

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

In the previous chapter, we established that although there is substantial theoretical evidence that a relationship does exist between subjective culture and usability, the empirical evidence available in the literature is contradictory and therefore inconclusive. Our initial research problem, derived from this contradictory evidence, was to test whether this relationship does indeed exist, by measuring the effects of selected subjective cultural dimensions on the usability of computer-based information systems. Thus, this research problem falls within the specialization of HCI, within the discipline of Information Systems.

The purpose of this chapter is to establish the design and methodology context for this research problem. We begin this chapter with a review of HCI research, where we establish two important issues: firstly, that the methods and techniques used in HCI research are adapted and adopted from general, business and information systems research; secondly, that the choice methods and techniques are partly dependent on the choice of research topic.

Consequently, we discuss the types of research problems, research questions and research designs used in general and business research in sections 3.3, 3.4 and 3.5 respectively. We then turn our attention to data collection and analysis methods and techniques, which are discussed in terms of general and business research (section 3.6), information systems research (section 3.7). We then review how these methods and techniques have been adapted for HCI research, as well as those specifically formulated for this discipline (section 3.8). Based on the discussions of the preceding sections, we conclude this chapter by selecting, and providing more in-depth details on the methods and techniques most appropriate for the research problem at hand. This is discussed in section 3.9.

3.2 Research in Human-Computer Interaction

As discussed in section 2.2, HCI forms part of the larger discipline of interaction design, which is itself a multidisciplinary discipline, calling on the expertise of both scientific and design disciplines. Consequently, HCI has been viewed as a science discipline, a design science discipline and an engineering discipline [Sasse, 1997], with each of these views requiring a different approach to the way in which HCI research is carried out. Advocates of each of these

approaches argue that their particular approach will generate the knowledge required for the discipline. However, there are also arguments against these approaches and the resultant knowledge generated, suggesting that there is still no consensus on the strategy that should be used for conducting HCI research. These approaches and the arguments against the approaches are discussed next.

3.2.1 The Traditional Science Approach

HCI should be viewed as a traditional science, and therefore the research should be focused on providing engineering-style theories and tools for designers [Newell & Card, 1985; 1986]. This approach requires that HCI knowledge is expressed in engineering-style models of the user, requiring the use of empirical methods such as experiments to collect quantitative data as a basis for building and evaluating mathematical models. However, the argument against the use of these methods is that they are too expensive and time consuming [Sasse, 1997].

3.2.2 The Design Science Approach

HCI should be viewed as a design science; therefore the research should be focused on developing a craft-based approach and new research methods to evaluate existing systems in their intended contexts [Carroll and Campbell, 1989]. Research results should be focused on relevant and immediately applicable knowledge that can be used as design guidelines for future systems. Such an approach requires that HCI knowledge be generated from deep, explanatory theories of how humans interact with machines, using qualitative rather than quantitative methods. Carroll and Campbell [1989] formulated artifact theory as a research strategy to achieve these goals. The basic premise of this theory is that HCI research issues are best studied after they have appeared in a system or artifact; however, this premise must be rejected, as system design must also take into consideration issues other than usability (for example economic and legal) [Sasse, 1997]. In addition, it has been pointed out that craft-based methods result in 'folk-psychology' descriptions and ideas, which are not nearly as robust as the results obtained from the more formal experimental approaches.

3.2.3 The Engineering Approach

HCI should be viewed as an engineering discipline, therefore research should be focused on accumulating knowledge and formulating engineering principles. Research results should form the basis for user interface design and evaluation [Dowell and Long, 1989]. The engineering approach suggests that a combination of experiments, in-depth interviews and observations be used. This approach appears to compensate for the weaknesses identified in the previous two approaches, as HCI knowledge will result in a form which is both sound and accessible. However, as Sasse [1997] points out, 'the construction of these engineering principles is based

on a conception requiring a consensus with the discipline which does not exist at present [p 2_10].

3.2.4 Choosing appropriate methods and techniques

The arguments for and against these three approaches to HCI research signify that there is still no agreement on the research strategies that should be used to conduct HCI research [Sasse, 1997]. Therefore, such decisions need to be made by the individual researcher for the specific topic under investigation.

There are however, some guidelines that can be followed when selecting the most appropriate methods and techniques for a specific research undertaking [Riley, et al., 2000; Ghauri and Grønhaug, 2002; Hair, et al., 2003]. In some cases, the choice of research question will simultaneously decide the research design. Research design has been defined as 'the overall strategy chosen to obtain the information required to answer the research question' [Ghauri and Grønhaug, 2002, p 47]. Thus, the research design influences what data to collect and how the data should be collected and analysed, thus influencing the data collection and data analysis methods that are used [Riley, et al., 2000]. It is therefore necessary to review the types of research problems and questions, research designs, data collection and data analysis methods that are used in the disciplines that contribute to HCI and HCI research.

The primary objective of human-computer interaction research is to provide a scientific explanation of how humans interact with computers [Giacoppo, 2001]. Thus, the strategies used in social science research play an important role in HCI research: 'social scientists, such as psychologists and sociologists, seek to describe the realities of individual human behaviour and the interactions of humans within a society' [Hair, et al., 2003, p 5]. In addition, business research falls into the social science sphere, as business is about people.

Consequently, in order to identify the most appropriate methods and techniques for the current research undertaking, we review the research problems, questions and designs used in general, business and information systems research. We then review the methods and techniques identified from these disciplines as being the most appropriate, and discuss how they have been adapted for HCI research. We also review the techniques and methods that are unique to HCI research.

3.3 The Research Problem

Our research problem is empirical in nature, when viewed in terms of Mouton's [2001] Three Worlds Framework. According to Mouton, objects of enquiry can be selected from one of three 'worlds', which combined, form the Three Worlds Framework, and is used to determine whether the research is empirical or non-empirical in nature.

The Three Worlds Framework reflects that knowledge and knowledge production, which is the overriding goal of research, can be situated in the world of everyday life (World 1), the world of science and scientific research (World 2) or the world of meta-science (World 3). World 1 knowledge is focused on pragmatic interests such as social and physical reality and lay knowledge; World 2 knowledge is related to the knowledge, research and disciplines of science, while World 3 knowledge relates to understanding and reflecting on issues such as the philosophy and sociology of science, research methodologies and ethics. Research is conducted in World 2, and the objects of enquiry are selected from any of the three worlds.

When the object of study is a real life object (from World 1), the research problem is considered to be empirical in nature [Mouton, 2001]. In contrast, objects of study chosen from World 2 (for example, constructing theories or analyzing concepts) relate to conceptual or non-empirical research problems.

The initial research problem selected for this dissertation, as derived from the literature investigation, is to determine whether Hofstede's cultural dimensions influence the usability of software products. Thus, the object of study is the usability of software, as experienced by the user within a specific cultural context. This relates to World 1, as it is focused on social realities. Consequently, the research problem is considered to be empirical in nature.

3.4 Research Questions

A research problem is formulated into one or more research questions as a way of focusing the research problem. The research question formulated from the research problem is empirical and causal in nature. Mouton [2001] suggests that one initially distinguishes between two classes of research questions: empirical and non-empirical. Empirical research problems are formulated as empirical questions, whilst non-empirical questions are formulated as conceptual questions. Empirical questions are further categorized as exploratory, descriptive, causal, evaluative, predictive or historical. Non-empirical questions are categorised as meta-analytic, conceptual, theoretical or philosophical. Table 3.1 provides examples of these categories of questions [Mouton, 2001].

EMPIRICAL QUESTIONS		
Class	Type of Question	Example
Exploratory	What are the key factors?	What are the distinguishing features of a good leader?
Descriptive	Are x and y related?	Is there a correlation between parental support and scholastic achievement?
Causal	What are the causes of y?	Is alcohol the main cause of liver disease?
Evaluative	What was the outcome of x?	Has the new TB awareness programme produced a decline in the number of reported TB cases?
Predictive	What will the effect of x be on y?	What effect will the introduction of a new antibiotic have on population P?
Historical	What led to y happening?	What caused the demise of socialism in Central Europe in the late 1980s?

CONCEPTUAL QUESTIONS		
Class	Type of Question	Example
Meta-analytic	What are the key debates in domain x?	What are the key debates in current business risk studies?
Conceptual	What is the meaning of concept x?	What is the meaning of 'sexual harassment'?
Theoretical	What are the most plausible theories or models of x?	What are the most widely accepted models, definitions or theories of 'usability'?
Philosophical	What is the ideal profile of x?	Do animals have rights?

Table 3.1: Classes and Categories of Research Questions [Mouton, 2001]

Our research problem could be translated into one of two research questions, each of which relate to a different class of question, as illustrated in Table 3.2

Possible Research Question	Class of Question
Is there a correlation between Hofstede's subjective cultural dimensions and the usability of computer-based systems?	Descriptive
Will subjective culture, as defined by Hofstede's cultural model, effect the usability of computer-based systems?	Causal

Table 3.2: Potential Research Questions for Our Research Problem

According to Ghauri and Grønhaug [2002], descriptive and causal research are used when the research question is understood and well structured. However, descriptive research is used to describe some situation, for example, how performance and experience are related, or who is most likely to be satisfied with a particular product. In contrast, the main objective of causal research is to identify one or more variables that cause a particular effect, for example, whether a decrease in selling price causes an increase in sales quantity [Ghauri and Grønhaug, 2002],

or whether a particular user characteristic (such as culture) will cause an increase or decrease in usability.

The objective of our research is to determine whether or not subjective culture causes an increase or decrease in usability. Thus, we can accept that our research problem should be formulated into a causal, (and therefore empirical), question.

3.5 Research Designs

Empirical research questions require empirical research designs [Mouton. 2001]. From a general research perspective, Mouton identifies a multitude of empirical research designs; however, as discussed in section 3.4, our research question is causal in nature. Consequently, we are limited to select from only those research designs that are applicable to causal questions, as illustrated in Table 3.3.

Research Designs applicable to Causal Questions
Surveys
Comparative, cross-cultural and cross-national studies
Experimental designs (laboratory studies)
Field / natural experimental designs
Statistical modeling and computer simulation studies
Secondary data analysis (SDA)
Historical studies, narrative analysis
Life history methodology

Table 3.3: Research Designs Applicable to Causal Questions

Although the research question partially determines the research design that should be used, Mouton [2001] suggests that research designs should also be selected based on whether the research will make use of primary or secondary data.

3.5.1 Primary and Secondary Data

Primary data are data that are collected for the research study to hand, whilst secondary data are existing data that have been collected for prior research studies. The existing literature contains only a handful of international empirical studies on the effects of subjective culture on usability. In addition, there are no reports of such studies done in the South African context. Consequently, we can accept that there are no relevant secondary data sources available for this research, requiring the collection of our own, primary data. Thus our choice of research designs from a general research perspective is limited to the designs generally used with empirical, causal studies using primary data. According to Mouton [2001] these only include

surveys and experiments.

Our selection of experiments and surveys as research designs are supported from a business and information systems research perspectives as well. From a business research perspective, causality is established through experimentation [Hair, et al., 2003]. Experiments used in information systems research are normally supported by surveys and observations [Olivier, 2004].

3.6 Methods and Techniques in General

We have established in the previous section that the choice of an appropriate design for this research undertaking is limited to experiments and surveys. Consequently, in this section, we discuss the methods and techniques most frequently used in experiments and surveys.

3.6.1 Experiments

Experiments are a process of proposing and verifying one or more hypotheses [Atwater and Barbaria, 2001]. Thus, experiments support the traditional scientific approach to research. From a business research perspective, there are two main types of experiments, namely laboratory and field experiments [Hair, et al., 2003]. Laboratory experiments are also referred to as controlled experiments [Atwater and Barbaria, 2001]. They are considered to be the most rigorous of methods, as the results of a controlled experiment are always meaningful [Atwater and Barbaria, 2001] and can be used to extend a theory [Olivier, 2004].

The primary difference between laboratory and field experiments is that laboratory experiments are conducted in an artificial setting, while field experiments are conducted in a natural setting. The differences between these two types of experimental designs also influence the internal and external validity of the results. Internal validity depends on whether the observations are caused only by the experimental inputs and nothing else [Olivier, 2004]. External validity is attained when the results of the experiment can be generalized, in other words, the results are representative of the general population. Field experiments are conducted in a realistic setting, which increases the external validity of the results; however, as there is less control over other influencing variables in a natural setting, field experiments reduce the internal validity of the results. The opposite holds true for laboratory experiments, as laboratory conditions are different to those experienced in the 'real' world.

Experiments make use of independent and dependent variables. Dependent variables relate to the outcome of the experiment, whilst independent variables are the events or objects that are manipulated by the researcher in order to test the theory about the outcome. For example, the objective of a causal experiment is to determine whether or not a change in X causes a change

in Y. Such an experiment is 'a causal design in which a researcher controls a potential cause and observes any corresponding change in hypothesized effects' [Hair, et al., 2003, p 64]. The variable that is hypothesized to cause the change is referred to as the independent variable, and the effect is referred to as the dependent variable. Manipulation means the causal variable is altered over different levels or conditions. The manipulated variable is also called the experiment variable.

Different types of controlled experiments include single factor, multi-factor, quasi-experimental and case studies [Atwater and Barbaria, 2004]. We review the first three only, as case studies typically involve only one subject (be it one person, one organisation, or one event) which is obviously not suitable for our research undertaking.

3.6.1.1 Single Factor Method

There is only one independent variable in single factor experiments [Atwater and Barbaria, 2001]. Thus there are at least two levels of the independent variable. These levels are normally an experiment level and a control level. For example, if the objective of the experiment is to determine whether a larger font size increases legibility, then the two levels would be a standard font size (control level) and a larger font size (experimental level).

There are two approaches to conducting this kind of experiment, namely the use of an experimental and control group, or the use of a single group [Olivier, 2004]. Using experimental and control groups, participants are selected for the experiment and then randomly split into two groups. The experiment group is exposed to the experimental level of the independent variable, whilst the control group is exposed to the control level of the independent variable. The data is analysed statistically to determine whether there is a significant difference between the two groups. Internal validity may be reduced using this approach, due to different test subjects comprising the different groups.

Using a single group, the test subjects are first exposed to the control variable and then exposed to the experimental variable (or vice-versa). In this case, the data are analysed to determine whether there is a significant difference between the results of the group when exposed to the control and experimental variables. Internal validity is enhanced using this approach because the same group of subjects is used to collect both sets of results.

The primary advantages of single factor methods are that it is easy to control, and simple, robust statistics can be performed on the data. However, the primary disadvantage of using single groups is that the first test that the group is exposed to can influence the results of the second test [Olivier, 2004].

3.6.1.2 Multi-Factor Method

Multi-factor experiments involve two or more independent variables [Atwater and Barbaria, 2001]. When there is more than one independent variable, a between-subjects design or a within-subjects design can be used [Ghauri and Grønhaug, 2002]: between-subjects design requires that every test subject is only tested for one of the independent variables. This means that for every independent variable, a separate group of test subjects should be identified. In contrast, in a within-subjects design, test subjects are exposed to multiple independent variables.

The greatest benefit of this type of experiment is that interaction effects between the independent variables can be analysed. Interactions refer to the combined effects of multiple variables [Hair, et al., 2003], which could indicate that a combination of variables cause a greater effect than any two variables in isolation. Therefore, multi-factor methods are more efficient than single factor methods. The primary disadvantage of this method is that it can become too complicated if there are too many independent variables to be explored at once [Atwater and Barbaria, 2001].

3.6.1.3 Quasi-Experimental Method

Quasi-experiments are similar to single and multi-factor experiments, but do not have the same controls [Atwater and Barbaria, 2001]. In particular, where single and multi-factor methods require the random assignment of subjects into an experimental and a control group, quasi-experimental methods rely on naturally formed or pre-existing groups (for example, male and female, or groups that are formed from specific cultural profiles). The advantage of this method is that it is easier to implement, as it is easier to use naturally formed groups than to have to deal with randomization. The main disadvantages relate to inferior internal validity when two or more groups of test subjects are used. As discussed in section 3.6.1.1, it is impossible to know if the changes that occurred were as a result of the treatment or changes in the subjects [Atwater and Barbaria, 2001]. Due to this lack of total control, claims of causality should be treated with caution.

3.6.2 Surveys

Conducting a survey consists of the following steps [Trochim, 2000; Olivier, 2004]:

- a. Set the goals by formulating the hypotheses in order to identify what information is needed to answer the research question.
- b. Decide on the target population and sample size by determining the type and number of respondents required.
- c. Determine the questions by identifying what questions should be asked and how.
- d. Pre-test the survey by conducting a pilot study.
- e. Conduct the survey.

- f. Analyse the data collected and test the hypotheses against the data.
- g. Confirm, modify or reject the theory.

Survey methods consist of questionnaires or interviews for recording information about the respondents [Ghauri and Grønhaug, 2002]. Surveys are conducted using questionnaires that are either distributed to a group of people to complete (self-administered), or completed through an interviewing process (interviewer-administered) [Olivier, 2004; Hair, et al., 2003]. With self-completion methods, questionnaires are distributed to respondents for completion on their own. Interviewer-administered methods involve direct communication with the respondents in the form of personal interviews. Personal interviews are typically used to collect detailed qualitative information from a relatively small number of subjects, thus supporting the design science approach to research. In contrast, questionnaires are most frequently used to collect quantitative data from a large number of respondents, supporting the traditional scientific approach to research.

Questionnaires and interviews are effective tools for getting information about attitudes, opinions and values. They can be used to test theories about a particular phenomenon, for example, the satisfaction levels of populations with different characteristics, and can also be used to count the occurrences of phenomena such as the number of autobanks in a particular area, or the number of times a specific topic is referred to in the literature [Olivier, 2004].

3.6.2.1 Questionnaires

Questionnaires are especially good for collecting information on facts and opinions from a large group of people [Riley, et al., 2000]. There are two main types of questionnaires: mail and on-line [Kuter and Yilmaz, 2001]. On-line questionnaires can further be divided into e-mail, computer-direct and web-based questionnaires. The exception to this rule is when opinion surveys are conducted, where the interviewer records the respondents' responses over the telephone. However, telephonic completion should not be considered when anything of a deep psychological nature, such as attitudes, is to be measured [Riley, et al., 2000].

There are basically two classes of questions that are used in questionnaires, namely open- and closed-ended questions [Riley, et al., 2000]. Closed-ended questions, also known as structured questions, restrict the answers to a small set of responses, thus generating precise answers, and require the designer to have a good knowledge of the range of options that the respondent might have. Open-ended questions, also known as unstructured questions, do not impose restrictions, and provide deeper and richer responses, which are harder to analyse.

In general, there are three types of questions used in surveys, namely multiple choice, numeric open-ended and text open-ended. [Trochim, 2000]. There are also two types of response format, namely structured response and unstructured response. Structured responses might

not capture everything in the respondent's mind, and may be difficult to answer if the most correct answer has not been provided as an alternative. In unstructured responses, the respondent writes down a textual or descriptive response (as in answers to text open-ended responses). Questionnaires can therefore be structured, unstructured or semi-structured, depending on the type of questions and responses that they contain.

3.6.2.2 Interviews

Interviews require real interaction between the researcher and the subjects [Ghauri and Grønhaug, 2002], and therefore require more time and are best used with small groups of people [Giacoppo, 2001]. Like questionnaires, the questions asked can be structured, semi-structured or unstructured. Unstructured interviews is where the respondent is given almost full liberty to discuss reactions, opinions and behaviour on a particular issue [Ghauri and Grønhaug, 2002]. Unstructured interviews are therefore intended to act as an exploratory conversation, as they are useful for identifying areas that require further analysis [Giacoppo, 2001]. Unstructured interviews are good for investigating potentially emotional and / or sensitive personal issues.

Semi-structured interviews should only be carried out in a situation where broad issues may be understood, but the range of respondents' reactions to these issues is not known or is suspected to be incomplete [Giacoppo, 2001]. This type of interview is mostly applicable in situations where both qualitative and quantitative feedback is required.

With structured interviews, a standard format is used in conjunction with fixed response categories [Ghauri and Grønhaug, 2002]. Such responses lend themselves well to statistical tests [Giacoppo, 2001]. They are useful in situations where the respondents' range of replies may be estimated and there is a need to clarify details, opinions or ideas. Structured interviews work well when the assessment goals are clear.

For all types of interviews, reporting and transcribing the interview is a tedious job.

3.6.3 Qualitative and Quantitative Methods

The choice of research design is also partly dependent on whether a qualitative or quantitative approach is followed [Hair, et al., 2003]. Qualitative and quantitative methods are not mutually exclusive: for example, data may be collected qualitatively through observations and interviews, but the researcher may code the data collected in such a manner that would allow the data to be analysed through statistical (quantitative) techniques [Ghauri and Grønhaug, 2002].

In addition, qualitative and quantitative methods can be applicable to different stages of research. For example, qualitative data are used to 'explain phenomena, leading to the building of theories and the generation of hypotheses, while quantitative data is used to test such

hypotheses' [Ghauri and Grønhaug, 2002, p 88].

This suggests that that the two approaches are complementary and cannot be used in isolation of each other. Consequently, no method is entirely quantitative or qualitative. However, the techniques associated with the methods can be either quantitative or qualitative. For example, survey techniques such as structured questionnaires containing closed-ended questions are quantitative in nature, whereas unstructured and semi-structured questionnaires using open-ended questions are qualitative in nature.

3.6.4 Data Measurements

The reason for gathering data is to obtain the information required to answer the research problem [Ghauri and Grønhaug, 2002]. The quality of this information, and therefore the outcome of the research undertaking, is very much dependent on the measurement procedures used in the collection of data. These measurement procedures are partially dependent on whether qualitative or quantitative data are used, and include types of data measurements as well as the types of scales used.

3.6.4.1 Measurement Types

Data can be measured qualitatively or quantitatively. Quantitative data are measurements in which numbers are used to represent the properties of something [Ghauri and Grønhaug, 2002]. They are in a form that lends itself to statistical analysis. In contrast, qualitative research findings are not derived from statistical data analysis techniques. Qualitative data represent descriptions of things that are made without assigning numbers directly. Qualitative findings are derived through in-depth insights into the problem being investigated. Therefore, quantitative data are more objective in that the hypotheses are tested by applying statistical criteria to the measures. The researcher's opinion does not affect the test, unlike qualitative data which requires interpretation.

There are four types of measures that can be used in questionnaires, namely nominal, ordinal, ratio and interval measures [Olivier, 2004, Hair et al, 2003]. Variables measured at the nominal or ordinal level are discrete and referred to as categorical, qualitative or non-metric [Hair, et al., 2003]. Interval or ratio measures are continuous and referred to as either quantitative or metric.

a. Nominal Measures

With nominal measures, respondents are required to choose one alternative from a list of alternatives [Olivier, 2004]. Nominal measures are the lowest level of measurement and therefore provide data that is relatively low in precision [Hair, et al., 2003].

b. Ordinal Measures

Ordinal measures are the same as a ranking scale [Hair, et al, 2003]. It enables the researcher to determine if something has more or less of a characteristic than something else. However, it does not provide information about how much more or less of the characteristic the object has. For example, a question that requires respondents to rank how often they use spreadsheet applications, word processing applications, games and email. The ranking provided will not indicate whether the applications are used 50% of the time or 20% of the time, but only that one application is used more or less often than the other [Olivier, 2004].

c. Interval Measures

Interval measures use numbers to rate objects or events so that the distances between the numbers are equal. Interval measures are used to measure concepts such as feelings, opinions, perceptions and values, through the use of rating scales. Rating scales involve the use of statements on a questionnaire in conjunction with pre-coded categories. One of these categories is then selected by the respondent to indicate the extent of their agreement or disagreement with the statement.

d. Ratio Measures

Ratio measures are based on units of measures where 0 literally means 'nothing' [Olivier, 2004]. It also allows for the computation of ratios of points on a scale, for example, 100 is half of 200 when using ratio measures [Hair, et al., 2003].

3.6.4.2 Scales

In keeping with the metric and non-metric types of data measures, there are two categories of scales – metric and non-metric [Hair, et al., 2003]. Metric scales relate to quantitative data, while non-metric relate to qualitative data. Types of metric scales include summated ratings, numerical and semantic differential scales, whilst non-metric scales include categorical and rank order scales. As the data collected for the current research will be analysed quantitatively, we discuss the three metric scales in more detail below.

a. Summated Ratings Scale

This scale attempts to measure attitudes and opinions. It typically uses a 5-point or 7-point scale to assess the strength of agreement or disagreement about a group of statements. A label is developed for each point on the scale to describe the intensity of the respondent's feeling. When several statements are used to describe a single concept, the sum of the scales for all of the statements is referred to as a summated ratings scale. If the scale is used for individual statements, it is referred to as a Likert scale. Likert scales are also used to measure importance or intentions.

b. Numerical Scale

These scales have numbers as response options rather than textual descriptions. Similar to Likert scales, numerical scales can be used to assess the level of agreement or disagreement, but are more often used to measure behavioural intentions, for example, the likelihood of revisiting a Web site, or likelihood of purchasing a particular software product.

c. Semantic Differential Scale

This scale is yet another way of measuring attitudes. They are similar to summated ratings and numerical scales in that they can use either 5-point or 7-point scales, but differ in that they use bipolar end points rather than labels. The end points describe things using opposite adjectives or adverbs (for example, 'likely' and 'unlikely'), with the intermediate points being numbered. Respondents are then asked to select the number that best describes their feelings about the concept.

3.6.5 Data Analysis

Quantitative data is analysed through the use of diagrams and statistics, whereas qualitative data is analysed through the use of conceptualization [Ghauri and Grønhaug, 2002]. As our research is causal in nature, we require a relatively large amount of quantitative data [Hair, et al., 2003], thus we will use statistical techniques to analyse our data. A number of statistical techniques can be used to test hypotheses [Hair, et al., 2003].

When using statistics to test hypotheses, statistics are categorized into three types, namely univariate, bivariate and multivariate [Hair, et al., 2003]. Chi-square, t-test and ANOVA are examples of bivariate hypothesis tests. The choice of a particular statistical technique is dependent on the type of measurement used (as discussed in section 3.6.4) and the number of variables examined simultaneously.

3.6.5.1 Number of Independent Variables and Treatments

Univariate statistics can only assess a single variable, while bivariate statistics can assess two variables. In contrast, multivariate statistics can assess many variables at the same time, including dependent and independent variables.

In addition, where more than one group of subjects is involved, bivariate statistics must be used. For example, single factor experiments only use one independent variable, but if an experiment and a control group are used, either a t-test or a one-way ANOVA can be used [Atwater and Barbaria, 2001]. If there are only two treatment levels, then a t-test can be used, but if there are more than two levels then a one-way ANOVA must be used. In contrast, multi-factor experiments use two or more independent variables, and therefore the data will always have to be analysed using ANOVA.

3.7 Methods and Techniques in Information Systems

Olivier [2004] identifies three classes of methods relevant to information systems research, namely empirical, tautological and creative. Creative methods are defined as ‘those that are used to devise new abstractions or mechanisms to be used in computing’ [Olivier 2004, p 12]. Methods such as models, prototypes, algorithms and languages would fall into this category. Mathematical proofs and arguments are examples of tautological (manipulation) methods, which are defined as ‘those that transform their inputs to reveal something that was not obvious in their inputs’ [p 13]. In contrast, empirical methods are those that depend on observation, and include surveys, case studies and experiments.

Olivier [2004] proposes that the methods and techniques used in information systems research are dependent on the goals of the research. According to Olivier, there are three primary types of research goals in information systems research, namely technical, social and philosophical goals. Technical goals are defined as dealing with the implementation aspects of systems, whilst philosophical goals deal with responsibility, accountability, legal aspects and the implications of using computer systems. Social goals are defined as those that focus on the people side of computers. Social goals are most frequently achieved through empirical methods. According to Olivier, empirical methods are the most frequently used to achieve social goals. In contrast, technical goals are supported by creative methods and philosophical goals are achieved through the use of tautological methods. This is summarized in Table 3.2.

Technical	Philosophical	Social
Literature Survey	Literature Survey	Literature Survey
Models	Arguments	Surveys
Languages	Mathematical Proofs	Case Studies
Algorithms		Experiments

Table 3.2: Goal Categories and Most Frequently Used Methods

Viewing the research question in terms of information systems research designs, it is evident that our research has a social goal, as it is focused on the users in a specific cultural context. Therefore, from an information systems perspective, empirical methods such as surveys, experiments and case studies are appropriate for the current research undertaking. These methods have already been discussed in section 3.6.

3.8 Methods and Techniques in Human-Computer Interaction

As noted previously in section 3.4, our research question focuses on whether subjective culture influences usability. In order to ascertain this, we will need to evaluate and compare the usability of different interfaces when used by users with differing cultural profiles. Usability evaluation methods include user testing, observations, questionnaires and interviews, focus groups, logging actual use and user feedback [Nielsen, 1993]. We discuss below only user testing (a form of controlled experiment) and questionnaires and interviews, as these methods have already been identified as the most appropriate from a general, business and information systems research perspective (sections 3.6 and 3.7).

3.8.1 User Testing

Usability evaluation has emerged as a way of assessing how people interact with the World Wide Web, software and hardware, identifying the problems that people have using the software and hardware, and testing alternative designs of software and hardware [Zimmerman, 1999].

There are many usability evaluation methods that could be used to gather data, ranging from experiments with large sample sizes and complex test designs to very informal qualitative studies with only a single participant [van Greunen and Wesson, 2001]. These methods include heuristic evaluation and empirical evaluations of actual user performance [Nielsen, 1993].

Formal usability testing is an empirical method that requires the design of a formal usability experiment that is conducted under controlled conditions in a usability laboratory [Nielsen, 1993; Mayhew, 1999]. Usability testing is a form of controlled experiment, thus supporting the view that HCI is a science discipline. Usability testing is considered to be the gold standard, as it is only by testing real people, performing real tasks in a real environment that we can establish the true usability of the product [Landauer, 1995]. Usability testing has therefore become a standard method used in HCI research to determine the usability of software products.

The steps required to conduct a formal usability test are as follows [van Greunen and Wesson, 2001]:

- a. A goal for the usability test must be formulated.
- b. Research questions and hypotheses must be formulated.
- c. Participants must be selected.
- d. A test plan must be formulated.
- e. Data must be collected.
- f. Results must be analysed.

- g. Evaluation conclusions must be drawn.

The overall process for conducting the experiment is relatively simple: get some test users to perform a predefined set of tasks on selected test interfaces [van Greunen and Wesson, 2001]. Data is then collected in terms of usability measures, which can include effectiveness, efficiency and user satisfaction. Examples of metrics used include how long the participants take to complete a task, how many errors they make and user likes or dislikes of specific features of the interfaces. Methods used to obtain these metrics include observations, questionnaires or interviews [van Greunen and Wesson, 2001]. Accuracy and speed are measured on the basis of the time taken to complete the tasks and how correctly the tasks were completed [Spool, et al., 1999]. Satisfaction is measured through the use of questionnaires or interviews.

Usability tests are often conducted to compare the usability of two or more systems [Levi and Conrad, 2004]. In this case, there is an option of using either a between-subjects method or a within-subjects method for employing test users [Nielsen, 1993]. Given that usability is influenced by numerous user characteristics (as discussed in section 2.4.2), the within-subjects method is more appropriate for usability tests. This is because the same users will be used throughout the test, thus ensuring that any differences in usability measures are not caused by differences in user characteristics between different groups.

3.8.2 Questionnaires and Interviews

Questionnaires and interviews are important techniques used in HCI research [Kuter and Yilmaz, 2001]. They provide information about preferences and ideas about the interface design, and thus can be used to both inform the design and assess the usability of installed systems.

From a usability perspective, questionnaires and interviews are similar methods as they both involve asking users a set of questions and recording the answers [Nielsen, 1993]. Questionnaires are generally self-completed, not requiring the presence of the researcher. In contrast, interviews require that the interviewer read the question and record the answers provided by the respondents. Thus, as in other kinds of research, interviews are much more time-intensive for the researcher than questionnaires.

Questionnaires and interviews are best suited to gathering data about user satisfaction [Nielsen, 1993]. When used for this purpose, questionnaires and interviews are considered to be direct methods. They are also useful for studying how users use systems and what features of the interface they particularly like or dislike. In these instances, questionnaires and interviews are considered to be indirect methods, as they are not used to study the user interface itself, but rather the users' opinions about the interfaces.

From an HCI perspective, it is critical to correctly determine the sample that will be investigated through the use of interviews and questionnaires [Kuter and Yilmaz, 2001]. The sample should represent the target users of the interface, so that the true user context of use is used to determine usability.

As in general and business research, interviews and questionnaires used in HCI can be structured, semi-structured or unstructured [Nielsen, 1993; Preece et al., 2002]. The use of structured methods support the view that HCI is a science discipline, whereas the use of unstructured and semi-structured methods support the view that HCI is a design science discipline, as richer, deeper explanatory descriptions are generated. The use of both structured and unstructured techniques clearly supports the view that HCI is an engineering discipline, as the combined use of quantitative and qualitative data compensate for the individual weaknesses of each technique.

Questionnaires are used predominantly in HCI to collect information from a large sample of respondents. In cross-cultural usability research it is also essential to ensure that the test subjects are homogenous in all respects other than the cultural aspect being tested [Duncker, 2002]. Questionnaires are frequently used to determine such homogeneity. Questionnaires are therefore more frequently structured in nature, generating quantitative data that is amenable to statistical testing [Kuter and Yilmaz, 2001].

In contrast to questionnaires, interviews are flexible and participatory [Kuter and Yilmaz, 2001]. They are flexible because the interviewer has the freedom to change some questions, or the order of the questions, to suit the reactions of the respondent. They are participatory because they need both the interviewer as well as the respondent to interact in a conversation. Thus the interviewer is able to get richer, deeper information from the respondent than when using questionnaires. Unstructured and semi-structured interviews are used primarily to elicit users' ideas about the design of the interface, therefore they are used to inform the design rather than assess the design. Structured interviews, on the other hand, are used in conjunction with a fully developed system and contain questions to measure the user's reactions to that system. Structured interviews, like structured questionnaires, generate quantitative data, allowing for the use of statistical data analysis methods.

3.9 Appropriate Methods and Techniques

The preceding discussions have led us to the conclusion that an experiment is the most appropriate research design for our research undertaking. The experimental method used will be a usability test, which can be viewed as a controlled experiment. Questionnaires will be used to identify the user profile of the test subjects, as well as to collect data on satisfaction levels. Guidelines for the development of questionnaires are discussed in section 3.9.1 below.

All data will be quantitative in nature, thus requiring the use of statistical techniques for analysis. The hypotheses will require testing for differences in means between only two groups. The same subjects will be used in both groups, therefore a within-subjects design will be used, requiring the use of the t-test statistic. T-tests are described in more detail in section 3.9.2. The design and methodology used in the experiment are discussed in more depth in Chapter 4.

3.9.1 Guidelines for Questionnaire Design

The following guidelines have been proposed for questionnaire design [Riley, et al., 2000; Ghauri and Grønhaug, 2002; Olivier, 2004; Trochim, 2000]:

- Questions and answers provided should use simple and concise language. Consideration must be taken of the respondent's educational level, knowledge of the subject matter and home language of the respondents [Ghauri and Grønhaug, 2002] It is also necessary to check that each respondent understands the question in the same way, in other words, that each respondent draws the same meaning from both the question and the answers provided. This will prevent the users from answering the question with a different understanding, or not answering the question at all [Ghauri and Grønhaug, 2002].
- No unrealistic demands should be made on the respondents in terms of time, know-how, memory or willingness to respond. Insufficient time will cause the respondents to rush, decreasing the accuracy of the information provided. Asking respondents questions that they do not understand or that require a lot of effort to complete will more often than not cause them to give up [Olivier, 2004].
- Each question should be about one thing only. Having double-barrelled or portmanteau questions makes it difficult to select only one answer, thus potentially reducing the accuracy of the responses.
- Questions should not be of a suggestive nature, directing the respondent to a specific answer or opinion. This will result in the respondent contributing negatively to the conclusions of the study [Ghauri and Grønhaug, 2002] This is particularly relevant to respondents displaying high power distant characteristics, as such respondents will not want to be seen to disagree with the opinions of people in positions of authority [Hofstede, 2001].
- The provision of escape routes (for example, 'don't know' or 'not sure') for questions should be used with care. Self-administered questionnaires generally have a lower response rate (of about 22%) if no escape routes are provided. However, escape routes are used by respondents wanting to avoid answering questions, which will naturally prevent the researcher from obtaining the required information. Therefore, Ghauri and Grønhaug [2002] suggest that escape routes are not used. However, it has also been suggested [Hair, et al., 2003; Olivier, 2004] that each question should have an escape route, in order to prevent respondents from fabricating answers to questions that they may find sensitive in nature or genuinely do not have an answer for.

- Questions should be asked in a polite and soft manner. They should not irritate, offend or provoke the respondents [Ghauri and Grønhaug, 2002]
- The order of the questions must be considered. It is important to place sensitive questions in the right place so that the respondent can understand why the question needs to be asked. In addition, questions should be asked in a logical and systematic sequence to avoid misunderstandings [Ghauri and Grønhaug, 2002]. Easy to answer and positive questions should be asked first, otherwise the respondents may be given the impression that all the questions are complicated and difficult, resulting in them not responding at all.
- The layout should be easy to follow. In particular, the more professional the appearance of the questionnaire, the better the responses that are elicited [Olivier, 2004].
- Clear instructions must be provided. This is particularly important for high uncertainty avoidant users.
- A pilot study should be conducted to test the questionnaire before the real study begins. [Olivier, 2004]. This will allow the researcher to determine whether or not the preceding guidelines have been correctly implemented.

3.9.2 T-tests

T-tests are used to test differences in the means of two data sets [Riley, et al., 2000; Ghauri and Grønhaug, 2002; Hair, et al., 2003]. They are also used to determine causal relationships: ‘to assess whether or not some influence or treatment has resulted in a changed outcome’ [Riley, et al., 2000, p 200]. There are two versions of the t-test: paired samples and independent samples. An independent samples t-test is used to compare differences in means between two unrelated groups, for example, the means of a control group and an experiment group. A paired samples t-test is used when the groups are related, for example, when a single sample is used in an experiment, and measures are taken before and after exposure to the experimental variable. Paired and independent sample t-tests were used in the experiment, and are discussed in more detail in section 4.4.4.

3.10 Summary

The objective of this chapter was to determine the most appropriate research methods and techniques to be used in order to collect and analyse the data required to solve our research problem.

As HCI is viewed as a science, design science and engineering discipline, no consensus has been reached in terms of the methodologies that should be used in this area of research. From a research process perspective, however, the research question often dictates the type of research design, which in turn, dictates to some extent the choice of methods and techniques. In addition, we established that HCI is multidisciplinary, with many of the methods being

adapted and adopted from other disciplines such as business and information systems.

Our review of the research designs, methods and techniques used in general, business, information systems and HCI research led us to the conclusion that a usability test should be used as the primary research method. The cultural profile as well as the homogeneity of the users in all other respects, should be assessed through the use of structured questionnaires. The method used to collect data on satisfaction should be a structured questionnaire, using interval measures and a semantic differential scale that generates quantitative data. The hypotheses will be tested by comparing differences in means between two groups. The same subjects will be used in both groups; therefore a within-subjects design will be used. A within-subjects design, viewed in conjunction with the collection of quantitative data requires the use of t-tests as the method for data analysis.

In the next chapter, the experimental design and methodology is discussed in depth. The results of the experiment are also presented.