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INVESTIGATION OF EFFECTS OF CULTURAL BACKGROUND OF USERS ON INTERFACE DESIGN AND USABILITY

A Thesis in

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ABSTRACT

Over the past few decades, with an increase in technological innovation and world becoming a ‘Global Village’, a single interface or product may be used by individuals from varied nationalities. Since the early 1980s, researchers have demonstrated how the perception of icons, symbols, colors, and layout differs across cultures. Various terms like ‘Culturability’ and ‘Cultural Markers’ have been created to emphasize the relationship between culture and usability. In context of these developments, the experiment explores differences in perceived interface usability based on cultural dimensions as defined by Geert Hofstede. The two dimensions used for the experiment were Uncertainty Avoidance and Power Distance. The study was conducted for two cultures, namely, India and United States and user satisfaction as well efficiency of the users was measured during the experiment. No direct interactions were discovered between Nationality and Power Distance or Nationality and Uncertainty Avoidance. However, the difference in average time taken for a high Power Distance interface was found to be more than a low Power Distance interface irrespective of nationality. A significant three-way interaction was discovered between Nationality, Uncertainty Avoidance and Power Distance for User Satisfaction Ratings. The findings suggest a complex interaction between culture and interface elements whose comprehension needs further experimentation and analysis. Also, eight out of ten of the Indian subjects who worked with a low Uncertainty Avoidance interface said that they would have preferred a high Uncertainty Avoidance interface with more visual cues.

TABLE OF CONTENTS

LIST OF FIGURES v

LIST OF TABLES vi

ACKNOWLEDGEMENTS vii

Chapter 1 Literature Review 1

1.1 Introduction 1

1.2 Usability 2

1.3 Culture 4

1.3.1 Definition and Basics 4

1.3.2 Culture and Usability: 6

1.3.3 Usability and Hofstede's Cultural Model 9

1.3.3.1 Dimensions of Culture 10

1.3.4 Implications of Hofstede's Dimensions for Interface Design 12

1.3.4.1 Power Distance 12

1.3.4.2 Uncertainty Avoidance 13

1.3.4.3 Individualism 13

1.3.4.4 Masculinity 14

1.3.4.5 Long – term Orientation 14

Chapter 2 Hypothesis 16

Chapter 3 Methodology 19

3.1 Independent Variables 19

3.2 Dependent Variables 20

3.3 Experimental Design 21

3.4 Task and Interface Design 22

3.5 Participants 27

3.6 Procedure 27

Chapter 4 Results 29

4.1 Average Time and Errors 29

4.2 Ratings ... 32

Chapter 5 Discussion and Conclusions ... 36

5.1 Discussion ... 36

5.2 Future Work ... 38

References ... 40

Appendix A Pre-test Questionnaire ... 43

Appendix B Usability Evaluation Form ... 44

Appendix C Tasks with the HomeMaker ... 47

LIST OF FIGURES

Figure 3-1 Screenshot for high UA and low PD 23

Figure 3-2 Screenshot for high UA and high PD. 24

Figure 3-3 Screenshot for low UA and low PD 25

Figure 3-4 Screenshot for low UA and high PD. 26

Figure 4-1 Normal Probability Plot of residuals for Average Time........ 31

Figure 4-2 Probability Plot of effects for Avg Time. 32

Figure 4-3 Normal Probability Plot of residuals for Ratings. 33

Figure 4-4 Probability Plot of effects for Ratings. 35

LIST OF TABLES

Table 1-1 Scores for India and US from Hofstede's Study. 15

Table 3-1 Operational Definitions of Low and High Conditions of Independent Variables 21

Table 3-2 Demographics for subjects in the study.. 27

Table 4-1(a): ANOVA for Average Time. 30

Table 4-1(b): Regression Information for Average Time... 31

Table 4-2(a): ANOVA for Ratings.. 33

Table 4-2(b): Regression Information for Ratings.. 33

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Chapter 1

Literature Review

1.1 Introduction

Over the past few decades, with an increase in technological innovation, product design has begun to be driven by consumer preferences rather than the manufacturer's convenience. Interface design too has seen a similar trend where usability evaluations throughout the design cycle, participatory design are gaining more and more importance. A spiral model (Boehm, 2007) for system development is one of the numerous examples which supports the involvement of stakeholders and includes users, right from the beginning of the development until its release and maintenance. Today, in a user-centered design oriented scenario, individual differences of users, for example, cognitive abilities of users are becoming an increasingly important factor affecting interface design.

Further, web interfaces are no longer just utilitarian; they are used for social networking, career networking, planning, and have become an integral part of not only professional, but personal lives of users too. With the world moving towards becoming a Global Village, a single web interface or a product manufactured in USA may be used as far as Argentina or China and vice-versa. A call-center employee in India answering queries from all over the world might be using an interface designed in USA, shop-floor workers in a production company in Argentina, USA, and France might be using an interface designed in China. In the past decade, human factors literature has seen an increasing number of papers stressing importance of cultural background of the users as an important individual difference that should be taken into account while designing an interface. The present report is an attempt in the same direction, wherein culture has been integrated with interface design and tested to see how it may affect user performance and satisfaction. The following sections discuss and explain each of the guiding factors for this experiment in detail.

1.2 Usability

In recent years, Usability has fast grown from being a novel concept to being an important part of interface design and development cycle. The following sections define and explain the concept of usability in greater detail.

1.2.1 Definition and Basics

Usability describes the quality of a user interface and is the most important property of the interface (Shackel,1990).While utility measures whether the functionality of the system can do what is needed, usability measures how well users can use the functionality offered by a system, that is, how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process (Nielsen, 2003); thus usability is a key component of good user-experience.

According to the ISO 9241-11(1998) standard for usability, usability is “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. The standard further explains that effectiveness is measured in terms of accuracy and completeness, efficiency is measured as the resources used to achieve that accuracy and completeness and satisfaction is measured as freedom experienced by user from discomfort, and a positive attitude towards the use of the product.

Various studies employ different methods to measure each of the aforementioned aspects of usability. Effectiveness is measured as accuracy by quantifying the number of errors users make either during the process of completing tasks or in the solution to the tasks e.g. number of errors in data entry, clicking on the wrong link, pressing the wrong button etc. (Nielsen, 1994). Further there are two subgroups of accuracy Spatial Accuracy which measures the distance from target icon/link or orientation error, and Precision which measures the ratio of correct information retrieved to total information retrieved (Hornbæk, 2006). Completeness refers to measures of the extent to which tasks are solved.

Efficiency is the measure of time taken by users to complete a task once they have used and thus learned the interface. It is measured in terms of task completion time, Input rate, mental effort, and resources expended in communication processes. (Hornbæk, 2006).

Satisfaction defines how pleasant do the users find the interface to use. It is a subjective component of usability, since the meaning of satisfaction can vary from one user to another, for example, for some users the look of an interface may be more important for satisfaction than utility. At the same time, for another user the time taken for completion of tasks may decide how satisfactory do they find an interface. These preferences may be affected by their cultural background, their profession or simply the purpose for which the interface is being used. Various methods employed for measuring satisfaction of users with the interface include using standardized questionnaires, ratings for an interface, rankings for interfaces, measuring users' perception of the interaction or outcome of interaction with the interface etc. (Hornbæk, 2006).

While Nielsen (1998) defines Learnability and Memorability as separate aspects of usability but several studies consider learnability to be a part of efficiency (Hornbæk, 2006) and Memorability, also referred to as Recall (Hornbæk, 2006) as a part of the effectiveness of the interface.

1.3 Culture

1.3.1 Definition and Basics

Culture is a broad concept that incorporates a wide range of features. Merriam-Webster online defines Culture as "customary beliefs, social forms, and material traits of a racial, religious, or social group." Fons Trompenaars, a Dutch management consultant (1998), defines the various levels of culture, namely, National, Corporate and Professional. At the national level, culture refers to the part of an individual's personality that develops in a particular way because of his nationality. At the organizational level, it is the way attitudes are expressed; values are held by the members in a specific organization. At the professional level, culture is the orientation of the people belonging to similar professions or performing similar functions. This does not mean to imply that individuals from two different nationalities or organizations can't have more in common than those from the same organization or country. Personality of an individual makes him or her unique, thus, within a particular culture there may be differences between individuals, which make them more similar to individuals from other cultures than their own compatriots or co-workers.

Human interface design uses theories from the field of intercultural communication as a guide to include culture in product design. Instead of focusing on a particular culture, these theories give better insight into differences between various cultures, which can act as an effective guide to variations required in an interface to be designed for a culturally diverse audience. (Aykin, 2005).

Various new terms have been created by different authors for example, Hall, Hofstede, Trompenaars and Traindis, to name a few, to break up culture into smaller components and study the differences. Though these terms may have been named differently and defined at different times by different people, at times, they are overlapping or refer to similar components. For example, Hall (1990) talks about the concept of formal and informal time within cultures and refers to it as Chronemics while Trompenaars (1997) distinguishes cultures as Sequential or Polychronic, to discuss the idea of time. Hofstede's (1980) cultural model and theory of cultural dimensions is one of the most well-known and widely applied models in both the field of management as well as interface design. Khaslavsky(1998) demonstrated an instance of merging the existing cultural models by Hall, Trompenaars and Hofstede for applications in interface design. The present study used Geert Hofstede's cultural dimensions and these are explained in the following sections.

1.3.2 Culture and Usability:

Recent research has established cultural background of the users to be an important factor affecting the perception of an interface's usability. As early as 1990, Del Galdo provided guidelines regarding internationalization of interfaces and discusses that the perception of icons, symbol and colors differs across cultures. Later, Del Galdo and Nielsen (1996) discuss the layout of web pages as it might differ across cultures, for example, Arabic users read right to left and Chinese read top to bottom.

A study conducted by Evers and Day (1997) with 206 international students and a control group of 38 Australian students supported the view that design preferences are an important factor in interface acceptance and they vary across cultures, for example, Chinese users accept an interface they perceive as 'useful' more readily even if it is hard to use. However for Indonesian users', the more easy to use the interface appears, the more readily they work with it, while the Australian users' acceptance for an interface increases in proportion to its closeness to their design preferences. This study is further discussed in light of Hofstede's cultural model.

Barber and Badre (1998) coined the term Culturability to emphasize the relationship between culture and usability and they identified 'cultural markers'- interface design elements prevalent in particular cultural groups, for example, colors, spatial organization, fonts, shapes, icons and metaphors, flags etc.

Shappard and Scholtz (1999) found that absence or presence of cultural markers affects user performance with websites. Similarly, Cyr and Trevor-Smith (2004) analyzed design elements like use of symbols and graphics, color preferences, site features etc.,for

30 municipal websites each in Germany, Japan, and the U.S. Their findings supported the previous studies as their experiment concluded that design preferences differed across cultures. Layout, symbols, navigation, and the use of color are amongst important design elements that vary across cultures and need to be taken into account for localization.

In their study, investigating the cultural aspects of a website, Evers et al (1999) carried out a study with sixteen participants from four cultural backgrounds, four English, six Dutch, four Sri-Lankan and two Japanese. They chose DirectED, a virtual campus, and investigated the differences across participants of different cultures regarding the interpretation of campus metaphor. They found that participants from all cultures did not recognize the campus metaphor and that different labels and icons were interpreted differently by users from different cultures. Similarly, Duncker (2002) studied the usage of library metaphor and a library designed following the western conventions with respect to Maori, the native population of New Zealand. The study concluded that the usage of Library metaphor failed and the design of the library did not allow an effective use of the resources by Maori students, to the extent that they were scared and avoided the use of library.

A recent study by Reinecke and Abraham Bernstein conducted with Imbuto, software for Rwandan agricultural advisors (2007) established that Rwandans could not optimally use the software designed following the western design practices. Being used to following strict instructions, Rwandan subjects found it difficult to work effectively with range of functionalities available in the software. The look of the software was then adapted to a more colorful and playful one as well the functionality modified on lines of the local culture. Evaluations following this revealed that the efficiency of the users increased with the cultural adaptation.

Various studies in the field of e-marketing have analyzed differences in online consumer behavior based on their cultural background. A study by Chau et al (2002) conducted with subjects from Hongkong and America discovered that individuals from Hongkong used internet more for social communication as compared to their American counterparts, who used internet more for search purposes. Thus, the e-marketing websites designed for users from Hongkong and other such collectivist cultures (Hofstede, 2001) should have more community-like feel to themselves as compared to American websites which should have a strong information search functionality incorporated into them. Singh et al (2005, 2006) provided empirical evidence that in comparison to standardized websites, consumers from Germany, Spain, Netherlands, Switzerland, Italy, China, and India preferred culturally adapted websites. Cyr et al (2008) confirmed the same for Indian consumers in a study conducted on a localized and foreign version of Samsung website.

Another recent study (Gennadi and Porter, 2008) based on Hofstede's cultural dimensions conducted for the American and Chinese students demonstrated that perception of a website's features is affected by the cultural background of the user. Chinese students, belonging to a high Power Distance society gave more importance to the features of the website related to Power Distance, for example, linear, hierarchical menus, quality assurance etc. The American students showed a preference for website features supporting the low Uncertainty Avoidance, a characteristic of their culture. Similarly, Steenkamp and Geyskens (2006) conducted a study across 23 countries and 30 websites and found that consumers from individualistic cultures consider pleasure, privacy/security protection, and customization in their perceived value judgments to be more important as compared to consumers from collectivistic countries.

In one of the few studies of their kind, (Cyr, 2005; Cyr et al 2008) explicitly linked Hofstede's cultural dimensions to e-loyalty through website design. It was demonstrated that the perception of website design and its relationship with developing trust varies across cultures, and each of the design elements, that is, Navigation Design, Information Design, and Visual Design had different effects on satisfaction and trust of the consumers across varying cultures.

1.3.3 Usability and Hofstede's Cultural Model:

Hofstede defines culture as "the collective programming of the mind that distinguishes members of one group or category of people from another." Further he states that culture determines uniqueness of a human group, the same way as personality determines the uniqueness of an individual. He carried out a series of surveys spread over a span of four years in 53 countries. Through these surveys, originally Hofstede measured culture through the first four dimensions described below, that is, Uncertainty Avoidance, Individualism vs. Collectivism, Masculinity vs. Feminity and Power Distance, while a fifth dimension Long Term vs. Short Term Orientation was added later based on Chinese Value Survey (CVS) developed in Hong Kong. The five dimensions of culture as defined by Hofstede are as described below.

1.3.3.1 Dimensions of Culture

Power Distance

In simple terms, Power Distance is defined as the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally.

Power Distance Index (PDI) is a measure of Power Distance in a culture where a higher PDI means a higher inequality and culture's with low PDI believe in independence of individuals, equal rights and that the use of power should be legitimate and is subject to the judgment between good and evil, for example, USA, Norway and Netherlands . On the other hand, cultures with a high PDI, for example, India and Venezuela believe in the dependence of the weaker/powerless on those who are more powerful, the powerful are entitled to privileges and power is the basic fact of society that antedates good or evil: its legitimacy is irrelevant.

Uncertainty Avoidance

Uncertainty Avoidance is the extent to which the members of a culture feel threatened by uncertain or unknown situations. Uncertainty Avoidance Index (UAI) is a measure of tendency for Uncertainty Avoidance in a culture. Cultures with high UAI, for example, Singapore, Hong Kong, Malaysia consider it normal to express emotions, consider loyalty to company a virtue, have a larger generation gap, believe in consultative management and are more resistant to changes. On the other hand, cultures with a low UAI believe in Individual decisions, are less resistant to changes, and are more accepting to foreigners as managers.

Individualism

Individualism, that is, high Individuality Index (IDV) stands for a society in which ties between the individuals are loose: Everyone is expected to look after himself/herself and her/his immediate family only, for example, Norway, Finland and Australia. Collectivism or low IDV stands for a society where people from birth onwards are integrated into strong cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty, for example, Pakistan and Venezuela.

Masculinity

Masculinity, or high Masculinity Index (MAS), stands for a society in which social gender roles are clearly distinct. Men are supposed to be tough, assertive and focused on material success; women are supposed to be more modest, tender and concerned with quality of life, for example, Japan and Mexico. Feminity or low MAS stands for a society in which social gender roles overlap: both men and women are supposed to be tender, modest and concerned with quality of life, for example, Sweden, Norway.

Long – term Orientation

Long Term Orientation stands for fostering of virtues towards future rewards, for example, perseverance and thrift, for instance, East Asian Countries like China. Short Term orientation stands for the fostering of virtues related to the past and the present. Long Term Orientation Index (LTO) measures the extent of long term orientation of a culture. Cultures with high LTO believe in persistence, perseverance and savings while low LTO cultures, like Western Countries are not as savings-oriented and expect quick results.

1.3.4 Implications of Hofstede's Dimensions for Interface Design

A few recent studies have attempted to link Hofstede's Dimensions to usability and develop a framework for Culture and its implications on interface design. The outline of implications of some studies in this direction is presented as below.

1.3.4.1 Power Distance

For societies with high Power Distance, the website should focus more on company hierarchy, titles, social standing and the information should be highly structured with explicit barriers to access (Marcus and Gould, 2000). Further, for high Power Distance societies, there should a frequent usage of nationalist and religious symbols, mention of awards won, quality certifications, quality assurance etc. (Singh and Pereira, 2005).

For societies with low Power Distance, access to information and navigation should not be restricted. The sites should focus more on the employees, citizens etc. and there should be minimal usage of religious and authoritative symbols. (Marcus and Gould, 2000).

1.3.4.2 Individualism vs Collectivism

For individualist cultures, the website should focus on the personal achievement, and prominence should be given to youth and there should be an emphasis on change. (Marcus and Gould, 2000). Also, interfaces designed for individualistic cultures should allow customization and personalization by users. (Choi et al, 2005). Individualistic cultures value privacy highly and so a good privacy statement is essential to earn the trust of the users. (Singh and Pereira, 2005).

On the other hand, for collectivist cultures, the web interfaces should emphasize on group achievement, community-oriented look and feel, and should avoid having a controversial/argumentative style. (Marcus and Gould, 2000). Websites designed for collectivist cultures should include chat rooms, product-based clubs and support social communication (Singh and Pereira, 2005; Chau et al, 2002). Further, these websites should frequently use symbols, icons, links and references to local culture to give the users a feeling of familiarity and belongingness to the community. (Singh and Pereira, 2005).

1.3.4.3 Uncertainty Avoidance

For cultures with a high Uncertainty Avoidance, the choices provided by the interface should be limited, the navigation should be simple with cues to prevent the users getting lost e.g. breadcrumbs and help should be readily available to reveal the implications of an action. (Marcus and Gould, 2000). Also, round-the-clock customer service in form of call centers, emails, and chat should be provided. The site should provide testimonials from existing customers and seals of trust to reduce any uncertainty and distrust regarding safety of transactions. (Singh and Pereira, 2005).

Interfaces designed for cultures with low Uncertainty Avoidance should offer wide range of choices, encourage exploratory navigation and the content should be information-rich in nature. (Marcus and Gould, 2000).

1.3.4.4 Masculinity vs Feminity

Interfaces designed for high-masculinity cultures would be utilitarian and focus on work tasks, roles guided by developing mastery in those tasks, the navigation should be exploratory, control-oriented, hence, encouraging traditional distinctions and division in gender roles, age and family. (Marcus and Gould, 2000). Further, the interface should provide tips, tricks and useful information as well as promote products/services through information regarding the product's robustness, quality and functionality. (Singh and Pereira, 2005).

On the other hand, for feminine cultures the interfaces should be visually appealing, giving a feel of mutual co-operation and support and traditional distinctions, especially those based on gender should be blurred. (Marcus and Gould, 2000). The intangible and subjective aspects of a product or service should be used to promote the product/service. (Singh and Pereira, 2005).

1.3.4.5 Long Term Orientation vs Short- Term orientation

For cultures with a long-term orientation, the interface design should be practical in nature and focus should be on developing a relationship with the user so as to establish credibility and reliability as a source of information. (Marcus and Gould, 2000). Also, users from cultures with long-term orientation would be more likely to wait for a result as long as it seems credible and in line with their purpose. (Choi et al, 2005)

Interfaces designed for cultures with short term orientation should give quick results and the focus should be on reporting facts as well. The interface should have a modern, bright look to itself. (Marcus and Gould, 2000).

Table 1-1: Scores for India and US from Hofstede's Study

Cultural Dimension	**Highest**	**Lowest**	**India**	**USA**
Power Distance	112	11	(High) 77	(Med) 40
Uncertainty Avoidance	112	8	(Med) 40	(Med) 46
Individualism	91	6	(Med) 48	(High) 91
Masculinity	95	5	(Med) 62	(Med) 56
Long Term Orientation	118	00	(Med) 61	(Low) 29

Chapter 2

Hypothesis

In this chapter, inferences derived from the literature review are presented as the hypotheses to be tested later.

As discussed in the previous chapter, most of the studies based on culturally adapted interfaces have been carried out with regards to the e-business and these have tried to find out effect of cultural adaptation of websites on consumer preferences, customer loyalty etc . Very few studies have tried to test the effect of culturally adapted interfaces on the performance of the users with the interfaces. It is expected that a Graphical User Interface (GUI) customized for a culture will improve the performance as well the satisfaction of the users with the GUI. Also, the examples quoted in previous sections are from e-business websites and none of them mention a study related to task-based GUIs. The two cultural dimensions from Hofstede's cultural model that have been used in this experiment are Uncertainty Avoidance and Power Distance.

2.1.1 Influence of cultural customization on the efficiency of using an interface

H1.1: For countries with a high Power Distance score, the customization of a website to incorporate the hierarchical structure of the society into the interface will increase their efficiency with the interface as compared to their efficiency with an interface without a hierarchical structure.

H1.2: For countries with a low Power Distance score, the customization of a website to incorporate the hierarchical structure of the society into the interface will not significantly affect their efficiency with the interface as compared to their efficiency with an interface without a hierarchical structure.

H1.3: Subjects from countries with low Uncertainty Avoidance index will have a higher efficiency while working with an interface designed to decrease uncertainty as compared to an interface designed for high uncertainty.

2.1.2 Influence of cultural customization on the number of errors committed while using an interface

H2.1: For countries with a high Power Distance score, the customization of a website to incorporate the hierarchical structure of the society into the interface will decrease the number of errors committed while working with the interface.

H2.2: For countries with a low Power Distance score, the customization of a website to incorporate the hierarchical structure of the society into the interface will not significantly affect the number of errors with the interface as compared to those with an interface without a hierarchical structure.

H2.3: Subjects from countries with low Uncertainty Avoidance index will commit lesser number of errors while working with an interface designed to decrease uncertainty as compared to an interface designed with high uncertainty.

2.1.3 Influence of cultural customization on user satisfaction

H3.1: For countries with a high Power Distance score, the customization of a website to incorporate the hierarchical structure of the society into the interface will increase the user satisfaction while working with the interface.

H3.2: For countries with a low Power Distance score, a website with a hierarchical structure will decrease the user satisfaction while working with the interface.

H3.3: For countries with a low Uncertainty Avoidance index, user-satisfaction will significantly increase while working with an interface designed to decrease uncertainty as compared to an interface designed with high uncertainty.

Chapter 3

Methodology

The literature review and creation of hypothesis for research was followed by development of a methodology to test the hypothesis. Present chapter presents the details and rationale for the experimental design followed to test the hypothesis.

3.1 Independent Variables

As discussed before, based on the literature review and application to a task-oriented interface, the two dimensions chosen to test were those of Power Distance and Uncertainty Avoidance. Both the dimensions were manipulated on two levels, low and high, through the design of the interface.

As discussed in Section 1.3.4, the high Power Distance features included a very clear and defined hierarchy of the interface elements. Also, the menus are deep instead of broad. An interface designed with a low Power Distance on the other hand, doesn’t have a clear hierarchy and broad menus and an open navigational design.

The interface for high Uncertainty Avoidance was designed to have a clearly visible navigation path for the user. Further, visual cues were provided in the form of background pictures to keep the user aware of their position in the interface. Alert-boxes were provided to notify the user of results of their actions. Status indicators with redundant visual cues were made available. On the other hand, the interface designed for low Uncertainty Avoidance didn’t make the navigation path visible nor were there any redundant clues provided and the design was more exploratory in nature. Four different interfaces were created to support these combinations of high and low variables; this is discussed in more detail in section 4.4.

3.2 Dependent Variables

The main dependent variables measured during the experiment were related to user performance. The two measures of user performance were efficiency measured as the time taken to complete each task and the number of errors committed while completing each task. The time taken to complete each task was measured using a stop-watch. The errors were recoded while observing the users during the completion of a task.

As an additional dependent variable, user satisfaction was measured using an adapted version of the IBM Post-Study System Usability Questionnaire, found in Appendix B. The original version (Lewis, 1993) consists of 19 questions, but it was modified as two of the questions didn't apply to this study. For each question the participants had to mark their responses in the form of a Likert scale, by choosing a number from 1 (Strongly Agree) to 7 (Strongly Disagree). The average of these responses was used to obtain an overall perceived usability score for each completed questionnaire.

3.3 Experimental Design

A 2 x 2 full factorial between-subjects design was used in this study. A between-subjects design was specifically used to avoid any training effects that might result from the usage of the system twice. Each of the independent variables, Uncertainty Avoidance (UA) and Power Distance (PD) were varied on two levels, low and high. As discussed in Section 4.1, high Power Distance was operationalized in the high condition by designing menus with clear deep hierarchy versus broad, non-hierarchical menus in the low PD condition. Uncertainty Avoidance was operationalized through visual cues, guided navigation, with unguided navigation and few visual cues in the low Uncertainty Avoidance condition versus more redundant visual cues and guided navigation in high Uncertainty Avoidance condition. The order of the four experimental runs was randomized, and the orders were randomly assigned to participants.

Table 3-1: Operational Definitions of Low and High Conditions of Independent Variables

	Power Distance (PD)	Uncertainty Avoidance (UA)
Low	Broad Menus using tabs	- Fewer visual cues - Unguided Navigation - No/Few Confirmation messages
High	Deep Hierarchical Menus using tree structure	- Redundant visual cues - Guided Navigation - Confirmation messages

3.4 Task and Interface Design

The task that the participants completed in this study was a usability assessment of a GUI for controlling the electrical appliances in a home. The subjects were asked to imagine a scenario in which all their electrical appliances at home can be remotely accessed through their computer using a program called "HomeMaker". (See Appendix C for scenario information). The various appliances controlled through the Homemaker are:

- Lighting
- Heating/Cooling
- Refrigerator
- Burglar Alarm
- Vacuum Cleaner

They were then provided with a list of tasks that they had to complete using the interface. This GUI was especially created for this experiment. One of the major reasons for selecting this GUI was that the previous experience of the participants should not affect their expectations from the interface. Since most of the participants were students at Penn State University, it was assumed that they would have no or very limited experience of dealing with such an interface since such a scenario in real life would entail owning a home, not to mention the very expensive set-up of such a system. At the same time, the interface should be manipulated in ways that appeal to an everyday life application. The subjects were told that they were to test a particular interface for its usability.

The four combinations of the interface were those with

- Low UA, Low PD
- Low UA, High PD
- High UA, Low PD
- High UA, High PD

The interface was developed from scratch for the purpose of this experiment. A few screenshots of the interface are presented in Figures 3-1, 3-2, 3-3 and 3-4.

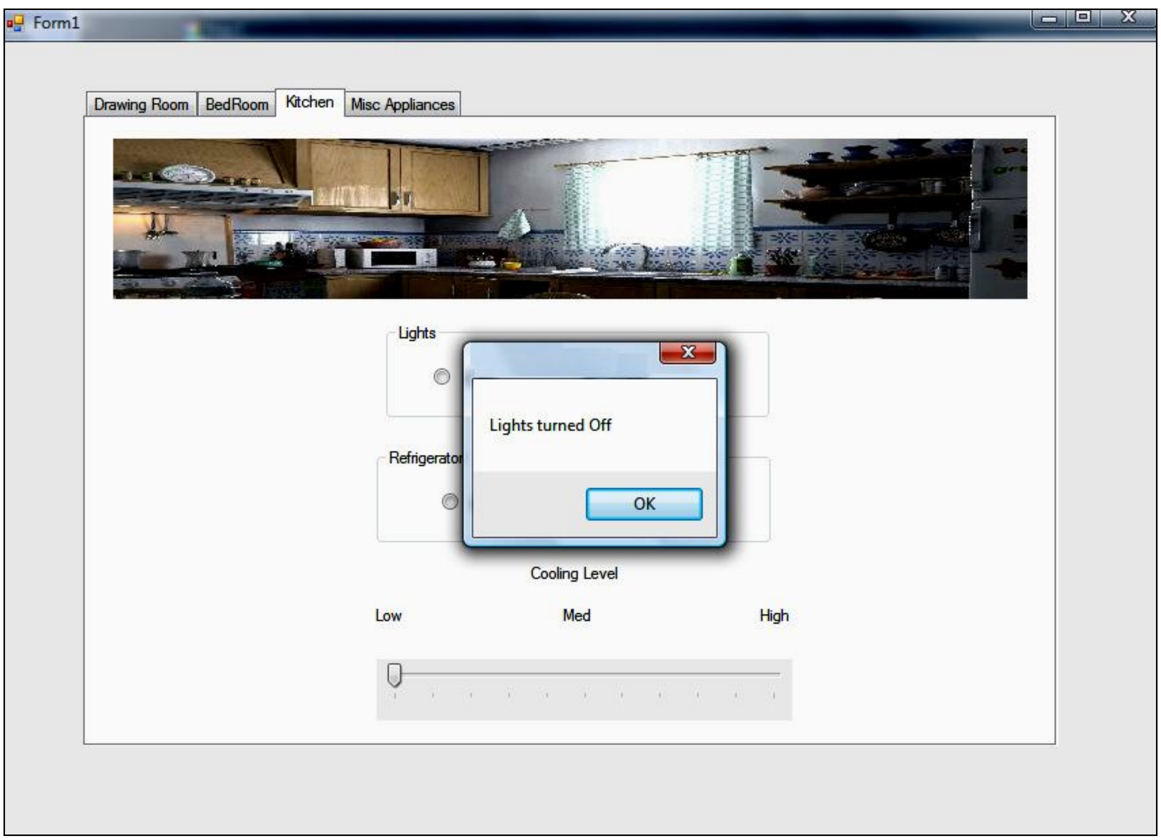

Figure 3-1 Screenshot for high UA and low PD

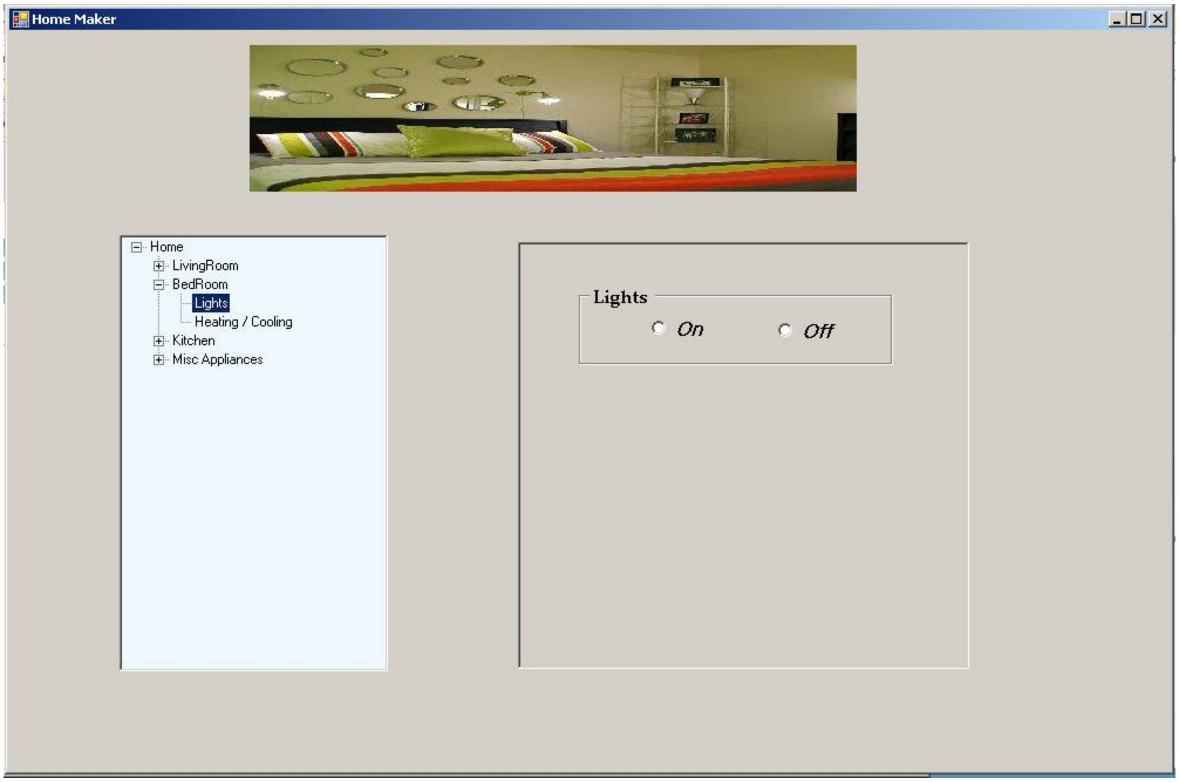

Figure 3-2 Screenshot for high UA and high PD

The High Power Distance feature of the interface was manipulated using a tree structure with deeper hierarchy as compared to the low Power Distance interface which had a broader menu operationalized using tabs. The High Uncertainty Avoidance features included confirmation messages at the end of every task, visual cues in form of change of pictures in the background to give user a better idea of where they were and a guided navigation through redundant visual cues. The interfaces were reviewed by a Senior Software Engineer and a Business Analyst with previous experience in usability field.

The various tasks designed for the experiment were:

- Switch on the lights in the living room.
- Set the temperature of the refrigerator to normal

- Turn the heating in the bedroom “On” and set the temperature to 75 degrees Fahrenheit.
- Reset the passkey of the Burglar Alarm from 1234 to 5467
- Track the current status of the vacuum cleaner and send it to a particular room.

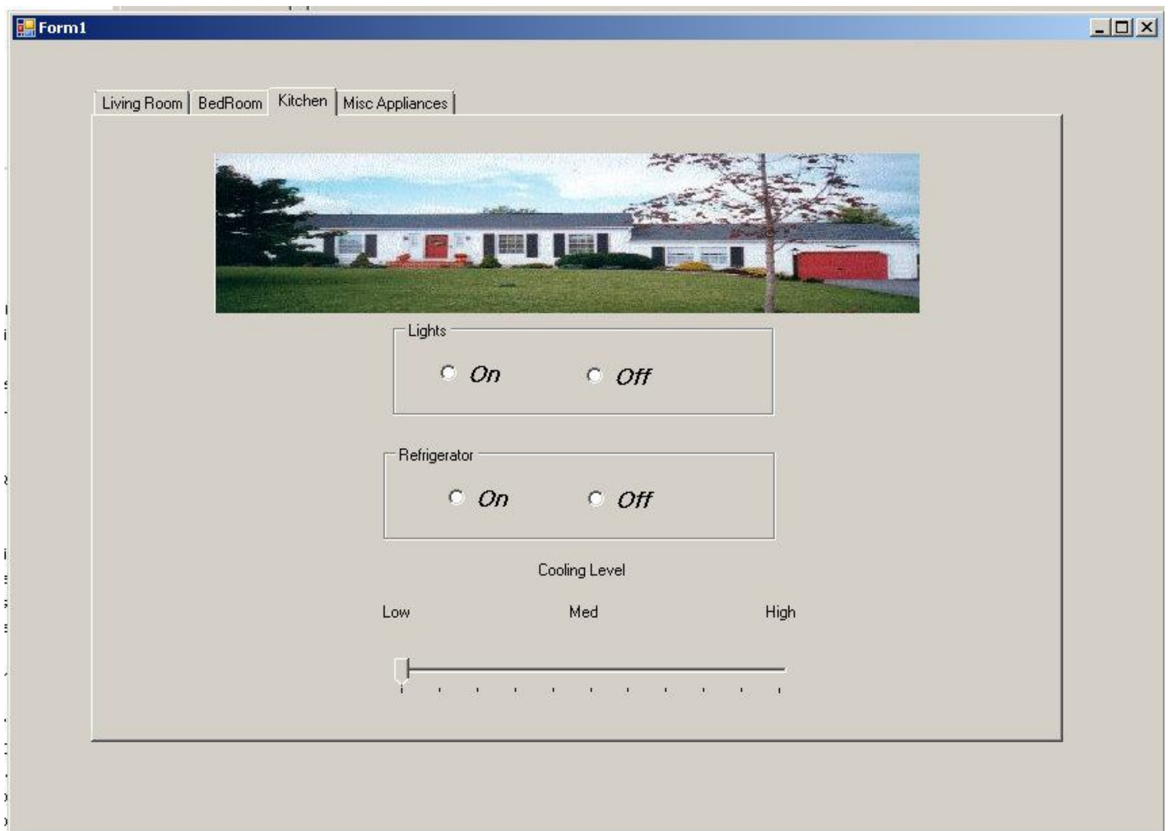

Figure 3-3 Screenshot for low UA and low PD

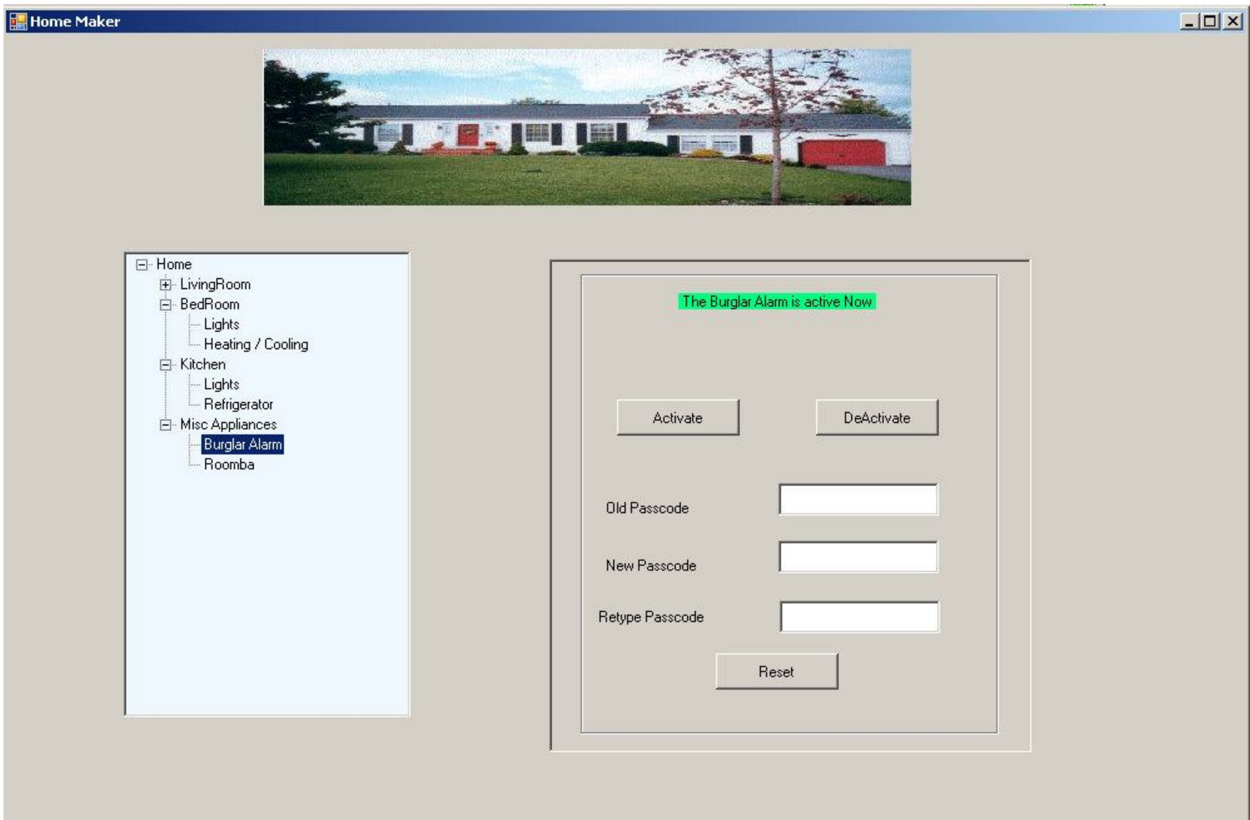

Figure 3- 4 Screenshot for low UA and high PD

Since the automatic control of the vacuum cleaner is still not a widely used concept, the scenario contained a more detailed description of this task where they were given a description of how does Rumba - the vacuum cleaner operate. To keep the users getting biased by the visual appearance of the interface, the look of the interface was intentionally kept very plain and just included the minimum aesthetics needed for conducting an experiment.

3.5 Participants

The study recruited participants from the two nationalities, that is, Indian and American. All Indians were originally from India and all Americans were Caucasian, third generation Americans. Since the study was conducted at a university, all participants were students from different backgrounds and educational levels. Data was collected from 41 participants in all, 20 Indians and 21 Americans; other details are presented in Table 3-2 below. None of the participants had any previous experience with remote control of appliances.

Table 3-2: Demographics for subjects in the study

Nationality	**Gender**	**Age**		**Educational Level**	
	Male: Female	Range	Average	Under-graduate	Graduate
Indian	16: 4	21-27	25.5	14	7
American	7: 14	18-24	21	0	20

3.6 Procedure

The study was conducted in a quiet corner of the HUB-Robeson Center at the University Park campus of the Pennsylvania State University. The location was selected mainly for easy access for participants. A Dell Vostro 1000 laptop was used for the study. Participants were first given the implied consent form to read and sign and they were encouraged to ask questions if they had any. Then they were given a demographic questionnaire, attached in Appendix A to fill out which asked them about their age, gender, nationality, and experience with computers. Then they were provided with a short introduction to the application that they had to interact with. Since it was a within-subject design, each subject worked with one of the four versions of the interface, the first task was counted as a warm-up task and was excluded from the analysis. The order of the runs with the subjects was randomized, and different versions of the interface were randomly assigned to participants.

Once ready, the tasks were handed one at a time and in a serial order. After the subject had read the task, and was about to start, he/she was asked to say ‘Start’ and once they thought they were done, they were asked to say ‘Done’ or ‘Stop’. This was especially important since the interface with low UA had fewer alerts and cues regarding the completion of the task, so it was assumed that the subject would take some time to be assured of the fact that the task was completed. The task description was designed to provide them with assumptions, such as the previous passcode for burglar alarm and the new one. This information was provided because it was undesirable for any time to be spent on trying to think of a new passcode. The experimenter recorded the time on a stop-watch for each task, an average of all the tasks was used to calculate efficiency. The errors were recorded by the experimenter while observing the user completing the task. Once the users had completed the tasks, they were asked to fill out the adapted version of the IBM Post-Study System Usability Questionnaire (Lewis, 1993). After the completion of this survey, the users were asked if they had any comments or questions and were debriefed about the study.

Chapter 4

Results

The collected data from 41 participants was analyzed using Analysis of Variance (ANOVA) in ReliaSoft DOE++ where a comparison for the response variables Average time and Rating was done using Adjusted SS for Tests.

4.1 Average Time and Errors

The results for average time were as shown below. Data from 2 subjects was excluded from the analysis as they forgot to say ‘Start’ and ‘Stop’ for 3 tasks affecting the data collected for time. However the user satisfaction ratings for these subjects were included in analysis for the variable Rating.

As discussed in the previous section, the first task was counted as a warm up task and thus not included from the analysis; the average time over the rest five tasks was taken into account for analysis.

First the data analyzed was checked for any transformations needed to meet the Normality assumptions and a natural log transformation was carried out, that is,

$$Y' = \ln (Y)$$

A normal probability plot of the residuals after the box-cox transformation is presented in figure 4-1 below. All calculations were done at an alpha with a value of 0.1. As we can see in the tables 4-1(a),(b) presenting the ANOVA and figure 4-2 presenting a normal probability plot for average time below, the variable Power Distance showed a p-value < 0.05 and suggests that the average time taken for High PD was greater than that for a low PD. However, no significant interaction was found for Nationality*PD and Nationality*UA.

The number of errors committed while task completion was 2, and thus too low to be subject to statistical analysis.

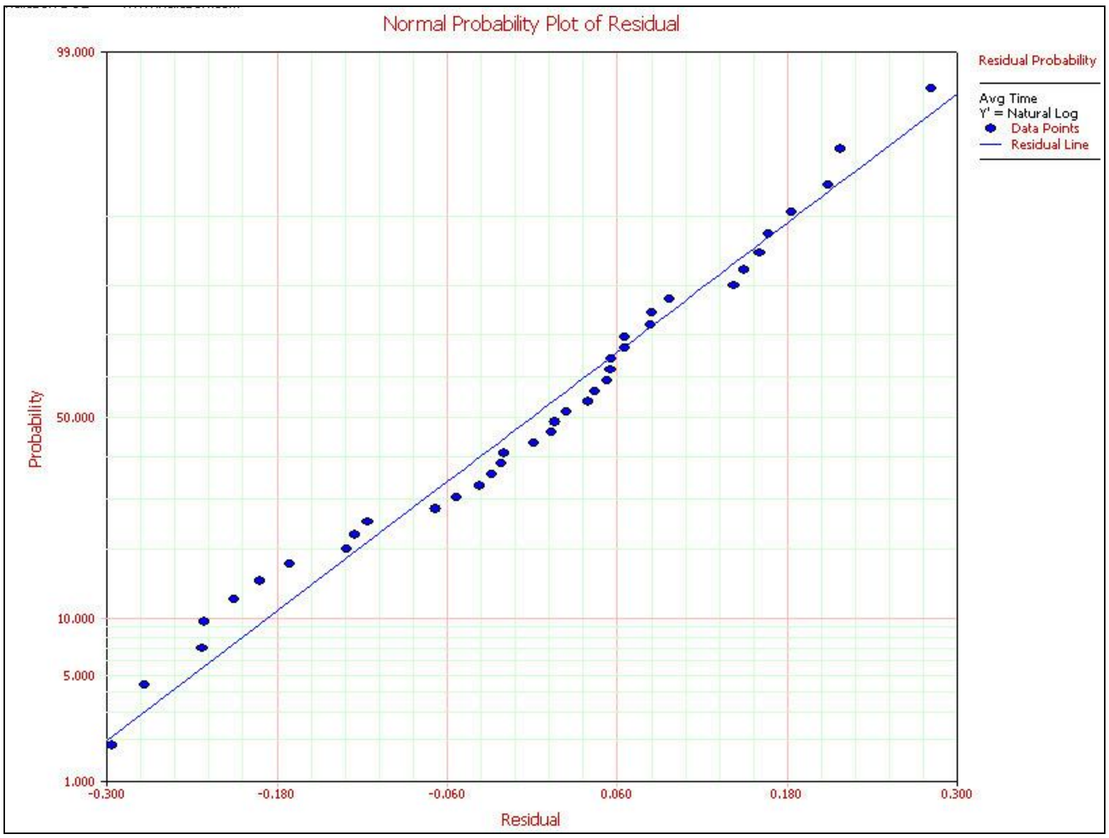

Figure 4-1 Normal Probability Plot of residuals for Average Time

Table 4-1(a): ANOVA for Average Time

ANOVA Table

Source	DF	SS [Partial]	MS [Partial]	F	P
Model	7	0.3341	0.0477	1.741	0.1358
Main Effects	3	0.3094	0.1031	3.7619	0.0206
2-Way Interaction	3	0.0112	0.0037	0.1366	0.9374
3-Way Interaction	1	0.0023	0.0023	0.0838	0.7742
Residual	31	0.8498	0.0274		
Pure Error	31	0.8498	0.0274		
Total	38	1.1839			

S = 0.1656

R-sq = 28.22%

R-sq(adj) = 12.01%

Table 4-1(b): Regression Information for Average Time

Term	Effect	Coefficient	Standard Error	Low CI	High CI	T Value	P Value
Intercept		2.2671	0.0267	2.2218	2.3124	84.8522	0
A:Nationality	-0.0357	-0.0178	0.0267	-0.0632	0.0275	-0.668	0.509
B:PD	0.168	0.084	0.0267	0.0387	0.1293	3.1443	0.0037
C:UA	0.0443	0.0221	0.0267	-0.0232	0.0674	0.8285	0.4137
AB	-0.0219	-0.011	0.0267	-0.0563	0.0343	-0.41	0.6846
AC	-0.0257	-0.0128	0.0267	-0.0581	0.0325	-0.4808	0.634
BC	-0.0032	-0.0016	0.0267	-0.0469	0.0437	-0.0603	0.9523
ABC	-0.0155	-0.0077	0.0267	-0.053	0.0376	-0.2894	0.7742

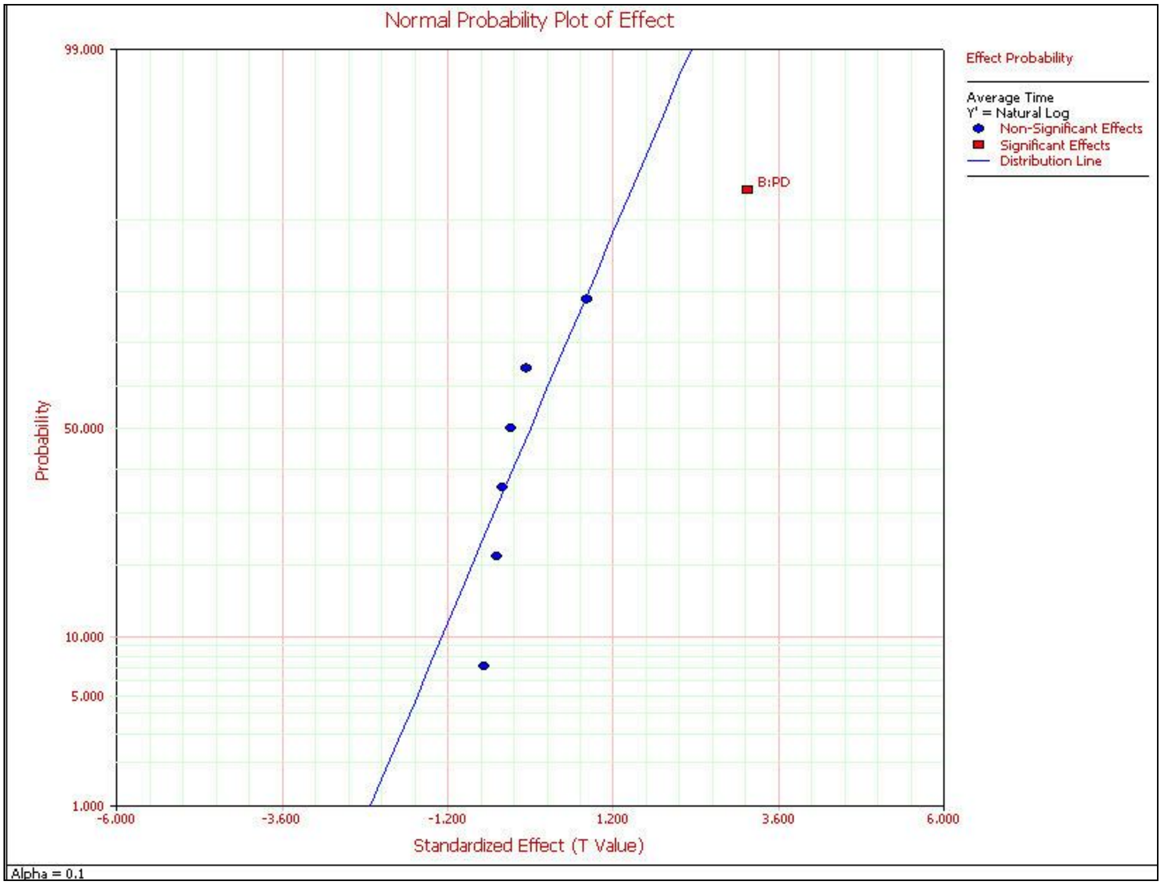

Figure 4-2 Probability Plot of effects for Avg Time

4.2 Ratings

The results for variable 'rating' are as shown below. The rating scale was inverted to use '7' as the best rating and '1' as the least for ease of analysis. An average of rating provided to each of the answers in modified PSSUQ presented in Appendix B was calculated to get a variable rating. First the data obtained was analyzed and for any transformations needed to meet the Normality assumptions and a square transformation was carried out, that is,

$$Y' = Y^2$$

A normal probability plot of the residuals after the box-cox transformation is presented in figure 4-3 below.

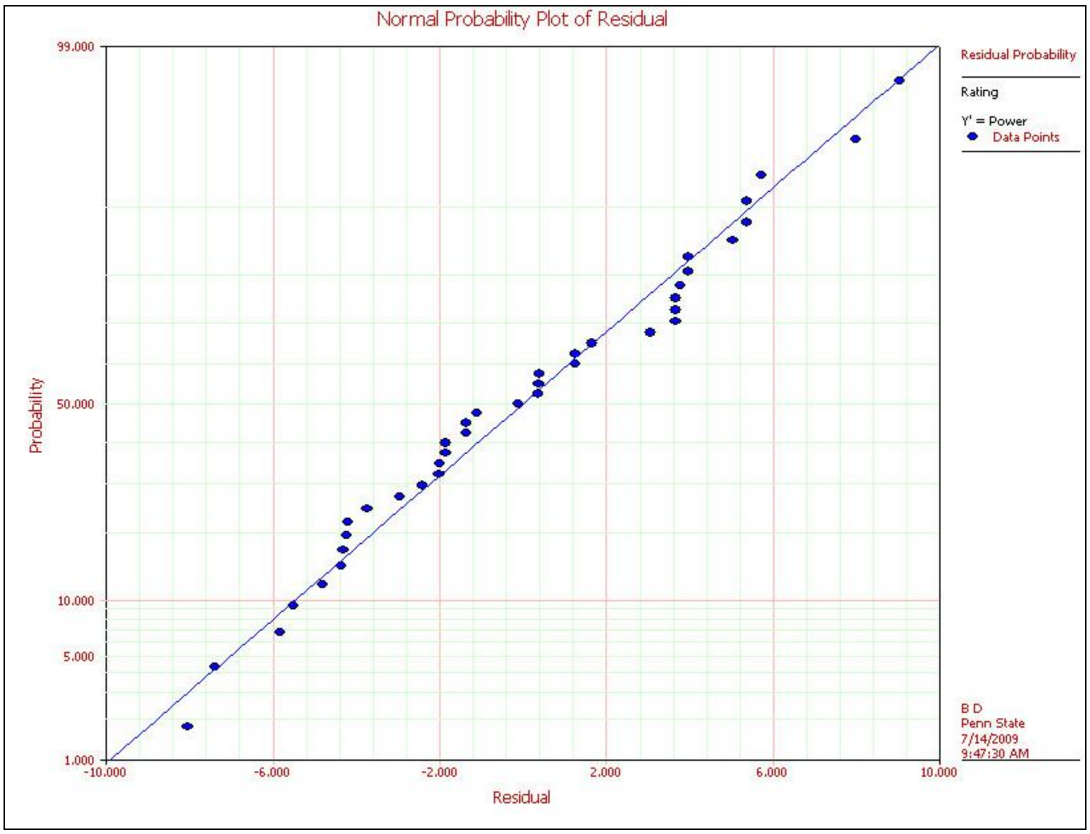

Figure 4-3 Normal Probability plot of residuals for 'Rating'.

As we can see in Tables 4-2(a),(b)for ANOVA and Probability plot of effects for Figure 4-4 presented below, a three-way interaction between the variables nationality, PD and UA was found to be significant but with an adjusted R-sq value of 1.25%. None of the other main effects or two way interactions were found to be significant.

Table 4-2(a) ANOVA and Regression Information for Rating

ANOVA Table

Source	DF	SS [Partial]	MS [Partial]	F	P
Model	7	166.7931	23.8276	1.069	0.4062
Main Effects	3	8.4688	2.8229	0.1266	0.9436
2-Way Interaction	3	25.8002	8.6001	0.3858	0.764
3-Way Interaction	1	120.9068	120.9068	5.4242	0.0266
Residual	31	690.9931	22.2901		
Pure Error	31	690.9931	22.2901		
Total	38	857.7862			

S = 4.7212

R-sq = 19.44%

R-sq(adj) = 1.25%

Table 4-2(b) **Regression Information**

Term	Effect	Coefficient	Std Error	Low CI	High CI	T Value	P Value
Intercept		29.3101	0.7695	28.0055	30.6148	38.0914	0
A:Nationality	-0.3608	-0.1804	0.7695	-1.4851	1.1242	-0.2345	0.8162
B:PD	-0.8805	-0.4402	0.7695	-1.7449	0.8644	-0.5721	0.5714
C:UA	0.1	0.05	0.7695	-1.2547	1.3546	0.065	0.9486
AB	-0.5482	-0.2741	0.7695	-1.5787	1.0306	-0.3562	0.7241
AC	1.4871	0.7436	0.7695	-0.5611	2.0482	0.9663	0.3413
BC	0.4034	0.2017	0.7695	-1.1029	1.5064	0.2622	0.7949
ABC	-3.5842	-1.7921	0.7695	-3.0967	-0.4874	-2.329	0.0266

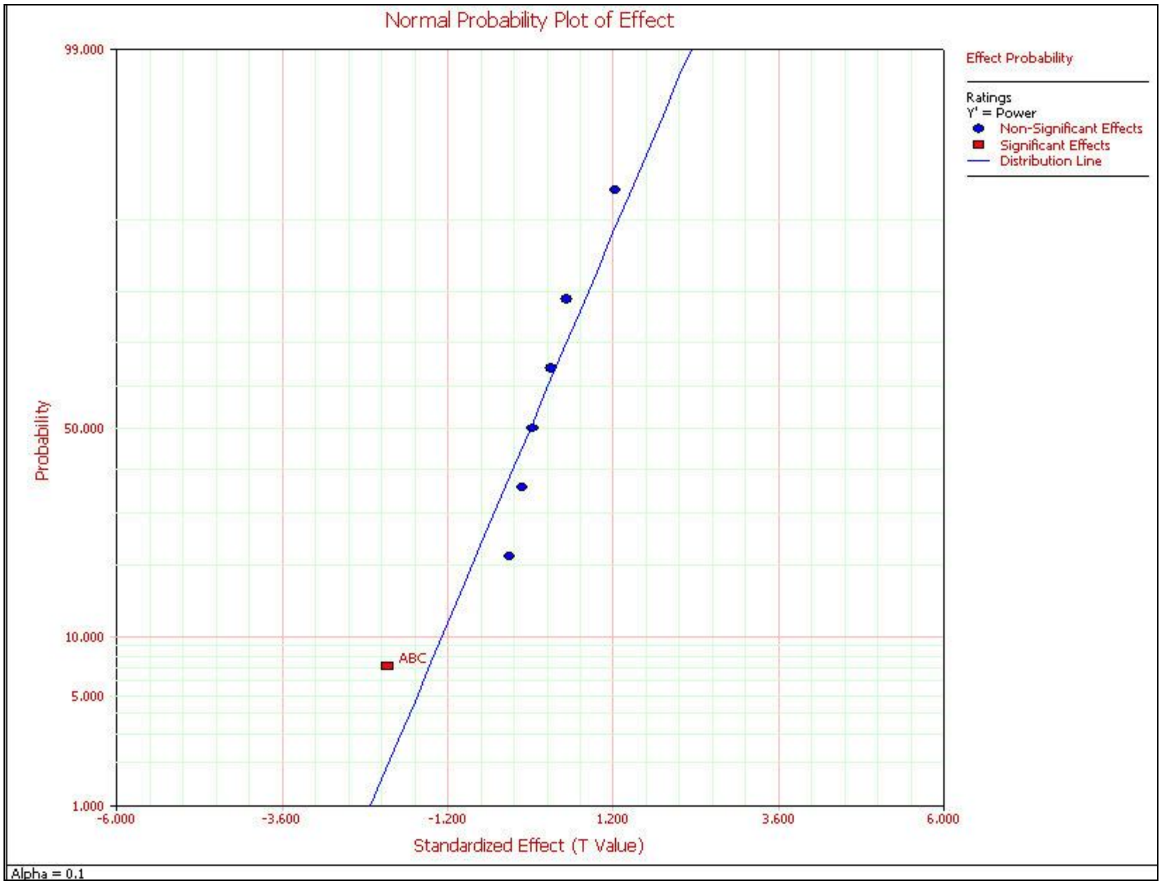

Figure 4 - 4 Probability Plot of effects for Rating

Chapter 5

Discussion and Conclusions

5.1 Discussion

As shown in section 4.1 above, although the p-value for the Power Distance variable was found to be significant the R-sq adjusted is too low to conclude anything significantly. Moreover, another factor that might have contributed the differences in the values is the one extra click that was involved in a High PD interface, since it was designed to have a deeper menu, the user was first required to click on the room and then on the related function e.g. lighting, heating etc while in a low PD interface, once clicking on a tab for a particular room, all functionalities i.e. lighting, heating etc were available on the same page. The time difference between the high PD and low PD interface was calculated using the KLM model in CogTool v1.0.4 (John, 2009) and was found to be 1.784 secs. This was followed by calculation mean difference for average time between high PD and low PD interfaces in the data collected, it was found to be 1.07 secs. This suggests that the one extra click contributed to the appearance of significance for Power Distance irrespective of the nationality.

Since the number of errors committed was too low for any statistical analysis, no significant inferences could be drawn regarding the acceptance or rejection of the Hypotheses 2.1, 2.2 and 2.3.

Further as discussed in section 4.2, none of the main effects were found to significantly affect the ratings of the interface. The ironical reason for this could be the novelty of the interface. As discussed previously, the interface was chosen in a manner that the users do not have a previous mental model that may affect their performance with the interface. However, this proved to be self-defeating in the sense that users found the novelty of the interface to be appealing. 28 out of 41 users found the idea of using a computer interface for controlling home appliances to be very innovative. They made comments like “Neat”, “this is cool”, “I find it very innovative” etc. Another factor that might have contributed to no significant difference in ratings could be the fact that the study was a between-subject design and each subject could only rate the version of the interface that they had worked with, a comparison between the interfaces could have resulted in different ratings which could not be carried out in the present scenario.

Another factor which might have affected the findings of this study could be the gender ratio. 75% of the Indian subjects were males (75%) while the majority of the American subjects were female (67%). This might have confounded the effect of culture with that of gender, that is, the effects discovered could be because of gender difference instead of cultural difference and a distinction can not be made definitively within the scope of this study.

Further, the three-way interaction between Nationality, Power Distance and Uncertainty Avoidance is showing a p-value < 0.05, although with a very low value for adjusted R-sq. Since none of the main effects were found to be significant, the available data is not enough to make definitive conclusions; the three variables are interacting with each other in a way which needs further experimentation to be detangled.

Although Uncertainty Avoidance was not found to be factor significantly affecting the performance of users or their satisfaction ratings but 8 out of 10 Indian subjects who worked with the low Uncertainty Avoidance interface mentioned at the end that they would have liked to see more visual cues in the interface showing the original status of the appliance, any changes to the status as a result of their actions etc. Though, India and US have nearly the same scores for Uncertainty Avoidance, this discovery was unexpected. A reason for this could be the fact that unlike US, the usage of computers, automatic machines etc for completion of everyday tasks is still not as prevalent in Indian culture. Thus, while encountering a new computer interface, an Indian will expect it to resemble the realistic set-up, which he/she is used to in everyday life, as closely as possible.

In conclusion, the findings in this study suggest that a High Power Distance interface may increase the task time for users irrespective of their nationality. Although, further evidence is needed to extend this generalization to more complex interfaces. For Uncertainty Avoidance, the results obtained were not statistically significant for Average Time or Ratings. However, for User Satisfaction Ratings, the scope of this study did not prove sufficient to address the complex three-way interaction between Nationality, Power Distance and Uncertainty Avoidance and further experimentation will be needed to unravel the relationship between these variables. Even though no statistically significant results were obtained for the present study but it is an important step in the direction of studying culture and interface design. It further confirms the fact that the issue of designing interfaces for different cultures still needs extensive research.

5.2 Future Work

Several new questions were raised during this study. While recruiting the participants the first question that arose was that for how many generations does the effect of the original culture last in an immigrant family. The study used participants who were third-generation or later Americans as American subjects but very limited information is available regarding the ‘acculturation effect’, that is, the blending of the culture of the immigrant with that of the dominant host culture and the effect of this cultural blending on interaction with interfaces.

Further, because of the demographics at the University Park campus in Pennsylvania State University, all the American subjects who took part in the study were Caucasian. There is a possibility the results could have been different with African-American subjects since there are several cultural differences between the two as studied extensively in literature.

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Appendix A

Pre-test Questionnaire

1. Please indicate your age _______
2. Gender _______
3. Nationality __________________
4. Please indicate your educational level ________________
5. Please rate your expertise using computers

Amateur Expert

1 2 3 4 5

5. How often do you interact with computers?

No interaction Very often

1 2 3 4 5

Appendix B

Usability Evaluation Form **Subject #**

This questionnaire gives you an opportunity to tell us your reactions to the system you used. Your responses will help us understand what you thought about the usability of this system. Please read each statement and indicate how strongly you agree or disagree with the statement by circling a number on the scale. Thank you.

1. Overall, I am satisfied with how easy it is to use this system

Strongly agree Strongly disagree

1 2 3 4 5 6 7

2. It was simple to use this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

3. I could effectively complete the tasks and scenarios using this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

4. I was able to complete the tasks and scenarios quickly using this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

5. I was able to efficiently complete the tasks and scenarios using this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

6. I felt comfortable using this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

7. It was easy to learn to use this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

8. I believe I could become productive quickly using this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

9. I Whenever I made a mistake using the system, I could recover easily and quickly.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

10. It was easy to find the information I needed.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

11. The information provided for the system was easy to understand.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

12. The information was effective in helping me complete the tasks and scenarios.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

13. The organization of information on the system screens was clear.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

14. The interface of this system was pleasant.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

15. I liked using the interface of this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

16. This system has all the functions and capabilities I expect it to have.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

17. Overall, I am satisfied with this system.

Strongly agree Strongly disagree

1 2 3 4 5 6 7

Appendix C

TASKS WITH "HOMEMAKER"

The "HOMEMAKER" is a software for controlling home appliances through a computer. Complete the following tasks in a serial order using this interface. At the beginning of each task say 'Start' and once you feel you have completed the task say 'Stop'.

1. Switch off the lights in the bedroom.
2. Turn the refrigerator on.
3. Turn the burglar alarm off.
4. Roomba - The vacuum is automatic and once started can be programmed to clean the house on its own. Send the vacuum cleaner to the bedroom.
5. Adjust the temperature in the refrigerator to "Medium".
6. Your old Passcode for burglar alarm is: 1234. Reset the passcode for burglar alarm. The new Passcode is 7490.