conference but which nevertheless represented sound and relevant research. The papers published in this volume therefore represent research of an internationally high standard and we are proud to publish it. Full electronic papers will be available on the conference web site (http://www.cs.unisa.ac.za/saicsit2001/).

Computer Science and Information Systems academics in South Africa labour under difficult circumstances. *The popularity of IT courses stems from the fact that IT qualifications are in high demand in industry, which leads in turn to a shortage of IT academic staff to teach the courses, even when posts are available. The net result is that fewer people teach more courses to more students. IT departments thus rake in ever-increasing amounts of state subsidy for their universities. These profits, euphemistically labelled "contribution to overhead costs", are deployed in various ways: cross-subsidization of non-profitable departments; maintenance of general facilities; salaries for administrative personnel, etc. Sweeteners of generous physical resources for the IT departments may be provided. We have yet to hear of a University in South Africa where significant concessions have been made in terms of industry-related remuneration. At best, small subventions are provided. As a result, shortages of quality staff remain acute in most IT departments – especially at senior teaching levels. What is even worse is that academics in these departments have to motivate the value of their conference contributions and other IT outputs to selection committees, often dominated by sceptical academic power-brokers from the more traditional departments whose continued survival is underwritten by IT's contribution to overhead costs.* [1]

The papers published in this volume are conclusive evidence of the indefatigability and pertinacity of Computer Science and Information Systems academics and technologists in South Africa. We are proud to be part of such a prestigious and innovative group of people.

In conclusion, we would like to thank the conference chair, Prof Paula Kotzé, for her support. We also specially thank Prof Derrick Kourie for his substantial contribution. Finally, to all of you, contributors, presenters, reviewers and organisers – a big thank you – without you this conference could not be successful.

Enjoy the Conference!
Karen Renaud & Andries Barnard

[1] This taken almost verbatim from Professor Derrick Kourie's SACLA 2001 paper titled: "*The Benefits of Bad Teaching*".

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Keynote Abstracts

The Effect of Colour, Luminance, Contrast, Icons, Forgiveness and Closure on ATM Interface Efficiency

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Abstract : *Automatic teller machines (ATM) are an intermediate stage in the progression of banking technology. This intermediate stage is expected to remain until user perceptions of electronic banking have improved. ATM transaction costs are high and it is a concern to banks to keep their customers using their ATM machines rather than those of their competitors. The paper attempts to answer the question of what can make it easier for users to use ATM machines. A research instrument was created to test the users' reactions to certain interface principles, with the hope of determining what principles significantly reduced the time to complete a transaction. The variables tested were colour, luminance, contrast, icons, forgiveness and closure. Of these variables, the grouping of colour, luminance and contrast resulted in a significant difference in mean time to complete a transaction. Further testing of these times found that the decrease in transaction time did not significantly increase the user efficiency*

Keywords : *User Interface, Colour, Luminance, Contrast, Icons, Forgiveness, Closure*
Computing Review Categories : H.5.2, H.3.5, H.1.2, H.4.3, C.0

1. Introduction

People's lifestyles are changing dramatically through the use of technology. Banking is no exception, and the importance of efficient and speedy banking is a growing concern. One way to facilitate banking is the use of automatic teller machines (ATMs).

The costs saved by decreasing transaction times by just a few seconds are expected to be worthy of concern. Costs imposed on the user for transactions at certain ATM machines are high. If a bank loses its ATM customers to other banks, it is obvious that serious losses can be incurred. In the same vein, attracting another bank's customers can be profitable.

These reasons have prompted this study of the effects of luminance, contrast, colour, icons, closure and forgiveness on human reactions to using ATM's.

By answering the following questions, this paper will address whether the time to make a transaction can be reduced:

- Can too high luminance increase the time to complete a transaction?
- Is a negative contrast (where the background is lighter than the foreground) preferred?
- Is blue a preferred colour in screen design, and does it decrease transaction time?
- Does the concept of forgiveness (allowing a way out of a situation) decrease the time to complete a transaction?
- Does the concept of closure facilitate quicker transaction time?

The computer is not researched in any detail in this study as the design of the computer itself is not crucial to the success of the human-computer interaction, but rather the computer interface residing on the hardware itself.

2. Human Aspects of Interaction

Effective design of human-computer systems requires the designer to have an understanding not only of the technical components of the system, but also the human components [7].

Humans are limited in their capacity to process information. This has led to the need to create systems that are suited to exploit our physical and mental capabilities while restricting the interaction with our limitations [6].

A person's interaction with the outside world occurs through information being received and sent: input and output Input in the human occurs through the senses [6], those of interest being sight and hearing. They are grouped together into the perceptual system. Output in the human occurs through the motor control of the effectors, the main effectors being the limbs, fingers, eyes and vocal system. These combine to form the motor system. Finally the cognitive system provides the processing to connect the perceptual and motor systems [6].

2.1 Input via the Perceptual System: Vision

Human vision is a highly complex activity with a range of physical and perceptual limitations, yet it is the primary source of information for the average person [6]. Six characteristics of vision need to be highlighted in order to understand its relationship with HCI [7].

Luminance: The light reflected from the surface of an object. As the luminance increases so does the eyes ability to discern small detail. As the luminance of an object or display increases so the eye will become more sensitive to flicker [15].

Contrast:: Is the relationship between light emitted from an object and light emitted from the background surrounding the object [10]. Research conducted by Bauer and Cavonius [2], in the field of improving the legibility of visual display units through contrast reversal, proved that negative contrast screens (when the background emits more light than the object) are preferred, and result in more accurate performance.

Brightness: Is a subjective response to light and is directly correlated to luminance.
Colour: A person with normal colour vision can only distinguish 8-10 different colours. Furthermore people's sensitivity to colour is not uniform across their field of view. The eye is least sensitive to red, green and yellow light at the periphery of colour vision and most sensitive to blue light. An important fact to remember when using any colour coding is that 8% of men and 1% of women have some form of colour blindness [10].

Ease of reading: This is an important concern within the field of HCI. It is unlikely that words are scanned serially. Experiments have shown that words can be recognised as quickly as single characters. The concept of recognising a word from its shape, rather from the letters that compose it, is a phenomenon called word shape, and is of interest to interface design [6].

Experiments by Tinker [16] show that standard font sizes of between 9 and 12 font are equally legible given proportional spacing between lines. Muter, Latremouille, Treurniet and Beam [11], in a study of continuous reading of continual text on television screens found that reading from a computer screen is slower than reading from a book. This was thought to be due to a longer line length, fewer words to a page, orientation and the familiarity of the medium of the page [11].

Output via the Motor Control of the Effectors
Motor control of the effectors is the primary means of output from the human into the computer. The four main effectors are the limbs, fingers, eyes and vocal system [7].

The path of information from a computer to a person and back again involves a few distinct steps. Firstly the stimulus is received through sensory receptors. Then the question is processed and a valid response generated. The brain then signals the appropriate muscles to respond. This is divided into reaction time and movement time. Movement time is largely dependent on physical characteristics. Reaction time is, however, a variable that can be tested in interface design [6]. It is dependent on the sense that received the stimulus. It is shown in research results presented by Goldstein [8], that responses are generated the quickest to auditory stimuli, followed by visual stimuli and then pain.

2.2 Cognitive System

This is the system that lies between the perceptual system and the motor control of the effectors. It can be thought of as the thinking behind the response to a stimulus, and can be thought of in terms of storing information, processing information, problem solving and acquiring skills [6].

Storing Information: Badderley [1] argues that information is stored in three types of memory or in one type of memory with different memory functions, these being sensory memories, short term or working memories and long term memories.

Sensory memory is further divided into iconic (sight), echoic (sound) and haptic (touch) memories. These memories are extremely short term, lasting for only 0.5 seconds [1]. Sensory memory could possibly be used in interface design as a means of directions for navigation. A flash towards a button can register in a person's sensory memory, directing them towards pressing the button.

The second form of memory is short-term or working memory. Downton et al [7] state research results that show that short-term

memory is in the region of 20-30 seconds. Experiments by Postman and Phillips [14] showed that recall of the most recent things said or shown to a person were those that were the best remembered. This is known as the recency effect. However if the person is asked to do another task between presentation and recall, the receny effect is eliminated.
It is as a result of the recency effect that systems call for closure [7].

Closure is the term used for closing a current task once it is complete, such as to discard any information regarding that task that resides in short term memory.

3. The Interface

User interfaces accomplish two fundamental tasks: communicating information from the machine to the user, and communicating information from the user to the machine [5]. According to Downton et al [7] the design of text and the design of graphics are the two main aspects of screen design,

3.1 Text on the Screen

Spaciousness: According to Downton et al [7] clutter on the display greatly increases visual search time. Research by Shneiderman [15] on user interface consistency found that the toned down use of colour for similar objects resulted in the space to display extra information without cluttering the display.

Grouping: The 'chunking' of information allows an easier form of condensing data into short-term memory, and hence decreases search times. The Common Front Group [5] states that people tend to view panels from the top down and left to right. That means that the most important information should be positioned in the top left corner of the panel, and that information regarding a conclusion, such as "Ok" and "Cancel" buttons, should be placed in the bottom right corner. The Common Front Group further argues that items on any panel should be positioned based on commonality. Things that all relate to each other should be clustered together with white space separating different clusters.

Consistency: Consistent location for important objects can focus users' attention and bring confidence to expectations. Furthermore Shneiderman [15] conclude that consistent wording throughout the interface simplifies comprehension. Nielson [12] states that consistency leads to "improved user productivity by leading to higher throughput and fewer errors because the user can predict what the system will do at any given situation and can rely on a few rules to govern use of the system".

Simplicity: The screen should display the appropriate quantity and level of information in the simplest way possible. Nielson [15] feel that simplicity can be maintained by providing the user with small sets of choices at any one time.

3.2 Graphics on the Screen

Visual Order and User Focus: Graphical interfaces provide the opportunity to exploit very powerful visual stimuli, which can clutter the interface when used in excess. Downton et al [7] state that the most important aspect of graphical interfaces is that the user can focus on the area on the screen on which attention is intended.

The associated psychological problem addressed is that of focused and divided attention. When there are multiple sources of information we must make choices about what to attend to and when. At times, we need to focus our attention exclusively on a single item without interference from other items. At other times, we may need to time share or divide our attention between two (or more) items of interest. In this case, we rapidly switch attention back and forth between the items (necessitating minimal "switching costs"). There is a trade-off between these attentional requirements [4]. The need for focused or divided attention is largely determined by the demands of the user's task. However, our ability to successfully focus or divide (share) attention can be enhanced or degraded by the display design choices we make.

Consistent and Appropriate Graphic Vocabulary: As discussed on the section on screen text, consistency in the graphic form is also essential. Results of research by Shneiderman [15] once again emphasise the importance of consistency in the form of object location, shape and colour in interface design. Research by Mayes et al [9] shows that information is picked up, used and discarded at a sub-conscious level. Mayes et al [9] showed that although the detail of the symbology may only be identified at a subconscious level, inconsistency will inhibit interaction and familiarisation with the interface.

Forgiveness: Due to the navigable nature of interfaces today, users can find themselves in places where they do not want to be [5]. This requires that there always be a way out and that special care is taken to make it particularly difficult to "shoot themselves in the foot." [5]. Furthermore Dix et al [6], Downton et al [7] and Berlage [3] comment that it is important to provide a recovery operations for applications with a graphical or text based user interface.

4. Hypotheses

4.1 Primary Hypothesis 1:

The current design of the ATM interface does not result in efficient usage.

In order to prove the primary hypothesis true, any of the following secondary hypothesis could be proven true, and visa versa.

4.2 Secondary Hypothesis 1:

The design of the ATM interface can be made more efficient by decreasing the time to make a withdrawal by 3 second through changing a combination of the luminance, contrast and colour.

The above three interface characteristics, namely luminance, contrast and colour was grouped together because of their commonality to their appeal to the human aspect of sight.

4.3 Secondary Hypothesis 2:

The design of the ATM interface can be made more efficient by decreasing the time to make a withdrawal by 3 second through the utilisation of icons.

Although the use of icons also appeals to the human sense of sight, they were removed from the first secondary hypothesis because they appealed more to the short term and sensory memories incorporated in the human cognitive system.

4.4 Secondary Hypothesis 3:

The design of the ATM interface can be made more efficient by decreasing the time to make a withdrawal by 3 second through adhering to rules forgiveness and closure.

This third secondary hypothesis included the HCI characteristics of forgiveness and closure. They were grouped together as they were specific in terms of HCI to research on the interface side, rather than the human side.

5. Methodology

A digital camera was used to capture exact replicas of the existing First National Bank's BOB Automatic Teller Machine screen. Screen shots from the cash withdrawal transaction were used.
The screens were then imported into Visual Basic and used as backgrounds to forms. The idea was to create a functional program that would time the respondents to complete one transaction.

5.1 The Program

The Visual Basic project comprised four separate applications, each of which contained five separate forms. The idea was to create one application per hypothesis.

All of the screens in each application were presented in the center of a larger screen that incorporated buttons at the side of the inner screen. The combination of the larger screen and the side selection buttons created an exact replica of the present BOB ATM machine.
The respondent was presented with the first screen of the withdrawal transaction. In order to reduce learning effects, the applications were presented to the respondents in random order.

The same process was then repeated until all four hypotheses were tested per respondent.
All information pertaining to the respondent and the time to completion of each respective transaction was recorded in a database. Once the desired number of responses was reached, the data was exported to a statistical package and an analysis of the data performed.

5.2 Secondary Hypothesis One

The function of the initial screen was to capture the respondent's details. Details of relevance to this study were the respondent's age and home language. It was explained to the respondents that once the initial screen was completed, the program would start, and consequentially once it had started, what they should do. The steps were to enter a pin number of any four digits and to complete a withdrawal of an amount of R30.

The second screen would then be presented to the respondent, in which he/she was required to type in a given four-digit pin number. Once the last digit in the pin number was entered, a built in timer would be triggered, recording the time to complete the first stage in the withdrawal transaction. At this point a pause of 2 seconds would be initiated. This is to simulate the lag time on a real ATM transaction.

Once the pause was complete, the third screen would then be presented to the respondent. This screen determined what type of transaction the respondent wished to make. If an incorrect selection was made, i.e. a withdrawal was not selected, then a penalty would be recorded. Penalties would continue to incur until the option of withdrawal was chosen. At this stage, a built in timer in the program would be triggered, recording the time to completion of the second stage of the withdrawal.

After another pause, the fourth screen, determining how much the respondent wished to withdraw, would be presented. Once again, penalties incurred if the incorrect choice (anything other then "Another Amount") was selected. When the correct choice was selected, another built-in timer would be triggered, recording the time to complete the third stage of the withdrawal.

Finally, the respondent would be presented with a screen that allowed them to enter in the amount they wished to withdraw. Once this was entered, they could press the proceed key. Another built-in timer would be triggered, and the first hypothesis test would be complete.
Specific adjustments to the ATM screens in order to test secondary hypothesis 1 were as follows:

The background colour was lightened, and the foreground colour was darkened. The combination of these two points results in the desired contrast suggested by Bauer and Cavonius [2]. According to Dix et al [6] the human eye is more susceptible to blue. For this reason the foreground colour was changed to a dark blue.

The luminance of the background colour was reduced. This change was expected to reduce flicker [15], and hence enable easier viewing. In general the colour scheme moved away from reds to blues, following results presented by Dix et al [6].

5.3 Secondary Hypothesis 2

The screens that were used in order to test this hypothesis incorporated the same functionality as described the section pertaining to secondary hypothesis one.
Specific adjustments to the ATM screens in order to test secondary hypothesis 2 were as follows:

In order to facilitate sensory iconic memory, icons were used. With respect to screen 2, where the respondent is given a choice as to which transaction they wish to make, simplicity was maintained by only adding icons for the most common transactions, namely "Fastcash" and "Withdrawal".

Where the respondent had to choose the amount of money they wished to withdraw, icons giving visual clues to the amount of money to be withdrawn were used.

5.4 Secondary Hypothesis 3

The screens that were used in order to test this hypothesis incorporated the same functionality as described in the previous two hypotheses.
Two main aspects of interface design were addressed in this section, namely closure and forgiveness.

They were addressed in the following way:
Instead of a penalty for an incorrect decision, the user is presented with a screen showing that their decision was incorrect. They are then allowed to go back to the screen where they came from in order to make the correct choice. This is still recorded as a penalty it to enable comparison between the models. While the respondent is on the incorrect screen, the timer for the screen where they came from is still running. Once the correct choice is made, the timer is triggered, and the time to complete the screen is recorded. This addresses the concept of forgiveness.

The respondent can move backwards at any time by using the "Back" key. Closure is addressed by blanking the screen out once a correct decision is made. This is to clear the respondent's short-term memory in order to enable them to focus on the next task at hand.

6. Findings

6.1 Population Distribution

The models were presented to 54 potential respondents, all of who completed all four screens of all four models, resulting in a 100% response rate. The respondents were asked to enter in their age and home language. The number of choices of home languages were restricted to 5, while the age category was not limited.

The majority of responses (62% = 33) were attained from people living in English speaking households, followed by Afrikaans (9% = 5), Xhosa (7% = 4), Zulu (2% = 1) and Other (20% = 11). The reason for this was possibly that the majority of responses came from, an urban area. It was found that the majority of Xhosa, Zulu and Afrikaans responses were staff working for the English speaking proportion of respondents.

Age of the respondents varied from 19 to 66. This is a fairly broad category showing a fair representation of the population. A larger proportion of responses were received from the 21-31 category. This is possibly because the respondents came from an area near a university. In order to test the correlation between age and the times to completion and home language and time to completion, the Spearman's Rank Correlation Test was used.

	Valid N	Spearman R	T(N-2
Model 1	54	0.200487	1.47569
Model 2	54	0.237488	1.76299
Model 3	54	0.215358	1.59028
Model 4	54	0.132224	0.96192

Table 1: Home Language to Time to completion

As can be seen from the relatively high p-ratios (not significant at 5% level), the correlation between home language/age and time to completion for models 1,3 and 4 were not significant. It is however the belief of the researchers that age and time to completion could be correlated for the second model as it incorporated interface principals aimed at solving problems of poor sight commonly associated with aging.

	Valid N	Spearman R	T(N-2)	P level
Model 1	54	0.243282	1.8086	0.076285
Model 2	54	0.317834	2.4172	0.019179
Model 3	54	0.039476	0.2848	0.776862
Model 4	54	0.236092	1.7520	0.085668

Table 2: Age to Time to Completion

The results show that age is correlated to time at the 2% significance level for model 2, confirming the above belief. Home language correlates to time in model 2 at the 15% level. This shows a slight significance. This is not strong enough to show a significant correlation, but should perhaps be researched further with a larger sample. Because of the weak significance within the above results, age and home language will not be discussed any further.

6.2 Analysis of penalties

It is interesting to note that model 1, the original ATM screen, incurred the least penalties. This means that the original screen was perhaps the most intuitive to the user. All models shared the same basic screen design. There were no changes to the navigation in order to complete a withdrawal, however the penalties varied dramatically, by almost 400% between models 1 and 3 respectively. This data shows that some of the users responding to the test were possibly inconsistent between models.

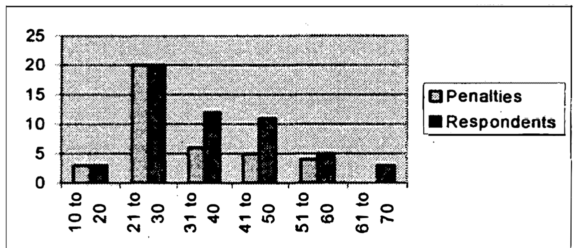

Figure 1: Penalties per each age group

Some interesting points arise out of the above graph. Firstly, there were no penalties for people in the age group 61 to 70. One reason for this can be due to the small number of respondents in this category. There are however as many respondents in this category as in the 10 – 20 category, yet less penalties were incurred. This goes against intuitive thought, as young people are expected to be more technically competent. It is expected that this contradiction may be because the number of penalties in the 10 - 20 category was attributed to only 1 person. Therefore, if this person was rejected from the analysis, the results to this analysis of penalties may have been truer.

The 20 to 30 category incurred the most penalties. Again, this goes against intuitive thought, as it is these people that are expected to use ATMs the most frequently. A possible reason for these results could be because the majority of responses came from this population group.

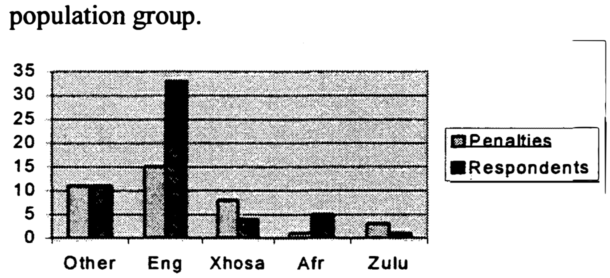

Figure 2: Penalties by home language

Of interest from the above graph, the number of penalties from the 'Xhosa', 'Zulu' and 'Other' groups where proportionally high relative to the number of respondents in these categories..

It is felt that the high ratio of penalties to respondents for 'Xhosa', 'Zulu' and 'Other' groups may be due to lack of comprehension, education or computer literacy skills associated to the groups.

6.3 Tests for Normality

The Kolmogorov-Smirnov goodness-of-fit test was used to test the populations for normality.
It was found that the population results in model 1 are normally distributed (p=0.4737375). The population results from models 2 (p=0.0356486), 3 (p=0.0261038) and 4 (p=0.0008515) did not fit a normal distribution. Because of the lack of significant normality of models 2,3 and 4, parametric tests cannot be used to compare the means of model 2, 3 and 4 to model 1.
For this reason, any further comparison of means will be conducted using non-parametric tests where the assumption of normality does not have to hold true.

6.4 Analysis of Means

As the data attained from this research is not normally distributed, and because the variables are dependent on each other, the Friedman test was used to determine whether the means of all the tests differed significantly to each other. It was expected that they should differ. For this reason the hypotheses to be tested were:

> H0: The mean time to complete a withdrawal is equal between models 1,2,3 and 4
>
> H1: The mean time to complete a withdrawal is not equal between models 1,2,3 & 4

A p-value of 0.03416 was found. This indicates that the means of this data are significantly different at the 3.4% level. This shows a high significance, and for this reason the null hypothesis is rejected in favour of the secondary hypothesis.

This result gives justified reason to further analyse the results in order to establish which means differ to the mean time for model one. If it can be identified that any mean differs significantly to the mean for model 1, and is less than the mean, then the primary hypothesis to this paper can be proven.

The findings to follow build on the above analysis of the means by individually testing the mean times to completion of model 1 to models 2, 3 and 4 respectively, and hence proving or disproving secondary hypotheses 1, 2 and 3 respectively.

Are the means between model 1 and model 2 significantly different and can the design of the ATM interface be made more efficient by decreasing the time to make a withdrawal by 3 second through changing a combination of the luminance, contrast and colour?

If the data was normally distributed a t-test could have been used to test the population means of the two samples for similarity. This data is, however, not normally distributed, and therefore the non-parametric equivalent to the t-test had to be used. The variables presented in the data are dependent on each other as the same person participated in all 4 tests. For this reason the Wilcoxon Matched Pairs Test was used rather than the Mann-Whitney test.

The hypotheses to be proven with the use of the Wilcoxon Matched Pairs Test test are:

> H0: The population means to the time to complete a withdrawal are not equal between models 1 and 2
>
> H1: The population means to the time to complete a withdrawal are equal between models 1 and 2

As can be seen from the above data, the sum of the positive ranks between model 1 and model 2 equal 455.5. The associated variance of this sample is 2.4711. Comparing this z-value to the normal tables shows that the means are significantly different at the 1.3474% level. For this reason H0 can be rejected with confidence, and the secondary hypothesis assumed to be valid.

The findings show that the design of the ATM interface can be made more efficient by changing a combination of the luminance, contrast and colour. It does not however prove that the efficiency can be increased by three seconds. The following section will examine whether this desired increase in efficiency was indeed present, and whether it was significant.

Does model 2 result in the significant increase in efficiency of 3 seconds?
The hypotheses to be proven in this experiment are:

> H0: Mean time to completion of a withdrawal using model 1 is not significantly greater than 3 seconds different to the mean time to completion of a withdrawal using model 2

H1: Mean time to completion of a withdrawal using model 1 is significantly 3 seconds less than the mean time to completion of a withdrawal using model 2

In order to prove these hypotheses, the time taken per respondent per transaction was increased in an Excel spreadsheet by 3 seconds. A replica of the previous experiment was conducted, once again using the Wilcoxon Matched Pairs Test.

It was found that the three seconds added to the times for completion within model 2 increased the sum of the positive ranks from 455.5 to 655.5. The associated z-value decreased dramatically from 2.471133 to 0.531166. Because of this decrease, the significance level rose from 1.3% to 59.53%, meaning that the primary hypothesis (H0) would have to be accepted. This means that the mean time to completion of a withdrawal using model 1, is not significantly greater than 3 seconds different to the mean time to completion of a withdrawal using model 2.

From the above findings it can be concluded that the design of the ATM interface can be made more efficient through changing a combination of the luminance, contrast and colour. This decrease is however not more than 3 seconds significant.

Are the means between model 1 and model 3 significantly different and can the design of the ATM interface can be made more efficient by decreasing the time to make a withdrawal by 3 second through the utilisation of icons?
Once again the Wilcoxon Matched Pairs Test had to be used.
The hypotheses to be proven with the use of the Wilcoxon Matched Pairs Test are:

H0: The population means to the time to complete a withdrawal are equal between models 1 and 3

H1: The population means to the time to complete a withdrawal are not equal between models 1 and 3

It was found that the sum of the positive ranks between model 1 and model 3 equal 716.5. The associated variance of this sample is 0.2238. Comparing this z-value to the normal tables shows that the means are significantly different at the 82.28% level. For this reason H0 cannot be rejected with confidence, and the secondary hypothesis (H1) cannot be accepted. It must be concluded that the design of the ATM interface cannot be made more efficient through the utilisation of icons.

Are the means between model 1 and model 4 significantly different and can the design of the ATM interface can be made more efficient by decreasing the time to make a withdrawal by 3 second through adhering to rules forgiveness and closure. In order to find an answer to this hypothesis some data manipulation must be performed to incorporate the concept of forgiveness. The model incorporated forgiveness by allowing the respondent to go back in a transaction. In addition to this, instead of generating a penalty for an incorrect choice, the user is presented with a screen telling them to go back. As explained in the methodology, the timer for each screen does not stop while the user is on the incorrect screen.

The data will therefore be manipulated by adding 15 seconds to the time of any results to model 1 that incorporated a penalty, while the results in model 4 will remain unchanged The amount of 15 seconds was decided on as a reasonable time to re-insert the card in the ATM machine to begin the transaction over. This time is however not backed up by research, as no research on this exists. To generate a simulation of inserting to card was beyond the scope of this study.
The hypotheses to be proven with the use of the Wilcoxon Matched Pairs Test are:

H0: The population means to the time to complete a withdrawal are equal between models 1 and 4

H1: The population means to the time to complete a withdrawal are not equal between models 1 and 4

The sum of the positive ranks between model 1 and model 4 were equal to 725. The associated variance of this sample is 0.150679.

Comparing this z-value to the normal tables shows that the means are significantly different at the 88.02% level. For this reason H0 cannot be rejected with confidence, and the secondary hypothesis (H1) cannot be accepted. It can be concluded that the design of the ATM interface cannot be made more efficient by decreasing the time to make a withdrawal by 3 second through adhering to rules forgiveness and closure.

6.5 Further analysis of means

The above results may be a result of differences within screens and between models. i.e. the time to enter a pin number differed significantly between models. For this reason, further analysis of means had to be conducted.

Box and whisker plots showed that it is not worth analyzing the difference between models for screens 1 and 4 as all the medians fall within a small range.

Of interest to us are the results from screen 2 and screen 3 where the medians are all dissimilar. For this reason the difference in means between model 1,2,3 and 4 for screens 2 and 3 will be analysed further. In order to do this, the Friedman test will be used again.
Once again the data to be analysed is not normally distributed, and the variables are dependent. In this section, each screen will be analysed separately.

Screen 2: The Friedman test is used to determine whether the mean times to complete screen 2 differ significantly within the models. For this reason the hypotheses to be tested were:

> H0: The mean time to complete screen 2 is equal within models 1,2,3 and 4
>
> H1: The mean time to complete screen 2 is not equal within models 1,2,3 and 4

The results showed that we must reject H0, as the p-ratio is extremely low, making the means significantly different at a 0.016% ($p < 0.00016$) level. This signifies that the mean time to complete screen 2 is not equal within models 1,2,3 and 4.

The reason for this may be that the second screen was where a lot of the changes between models occurred. In the case of model 2, where icons were used, icons were added to two of the menu options. In the case of changing the colour of the screen, the colour of the menu items and the background were changed. In the case of building in forgiveness and closure, closure by means of a blank screen was added, and allowing respondents to go back adhered to the principal of forgiveness. It was observed that a few of the users were confused with the idea of moving back in an ATM transaction as this feature is not incorporated in any ATM's studied to date.
All of these additions to the screen could create the varying difference in the means.

Screen 3: The Friedman test is used to determine whether the mean times to complete screen 2 differ significantly within the models. For this reason the hypotheses to be tested were:

> H0: The mean time to complete screen 3 is equal within models 1,2,3 and 4
>
> H1: The mean time to complete screen 3 is not equal within models 1,2,3 and 4

The results showed that we must reject H0 as the p-ratio is extremely low, making the means significantly different at a 0.028% ($p < 0.00028$). This means that we must accept the secondary hypothesis that the mean time to complete screen 3 is not equal between models 1,2,3 and 4.

Once again the reason for this may be because the third screen was where the majority of the changes between models occurred. In the case of model 2, icons were added to all of the menu options. In the case of changing the colour of the screen, the colour of the menu items and the background were changed. In the case of building in forgiveness and closure, closure by means of a blank screen was added, and allowing respondents to go back adhered to the principal of forgiveness. Iit was observed that a few of the users were confused with the idea of moving back in an ATM transaction, as this is not incorporated in any ATM's studied to date. All of these additions to the screen could create the varying difference in the means.

From this section it is seen that the mean times to complete screens 2 and 3 differ significantly within models. Further research into the reasons for these findings are beyond the scope of this paper, but should be addressed in further research.

7. Conclusion

The aim of the research was not to determine why people do not use ATM machines when faced with the task, but rather what factors affect their efficiency when using the machines.

Literature surveyed presented certain principles that should be adhered to with respect to the area of Human Computer Interaction. It was believed that if these principles could be built into an ATM interface, that the time taken to complete a transaction could be reduced significantly.
This paper therefore went about testing this belief. In order to do so three secondary hypotheses were created, each of them taking into account grouped principles of interface design. To test each of these hypotheses, a replica of a specific ATM interface was created, and certain factors were changed on the screen for the different hypotheses. The ATM interface was then tested for efficiency by timing respondents to complete a withdrawal.

Significant time differences were established between the interface that took into account factors to do with colour, luminance and contrast. It was found that a light blue background with dark blue foreground combined with low luminance created an interface that was more efficient than the present ATM interface. The interface was then tested to see if it attained efficiency levels that significantly decreased transaction time by 3 seconds. It did not.

From the variables tested against the present design of the BOB ATM machine interface, it can be concluded that the HCI manipulations used in this study cannot improve the efficiency by better than three seconds.

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