

COMPARATIVE STUDY OF USERS'
EXPERIENTIAL DATA COLLECTION
TECHNIQUES FOR HUMAN
COMPUTER INTERACTION DESIGN
IN CROSS CULTURAL SETTINGS

A thesis submitted in partial fulfillment of the requirements for the
degree of
DOCTOR OF PHILOSOPHY

by

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Department of Design,

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INDIA

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CERTIFICATE

This is certified that the work contained in the thesis titled “Comparative study of users’ experiential data collection techniques for human computer interaction design” submitted by Mr. Jyoti Kumar to the Indian Institute of Technology Guwahati for the award of the degree of Doctor of Philosophy has been carried out under my supervision. This work has not been submitted elsewhere for the award of any other degree or diploma.

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ABSTRACT

User Centred Design (UCD) process employed in solving design problems in the area of Human Computer Interaction, has to rely on the data from the users to generate predictive users' mental models of the interaction. These mental models become the basis of specifications and heuristics for the designers to conceptualize new interaction patterns and Graphic User Interfaces for software products. As computers become ubiquitous, the need for understanding users' mental models from a deeper cognitive level, rather than the surface level as is currently being practiced, has become necessary. Designers need qualitatively rich data from the users about their experiences which often the users of a computing product are not capable of expressing. The difference between users' and designers' mental models has increased due to cross cultural design situations where designers from one culture are designing interactive systems for users from another culture. This cross cultural design context requires data gathering techniques which are suitable to different cultures and are sensitive to cross cultural differences in users. Current practices of extracting data from the users are more concentrated on getting the functional and operational requirements of the users rather than experiential information. This requires search and validation of new data gathering techniques for use in experiential design process.

This thesis recognises user's experiences with interactive system as a conglomeration of instances of aesthetic, affective and intellectual experiences that the users undergo with the elements of interactive systems like, icons, menu items, error messages etc. An interaction designer has to make design decisions pertaining to these different elements of the interaction design. Three categories of such design decisions have been identified, decisions pertaining to the 'elemental', 'compositional' and 'transitional' levels of interaction. At elemental

level, designer takes decisions about the ‘elements’ of interaction, that is, the icons, buttons, images, graphic elements etc. At compositional level, it is the visual balance and the gestalt of composition of screen that the designer is concerned about and at transitional level, designer has to decide about the transition between the screens. Designers need suitable techniques to gather experiential data from users pertaining to the three levels of design decisions in order to take informed decisions.

In this thesis four user data gathering techniques identified from literature, namely - Mind Tape, Think Aloud, Repertory Grid and Semantic Differential - have been investigated through experimentation involving over 290 users across three different cultures - Indian, Chinese and Danish for their ability to gather experiential data in cross cultural situations. The four techniques have been compared for their ability to mine data from the users at a deeper experiential level. Results indicate that though Mind Tape technique is resource demanding, it yields good experiential data at the Transitional level. Repertory Grid Technique on the other hand is more versatile and can be used to aid all levels of design decisions. Based on the empirical and qualitative analysis of the experimental results, this thesis proposes a new combinatorial use of the four techniques. HCI designing heuristics are proposed employing the four techniques.

In this thesis, designers’ decision making process has also been experimentally observed to understand how designers make use of the users’ experiential data. Results from study of designers’ design thinking process suggest that in absence of users’ data, designers make assumptions about the users and are not confident about their decisions. In presence of user data presented in quantitative form, designers had difficulty in using the data. However, when qualitative data was added to the quantitative data, designers could relate to the users preferences

easily and designed with greater confidence. In an icon design exercise, tendency to replicate the features most preferred by the users directly in to the design was observed. However when perceptual rules derived from the experiences were presented to the designers they could create more novel solutions. Hence, it is posited that both quantitative and qualitative data about users' experiences, when provided to the designers in an appropriate way, could help improve the experiential design process.



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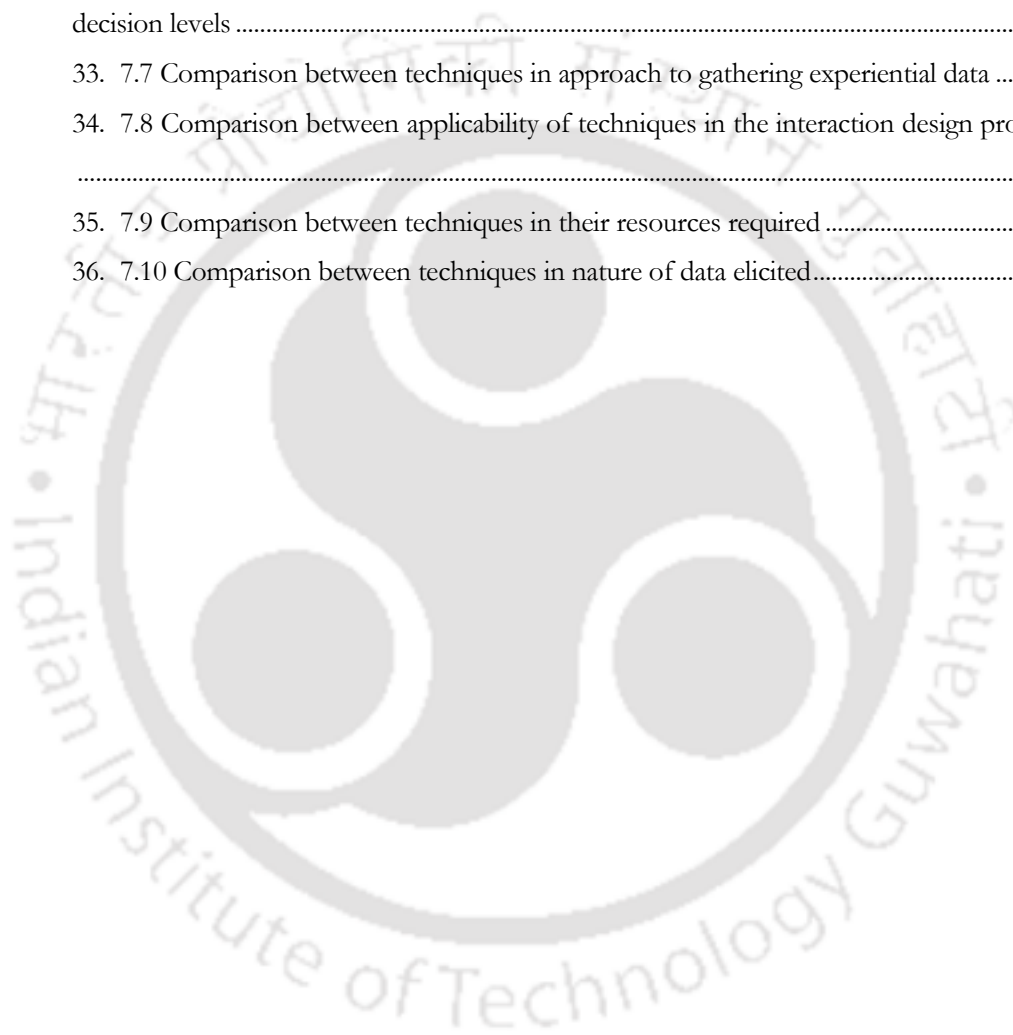
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GLOSSARY

Cultural sensitivity: Ability of a data gathering technique to gather data pertaining to cultural differences in users' experiences with HCI systems.

Cultural suitability: Capacity of a data gathering technique which enables it to be applied in different socio-cultural setups.

Data gathering Technique: Technique used to gather data from users for use by designers in designing interactive systems. Aim of these techniques is not to gather data 'about' the user (demographic, marketing data) but from 'within' the user (psychographic data).

Experiential Design: Process by which users experiences with a given system are gathered, analysed and built into the improved or new system.

HCI: Abbreviation for Human Computer Interaction. This term has been used in this thesis interchangeably between notion of HCI as a field of study and the process of interaction between the human and the computer.

HCI Design: The process of designing interactions between human and computer. This term is used in an encompassing sense covering all the design practices like the interface design, icon design, menu design etc. which form the components of the interaction with computers.

Interaction: Used in the same sense as HCI (Human Computer Interaction).

Interaction Design: Used in the same sense as HCI Design.

User Model: Simplified abstractions of an otherwise complex system. For instance, the human 'user' of interactive system is a highly complex entity, almost impossible to understand otherwise in completeness; hence a user model is used to approximate the users' behaviours.

UCD: User Centred Design Process. HCI design methodology which keeps users of the system at the centre of the design process, often involving direct contact with users through different data gathering and validation techniques.

Usability: 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.





HUMAN COMPUTER INTERACTION DESIGN

1.1 Introduction

Computer based systems are being used not only by the professionals to do repetitive computational tasks but also by laymen for doing shopping, chatting with friends and creating online social networks. This expansion in scope of activities that computers facilitate today has shifted the focus from technology involved in building the interactive systems to the experiences they generate for the general users. It is no more sufficient for the interactive systems to be able to perform the tasks they are meant for, but do much more. It has become imperative for the success of interactive systems that they generate an overall positive experience in the user to continue generating commerce for the product. Even a serious interactive system like online banking system needs to provide a positive experience and feeling of security in order to keep the users loyal to the site. Over and above fulfilling the basic needs of users, it is the overall interaction experience which is increasingly becoming the differentiator between any two competing enterprises.

This emphasis is not only because the user groups are far more diverse in composition and attitude but also because there is increase in competition in the interactive products' market. Interactive systems fulfilling similar tasks are now competing with each other and technology is ceasing to be the differentiator between them. It is the experience generated by the product, mainly due to the

design of their interactions, which is becoming influential in the users' purchase decisions. As a result of this, there is greater pressure on interaction designers to build systems, which not only fulfil the intended tasks but also give a rich and positive experience to the users.

Interaction design process, on the other hand, is a complex process requiring a multitude of skills. Interaction design process not only requires a good understanding of the prevalent technologies but also needs an in depth understanding of the users of the technology. While knowing prevalent technology is comparatively easier, as information is ubiquitous and behaviour of technology predictable, understanding users is far more complex, for the literature is scarce and users' behaviours highly unpredictable. As the users' behaviours are difficult to generalize across demographics and cultures, designers need to gather information every time an interaction design task is at hand. They have to gather this information not only 'about the user' or 'from the user' but they also need to gather information from 'within the user'. The users cannot explicitly utter what is going on 'within them' during the interaction. Hence designers need techniques to gather the required information from them. Gathering information from users is not only difficult because of users' inability to verbalise their feelings but also because their internal processes are very dynamic, complex and sometimes inexpressible. The users appear as complex information processors at times, using cognitive processes to evaluate, plan and act upon in the interaction with a system while at other times, they are affective agents who feel, emote, and experience the interaction. It therefore becomes difficult to understand and predict the users' behaviour in context of the interaction with computer based systems.

Creating simplified models of users to understand complex behaviours is one of the approaches in Human Computer Interaction field. There are several existing

models of users to aid designers comprehend actions and behaviours of the users. The most prevalent model is the information processing model which helps understand how users comprehend the interaction and plan their actions. However there are shortcomings of the information processing model of users. The information processing model fails which explains how users perceive and process information fails to throw light on how users feel, emote and experience during the interaction. Though the information processing model helps in understanding the cognition based actions of users which constitute a major part of the interaction process, it appears incomplete in ability to explain the experiential aspects of the interaction which include feelings, emotions and experiences with respect to the product usage. Further, there are issues in users' meaning making and decision making processes which are incomprehensible by the information processing model of the user. For instance, the users sometimes act as rational decision makers, choosing the most obvious, the most efficient paths during interaction, while at other times they depend on socio cultural heuristics to aid their decision making. The cultural colouration of the meaning making process and the cultural heuristics in decision making process asks for seeking other models of users for the interaction design field. As it is essential for designers to understand the complex interplay of affective and cognitive processes, coloured by socio cultural contexts, designers need to look for a more holistic model of users. The new model should be able to explain the users' experiential responses and help identify techniques to generate experiential data from users. Having understood the need for gathering experiential data from users for design, more enjoyable interactions and having assessed the complexity of modelling the users and identifying techniques for experiential data gathering, designers can use the experiential data gathered from the users to improve their design decisions in experiential design process. In order to gather the data from users, the designers apart from having a theoretical model of the users and the

techniques to gather experiential data, also need to identify stages in the design process where design decisions have to be made and identify the type of data they would need at each stage.

Interaction design process has been observed to be iterative (Norman, 2002). The products evolve over time as users' needs and desires are understood gradually in context of the system under use. Yet, the initial design phase, when conceptualisation of interaction happens, is one of the most critical ones as much of success of the product depends on it (Norman, 2002). The designing freedom is maximum at this stage and the cost of rectification is minimum but the bad designs passed through this stage would become more and more stubborn and untreatable. Hence the effort put at initial stages in understanding the users are crucial even if they are resource expensive. This design process centred on users is popularly known as the User Centred Design process or UCD in short. Another term for UCD is Human Centred Design which has been defined in ISO 13407 as 'the active involvement of users and a clear understanding of user and task requirements; an appropriate allocation of function between users and technology; the iteration of design solutions; multi-disciplinary design'. Involvement of users in design process and iterating the design process are two main characteristics of the UCD process.

Even though gathering information from the users has been identified as a central activity in the design process, the methods and techniques required for the purpose, has not been detailed out by either ISO standards or any other standards organization. Designers have to figure out the data gathering techniques based on prevalent practices or based on their own experiences. The task of choosing appropriate technique for gathering data from users pertaining to their experiences is even more challenging as this practice is newly emerging in interaction design field and the experiential design process is yet to get properly

organised. Techniques that extract data from users like questionnaires, interviews, focus group discussions and heuristic observations have been widely adopted by designers and are mentioned in consumer study, marketing research and product design literature (Hayes, 1992; Urban and Hauser, 1993; Nielsen, 1993). Understanding and interpreting the user's unexpressed needs has been the central issue in User Centered Design (UCD) methodology adopted for designing information technology products (Kramer et al 2000; Vredenburg et al 2002). One of the recognised processes in interaction design field is of Usability Engineering. Usability engineering focuses on making the system more 'usable' by establishing usability criterion and measuring the designs against it through usability testing. The most prevalent usability testing technique has been Think Aloud technique which is well researched for its strengths and weaknesses. As focus of experiential design is a little wider than usability engineering, it needs to be ascertained whether the Think Aloud technique would also be able to provide data for experiential design needs. Also, other techniques need to be explored and ascertained for their suitability in meeting the designers' needs of gathering experiential data from users.

From literature study (Hertzum & Jacobsen, 2001; Yeo 1998; Yeo 2001; Clemmensen & Goyal 2005; Vatrapu & Pérez-Quñones 2006) it is seen that culture is one of the variables affecting data gathering process from users. One of the prime elements of culture has been identified as 'value system'. Members of a cultural group share a similar value system. Value systems affect the rituals and behaviours followed by the members of a society. Social rituals expressed in gestures, social norms, social behaviours are often distinctly different in different cultures. Designers situated in one culture are designing interactions for users from another culture. Gathering data from users needs to be done by the designers who may not be aware of deep cultural nuances, behaviours and feelings of users. In case of experiential design, this factor becomes even more

critical as data on users experiences are subtler and are mined from deep down in users psyche (Krippendorf, 2007; McCarthy and Wright, 2004). Not only immediate import and comprehension of the experiential data in its cultural context is required but also an empathetic attitude towards the user during the process of data collection is required in order to successfully gather experiential data. Hence while investigating for suitable techniques for gathering experiential data from users, it is pertinent to focus on techniques suitable in cross cultural contexts as well.

In order to explore and ascertain a technique's compatibility for experiential design process, first we need to outline the criteria for suitability of the data gathering techniques in experiential design process. The challenge in understanding experience of users is that the designers need information not only about how the users have gone about fulfilling the tasks, but also how they have felt during the task fulfilment. This information does not come merely by superficially asking the users or by observing the users, but the technique needs to be able to mine data from deep within the users. The techniques should be able to identify and reach the deeper level cognitive processes and the affective connotations connected with them. The technique should be practically applicable in design process in terms of execution, data analysis and resource consumption. Further they should be able to gather data from across cultures as the design scenario in interaction design field is expanding beyond cultural boundaries.

Some research questions emerge from above. The first one is; which techniques would help gather data from within the users? Can these techniques help understand how the users 'feel' about the interaction? Can these techniques bring forth the data of users experiences in the socio cultural context? Can there be techniques sensitive enough to bring forth the differences in users' experiences

across cultures? Will these techniques be applicable in different cultures? Will the data gathered from users using these techniques be useful to designers? Will designers be able to use the data in designing for experiences?

Before investigating the above questions, it is imperative to know how designers 'design'. How do they go about thinking the interaction design patterns? How does a typical design process develop resulting in interaction design solutions? What kinds of design decisions are made? Can decision types be categorised? And do all design decisions require same kind of information from users? And if not what types of information do the designers need pertaining to the different kinds of decisions they take in the interaction design process? Also there is a need to know what type of data to gather in which context. Which stage of design process one needs to gather data and which design decision it supports? There is a need to identify or create context and use specific techniques to gather data from users.

1.2 Brief Overview of HCI Design

Foundational to the Human Computer Interaction (HCI) field was its predecessor, the field of Human Machine Interaction (HMI). Human Machine Interaction design field surged as an area of interest from the impetus provided by the Second World War and mostly was studied under the field of Human Factors or Ergonomics. With computers becoming widespread and increase in the complexity of interactions between man and computer, the term human computer interaction or HCI, in short, started becoming more popular since early 1980's. HCI today is a multi disciplinary field with researchers from Computer Science, Cognitive Psychology, Sociology, Marketing and similar allied fields are involved in collaborating and researching means to create usable and enjoyable

systems. Multidisciplinary character of the HCI field where act of designing being a central activity in HCI is evident from the ACM SIGCHI's definition for HCI- "Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" (Hewett et al ,2009, 'ACM SIGCHI Curricula for Human-Computer Interaction').

Designers ability to innovate and imagine interfaces and interaction methods capable of fulfilling users' task related goals and overall experience has been identified as the centre of the HCI design. For this, the designer needs to understand the user, the computer and the modalities of the interaction. The ideal designer of an interactive system is expected to have expertise in a range of topics; cognitive psychology, problem solving, graphic design and computer science being some of them.

There has been a great surge in publications in HCI design filed pertaining to the data gathering techniques from users in cross cultural situations (Roese and Clemmensen, 2009). More and more researchers have been reporting the need to gather data from the users in the interaction design process and the need to accommodate the cross cultural differences in the user-designer mental modes of the interaction.

1.2.1 The field of Human Computer Interaction: evolution and trends

In the beginning of the HCI field, the hardware, which is the name given to the physical parts of the computer, was the differentiator between the systems. The systems were less interactive, slower and depended directly on the hardware for its performance (Carroll, 2009). Soon the software programmes started leading the way. The softwares that could perform tasks were coded and executed with

aid of the physical hardware. The interaction between human and computer was still seen as a relationship of giving inputs to obtaining the results. The efficiency of the coded programmes, which on a higher level are called softwares, was the biggest differentiator between two systems. As the softwares started to be used for multitude of purposes, some of which were critical but used by non specialists in computer science, it was no longer sufficient for the systems to be error free and efficient, it had to be easy to operate, easy to remember and satisfying. This need for making the system more 'usable' led to the development of usability engineering practices within the HCI field. Standards were made and literature was published to aid the usability engineers develop more usable interactions. Currently usability engineering has been the most widely recognised practice in human computer interaction design field (Nielsen, 1993).

More than 31% of the total adult population across the globe, uses the internet and the number of internet users worldwide, who have shopped online is increasing by more than 50 percent every year (Pastore, 2001). With increase in web based technologies several activities which were so far facilitated from within brick and mortar structures only, have now become online. For instance, social or professional networking, dating and marriage, online trade and business, shopping and medical consultation, range of personal banking and insurance services, holiday planning and booking and numerous other activities are being done online across the globe now. For these activities being done online, it is no more sufficient for the computer systems to merely complete the task; they need to engage the user. It is no more enough for systems to be usable; they need to give a fulfilling experience. Even if a social networking site is a usable one, in terms of its ability to help in search and connect with friends and family, but if it is not enjoyable to use, a user will no more prefer to use it. Even if a banking service, say taking a loan, is available online, it does not necessarily give the experience of going to a bank, meeting the manager, seeing other people fill in

the forms and chat with them to confirm a loan option. One may or may not have enough positive reasons to commit for the transaction. Users have started demanding the same experience from the offline interactive systems as well. Users want the interactive systems to be more appealing visually, more joyful and more human like in responses so as to result in positive feelings. It is now essential for HCI designers to develop tools, techniques and processes for incorporating 'experiential' factors.

1.2.2 Evolution of users' understanding in HCI field

The user was seen as a cog in the system during 1970s (Kutti, 2001). The users were perceived as source for errors and the system as impeccable with no errors. Computers were seen as high speed, very efficient computation machines and humans were 'input' providers. With spread in usage of interactive systems, users started being seen as social actors in 1990s (Kutti, 2001). With emergence of online based interactive systems facilitating diverse consumers activities, users are seen as consumer who decide and choose from the available systems. With this change in status of users due to evolving nature of computer usage, the design approaches taken in HCI have also evolved.

In the 70's and 80's, computers were tools to do repetitive computational tasks accurately and the users were agents which entered the preformatted 'input' data field. The interaction between humans and computers looked very simple and a reductionist model of users' behaviour is reflected in theories that emerged at this stage. The structure of users' action was modelled and prescribed to HCI designers. An example of this is the GOMS model by Card, Moran and Newell (1983). Users were seen as having fixed 'Goals' which did not change during the

course of interaction with computers as they chose from the basic ‘Operations’ that could be performed, by creating ‘Methods’ and following some ‘Selection rules. Fundamental premise of GOMS and similar other models of this time (like keystroke level model, PHCI etc., see Card et al, 1983 for a detailed discussion) was the assumption that users’ goals are fixed and it choice one of the several possible paths in the interaction to fulfil them. This assumption is far from the way users interact with present day online systems like online shopping sites or social networking sites. Users’ goals evolve and are created on the fly during the interaction with system. 1990s the sociology and anthropology disciplines influenced perception of users by helping focus on the contingent nature of actions in everyday life and the users’ actions being relational to the socially situated practices (Suchman,1987; Lave 1993). Very much like social interactions, interaction with computers is an ongoing process where users negotiate meaning in their actions through responses of the system and it is not a fixed, pre-learned set of actions that users perform like in early days of computers. Of late even this model is insufficient to guide designers. With increase in online traffic and penetration of computers deeper into everyday social activities, computer based interaction systems are a consumer driven variable and the users are the ultimate choosers. With increase in competition among interactive systems catering to similar needs, users decide and choose between these available systems. There is greater need to understand users, with a consumer lens (Plummer, 1974).

1.2.3 Usability Engineering and User Experience Design

Unlike the word ‘usability’ which came into existence exclusively with the practice of Usability Engineering (UE) and thus had the luxury to be defined explicitly by

usability engineering practitioners, the word 'experience' has been in use in literary and philosophical treatises since almost advent of literature.

ISO 9241-11 (1998) defines usability as "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. This definition sees usability as a measurable quality of the system comprising of user fulfilling a task in a given environment using a product (Bevan, 2008). Whereas, Nielsen (1993) has recognised 'usability' as independent of the 'utility', both of which constitute the 'usefulness' of the product and play an important role in the product's 'acceptability' by the users. Here usability has been seen as a quality of the product independent of the environment and the user. Apart from the product and system views there has also been a 'goal oriented' view to usability. Usability definition of 'quality in use' (ISO/IEC 9126-1, 2001) emphasises on 'safety' which encompasses not only the users 'safety' but also the safety from financial loss to business due to usability issues. Here the goal of usability engineering is not only towards the ease of users but also towards the safety of service providers. Newman and Taylor (1999) argue that what usability means is contextual within HCI field.

Though the present metrics of usability, apart from having efficiency and effectiveness, which are purely task related, also has 'satisfaction' measure, which can be a key element of users' experience but on scrutiny it does not stand out to be so. Hassenzahl (2002) has pointed out that current approaches to satisfaction typically assess primarily the users' perception of effectiveness and efficiency, instead of any measure of users' experience. The satisfaction metrics is applied so that if users perceive the product as effective and efficient, they are assumed to be satisfied. For, these reasons there is a need to take a fresh perspective on the experience design within the HCI field.

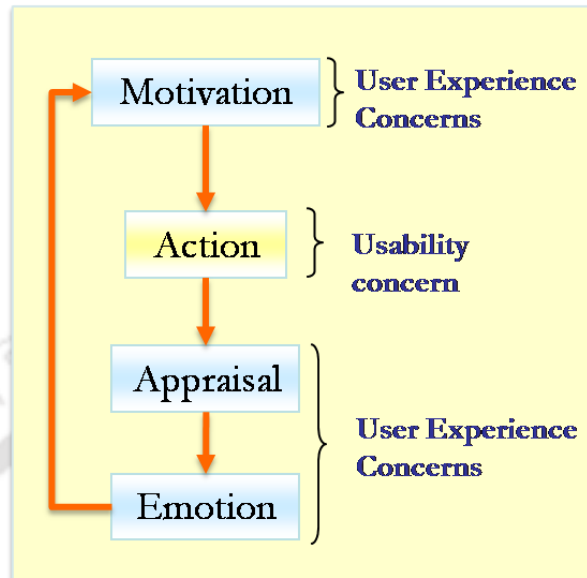


Figure 1. 1: Usability vs. User Experience design concerns

Several definition of user experience, commonly abbreviated as UX, also exist in the HCI field. One of the oft cited definitions of user experience is by UPA where UX has been defined as “Every aspect of the user’s interaction with a product, service or company that makes up the user’s perceptions of the whole” (UPA, 2007). While ‘usability’ has focus on ‘product’ or ‘user-task-environment system’ or the ‘goal’ of business, depending on the use context, whereas, ‘experience’ has a holistic perspective to the users’ interaction with the system. Experience not only focuses on the effectiveness, efficiency and satisfaction which are the requisites for system acceptability but also the feelings, the trust, the bonding the user develops with the interactive systems. Many authors have also differentiated usability and user experience design, for example Baekdal (2006) describes usability as a ‘straight highway drive’ while experience design as a ‘mountain road’. Bevan (2008), who is involved in revision of ISO 13407 (2007), is a co-editor of the definition of a new quality model for usability as part of

quality in use (ISO/IEC CD 25010, 2007) and is also involved in the revision of the standard for usability methods (ISO/TR 16982, 2002), expresses that these standards do not cater to the need for experiential design model. Bevan emphasises that all these standards should broaden their scope to incorporate aspects of user experience (Bevan, 2008).

Another difference in the usability and user experience foci are the scope of human behaviour attended to (fig 1.1). While usability is concerned about the user's ability to do a given task, users experience has a more holistic perspective on the intentions and aftermath of the task as well. For instance, usability focuses on appropriate selection radio buttons or checkboxes on an online fillable form to ensure error free form submission user experience also would look at the motivation towards the form filing, the appraisal of the action done to fill the form and the affective responses of the appraisal. The emotions felt during the interaction can further add to the motivation towards interaction through trust and goodwill built by the interaction in user.

It is evident from above discussion that while both 'usability' and 'user experience' terms have contextual meanings within HCI profession, usability is comparatively a better defined term having a formal structure for its applicability than user experience design. User experience design has also been seen as more challenging and still in its nascent phase. Much work needs to be done towards identifying the suitable tools, techniques and processes, before a formal framework for standardizing the user experience practice could emerge. This thesis is one such attempt to investigate an element of design process in general and the HCI design process in particular, namely the techniques to gather data from users, so as to better understand the experiential issues involved.

In this thesis, designing interactions aimed at user's experience has been seen as different from designing interactions for usability. Though designing for usability shares some of the concerns with user experience design, user experience design takes a much more holistic approach to the user-system interaction. Hence a newer way looking at the entire interaction design process and smarter techniques for gathering experiential data has been argued. For the purpose of use in this thesis, the 'experience design' term has been defined in context of Human Computer Interaction as 'the process by which users experiences with a given system are gathered, analysed and built into the improved or new system'. Unlike the UPA definition, which focuses on entire range of users experiences with product, service or company, focus in this thesis is on the experiences with the digital products alone. Though the techniques investigated in this thesis may have a potential for extension into other domains of user experiences as well but for the sake of brevity and attention, only the experiences with computer based interactive products have been studied in this thesis.

1.3 HCI design process and need for user data

There are numerous definitions of design, depending on the branch of knowledge the act of designing belongs to. For the purpose this thesis and in context of HCI research we shall define design as 'a purposeful, constrained, decision making activity' when used as a verb and 'the resultant outcome of such an activity' in the noun sense [Gero, 2004].

From the above definition of design it is evident that design involves 'constraints', in terms of the materials used, technology involved, standards abided by, time

and cost involved. The design constraints create boundary values of the design space within which the design decisions have to be made.

In case of HCI design, the computer and the human both create two sets of constraints which need to be matched. Human abilities are limited, they form one set of constraints. Similarly, the abilities of computers is limited, they create another set of constraints. Human cognitive processes are limited by bandwidth of each channel (Miller, 1956) and the amount of information user can process at a given point of time is limited. Even the number of items user can remember is limited (Miller, 1956) and kind of concepts user already has from prior experience constraints and directs it's meaning making processes in context of interaction with systems. The culture a user belongs to is another constraint in its functioning; the culture shapes its meaning making process of artefacts around (Nisbett, 2001; Hofstede, 2003). In case of computers, the constraints are the available processing speed, the available software technologies and the bandwidth of information transfer over net, the physical devices for input and output etc. A designer has to explore the possible matches between the user and system by working through their individual constraints and select the most suitable one. For instance, if the system is showing the bank balance sheet to the user and the constrain of system is that it cannot show all the data in one screen, then it should also not expect the user to remember all the digits form one screen to another screen. Some solution with in the interaction like, possibly a pop up, a roll over or information on the side bar has to be identified which matches to the constraints of both the system and the user. This selection of the most suitable match from set of alternatives, involves decision making by the designers which we shall refer as the designers' decision making process.

In HCI literature, there have been numerous attempts to aid the designers' thinking process of decision making in context of interaction design (Nielsen,

1993; Dix et al, 1998; Shneiderman, 2000; Preece et al, 2003; Lindgaard, 1995). It has also been criticized that the HCI literature has list of more do's and don't than how's (Brown 1988). From HCI literature, designers have a list of examples of 'good designs' and 'bad designs' which need to be used for inspiration. They also have sundry checklists of 'what needs to be done' to ensure the systems 'usability' but they lack a prescriptive process to enhance the occurrence of good design solutions in context of interaction design. We do have metrics and goals in HCI that the designed product needs to meet in order to qualify but we yet do not have detailed processes based on research which can make designers surer of getting the design solutions. Designers have to rely on their imagination to meet the goals and then test their 'imagination' (concept design) with the users to verify their suitability. It has been theorized that the designers employ 'opportunistic thinking' to arrive at the design concepts which creatively emerge from a 'sudden interlocking' of prevalent concepts in their memory brought forward from their own experiences (Koestler, 1975). With opportunistic thinking, designers create concepts in initial stages of design, both as an aid in the process of design thinking and also for validation of their solutions by users. These concepts are expressed as prototypes which aid in data collection from users. This method of collecting data from users has a long history in design (Shakel, 1991) and it has been accepted as a very efficient method of gathering data from users (Seminara, 1985).

Designers extend and generalize their own experiences to arrive at conceptual design solutions. As the initial concepts guide rest of the design process and make it difficult to rectify the concepts themselves, it is imperative that the designers pursue a more informed decision making process (Kaminsky, 1992). One of the ways to do this is to observe the users in interaction with computer based interactive systems and understand their needs, wishes, desires and goals (fig1.2).

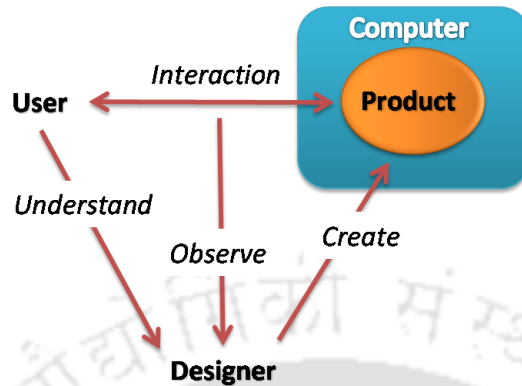


Figure 1. 2: Making informed decisions in HCI design process

One of the methods used in design to understand users is through the use of Mental Models theory (Johnson-Laird, 1983). Traditionally, designers extend their own experiences to create user's mental models, in user centered design process, initial user studies are recommended for creating more informed mental models of the users. What is interesting here is the fact that designers create mental models of the users' mental models as depicted in fig 1.3. Designers need to be informed about the users' experiences in order to create more accurate mental models of the users. This thesis argues for the need of taking more informed design decisions in the interaction design process especially at the initial conceptualisation stages of design. The need for data gathering from users becomes even more acute in case of experiential design tasks. Users in usability perspective are information processors where every user's information processing capacity is within a predictable limit of the established research findings. In comparison to the information processing model, users as experiencing agents are far more diverse. The problem of experiential design hence is far more challenging than design for usability. With interaction design tasks increasingly happening cross culturally, wherein users of interactive systems come from one culture and the designers from another, the challenge of understanding and

designing for experiences of users from another culture is even more daunting. Today, a designer situated in culturally different setup like India is designing for users situated in Europe or US. Culture studies have argued that the way users experience the world around them is influenced by the culture they belong to (Nisbett, 2001; Hofstede, 2003). Not only the value systems and rituals around them but also the symbols and forms used across cultures are different. Colours, for instance have different connotations in different cultures. Hence users from different cultures are likely to experience the same interaction differently. Designers generalizing their own experiences to predict another user's experience with an interactive system, even when the user is from the same culture is highly speculative and should ideally be avoided in any design decision making situation where stakes are high.

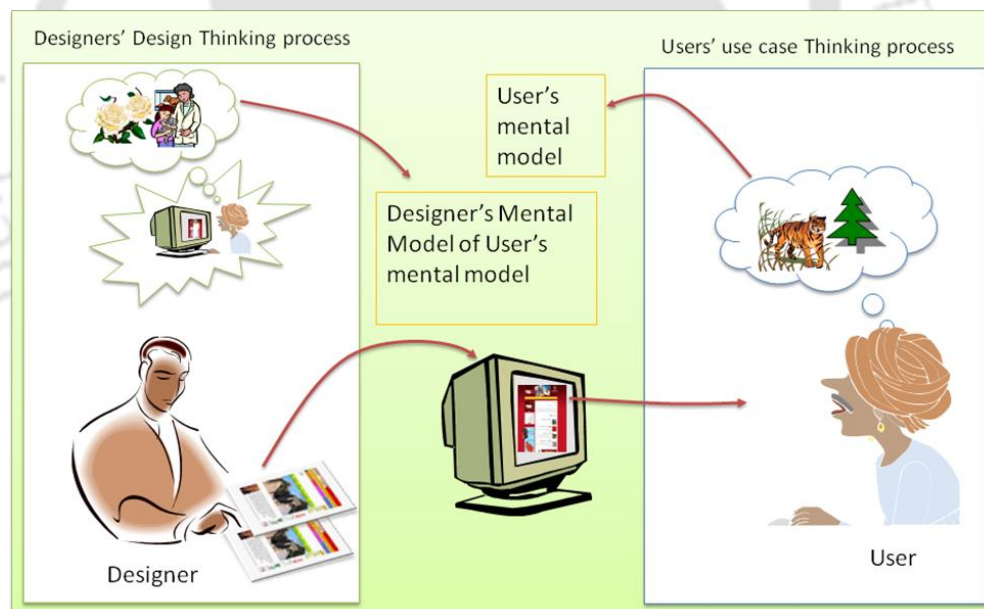


Figure 1. 3:: Users' mental models and designers design thinking

1.4 Objectives of investigation in this thesis

As discussed in this chapter so far, the evolution of computer based interactive systems have made them ubiquitous and now not only the professionals but also laymen are using them. Further there are competing digital products in the market which provide similar functions and hence functions are no more the differentiators in the interactive products market. Hence, there is greater need to design the systems not only focussed on functional aspects but also for the users' experiences. Also, it has been known that designers are not the users and hence their mental models of the interactive systems differ. In order to fill the gap between the designer's and users' mental models, designers need to gather data from the users and this has to be done iteratively during the entire interaction design process. Cultural differences between the designers and users further increase the probability of increase in mismatch of users' and designers' mental models. Also the cultural differences between users and designers social settings also increase the difficulty in gathering the data from users about their mental models. However, in spite of increased recognition of designing for users' experiences, doing so by gathering experiential data from users by using appropriate data gathering techniques suitable for use in cross cultural situations, not much information is available in HCI literature on the suitable data gathering techniques to aid in gathering experiential data from the users.

Even consensus on a working definition of 'User Experience Design' has yet not been arrived in the interaction design practitioners and academicians; nor any process for designing interactions aimed at users' experiences has been accepted universally. Though centring the design process on the users to ensure the success of the designed interaction is now an accepted fact in design practice, the processes and techniques by which data from users can be gathered to inform the designers in design decision making process has yet not been standardized. Even

a user model which identifies users as experiencing agents instead of mere task fulfillers has not been agreed upon in HCI literature.

This thesis identifies these gaps in the existing body of knowledge in HCI and raises research questions for investigating them systematically through literature survey and experimentation.

This thesis recognises a series of interdependent research objectives which must be fulfilled to arrive at any conclusion regarding the existing gaps in the body of knowledge in HCI filed raised above. Firstly, suitable techniques for gathering experiential data from users need to be identified in order to understand users' experiences in the context of interaction with the systems so as to be able to design for users' experiences. In order to investigate for suitable techniques, we need suitability criteria against which data gathering techniques could be checked for validity. Suitability criteria for techniques' ability to mine experiential data from users would have to be based on the theoretical understanding of how users experience the interaction. A model to understand users' experiences during interaction with computers would be needed. Also the stages of design decisions during the interaction design process where designers would need users' data need to be identified and the type of data needed at each stage need to be ascertained before gathering data from the users. This thesis thus aims to first create a user model for use in experiential design process then using this model distinguish the criteria for suitability of techniques for gathering experiential data from users. Then this thesis aims to identify the design decision categories where designers need the users' data and the type of data they need. Having criteria for suitability of data gathering techniques in place, and the type of data required from users in place, this thesis then aims to identify the techniques which could be used in experiential design process by experimentally observing them in use

and analyzing the data collected from them. Main objectives of this thesis are enumerated below.

What is the user model that can guide the experiential design process?

Where in the design thinking process the experiential data is useful? Are there any specific kinds of data that is sought at different stages of design process?

Which data collection techniques can gather experiential data from users?

Which data collection techniques are most suitable for gathering data in cross cultural design contexts?

How do designers use the experiential data gathered from users in their design thinking process?

With progress in the investigation of these questions, several ancillary questions arose from time to time which were also investigated and have been reported in this thesis.

1.5 Chapter summaries

Chapter 1 has presented a brief introduction to the problem domain and the research problem. **Chapter 2** presents the literature survey done towards understanding experiential framework in HCI design. Firstly, literature is studied for understanding designers design decision making process and need for user data as an aid in design decision making process. Further, literature has been sought on prevalent user models which are used to understand users' behaviours in interaction design context and need for a more holistic user model for use in experiential design framework has been identified.

Based on the need identified in chapter 2, **Chapter 3** presents a user model created for use in experiential design framework. This model has been used in

this thesis to set criteria for suitability of experiential data gathering data techniques.

Chapter 4 identifies the data gathering techniques suitable for experiential design process from literature study. Four data gathering techniques have been identified from the literature for further experimental investigation for their suitability in gathering experiential data in cross cultural settings.

Chapter 5 describes the research methodology and research design adopted for experimental investigations.

Chapter 6 presents investigations with each of the four techniques in separate sections from section 6.2 to 6.5. Each individual experiment has been treated as a subsection within the four sections and details of participants, research method, research setup, observations and findings have been discussed for each experiment in these subsections. Section 6.6 describes the investigations done on designers design thinking in presence of the user data.

Chapter 7 is the concluding chapter where merits and limitations of each technique have been comparatively discussed and an experiential design process making use of the four data collection techniques has been suggested. The thesis concludes by comparing the strengths and weaknesses of each of the techniques and suggesting a plan for their use in HCI experiential design process.

Appendices, total eight in number, have been included at the end of the thesis which provide with details of experiments which could not be included in the main text for the sake of maintaining the flow for reading. **Appendix A** presents stimuli used in experiments, **Appendix B** presents the gesture analysis and paper prototype experiments with Think Aloud technique. **Appendix C** details out some of the experiments done with Repertory Grid Technique and **Appendix D**

similarly details out some experiments done with Semantic Differential technique. **Appendix E** illustrates slides of ‘User data tool’ used for experiment with designers as described in section 6.6. **Appendix F** illustrates creation of Fuzzy Inference system from user data for use by designers as described in section 6.6. **Appendix G** describes the experiments with designers’ design thinking process in presence of user data and the last appendix, **Appendix H** mentions the list of publications associated with the output from this thesis work.



UNDERSTANDING USERS' EXPERIENCE IN HCI: A LITERATURE SURVEY

2.1 Introduction

This chapter presents the findings from literature survey in the HCI and allied fields. First a plan for literature survey has been presented in section 2.2 describing the background of need of work in this thesis and the sources from which the literature is sought. Section 2.3 briefly describes the widely used design methodology, namely user centred design methodology, also adopted in this thesis as framework for HCI experiential design process. Section 2.4 furthers the discussion on the design methodology by citing literature on designers' design thinking process and role of data as an aid to it. Section 2.5 then takes a deeper look at the user models existing in literature which guide the user data collection methods. This is followed by a comparative discussion on the user models in section 2.6. Section 2.7 identifies the gaps in the literature and paves the way for chapters 3 to 5.

Existing theoretical models of the user in literature of HCI and allied fields have been carved out for consideration in experiential design framework which is the focus of study in this thesis. A theoretical model of user is an abstraction of the otherwise complex human system. In this thesis, the term 'user model' has been used for all these different theoretical models. This is done to imply that these theoretical models are 'simplified models' and they do not explain the users' behaviours fully. This approach becomes helpful as the subject of study- 'human experience', is a complex phenomena and a satisfactory universal theoretical

model for practical purposes like designing interactions, yet does not exist. In the search for a theoretical model of users' experiences, which can be used in HCI design, it is helpful to see existing models as simplified abstraction. By looking at complementary elements in the existing models which are complete in themselves, one can borrow the complementary elements to create a working model for practical purposes in experiential design. This way, while these models, which come from different scientific traditions, continue to grow in light of new research findings and become more complete in their explanation of human system, the practice based fields like design, need not wait for the complete model to emerge. By creating a working user model for experiential design purposes, the intention is not to again give a complete model of user behaviour, but to have enough grounds to understand those aspects of the users' behaviour which have relevance to the experiential design field. Instead of creating this working model right from scratch, it seems more logical to borrow from the existing models under well reasoned arguments as to why each of those elements has been borrowed. In order to do this, first, theoretical models which seem to explain some aspects of the users' behaviours, coming from different traditions of scientific enquiry, have been studied. Components of these existing theoretical models, theoretical strength of each component and their contribution to understanding human behaviour as outlined in literature have been studied. As each of these models come from a different theoretical perspective their traditional background of each model has also been outlined here for the purpose of discussion. After this, literature pertaining to understanding of users' experiences has been studied. Models of users' experiences from within and outside the HCI field have been sought. These models have been compared and discussed. Concerns and pursuits of the existing user models with those of experiential design goals have been compared. By identifying overlapping interests of the existing user models and that of the experiential design process

and by borrowing and merging mutually compatible ideas into one pragmatic whole, creation of a working user model for use in experiential design process is intended. A schematic diagram of this process has been presented in fig 2.1. The ideas generated from the literature survey of the existing user models in this chapter has been taken forward in the next chapter when a user model for use in experiential design framework has been created.

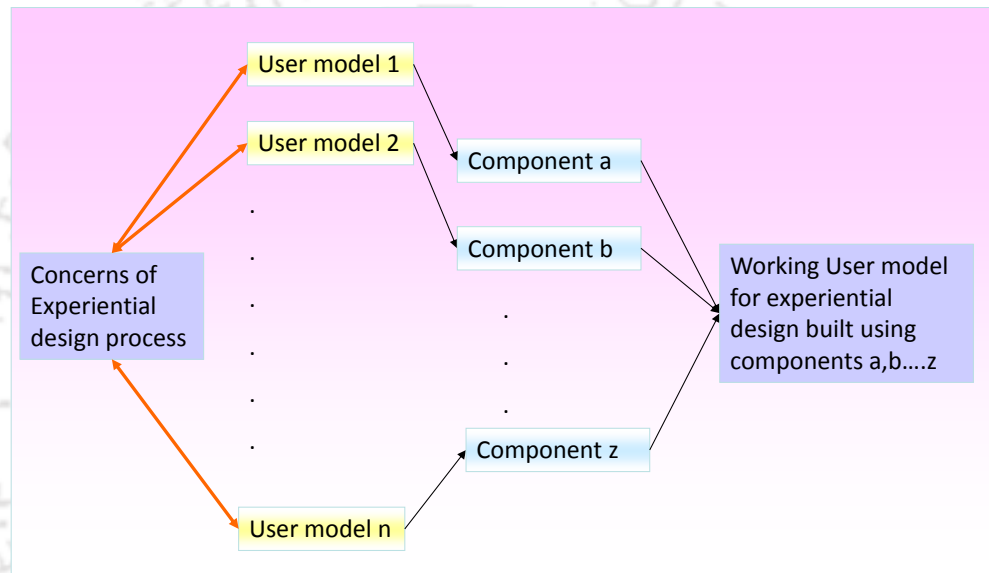


Figure 2. 1: Plan for creating user model for experiential design process by literature survey

Data gathering techniques, auguring for experiential data gathering ability, have been identified from literature. Information on strengths and weaknesses of the available data gathering techniques has been sought. Based on literature survey, four techniques have been identified and their suitability for gathering experiential data from users has been hypothesized. A research methodology as suggested in literature for such studies, has been adopted and a research design formulated. Further on, in this thesis, in chapter 4, experiments conducted to test the hypothesis have been described.

2.2 Literature survey plan

The research problem investigated in this thesis pertains to the field of HCI Design which is multidisciplinary in nature. For instance, inputs from cognitive psychology help in determining users' mental and motor abilities like memory, reading speed, mouse movement and clicking speed. On the other hand, sociological and cultural studies aid in identifying culturally and socially suitable metaphors for interface designs. At one end of the research problem are the designers who need the users' data and at the other end are the users from whom the experiential data needs to be gathered. In order to understand the need, suitability and usefulness of the data gathered from users in design process, it is necessary to understand the designers' design thinking process too, apart from the theoretical models of user. On the other hand, in order to understand which techniques would be suitable for gathering experiential data from users it is necessary to understand simplistic user models that is reported in literature. It is in the interconnection of the models of users and designers that the framework for assessing suitability of data gathering techniques has been assumed to exist.

Existing literature was studied keeping the following questions in mind: What is the recommended process for HCI systems Design? How do designers make design decisions in designing HCI systems? What are the experiential processes occurring within the users? What are the techniques for gathering users' experiential data from users? Can these techniques help gather data from across cultures and bring forth cultural differences in experiences of users? Among the available ones, which are the most suitable techniques for gathering experiential data from users for aiding designer's design decision process? In order to seek answers to above questions, literature from disciplines of cognitive psychology, design, HCI, and cultural studies were sought. Findings from the existing literature reported and discussed in sections 2.3 to 2.6 below. As stated earlier,

this being a multidisciplinary topic, the literature survey had to be done on a very wide range of issues.

2.3 HCI design as a User Centred process

In HCI Design, a User Centred Design (UCD) process or Human centred design process, has been recommended (ISO 9241-210) instead of technology centered or management centred processes for success of designed Interaction with users. UCD stresses that understanding users is critical to the success of design hence UCD involves direct contact with users to gather data. Keil and Carmel (1995) conducted a study which demonstrates importance of UCD process in success of an HCI project. Out of 31 projects from 17 companies Keil and Carmel reported that no HCI project succeeded which lacked direct user contact during development process. Also the more successful projects had greater contact with users. The data collected from users in UCD is not only about the demographics of users but also about the psychographics of users. Psychographic data has been stressed to be important to build systems that can successfully match users' needs.

2.4 Designer's design thinking process and need of users' data

There has been much debate on the nature of design process and even on the definition of 'design', the need to recognise design as a rational and intentional process has been undisputed. There are both prescriptive and descriptive theories for design process. Some of the theories argue design as an orderly systematic process following stringently an existent methodology (Alexander 1964, Asimow 1962, Jones 1970, Simon, 1981, Dasgupta 1989). While others have argued that design cannot follow a prescribed methodology (Alexander 1971, Broadbent,

Lawson 1981). The reason for impossibility of a step wise sequential process to be a pragmatic model for design process has been argued on the basis of the inseparability of the analysis and synthesis phases in design thinking. The analysis and synthesis phases depicted as separate steps of a sequential design process in the design methodology, has been argued to not exist separately in practice (Gedenryd, 1998). The requirement gathering phase prescribed in design methodology. The inseparable nature of the problem analysis, prevalent in requirement gathering phase of design methodology and the solution synthesis, called as conceptualisation phase in the design methodology is characteristic of the methodological design process.

Design activity has been identified as a special form of problem solving involving creative thinking (Newell et al., 1962; Guilford, 1964; Mumford et al., 1994; Matlin, 2001). Though designers are problem solvers the problems are not well defined. They fall into the category of ill defined and ill structured problems and thus design activity is a special category of problem solving activity (Reitman, 1964; Eastman, 1969; Simon, 1973). Designers have an ill defined and ill structured problem space which they expand and alter in the process of finding the solutions. Designers use mental representations to help evolution of solutions. These representations are based on individual imageries and experiences specific to the designer (Falzonetal., 1990; Simon, 1995). This also explains the reason why different designers solving the same problem reach different solutions (Bisseret et al., 1988). Designers based on their experiences develop specific viewpoints and they use opportunistic reasoning based on these viewpoints to arrive at design solutions (Hayes Roth and Hayes Roth, 1979; Guindon, 1990; Visser,1990; Bonnardeletal., 2003). The creative problem solving in design is said to be a product of selective relationship between the working memory and the long term memory of the designer which gives a “sudden interlocking of two previously unrelated thoughts”(Koestler, 1975). It has further

been reported that individuals have a tendency to rely on exemplars (Jansson and Smith, 1991), even when they are instructed to be creative in their thinking. For creative solutions it has been suggested that people move away from the first evoked sources (Wardetal, 2002). To sum up, the design solutions come from the sudden ‘interlocking’ of working memory, engaged in the problem and the designers’ ‘selective’ experiences, stored in the long term memory, the tendency of the designer to hook on to the exemplars in one’s experience is present which restricts the designers from achieving the best solutions.

Gedenryd (1998) further argues that design cognition is not an intra-mental process like pure thinking. It is not an intellectual processes comprising of the rational and logical steps in thought linearly ordered and separated from each other by cause and effect relationship. Design thinking doesn’t consist of the intention to action schema in practicality rather design thinking is an interactive thinking involving activity in the world and having the nature of ‘inquiry’ (Dewey, 1929,1938,1949; Schon 1983, 1987, 1988). Designers’ actions in the physical world are part of the design cognition and hence the role of sketching or prototyping is a way designers avoid pure intra-metal thinking to arrive at design solutions. The intermediate design ideas in mind continuously evolving to arrive at a solution have been recognised to be aided by external representations Lawson, 1994). Sketching has been a traditional medium aiding the designers in design cognition process. The intermediate design concepts are created in the process of some sort of a self dialogue where continuously an idea is created, represented, evaluated and recreated in a stream of thought process helps self evaluation of concepts before communicating. The sudden interlocking of previously unrelated thoughts occurs in this process within the designer (Koestler, 1975). It is argued here that the method of prototyping used in HCI design process is an extension of this self dialogue occurring within the designer during design cognition, to include the users’ responses and reaction to a design

concept in addition to their own to aid arriving at better design solutions. Involvement of users minimizes the risk of failure of final product. As often the designers of the interactive systems are not the users, hence accommodating the users thinking process early enough in the design process minimizes the risk of failure of design. Therefore, in interaction design, designers use various kinds of prototypes and prototyping methods to gather data from the users. From very early, low fidelity prototypes to later, finished and detailed, high fidelity prototypes, several versions of prototypes exist in HCI design field. These prototypes are used to verify the designed concepts appropriateness and gather data from the users to aid in any corrective thinking.

Though user data can be gathered in absence of any prototypes, as it happens in ethnographic inquiries within HCI, there is some form of the stimuli in response to which the user elicits the data. Whether it is in the form of use of some previous system or a general understanding related to the domain in which the system is intended to function, the user gives responses on the basis of some prior experience. Also, the testing of fully functional systems, a very popular form of which is usability testing, is done to assess the functioning of the designed system often towards the end of the design process is a form of data gathering from the users. The HCI design process being iterative, every instance when the user is involved in the design process, whether it be early or late, whether it be with low fidelity, non functional prototypes or with high fidelity, fully functioning, almost finished products, It is not only an opportunity to find problems in the exiting concept but is also a start point for better design solutions. Hence, all the instances of involving users during HCI design process has been called as data gathering process and all such techniques have been addressed as data gathering techniques in this thesis. As outlined above, in light of the need for users' data to aid designers' design cognition, these data gathering techniques become an essentiality for HCI designers. In context of designing for

users' experiences, role of these data gathering techniques become even more critical due to the fact that the experiential differences in users and designers are even greater than the performance related differences. In usability model, though the designers are not the users of the system but the normal human information processing capacity being within a narrow range, it is still possible for the designers to make certain assumptions about the users' performance but it is far more difficult to predict the users experience with the system. Hence, first it is required to understand the users in experiential framework and then to identify the technique that would inform the designers about users' experiences with the systems. Next section looks into the user models available in order to identify or create the user model in experiential design framework.

2.5 Use of 'user models' in HCI

Users of HCI systems are human beings, who are highly complex organisms with much evolved behaviour patterns. The internal processes and structures that cause or contribute to the observable behaviours are fairly complicated. At the same time, a model to understand the user behaviours is needed. For this purpose, several user models exist which are simplistic abstractions of the otherwise highly complex human system called user in HCI. These user models help in aligning the data gathering and design thinking processes.

According to Fram and Grandy (1995) study, UCD process demands understanding of the users. Also the vendors need to understand users of their systems for successful business. Models to understand users have been identified as a pressing research issue (IBM Thought-Leaders Forum, 1999). Yet, research on online and offline users is very much in its infancy (Hoffman and Novak, 1997; Vellido, 2000). The reason for this gap in need and effort made has been

due to several factors, one of them has been absence of a clear, well accepted user model in HCI. Some researchers argue for empirical modelling of users for objectivity (Fischer, 2000), while others have criticized it on the grounds that statistical information does not aid in design thinking (Hasdogan, 1996). Further, artificial test environments have been in use to aid in understanding the users' behaviour which have been found to have effects on users' opinions and behaviour. This modulation of users' behaviour has been recognised as a hindrance to true understanding of the users' behaviours. Yet the experimental involvements of the users have been found to aid designers thinking process (Hasdogan, 1996). Usability evaluators have been reported to have made faulty and inaccurate assumptions about the users (Jacobsen, 1999; Hertzum and Jacobsen 2001; Vermeeren et al, 2003). Difficulty in developing simple, accurate and realistic models of otherwise complex users' behaviours has been at the root of this failure. Attempts to model human mental processes and structures have existed in literature traditionally and some of them are in use in HCI design field. We will take a bird's eye view at these models before discussing the strengths and weaknesses of each.

Users have been seen as an information processor (Card, Moran and Newell, 1983; Newell and Simon, 1972), as a decision maker (Herbert Simon, 1983), as an affective agent (Lazarus, 1984; Norman, 2002), as a network of concepts of class of objects (Kunda, 2002), as artifactual and ecological meaning makers (Vimha, 1995) and as having mental models (Johnson-Laird, 1983) of simplified representations of the world. Each of these models of the users has been in use in some or the other context in HCI.

2.5.1 Users as information processors

The most prevalent model of the user in HCI has been of an information processor (Ashcraft, 1998). Users' are seen as a congregation of 10 billion neurons that receive, process and store information. There are fundamental limitations to the speed and capacity of the information processing system. Users get the initial information in the sensory memory, process it in the Short Term Memory (STM) and store it in Long Term Memory (LTM). Memory is stored as interconnections between neurons and has a web like structure (Ashcraft, 1998). A packet of information within the web of neurons is called a schema (plural schemata) (Bobrow and Norman, 1975). Users think and remember on the basis of these schemata. Understanding the schemata of users through various data gathering techniques is at the centre of the user centered design process (Heuer, 1999). The basic assumption of the information processing model is that the mental processes exist and they can be scientifically studied (Ashcraft, 1998).

Information processing model borrows its theoretical basis from the cognitive perspective which is the most widely used theoretical perspective in HCI field (Card, Moran and Newell, 1983; Newell and Simon, 1972). Reason for such wide acceptance of the cognitive perspective in HCI is that the user is in interaction with computer where he/she assess tasks and selects appropriate actions. Modeling user as having mental processes, which have limited channel capacity and speed, empowers designers with simple rules to design for efficient task fulfillment by users. Fitts Law is one such law based on information processing theoretic which explains the information capacity of human motor system and is applied in HCI to design both hardware and software systems (Fitts, 1954).

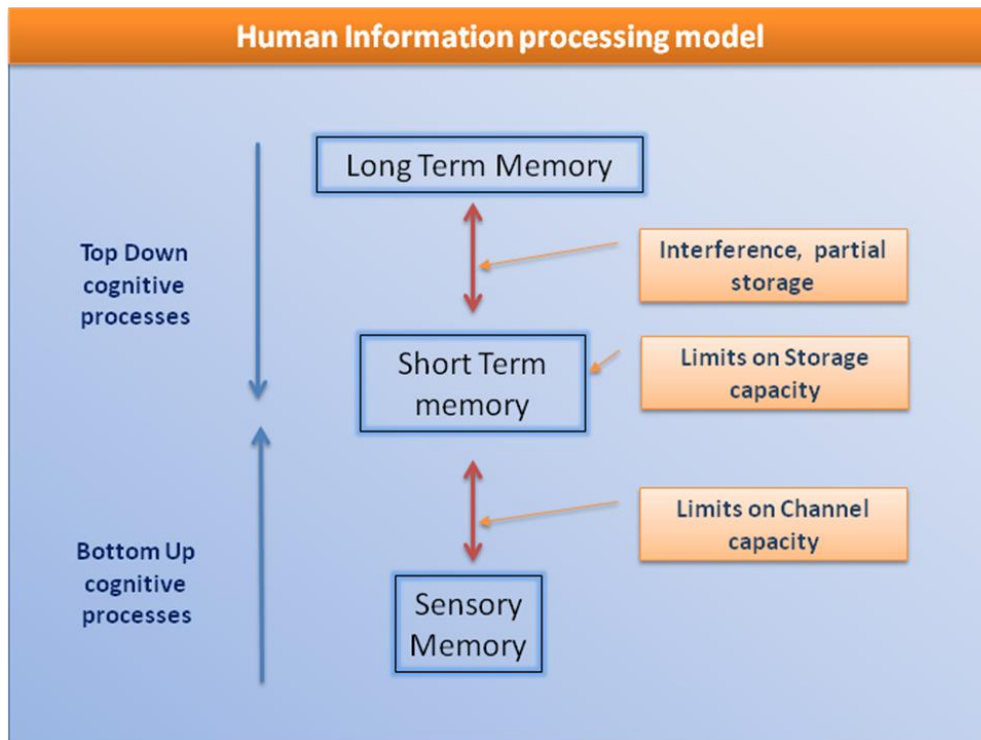


Figure 2. 2: Information processing model from Cognitive Psychology (Based on Atkinson and Shiffrin, 1968)

As shown in fig 2.2, a combination of ‘Top-Down’ (LTM to STM) and ‘Bottom-Up’ (From Sensory to STM) processes account for the abilities and behaviour of users. Several operational simplistic models based on Information processing theory have been created in HCI to understand users’ task fulfillment activity. For example, GOMS (Goals, Operators, Methods, and Selections) proposed by Card et al. (1983) aims to calculate and predict task completion times for a range of varying tasks. It is assumed in GOMS philosophy that users segment large tasks into sequence of small discrete subtasks. The human information processing model allows the system designer to predict the time taken to carry out each large task on the basis of expected time taken by each subtask due to fundamental limit of human information processing capacity by summing up the time taken for each subtask. For example an ‘editing text’ task can be broken down into ‘deleting’, ‘typing’ etc. and the speed at which each of the subtasks could be

performed can be estimated on the basis of general human abilities. A key level model of these tasks could also be prepared on the same model which is called in short KLM (Key Level Model) and has been in use in HCI design process.

2.5.2 Users as probabilistic network of concepts

One of the available aids in literature to understand users' mental processes is by the theory of 'concepts'. Concepts are seen as building blocks of cognition. They are mental representations of a class of objects that are believed to be together (Kunda, 2002). Several models of concepts exist in literature, basic structure underlying most of them is that concepts are networked, have some sort of hierarchy and they evolve with newer information. Concepts are acquired from early childhood, when recognition of regularities in the world begins and language to label and identify them start evolving (Macnamara, 1982). Users' use the concepts they have acquired throughout life to make meaning of the interaction with world around them. Individuals rely on variety of 'concepts' to make sense of the world (Kunda, 2002). A concept is a mental representation of a category (Smith, 1990). Concepts that a user has, helps him/her in classification of new information (Trope, 1986), inferring attributes (Bruner, 1957), guiding attention (Sagar and Schofield, 1980), communication and reasoning (Kunda, Miller and Clair 1990). The concept model hence becomes crucial to meaning making of the artifacts in HCI scenario. Due to the influence of prevalent concepts in classification and guiding attention, the menu organisation and visual hierarchy determination of the interface in HCI can greatly benefit from the theory of concepts. But these concepts are not static, they continue to grow, expand and organize in a probabilistic framework (Rosch and Mervis, 1975). Further, these concepts are activated by stimulus features (Higgins 1996), Saliency (Biernat and Veisco 1993), priming (Srull and Wyer, 1979), chronic accessibility (Marcus, 1977)

and goals (Kunda, 2002) of the user. The experience of the user with HCI systems, thus is largely influenced by the concepts they possess. The stimulus features present in the visual or auditory forms in the interfaces have potential of activating concepts. These concepts help create the meaning in users by influence through the top down cognitive process (Samuel, 1996). This way, the meaning that would be created in the user by the stimulus would depend upon the concept the user already has. The new concept formation due to repeated use would further be guided by these experiences. Hence in conclusion, concepts pertaining to HCI systems are continuously formed on the basis of the experiences user undergo with the systems and they in turn influence the experience users have with the system. Thus, understanding the users' concepts pertaining to the interaction with HCI systems would help designers design for users' experiences in UCD process.

2.5.3 Users as operating through 'Mental Models'

Mental models have been another theory in use in HCI to understand users' mental processes and behaviours. The term 'mental model' has been used interchangeably with 'conceptual model', though opinions differ on whether these terms mean the same thing (Booth, 1989; Murray, 1988). In mental model theory, it is theorized that the mind constructs a small scale model of reality and uses it to reason and to anticipate events. These models are constructed from perception, imagination, or interpretation of discourse (Johnson-Laird, 1983). The mental model theory denies existence of any propositional logic in users when making inferences about the world. Instead mental models are seen as an image, a script, a set of related mental models, controlled vocabulary, or a set of

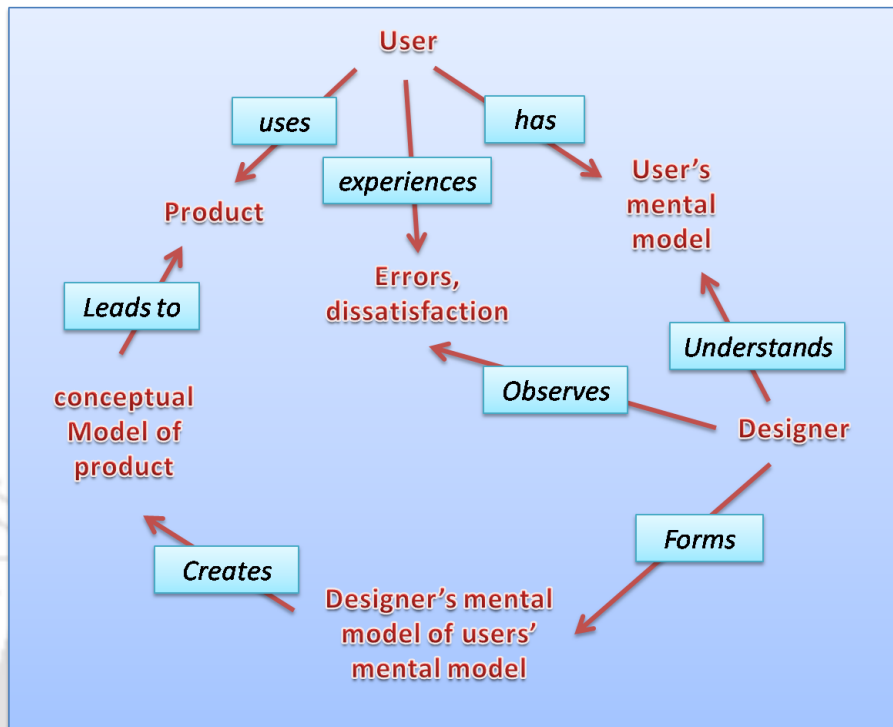


Figure 2. 3: Schematic diagram of how users' mental models are used by designers

assumptions (McDaniel, 2003). Though there have been several theories of mental models (Payne, 2003), generally mental models have been recognised to be, incomplete, inaccurate, constantly evolving. They are a simplistic representation of complex phenomena which can be represented by a set of if-then-else rules (Norman, 1983). It is envisioned that the mind constructs a simplified reality of the model based on perception or imagination and thus greater the complexity of the model is, the greater are the chances of it being inaccurate (Craik, 1943). Mental model of an interactive system formed by users will affect how the user interacts with the system. Greater the matches between the users' mental model and the system's existing model, the more successful the interaction will be. Even though it is theorized that people use mental models and

designers are suggested to use mental models of users during the execution-evaluation cycles of iterative design process (Norman, 1990; Fisher, 2003), there is little research about how to design for best match with users' mental models (Preece, et. al., 1994). The author sees the usage of much recommended use of mental model as complex phenomena where the final design is not directly influenced by the users' mental model but is actually influenced by the designer's mental model of the users' mental model. As depicted in fig 2.3, the designer forms his/her own mental model of users' mental model through subjective interpretation of information received from users through verbal reports or behavioral observations. Designer then creates a conceptual model of the product based on his/ her observations.

2.5.4 Users as meaning makers

Study of how meaning is conceived by the human mind had been a problem of investigation in several diverse fields. Semiotics has been one of the traditional fields with this focus and approached the understanding of meaning making through the "theory of signs". One of the early proponents of semiotics, Charles Sanders Peirce, used the concept of 'sign' as "a vehicle conveying into the mind something from. That for which it stands is called its object, that which it conveys, its meaning, and the idea to which it gives rise, its interpretant" (fig 2.4). The meaning arising from the object has been recognised to be through the modes of icon, index or symbol (Vimha, 1995).

Semiotics was further divided into syntax, semantics, and pragmatics (Morris, 1971). Syntax was concerned with the relationships between signs; semantics was concerned with the study of meanings and pragmatics with the overall psychological, biological and sociological phenomena occurring in conjunction

with the functioning of signs. Two components of Semantics, also recognised as two kinds of meanings, are denotative and connotative meanings (Eco, 1976). Osgood (1952) has developed a method of measuring connotative meanings through language. This method is known as the semantic differential. Semantic differential technique has proved helpful aid in personality, psychotherapy and communication researches (Osgood et al, 1978).

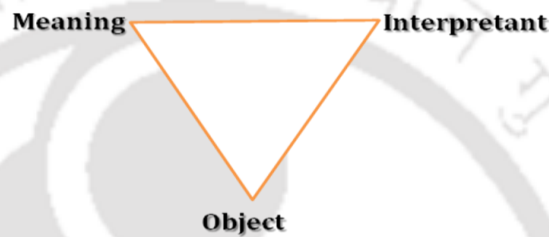


Figure 2. 4: The semantic triad of Charles Peirce

Semantic theory has been in extensive use in literary researches. Krippendorf and Butter (1984) drew attention of the product designers' community towards using semantic approach in product creations. Many designers since then have taken up research in semantic area. While the denotative meanings have been easier to express by design, it is the connotative meanings which have been challenge to designers (Yammiyavar, 1999, Byrne, 1990). The meanings connoted by the product have been difficult to capture. There has been little research to find a process of building connotative meanings into products. Yammiyavar (1999) has illustrated a process of identifying and building connotative meanings into designed products. Yammiyavar (1999) has also established emotions as a semantic construct in product design.

Of late, semantic approach to design has also been extended to the interaction design field by Krippendorf (2006). In '*The Semantic Turn*', Krippendorf (2006)

argues meaning to be prelude to all action. He says, "One always acts according to the meaning of whatever one faces" (pp. 58). Hence the semantic consideration of the designed interactions should be central to the interaction design process. Further, Krippendorf suggests constructivist approach to meaning, implying that the meaning is dependent on the context and culture, has been recommended by for use in design context. In order to understand the users' meaning one has to observe the actions of the users during the interaction with computers. Krippendorf notes that all the meanings acquired by artefacts are framed in language and the meaning of the artefact itself is acquired in the context of its interaction with its ecology. Hence, an ecological design with narrative interface structure has a greater chance of success in engaging and satisfying the users.

In past few years, some other semiotic approaches have also been proposed for HCI design (Nadin, 1988; Andersen, 1990; Marcus, 1992; Souza 1993). These works focus on a set of theory based guidelines for user interface design. These theories converge to identify the symbolic nature of HCI design with emphasis on the presentation aspects of the textual and iconic elements of design.

2.5.5 Users as affective processors

Role of emotions in human behaviour is a matter of general observation. It has also been established by several research investigations. Since Charles Darwin's book 'The expression of the emotions in man and animals' (1872), several theoretical traditions in research of emotions have emerged and still exist. One of the preferred theoretical traditions in emotion has been of cognitive perspective to emotions. As the cognitive model has been the favorite model of users in HCI, it is pertinent to take a look at the cognitive tradition of emotions here. This will

help in identifying the overlapping concepts between the cognitive and affective models and aid in an integrative thinking towards modeling users in experiential framework.

Sperber (1996) outlined that the triggering conditions are responsible for emotional arousals. These triggering conditions are the mental representations of outputs of sensory and conceptual processes. The functional role of these sensory and conceptual processes is to supply information for one's detection and categorization of an incoming stimulus. Lazarus (1984) has argued that cognition, that is some type of information, processing precedes an emotional response. Also there are studies that argue that emotions prepare an individual to respond to a situation immediately much before any information processing has happened (Zajonc, 1980). Some researchers have attributed the discrepancy between the two approaches to the way the terms "cognition" and "emotion" are defined and employed (Nussbaum, 2001; Parkinson & Manstead, 1992). According to Cosmides and Tooby (2000, p. 98), "the term cognition is often used to refer to a particular subset of information processing, the effortful, conscious, voluntary and deliberate. However, from an evolutionary cognitive perspective, cognition refers to all of the brain's operations, including emotion and reasoning. If the brain evolved as a system of information processing relations, then emotions are in an evolutionary sense, best understood as information processing relations (programs)."

Emotions viewed as just another information-processing system, like memory and perception, differs from other cognitive processes by the mode of processing and the functions they serve. For example, LeDoux (1996) has specified two complementary neural pathways involved in detection (appraisal) of a stimulus, the emotion route (thalamus–amygdala) and the cognition route (thalamus–neocortex–amygdala). These processes seem to work parallel to each another.

However, the emotional route is faster and it takes over the cognitive system depending on the nature of the input received.

It has also been known that emotional processes affect other cognitive processes. For instance, emotions have been found to influence attention (Herbert Simon, 1983, p. 21) and help to focus on more important pieces of information overlooking peripheral ones (Faucher & Tappolet, 2002). Emotions also have been found to affect the learning processes by directing the focus to specific information while ignoring others (Holland and Gallagher 1999, p. 68; LeDoux, 1996; Mineka & Cook, 1988). Emotions have also been reported to influence memory. People have been found to remember and recall events associated with emotions better in comparison to emotionally neutral events (Bower, 1981; Christianson, 1992). It was observed that the degree of activity in the human amygdala related to memory increased almost linearly with the degree of subjective arousal induced by the stimuli (Packard & Cahill, 2001, p. 754). The emotional information having privileged access to the processing resources has been explained as a possible reason for the memory enhancement (Dolcos & Cabeza, 2002). The strong connections of Amygdala with other brain regions involved with memory, such as the hippocampus and lateral prefrontal cortex (LeDoux, 1996; Panksepp, 1998) has been seen as another reason for the memory enhancement. These findings on the influence of emotions on attention, learning and memory are of prime interest to an HCI designer as the prevalent practices in HCI emphasise on the learnability and memorability of the information systems (ISO 9241-11). Further, attracting and guiding the attention of users is one of the prime concerns of the designers in HCI. Knowing the possibility of interference of emotions with the cognitive processes like attention, learning and memory, Norman (2004) argues for a deeper understanding of affective experiences of users with the system. Rosalind Picard (2000) has demonstrated the role that emotion can play in interaction with information

systems and has argued for “affective computing”, an emotional competence on the part of computer systems, for making interaction more efficient and effective.

Mental processes involved during the affective evocations have been studied in neurobiological research. It has been recognised that the major neural structures used for emotion processing are amygdala, orbital cortex, and anterior cingulate cortex (Damasio, 1994). The same neural structures also play an important role in cognitive processes. On the basis of observational findings, Antonio Damasio (1995; 2000; 2003) has argued strongly for the critical role that emotion plays in practical human reasoning and in the effective working of rational decision-making. These observations of interference of the emotions with higher forms of cognitive processes like decision making are valuable information for HCI designers. As the users of HCI systems are no more doing mere clerical tasks but are consumers now (Kutti, 2001), understanding the role of emotions in users’ browse and purchase behaviour has become critical to interaction design process now.

Importance of understanding and designing for emotions evoked by the products has been felt in product design field as well (Yammiyavar, 1999). Several conferences of this theme have been organized and many special issues of design journals have been published (Green & Jordan, 2002; McDonagh et al., 2003). Major corporations like Nokia, Philips, Nike etc. claim to have adopted an emotional design strategy for their product development. Donald Norman, has published a popular book in the name of ‘emotional design’ (Norman, 2002). Norman argues that the users cognitive processing broadens under positive emotions. This helps in better performance. This argument of influence of positive emotions on improving the performance goes a long way in arguing for emotional design as it also helps improve the perceived usability of the product.

Arnold (1960) has used product appraisal, which he defines as “the sense of judgement of weal or woe”, as the heart of emotional design. Frijda (1986) has posited that the users ‘concerns’ are the points of reference in the appraisal process. It is in the light of concerns that the users judge any given product and it is the outcome of the judgement that leads to emotion. The positive judgments lead to positive emotions and the negative ones lead to negative emotions. Desmet (2002) has used a triad model of product, concern and emotion with the appraisal process sitting in the middle, mediating the judgment of product with respect to the users concerns (fig 2.5).

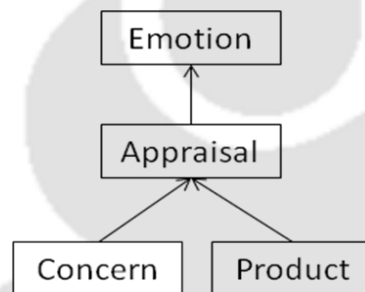


Figure 2. 5: Product appraisal and emotion (after Desmet, 2002)

It has been postulated by Desmet that emotions elicited by users can be understood if their concerns could be understood. He also has recognised the difficulty in understanding users’ underlying concerns with respect to the use of products. One of the reasons recognised is that the number and the variety of human concerns is very large. Various typologies of concerns exist in fields of organizational behaviour (e.g. Maslow, 1943), personality psychology (e.g. Murray, 1938), social psychology (e.g. Rokeach, 1973), and consumer behaviour (e.g. Hanna, 1980). But they do not seem to make the task of identifying users concerns in context of product use easy. Lazarus (1998) has used ‘motivation’ in a similar way to Desmet’s use of ‘concerns’, in aiding the appraisal for the

emotional evocation. Lazarus also has added the need of meaning in appraisal in place of the product itself, as Desmet has used. In spite of these differences the common structure of emotional evocation mediated by appraisal, which uses the meaning of the product to the user and motivation or users concern as the aiding factor in the judgement, seems to be good enough for creating user's model in affective framework. We will use this framework and expand it with aid of contribution from other user models.

2.5.6 Users as decision makers

Users are now consumers (Kutti, 2001) and study of consumers is the study of how they make decisions to spend their resources like time, money and effort etc., hence study of users as decision makers becomes imperative. In the experiential context, users' decision making has been found to be not purely cognitive as emotions have been found to have a profound effect on consumers' choice behaviour (Simon, 1983). Emotions have not only been seen as associate processes but as causally powerful processes (Muramatsu and Hanoch, 2005) which can interfere with rational thinking and problem solving (Kaufman,1999).

Individual's decision making process has been seen from a 'bounded rationality' perspective (Simon, 1983). It has been recognised that users have limited time, limited information and limited cognitive resources to aid their decision making process. It is theorized that individuals rely on decision strategies that can economize on their cognitive processing capabilities. In 'bounded rationality' perspective, users tend to use an adaptive toolbox of fast and frugal heuristics (Gigerenzer & Selten, 2001; Gigerenzer et al., 1999). Users use heuristics to minimise the computational effort required for decision making and this process has been thought to be fast and frugal. They are fast as they rely on fewer cues,

thus using less cognitive effort and they are frugal as they make selective search for cues and alternatives. Emotions have been envisioned to be a part of this adaptive toolbox of heuristics for making decisions. Emotions along with other domain-specific heuristics constitute the users' mental architecture (Gigerenzer et al., 1999; Muramatsu and Hanoch, 2005).

Emotions as a the tool in a toolbox of specialized cognitive shortcuts which aid in making adaptive inferences and choices, give direction to search and stopping. They help create the decision rules that produce choice behaviour ((Levenson, 1999, Muramatsu and Hanoch, 2005). Emotions facilitate users' inferences about the consequences of an action. According to Damasio, "emotions of all shades eventually help connect homeostatic regulation and survival 'values' to numerous events and objects in our autobiographical experience" (Damasio, 1999, pp. 54–55).

Kelly's personal construct psychology (1955) offers an additional angle on the role of emotions within the decision-making process. From Kelly's perspective, it is not only how the environmental cues trigger emotional programs, but how agents construct or view the environment that, in return, affects what emotional program is likely to be activated. Kelly's framework suggests that when external conditions are aligned with a person's core construct, decisions will tend to follow a more reflective procedure. In contrast, an emotion-driven behaviour is expected to occur when a chasm exists between a person's core construct and the environmental challenges she or he faces (1955, p. 495). This personal construct psychology perspective of Kelly has also been applied in an economic framework (Earl, 1983, 1986). In this thesis emotions are of interest because they are primary building blocks of 'experience'. In the process of extracting experience related data from within the users encoding and decoding the emotions become vital.

2.5.7 Users as aesthetics appreciators

Users not only have intentions which they try to fulfil but also have tastes/preferences for objects around them. They chose and appreciate visual quality in objects around them. Beyond the function of the object and the affective value that the object has due to prior experiences and associations of users, the mere appearance of the object creates a value by itself. Several terms for the value due to appearance of the interfaces have been used in HCI field like, 'look and feel', 'visual appeal' etc. but in classic literatures this phenomena has been studied under the name 'aesthetics'. There has been a growing demand from within the HCI field for giving importance to aesthetics as an application issue with respect to interface designs.

Recent empirical studies in the field of human-computer interaction have found that aesthetics of the interface plays an important role in users acceptance and satisfaction with the HCI systems (Kurosu and Kashimura, 1995; Tractinsky,1997; Tractinsky et al., 2000). To the surprise of researchers, not only did the interface aesthetics affect the users' affective responses towards the system it but also improved the performance (Tractinsky et al., 2000; Norman, 2002). Norman has attributed phenomena of improvement in cognitive functions under influence of aesthetics appreciation by user as broadening of awareness. The role of aesthetics has been argued to be even more important in context of the online systems (Schenkman and Jonsson, 2000; van der Heijden, 2003). As a vast amount of business is facilitated by online systems, and the aesthetics of the online systems, very much like the aesthetics of physical retail environments, has been known to influence the buyers purchase behaviour (Russell and Pratt, 1980; Russell, 1988).

More researchers are arguing that HCI design has placed too much emphasis on performance and not enough on aesthetics which is also important for a

product's success (e.g. Green and Jordan, 2000; Norman, 2002). Though aesthetics has been recognised as an integral part of effective interaction design (Alben, 1996) and beauty of the website has been found as an important factor in perception of the quality of website (Schenkman and Jonsson, 2000; van der Heijden, 2003), yet HCI literature has scanty instances of aesthetic considerations in HCI design (Lavie and Tractinsky, 2004). Hence it becomes imperative to dig into the body of literature concerning study of aesthetics to understand what constitutes aesthetics and how to measure it, in order to bring it to HCI design practices.

It was only in eighteenth century that the word 'aesthetics' was introduced by Baumgarten (Saw and Osborne, 1968). There have been several different viewpoints to what is beautiful. For some philosophers, the perception of beauty has been of cosmic importance and beauty is in an inherent 'order' in things while others see a 'delight' in perception is sufficient for something to be beautiful (Feagin and Maynard, 1997). Aesthetics as an expression of an artist's personality more than any objective thing in itself has also been argued (Arnheim, 1964/66; Osborne, 1968).

In modern study of aesthetics pertaining to designers concerns, two extreme views exist. The first view is expressed in the functionalist theory of aesthetics, oft quoted in Louis Sullivan's phrase 'form follows function', maintains that if an article performs the function it is meant to do and does it well then it is a beautiful article (Osborne, 1968, p. 24). The second view is Kantian theory of aesthetics which emphasizes the need of absence of any purpose for an aesthetic attitude (Osborne, 1968). According to Kant, only in the absence of the 'purpose', while attending the object that the aesthetic appreciation can happen. An extreme expression of this view by Theophile Gautier is 'Nothing is truly

beautiful except that which can serve for nothing; whatever is useful is ugly'(Osborne, 1968, p. 200).

For Interaction design, neither the Kantian view nor the functionalist view would suffice alone. As Kant is interested more in the article's intrinsic properties (Borev, 19810) and the functionalists take the instrumental view of the article in use. For interaction design purpose, the use is the context which sets the boundaries for aesthetic appreciation but use alone does not deem a system beautiful. The intrinsic appreciation of the interfaces, their composition and their visual elements appearing sequentially during the interaction has a role to play in the aesthetic perception by the user. At this point a pertinent question would be whether the aesthetic perceptions are user dependent and are they objective in nature. The objective view emphasizes specific properties such as order, proportion and symmetry (Osborne, 1968; Fenner, 1996) whereas the subjective view emphasizes that the beauty is in the observer and not in the object (Sircella, 1975). Current theories take a middle stand in the subjective objective debate and advocate an interactionist approach where the aesthetic perception depends both on the stimulus as well as the aesthetic attitude of the perceiver (Rajamannar, 1961; Porteous, 1996). According to Osborn, even Kant identifies the aesthetic pleasure as different from the aesthetic perception itself (Osborne (1968, p. 129). The former is more subjective while the latter resulting from fundamental sensory processes common to all humans. The objective viewpoint enables the quick experimental approaches based on bottom up process (Swede, 1994). And the subjective issues expressed in Top down mental processes would need a more ethnographic approach to unveil.

Several researches have used the quantitative techniques to measure objective aesthetic qualities of objects. For instance, Pickford (1972) using factor analysis

identified general factors of emotional expression, harmony of design, harmony of colour and dynamic expression influencing aesthetic perception. Hussain (1968) identified three levels of aesthetic preference: 'emotional evaluation' (the feeling produced by stimuli (an integration of the first two), 'perceptual evaluation' (the perception of details and its contribution to the whole) and 'aesthetic evaluation' (an integration of the first two). Experts have been found to differ in their aesthetic perception from laymen (Hershberger, 1969), but across cultures (US and Japan), the perceptions of orderliness, diversity and novelty remain same (Nasar, 1984). Oostendorp and Berlyne (1978) identified Design clarity, hedonic tone/arousal, complexity, and familiarity as major dimensions of preference. In another study, Nasar (1988) found three major dimensions: visual richness (e.g. ornateness, colourfulness and complexity), openness (vs. closeness) and clarity (vs. ambiguity). There is a new wave of research studies in the effects of visual aesthetics on users (e.g. Tractinsky, 1997; Jordan, 1998; Jennings, 2000; Karvonen, 2000; Tractinsky et al., 2000; Lindgaard and Dudek, 2002).

This thesis sees aesthetics as the third level of aesthetic preference pointed out by Hussain (1968) that of the 'aesthetic evaluation' where an integration of both the feeling produced by the stimuli and the perceptual evaluation of the details of stimuli are taken into account. In context of users' interaction with computers, whatever induces the feeling of appreciation for the system on basis of visual qualities of the system are taken as the 'aesthetic experience' induced by the system.

2.5.8 Users as members of cultural entities

Users of HCI systems are not only individuals as have been treated in other user models so far. They are also members of social groups. They inherit socially

transmitted ideas, techniques, behaviour patterns, rules, rituals and customs (Foxall and Goldsmith, 1997). Culture can also be seen as the collective mental programming of individuals of a group that distinguishes them from other groups (Hofstede, 2001). According to Hofstede, the outside influences like forces of nature, trades and ecological factors like demographics, hygiene, technology and urbanization lead to the value systems which are manifested in the social systems (fig 2.6). In the HCI field, the need for considering users' cultural influences while designing systems has been strongly emphasized. For instance, Clemmensen and Plocher (2007) have argued that cultural models should be at the heart of the study of HCI. Barber and Badre (1998) have argued that users' cultural background can directly influence performance; Marcus and Gould, (2000) have showed cultural differences in the websites constructed in different cultures and Honold (2000) showed that Indians and Germans use washing machines quite differently and Sheppard and Scholtz (1999) have talked about the effects cultural markers have on use by the users. It has also been recognised that culture would influence the data collection techniques used in HCI design process (Vatrapu and Pérez-Quiñones 2006). These researchers augur for a deeper understanding of what culture constitutes and how it can impact the experiential design and data gathering processes.

There are several theories regarding the elements of culture that contribute to the cultural makeup of an individual. For instance, Johnson (1962) identifies Beliefs, Values, Symbols and Behaviour patterns as elements of culture. Hofstede (2001) has identified elements of culture as Values, Rituals, Heroes and Symbols and presents them as existing at different levels of depth in manifestation (fig 2.7). However some elements have been almost commonly identified among the

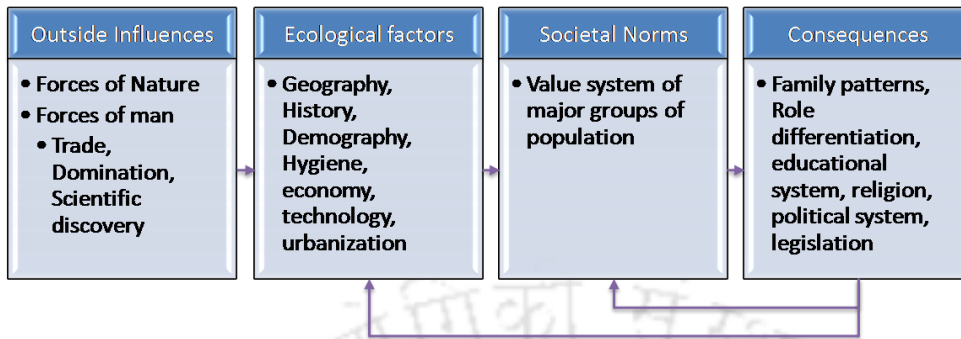


Figure 2. 6: Stabilizing of Social patterns (Hofstede, 2001).

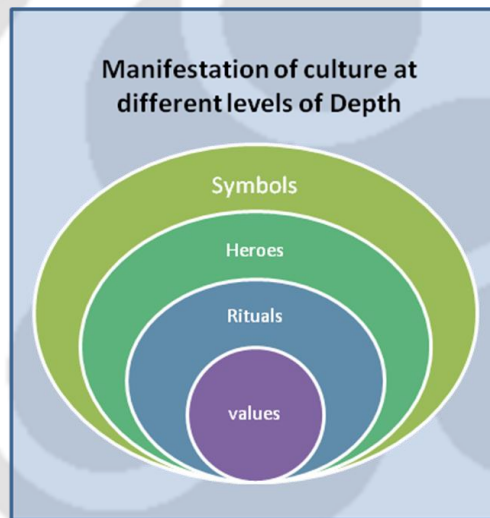


Figure 2. 7 : Manifestation of culture (Hofstede, 2001).

different theories. For instance ‘Values’ have been considered as a core cultural element. Hofstede has placed values as the core element of the culture. It is the values that are expressed through the symbols prevalent in a culture. The value system of users needs to be understood in order to accommodate and reflect it in the designed HCI systems. It is important for HCI designers to have techniques that could help understand the cultural differences in values. Several different

value typologies exist and among different methods, a questionnaire method has been in use to assess individual's values. For example, Schwartz's (1992) typology includes 10 distinct value types (i.e. power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity and security) and These value surveys cannot be universally applied as these value surveys have been developed keeping in mind the specific cultural groups for which they were developed. Hofstede (1991) posits that only some of the values that are important in a particular culture also prevail in other cultures. He found that the Rokeach Value Survey (Rokeach, 1968) which was developed specifically for the United States of America has an item 'salvation,' which is not understood by most Dutch people. The measurement of differences in the users' values from different cultures would be needed to be an integral part of the user data gathering technique. In this thesis, the author posits that the users' experiences with a given HCI system would be highly influenced by the value system the user has inherited. The success of any users' data gathering technique to get experiential data would also depend on its ability to bring forth the data on cultural value system of users. To conclude, the data gathering technique should be sensitive enough to be able to bring forth the cultural differences in users' values in context of interaction and should also be applicable in different socio-cultural settings to be able to do that.

2.5.9 User models for experiential design in HCI

There is an increasingly greater recognition being given to the experiential design approach to interaction design from within the HCI field. For instance, McCarthy and Wright have emphasised that the users should be seen as individuals engaging and experiencing the technology in a very personal way rather than merely using it dispassionately (McCarthy and Wright, 2004). Users see a meaning in

technology and there is a personal experience that takes place during the interaction (Pacey, 1999). Ben Shneiderman has emphasised that the “new computing” has begun where successful technologies are no more those that focus on what users can do but rather what activities does the interaction support to enrich the users’ experience (Shneiderman, 2003). Research has indicated that users’ interactions with computers are essentially social, and that their responses resemble responses to social situations (Reeves and Nass, 1996). Turkle (1995) points out that the experiences with computers can only be understood as part of a larger social context. These indications

HCI Research and practice is already moving towards experiential design methods and processes (McCarthy and Wright, 2004; Shaffer and Weinschenk, 2008). Though the experiential design approach in HCI is in the very beginning stages, a few models to understand the users in experiential mode have been developed.

User model suggested by Preece et al (1994) identifies the user experience capabilities which a system should have in order to be experientially good. The suggested model is an envelope model over and above the usability model. Preece et al (1994) suggest that usability are specific in nature and are central to interaction design whereas the less clearly defined users’ experiences can be seen as an envelope model over and above the usability matrices (fig 2.8). This model envisions users experience as tied to usability of the product and existing on the surface of it, while the products’ usability remains central to the products success. This model does not take into account the likely conflicts which may arise in the usability and experiential design goals. This model assumes that a product can give good experience only when all its usability concerns have been met. In practice a system can be designed with an aim on experiential design, which may not have usability in it at all. For instance designing a computer based game

purely aimed at giving experience of fun and efficacy of the users. In context of experience design, feeling of efficacy which comes from achieving difficult tasks can be a major difference between the usability and user experience design concerns. Surprise and novelty could be other differentiators between the usability and user experience design goals. This model also assumes that the users' experiences with products are more superficial concerns for interaction design while the usability of the system is a core concern. In the experiential design framework, the users experience may take the driving seat in deciding design goals and the usability concerns may play a second fiddle as illustrated in the game example above. In spite of these criticisms of the way in which the user experience and usability concerns have been related in this model, this model lists the major concerns in a comprehensive way. Importance of emotional fulfilment and aesthetic pleasure has been recognised as major goals in UXD. Satisfaction, enjoyment, motivation, rewarding, support for creativity and entertainment are the other concerns listed. However, Preece et al have not described a process to achieve these goals in experience design. Detailed descriptions of each of these concerns and their grounding in the theoretical research have not been mentioned, making it difficult to identify boundaries of each of these concerns and how to elicit them from users.

Another approach to modelling users' experiences has been by identifying the factors that affect the users' experience. For instance, Peter Morville (2003) has suggested a seven factor model for modelling users' experiences for interaction design (fig 2.9). In this model usability is positioned as one of the seven factors in the users' experience with system but it has been stated that mere usability is not sufficient. It needs six other factors with it. Designers need to use creativity to ensure that the products are really useful for the users. A desire for the product needs to be created in the user by creating value for the brand. Users should be able to get what they are looking for in the interactive system and it should be

easily accessible my majority. The design should be able to deliver ‘value’ to the users and that it should be credible and be trusted by them. In this model delivered value as perceived by the user is at the core of the users’ experience and

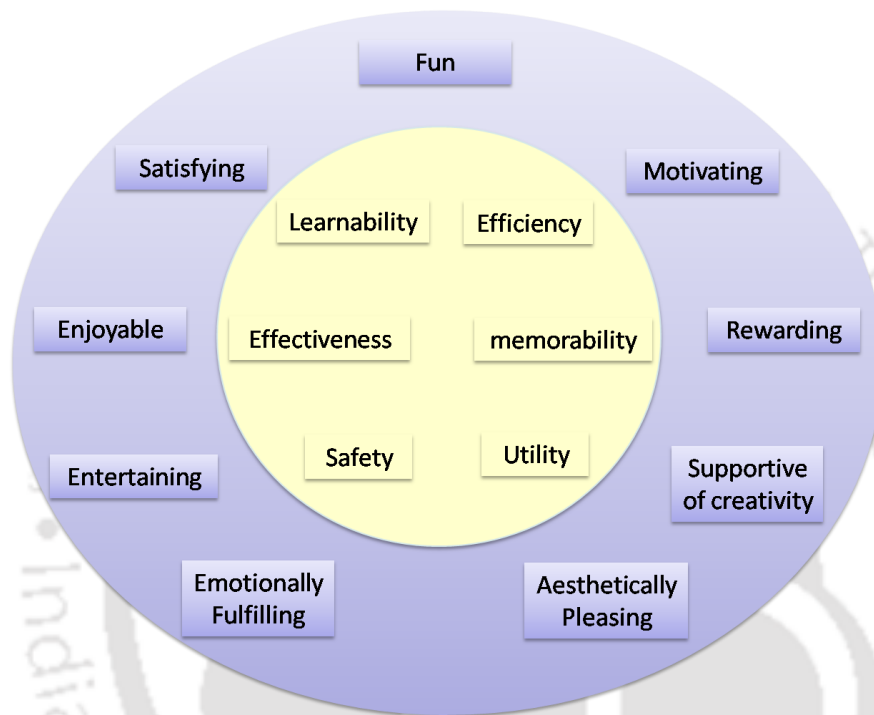


Figure 2. 8: User Experience model by Preece et al (1994)

it is achieved through making the system useful, desirable, accessible, credible, findable and usable. This model does not talk about how these different factors are connected to each other. For instance how accessibility is related to the value or how desire is contributing to it. The theoretical grounding of this model is also not available. How to measure these and how to gather data from users regarding these factors to measure if a certain system is, for instance, desirable enough has also not been mentioned in literature. Interestingly, this model has not talked of any affective or aesthetic factors related to the value felt by the users, which

others have strongly argued. Affective dimension of users' interaction has been seen as separate from what the usability concerns have covered. Surprisingly the aesthetic concerns of the system have not been mentioned in this model. Also the temporal quality of the experience has not been taken into account in the models, Preece et al's and Morville's.

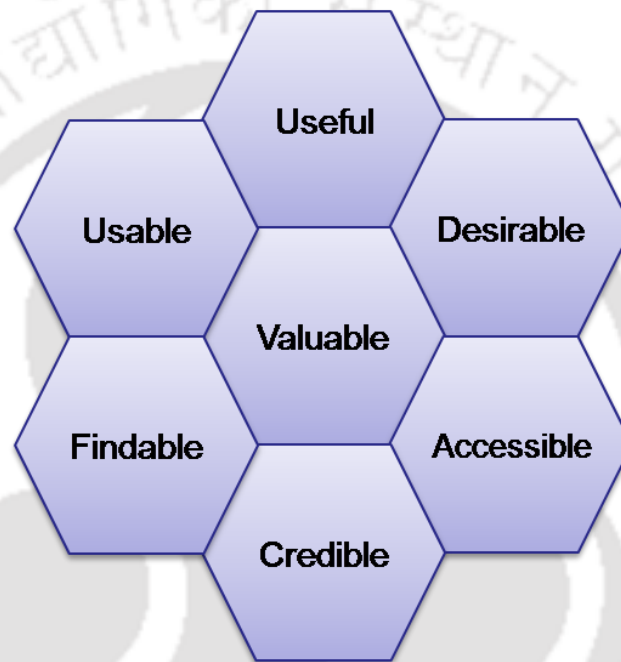


Figure 2. 9: User Experience model by Morville (2003)

Emphasis on emotional value of design has been iterated in several places in recent literature pertaining to HCI design and allied fields for instance; Norman (2002) has given a three tiered model of design in general which are also applicable to HCI design. Norman's 3 tiered design model of design consists of visceral, behavioural and reflective levels (Norman, 2002).

Jääskö and Mattelmäki (2003) have seen the users' experience as a conglomeration of products look and feel, socio cultural context, users' memories and past experiences, the physical environment of use, the use context (tasks and scenario) and the market context. Both aesthetic and cognitive concerns of the product usage have been taken into account in this model but the arousal resulting from the appraisal of meanings identified in the product and its temporal nature has not been given place in this model. These models also do not specify the methods and techniques for eliciting the experiential data from users.

Krippendorf in *'The Semantic Turn'* (2006, p. 89 ff.), details three qualities of experiences with artefacts; Recognition, Exploration and Reliance. He argues that for an interaction design to be successful, it should succeed through all three stages. Achievement of reliance by users in technology through recognition and exploration should be the goal of User Centred Design process. Krippendorf stresses that users' ability to make meaning of the instances of interaction is common through all these stages. The willingness to act is created through the meaning a user sees in interaction. Krippendorf follows Heidegger's notions of 'relationality' and 'temporality' of the experience in emphasizing centrality of meaning to the process of experiencing. He suggests that there is a need to overcome the subjective/objective dichotomy in understanding of experiences and focus on the process of experiencing by acting and creating in the real life. He stresses that it is impossible to share an experience. The natural discourse which facilitates the sharing of experience is due to the presence of con-sensual elements in the discourse. The understanding of an experience jointly attended to, creates a platform for the discourse to happen between the individuals. Language helps in making the experience become social and hence the experience goes beyond being subjective. The expectation of being understood helps in sharing the experience and only when shared, the experience 'settles down'. It is the faith in the interest and sympathy of the listener more than the language itself which

makes one attempt to share the experiences. Krippendorf further argues that it is obtrusive for the user to express the experiential phenomena as it interferes with the task at the reliance stage of use (Krippendorf, 2007).

McCarthy and Wright (2004) in their book *Technology as Experience* have proposed a model for users' experiences with interactive systems based on John Dewey's Pragmatist philosophy. McCarthy and Wright take a stand that theorizing of pragmatism is valuable for understanding technology and design. The suggested model is based on the idea that the felt experience and the meaning made of it are never available a priori but it must always be accomplished dialogically. It always occurs in the tension between self and other (Bhaktin, 1993). McCarthy and Wright quote Bhaktin in emphasizing 'creative understanding' of artifacts in interaction as central to the felt experiences and describe it as a dialogical process of bringing together different perspectives of the seer and the seen. It is in the dissolution of the identities of the seer and the seen that the meaning of the interaction emerges. This creative meaning making process is central to the felt experience of users. This model also gives priority to the aesthetic experience in understanding the users' experience with interactive systems. Meaning has been identified as central to the experience in this model as well (fig. 2.10). The cyclic processes of anticipation, cumulation, conservation and tension which occur during the process of experiencing something are with respect to the meaning of the phenomena being experienced.

Another way of looking at the Dewey's model of experience is through the process of discovery, where the perceiver, through application one's abilities first develops a disposition towards meaning and then with further adherence with the phenomena identifies a meaning (fig 2.11). The process of experiencing does not stop here as it is an ever ongoing process. Further seeking into the phenomena, one then disassembles the existing meaning to create a furthered, deeper meaning

by reconstructing the experiences. This way the cycle of experience mediated by meaning continues forever.

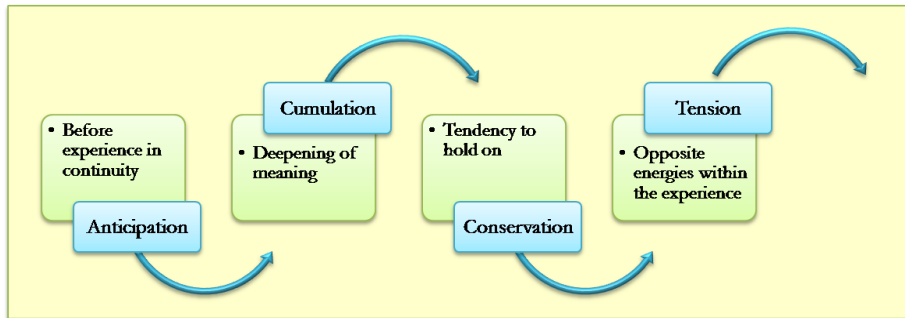


Figure 2. 10: Experience as temporal tendencies (after McCarthy and Wright, 2004)

However, the method to understand users' experiences in HCI according to Dewey's model of experience, as suggested by McCarthy and Wright is through the accounts of the self who felt the experience. Reception of accounts of felt life with an acceptance towards the complexity of the concepts used in conversation has been suggested to be the method for eliciting experiential data. Personal reflection and recounting has been suggested to be one of the methods for

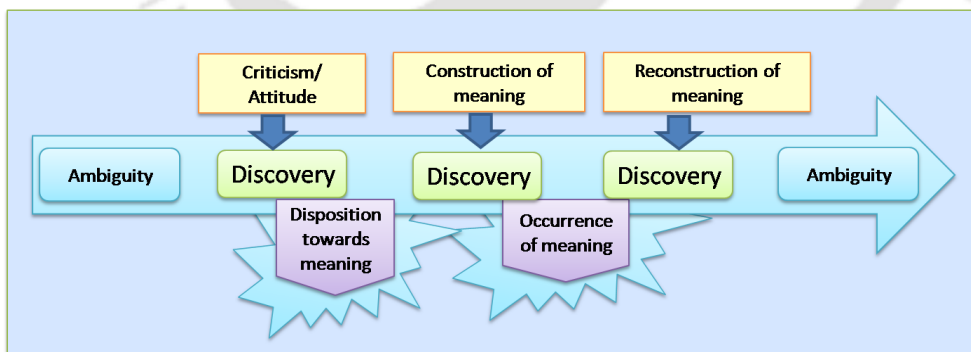


Figure 2.11: Experience as discoveries of meaning (after Dewey, 1988)

understanding experiences. The other method, more important for the experiential design process, has been suggested to be of 'situated observation'. The researchers involved in experiential data gathering are suggested to bring their day to day life aesthetic and affective sensibilities to the research and try to understand the felt quality of interaction being undergone by users. It is an attempt to understand the intrinsic meaningfulness of the interaction for the users by the researcher. This model though recognizing the temporal quality of experience and the aesthetic and affective components of felt experiences, seeing meaning as central to the process, doesn't suggest anything on the process of use of this model in an interaction design process. The process of analysis of the experiential data thus gathered from the situated observation of the users in action for use by designers has also not been described. The process of designers design thinking in context of interaction design specifically has not been highlighted as the background for the experiential data gathering activity.

2.6 Discussion on prevalent user models

The prevalent user models, be they affective, aesthetic, cognitive, semantic or cultural, described in section 2.5, come from different traditions of inquiry. Each model has its own strengths and weaknesses. The very perspectives these models keep towards understanding the users' behaviours are also responsible for their limitations as well. Need to focus on one aspect of the complex human behaviour sidesteps other facets of the behaviour. As the experiential design process needs to focus on a more holistic prospect of human behaviour, there is a need to identify gaps in each model and compare them with strengths of another model so as to be able to create a user model which could be used in the experiential design process.

For instance, Information processing model has helped design HCI systems aimed at efficiency since very early days of practice. The Information processing model helps in understanding user's behaviour in terms of temporal relationships between different processes that constitute the mental functioning. However it does not focus on the underlying mental tendencies which shape these processes themselves. For instance, affective state has been found to have significant effect on the cognitive processes (Norman, 2004) but the cognitive model does not accommodate effects of affect on information processing. The cognitive model focuses on outlining the various components of the mental and sensory processes, their capacity and limitations. While this no doubt adds substantially to our understanding of how human experiences the interaction while performing certain tasks using computers, it certainly does not tell much about the emotional state or the aesthetic appreciation that the user has undergone during the interaction.

Users as having mental models of external world and processes which guide the actions of users has also limitations as it does not accommodate the meaning making process that user undergoes and the affective states that user experiences. Users as having groups of concepts which helps categories and connect the various external world entities in mind, does to some extent hint at the way connotative meanings are formed but still it does not help identify the exact process by which meaning occurs. It does not help understand the affective experiences in users.

The affect model looks at the powerful influence that emotions have on the cognitive processes in particular and user behaviour in general. Centrality of 'meaning' has been argued in the semantic model which presents meaning as the mediating process between the intentions and actions of the user. But the users' actions are not solely a product of what is being seen on the interface but is also

affected by the mental model that the user has of interaction. Users also have aesthetic tastes and have inbuilt appreciation for visual quality in interfaces which helps the users' interaction much beyond the visual. Much of the meaning that users makes of the world around in general in interface elements in particular is influenced by the deep values systems and representative symbols that they have been programmed with through the culture that they belong to. Hence none of these models are helpful to the experiential designers in entirety.

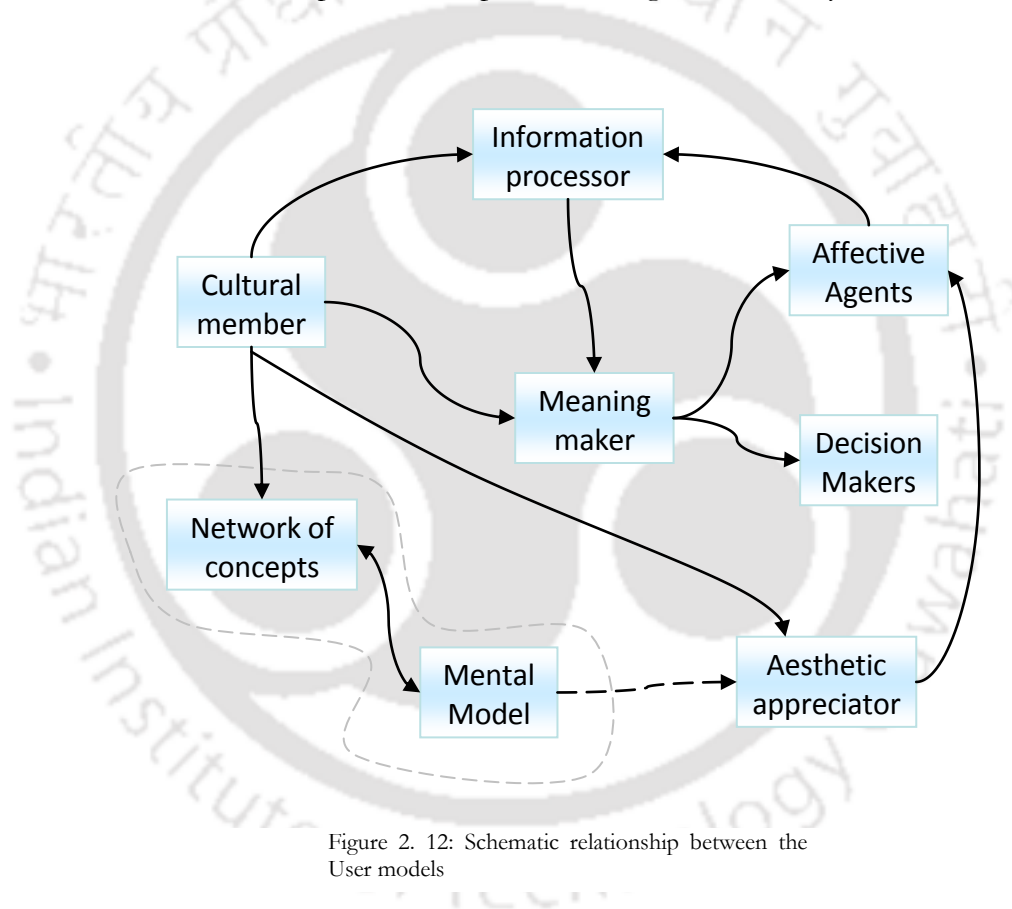


Figure 2. 12: Schematic relationship between the User models

Further these models do not explicitly mention techniques by which data pertaining to the model could be gathered from the users. Though, Think Aloud technique has been used in HCI for gathering data pertaining to the information processing model and Semantic Differential technique is used to understand

underlying connotative meanings that user has felt in general we do not find established techniques to gather affective, aesthetic, conceptual and mental model data in HCI literature. Sundry, techniques have been in use in practice but there isn't enough literature around them.

Mental models theory has been used by HCI designers in understanding users' expectations and actions. Other models though have been mentioned and argued for use in HCI literature but due to lack of any formal techniques or methods to aid the design process with perspectives of these theoretical models, not many reports of practice are found in literature. In the present thesis, the user is being seen as an experience of the system and a user model to understand the user as an experiencing agent is being sought. None of the models mentioned above can on their own fulfil the need of understanding the users as experiencing agents. There is need for a more holistic and integral model of user for use in the experience design process. In next section, literature study done to identify a user model useful in experience design process is being presented.

Though these models come from different fields, some links and commonalities are visible in them. Some of the possible links have been illustrated schematically in fig. 2.12. These links can be seen from perspective of the traditional concerns of disciplines these models come from. For instance, as per the semantic tradition, meaning is seen central to all actions and the meanings themselves are dependent on both the bottom up and top down processes. Also culture has been known to influence the meanings in artefacts. Meaning and decision are associated in the sense that the artefacts have to mean something to the user in order to decide. Meanings would also lead to emotions as the appraisal of action leads to emotions which is mediated by meaning. These relationships observed here will be taken forward to create the user model for use in experiential design process in chapter 3.

2.7 Gap analysis

Section 2.3 brought forward the need for the interaction design to be centred on the users of the intended system. By focussing on the users the design process can iteratively gather data from users and design to suit their needs and requirements. In section 2.4 further the designers design decision making process was observed and it was noted that the designers making opportunistic thinking to arrive at the design solutions and in this process they use the information present with them regarding the users' mental models. Hence the interaction design process aimed at creating interactive systems intended to give positive experience to the users should involve gathering experiential data from users. This information from users will guide the designers' design thinking process in the experiential design process. In order to collect the experiential data from users, designers need to use suitable data gathering techniques. The selection of techniques for gathering experiential data will not only be affected by the type of data needed but the design situation pertaining to which the data has to be collected. Nowadays a lot of cross cultural design activities are being undertaken where designers from one culture design for the users of another culture. As both designers and users are culturally influenced by the culture they belong to hence cultural suitability and sensitivity of the data gathering techniques also have to be ensured. But before gathering the experiential data from users, it is important to understand the users in context of the experiences they undergo during interaction. Hence a user model needs to be constructed for use in the experiential design process. Section 2.5 has discussed the various user models in use in HCI and allied fields and section 2.6 has discussed some of the links that are present between the different user models which can be capitalized in order to arrive at a new user model for use in experiential design framework.

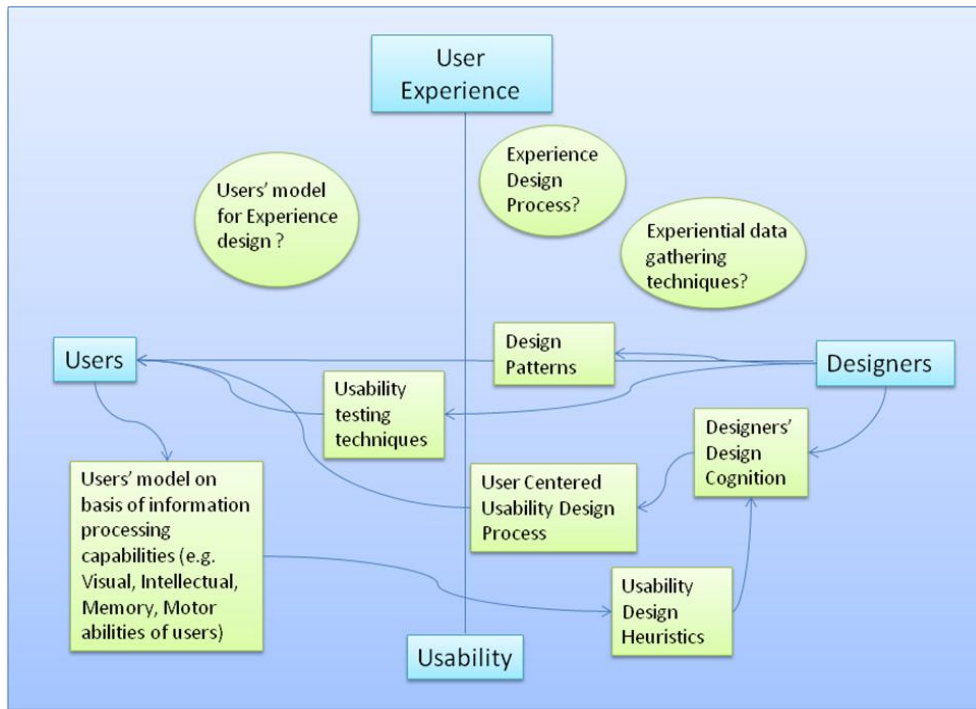


Fig 2.13: Perceptual gaps in literature regarding experiential design process for interaction design

In the existing body of literature in HCI, design for usability appears to be a major trend. However, there is very little literature available on experiential design in HCI field. As illustrated in fig 2.13, the usability design process has got some maturity in the interaction design field now, with clear definition of the user model at which the usability design process focuses on and the criteria against which the usability of an interactive system is evaluated. Also the design heuristics for the usability design have evolved (Shneiderman, 2003; Preece et al, 1994). Such advancements have not occurred for the experiential design process for the interaction design. The literature reported in section 2.2 to 2.5 has clearly iterated the need for identifying data gathering techniques which can gather experiential data from users but has also accepted that there is lack of such processes and techniques for experiential design (McCarthy and Wright, 2004;

Shaffer and Weinschenk, 2008). Hence this thesis identifies the need for a user model for use in experiential design process and then recognises the need for identifying suitable techniques for gathering experiential data form users in cross cultural situations.

2.8 Conclusions

From the literature studied and presented in this chapter, a need for creation of a user model for use in experiential design process through literature survey on the users' models in HCI and allied literatures has been identified. It has been observed that each of the cognitive, affective, aesthetic, experiential, cultural models has an over simplified model of the users' actual behaviour which does not suit the experiential design process. The need for a dynamic model which could accommodate the temporal quality of experience, guided by cognitive processes and mediated by meaning, has been identified. Theories from Lazarus (1984) on the cognition-emotion, theories of Dewey (1949) on temporal and immersive continuum of experiences and a gist of decision making accounts (Simon 1981), aesthetic influences (Norman, 2002) and semantic intermediary to action (Vimha, 1995) will be taken forward in next chapter to guide creation of a user model for use in experiential design framework.

Further, literature has been surveyed on existing data gathering techniques in use in HCI and allied fields. By comparing the concerns of user experience design with the capabilities of each technique as mentioned in literature, four likely candidates for further investigations have been identified. Three design decision categories have also been identified where the user data is needed as an aid to decision making. Experiments done with the four data gathering techniques along the three design decision categories will be described in chapter 4. The

approach taken here has been to use these existing models to enrich the experiential model which will be used for the identification of suitable data gathering techniques.



CREATING A USER MODEL IN EXPERIENTIAL DESIGN

3.1 Introduction

This chapter presents a user model for use in experiential design process. Purpose of the user model is to guide the identification of techniques suitable for gathering experiential data from users to aid designers make design decisions in HCI design process. The user model proposed in this chapter is guided by the findings from literature survey presented in chapter 2. This chapter also identifies culture as a variable influencing the data gathering process in HCI. The user model is oriented to accommodate the cultural influences on the data gathering process. Model presented here will be used to identify suitability of four data gathering techniques in the next chapter.

3.2 Creating a user model in experiential design- a proposal

As discussed in Chapter 2, section 2.5, the existing user models do not suffice for need of experiential design process as they have piecemeal approach to the users' complex behaviours. The experiential design framework needs a holistic approach to the user. This section thus puts an effort towards creating a user model to be used in experiential design framework which is under study in thesis. In order to achieve the aim of this thesis, which is, to identify suitable user data gathering techniques in experiential design framework, a user model is needed to guide the identification process. The user model would help set the criteria for suitability of data gathering techniques as it would engender the characteristic

processes involved in user experience process which would in turn help identify how to elicit them from the user.

As pointed out in Chapter 2, section 2.6, one way to work towards the user model for use in experiential design framework would be to take a closer look at the existing models and borrow from them the ideas relevant to experience design field. The user models described in section 2.5 have focused on different specific aspects of otherwise complex entities that users are. Some of the considerations that have gone in creating these user models may or may not have common goals with experience design process. As the experience design field is new, there is no commonly accepted model of user to explain the experiences that users undergo. This thesis has attempted to create a user model that can help understand the users' internal processes associated with users' experiences. Such an understanding would guide identification of data gathering techniques suitable to experiential design process.

Each of different user models has different advantages and weaknesses over others. Much of the characteristics of each method are due to the field of enquiry they come from. For instance, the information processing model comes from the field of Cognitive Psychology and has been in extensive use in the Artificial Intelligence stream of computer science. Its procedural emphasis with considerations for limitations on speed and channel width in processing has helped create simplistic artificial imitations of human mind through computer programming. The Phenomenological model, on other hand, lays emphasis on experience being central to all human perceptual and cognitive processes and takes the view of an embodied human experience instead of stage theory model (Atkinson and Shrifin, 1968) of information processing. Similarly every model has its characteristic viewpoint of the human perceptions and reactions to the environment.

All the models described in chapter 2 are not necessarily mutually exclusive. They have overlapping concepts and assumptions about the human mind and body. Some attempts at showing connections between the different theoretic perspectives have also been made. For instance, Jackendoff has emphasized the role of semantics as a bridge between the linguistic theories and the theories of other cognitive capacities such as visual perception and motor control (Jackendoff, 1985). At the same time a caution has been raised against any forced attempt to merge these models (Jackendoff, 1985). It has rather been suggested that as these different traditions become matured they would in due course merge on themselves. These different models of users are simplistic conceptualizations from different perspectives about the way human mind works. Chomsky (1975) argues that attempts to reduce these different functions of mind to a few general principles would be like reducing all the physiological functions of human body to few general principles without knowing completely how each organ works and contributes to the system (Chomsky 1975).

Hence, while attempting to create a working user model for experiential design process to be used in this thesis, it has not been intended to merge the existing user models so as to create a complete and exhaustive understanding of the user. Rather, the salient features from each model which were felt by the author to be essential for creating a simplistic model of users' experiences in context of HCI has been borrowed, discussed and incorporated in the framework here. The purpose of creating such a model was to help understand the essentials of the data gathering techniques in experiential design context. The utility of a simplistic model of users' internal structures and process with respect to their experiences was as an aid in identifying the pertinence of data gathered by different techniques to the experiential design process. Which structures and constituents of data obtained by the techniques would aid in understanding the users' experiences can be identified in light of the users' experiential model created here.

Towards creating the user model for experiential design, first the body of literature which takes an integrative and holistic perspective towards user models would be cited here and then by borrowing from the different traditions in light of these citing a working model would be created.

From the design perspective, several authors have argued for a holistic and integrative approach to understanding users. For instance, Norman (1983) takes an integrative look at mental models and conceptual models. He suggests a list of processes by which mental models of users are formed. Some salient processes are affordances (range of possible actions by a user on an artifact), mapping (relationships between controls and their effects on a system), constraints (limits on the number of possibilities in physical, semantic, cultural, and logical terms), causality (appearance of event caused by an action) and transfer of previous experience. Norman exemplifies these processes first suggested by Gibson (1977), by example of a scissor, where the holes 'afford' putting fingers in them and give physical and semantic 'constrain' by their different sizes so as to give a 'mapping' of putting thumb in one hole and rest of the fingers in another hole. Projecting the correct conceptual model so as to fit with users' mental model is recognized as the aim of the designer. Gap between conceptual models or the mental models of the designer and users has been recognized as a major issue in design process. Identifying design techniques and processes that fill this gap has been the challenge. Though the mental model theory has been argued strongly by Norman for use in HCI and it has been seen as holistic and complete in explaining users' behaviours as described above, yet there are hindrances to use of the mental model theory. It is the capturing and validation of mental models which has been the greatest limitation in applying mental model theory in HCI. Mental models have been recognized to be created 'on the fly' and hence the techniques that gather information on mental models of users have to be

sensitive enough to not modify the mental models themselves in the data gathering process (Preece et.al., 1994).

3.3 Affective vs. aesthetic processes

Norman (2004) does not seem to differentiate the aesthetic process from the affective processes in the brain. He though differentiates the affective and cognitive systems and suggests that affective and cognitive attributes result from three different levels of the brain: the automatic, prewired layer, called the 'visceral level'; the part that contains the brain processes that control everyday behaviour, known as the behavioural level; and the contemplative part of the brain, or the reflective level. Norman has proposed a three level design approach based on above understanding. At level one, the 'Visceral level' design is about the appearance, the touch and feel. The 'Behavioural level' is about the functional experience with the product. And the 'Reflective level' is about the long time reflections, the self image and long term satisfaction. Norman also talks about the 'reflective' process of users being responsible for giving any used product a personality that is a unique way of looking and behaving. This concept of product personality is a holistic outcome of the users' internal processes and has been used in product marketing and advertisements.

The cognitive and affective user models have been discussed and debated in their respective dedicated fields as well. The debate whether emotions precede cognition (Zajonc, 1980; Bornstein, 1992) or cognition precedes emotion (Epstein, 1997) has a long history in the emotions research. Lazarus (1998) suggests that both emotion and cognition are fictitious concepts of mind, created for the purpose of scientific analysis, which truly do not exist independently in nature. He further emphasizes that the emotions do not occur in absence of

meaning. Meaning is central to the affective process. Affective arousal has been reported to be ahead in time from the thoughts associated with them (Zajonc, 1980). The meaning though would need cognitive process to happen, causing the cognition to precede affect. Lazarus takes a stand that, emotions are always a response to meaning. But he emphasizes that the issue of temporality in emotion cognition debate is an epistemological error. There is no issue of primacy of one over the other. To explain this he takes a systemic view of the emotion-cognition and states that both the processes are in continuous flow. This theory of mental state being a continuous flow of simultaneous affective and cognitive processes has been taken up in this research. Similar theories of mental state have also been stated by Slife (1981) and Scheff (1985). The concept of mental state as a continuous flow also matches with Dewey's account of the process of experiencing. Meaning being central to the affective arousal and cognitive processes as involved in meaning making create a continuous flow of the mental processes. In this flow any of the processes can precede or follow any other and thereby the preceding process would influence the following processes. This theory seems good fit for understanding users' experiences with the interactive systems. The arousals due to perception of menus and icons in the preceding interface would influence the cognitive process in the next one, making the interaction a continuous series of affective arousals, cognitive processing, meaning making and another arousal. The preceding arousals will colour the meaning making process for the successive interfaces, by creating context and loading expectations or apprehensions in the users.

Involvement of motivation both as an antecedent that creates personal stake in emotional transaction and as a consequence of the emotion itself has been emphasized by Lazarus for a better picture of the affective process (1998). In the context of interaction with computers, users come to the system with a motivation. This motivation preceding the engagement with the system becomes

a reason for it and also shapes the interaction through goals and expectations. During engagement with system, the user undergoes meaning making processes. User makes meaning of the perceived icons, menus, text and visuals etc. on the interfaces. An evaluation or appraisal of the meaning in context of motivation occurs. The appraisal leads to emotions. These emotions felt momentarily give rise to further motivations for engagement with the system. We shall call this model of the ‘motivation-engagement-meaning-appraisal-emotion-motivation’ as the dynamic flow model of the user.

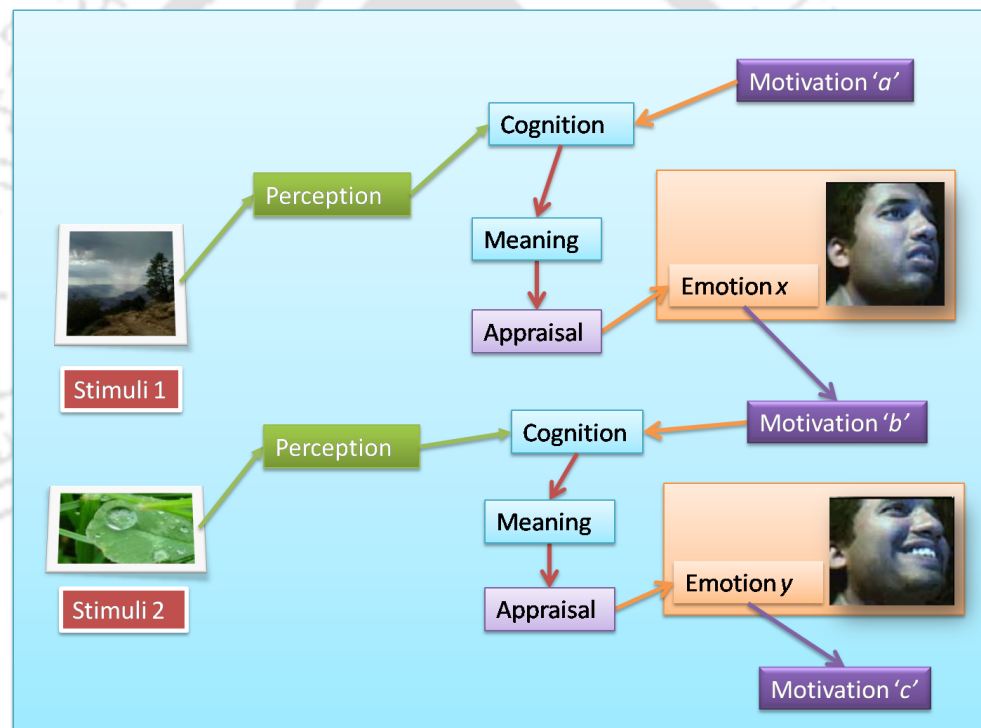


Figure 3. 1: Dynamic flow of motivation, cognition and emotion (after Lazarus)

3.4 Arguing for affective-cognitive based framework

The most prevalent user models in HCI, which have been based on pure cognitive theory, have met criticism from another perspective as well. For instance, the GOMS model (Card, Moran and Newell, 1983), which is an oft used user model in HCI is based on pure cognitive perspective. GOMS stands for Goals, Operators, Methods and Selection rules, provided a user model for analysing systematically the goals, methods and actions undertaken by users during the routine task fulfilments. In GOMS model, it is presumed that the users have a fixed goal with which they approach the system for its fulfilment. This is opposed to the Lazarus model mentioned above, which is a dynamic flow model and the intentions for goals are not fixed rather are dependent on the appraisal of the preceding ones. Also in situated action theory, Suchman (1987) has argues for a similar reality of the interactive behaviours of users. Suchman argues that the users do not work by making a plan, and then executing it. Lucy Suchman promotes the idea of 'situated action' and debunks the popular belief that people work by making a 'plan' and then executing it. She uses the concepts of communication prevalent in ethnomethodological frameworks, that of the construction of social reality through negotiation of meanings and argues it's pertinence in analysis of human-computer interaction too. Importance of understanding the interaction in terms of shared meanings between the user and the system has been emphasised. A user rarely goes into details of planning the action, as they take for granted their ability to continually evolve the plans in response to the situation. It is difficult to describe the situation awareness of the users. Plans only serve as a resource of action rather than as a blueprint that user is trying to follow. Here again the phenomenological perspective of communication has been emphasised. Where the meanings are negotiated in interaction with the environment and the actions also play a role in creation of such meanings. The intention for actions have a loose structure which

continuously evolves to acquire the details of the structure. The GOMS model and other user models in the strict cognitive perspective of the users can be seen as an instance of the dynamic flow model. The loosely structured goals are still created before the task fulfilment begins but only that now these goals are not fixed. Hence a dynamic flow model of user instead of a fixed model appears to give a more pragmatic account of the users' behaviour and is accommodative of both the affective and cognitive perspectives.

In the 'mental model' perspective too, it is the dynamicity of the mental models which gives a more realistic account of the users' behaviour rather than a fixed mental model. The users' mental model itself gets dynamically revised and reformulated in the light of the experiences user undergoes with the interactive system (Mildeova, 2003). What causes the reformulation of the mental model is still a gap in mental model literature. The affective-cognitive paradigm mentioned above have a clearer picture of this selective transformation process by mediation of motivation and meaning. The gap present in the mental model literature has also been accommodated for in the dynamic flow model. Mental model literature has been expanding to accommodate the process of creation of mental models and how it affects the decision making process. For instance, Mildeova and Vojtko have attempted to create a double loop model to explain how the external world helps in evolution of mental models of an individual and in turn how these mental models affect the decisions related to the external world (Mildeova and Vojtko, 2003). However the missing links in how these processes happen can be filled by the motivation-cognition-affect cycles in the dynamic flow model described above.

The dynamic flow model also accommodates the experiential model from phenomenology. The mediation of meaning in the experience created from the perception of surroundings has been taken care of in the flow model. As depicted

in fig 3.1, in phenomenological understanding, discovery of patterns in the chaos in surroundings by application of intelligence leads to meaning and this meaning is central to the experiences of the individual. This centrality of meaning has been accommodated in the dynamic flow model.

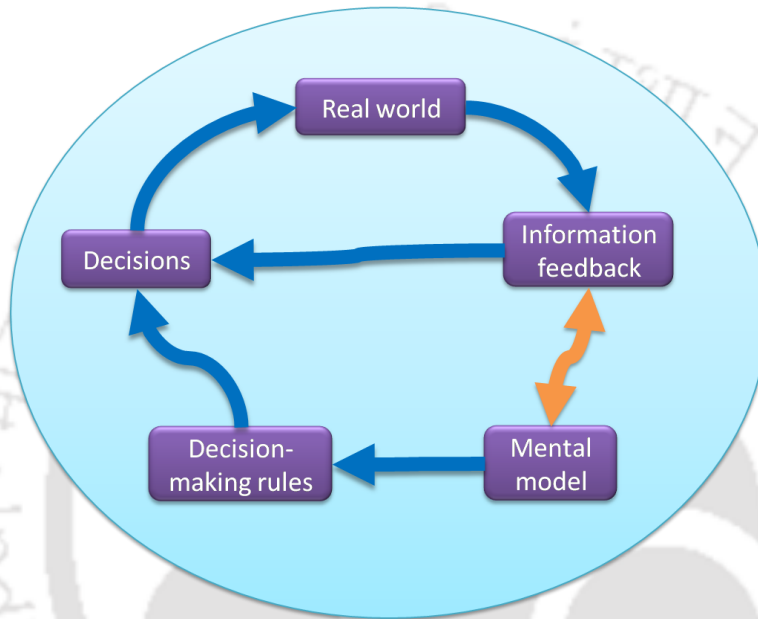


Figure 3. 2: Mental model and real world mutual feedback (from Mildeova and Vojtko, 2003)

The concepts prevalent in users' memory contribute to the meaning making process in the users. They help in categorization and attributions of features as described earlier. This way the dynamic flow model partially accommodates the theoretical perspective of the concept theories. Even the mental model theory accommodates the creation and evolution of mental models through real life experiences as depicted in fig 3.2 which is very close to the flow model in fig 3.1.

Even the decision making account of users uses a dynamic model that comprises of a fast and frugal adaptive toolbox of affective, rational and heuristic tools

which is dynamically operated in decision making process. All the cognitive and affective tools visualized as alternative neural pathways in the physical brain, existing in parallel to each other, follow a complex selection rule when aiding the users. As the users of the modern day HCI systems are buyers and consumers whose decisions run the business of HCI systems, ability of the designer to be quickly assess the performance of a given system in aiding users decision and gathering data to design better systems would also be essential. To this end, it would be helpful if the user model in experiential framework also has flexibility to accommodate the users' decision making behavioural patterns. A dynamic flow model comprising of affective, cognitive and semantic perspectives seems to augur well towards this cause also. But before we conceptualize the user model in experiential design framework, there is one more perspective that needs to be accommodated, aesthetic perspective.

Much before the meaning happens and succeeding appraisal of meaning happens during the perception-cognition-emotion cycle, it is the aesthetic appreciation which happens and precedes all the mental processes. Aesthetic responses are rapid, involuntary and bipolar (positive or negative). Aesthetic response has been reported to occur in an instant, within first 100 seconds of the sensory interfacing with an object. Not only the aesthetic responses are fast but they are lasting too. Lindgaard and Dudek (2002) confirmed that initial aesthetic impression has a lasting nature. It does not change even after prolonged usage of the system. Though the other responses of the user with regard to the system in use like, perceived usability, likeability and expectation from system change during the course of interaction but the assessment of aesthetics of system does not change even after system causes serious usability problems. The momentary aesthetic response having a lasting character not only affects the acceptance of the system on its own but also causes confirmatory biases towards succeeding experiences. It has been submitted that the confirmation bias caused by aesthetic appreciation

towards an HCI system does not change easily (Doherty, Mynatt & Tweney, 1977). It makes users seek only that information which helps them build upon their previous impression. It has also been argued that the aesthetic perception is based on prevalent arousal level of the user (Berlyne, 1971; 1972). Like affective responses, the aesthetic appreciation is posited to be evoked via the shorter route to amygdala, not via the hypothalamus (Damasio, 2000; LeDoux, 1994;1996; Goleman, 1996) and can be overridden by pre-exposure decisions (Epstein, 1997). Though the cognitive explanations of aesthetic responses are far from being conclusive, the study of aesthetics in applied fields of art, architecture and design has been aplenty. But these fields have not focussed as much on the process of the aesthetic response as they focussed on what causes positive and negative aesthetic responses. Having observed above that the aesthetic appreciation precedes both emotion and cognition and also creates a confirmation bias towards the product in use, it becomes an essential component of the users experience with the interactive systems. Including aesthetic experience in the above dynamic flow model, is likely to make the picture closer to being realistic.

3.5 Proposed user model

The model being proposed in this thesis for experiential design process has been exhibited in fig 3.3. This model is a simplified picture of users' internal processes and has been created for use in this thesis to help identify techniques suitable for data gathering in experiential design process. It is an extension of the dynamic flow model exhibited earlier. The proposed model has been used as the working user model for the experiential design framework in this thesis. The aesthetic experience occurs instantly but lasts longer and influences the affective state of the users. Meaning as central in the cognition-emotion interaction has already

been illustrated in the dynamic flow model created after Lazarus (1998). Not only the cognitive processes contribute to the affective states but also the affective states influence the cognitive processes (Norman, 2004). The meaning is created by the combination of both top-down and bottom up processes where the prior experiences stored through network of concepts or the structural mental models. This meaning through the appraisal leads to the affective states.

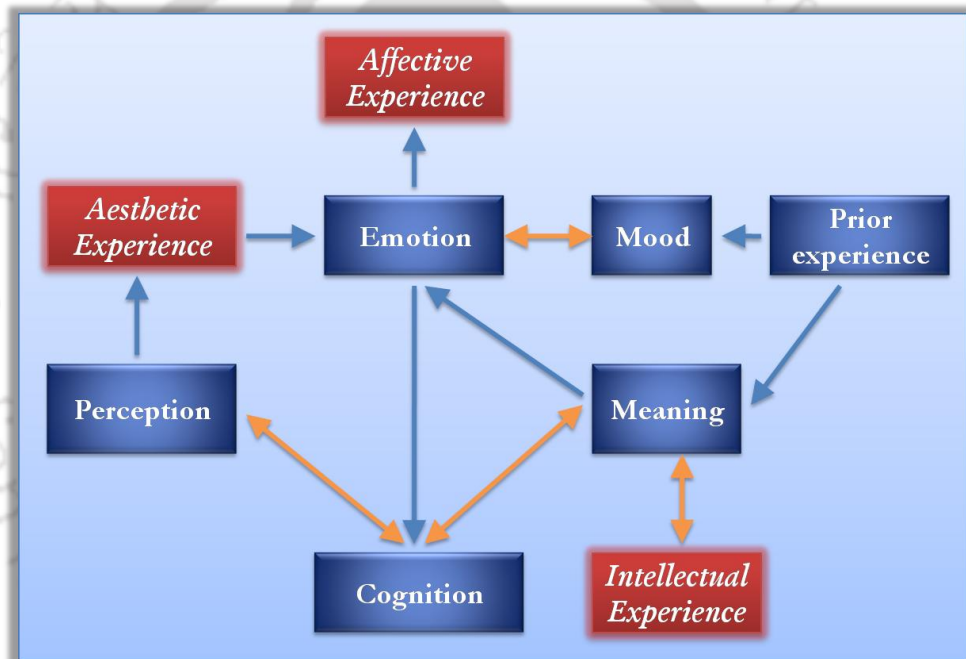


Figure 3. 3: User model created for UXD process for use in this thesis

In this model, three categories of experiences have been identified as Aesthetic, Affective and Intellectual. These three categories have been created under influence of the literature survey reported above. Norman's (2004) three tier

model of 'visceral, behavioural and reflective' and experiential models after Dewey's phenomenology has been compared for the commonalities of concepts along with the dynamic flow model described above. Norman's 'visceral' experience has been partitioned in this model into 'aesthetic experiences' which is instantaneous and 'affective experiences' which are mediated by meaning. Still the part of aesthetic experience overlapping and affecting the emotional experience has been accounted for in this model. The centrality of meaning as accepted in the phenomenological perspective of experience has been extended with help of the Lazarus's model to show a relationship between the cognition and emotional experience in this model. Norman's behavioural and reflective level of experiences has been accepted partially in the 'intellectual experience' as they involve greater duration of time and intellectual participation. In context of HCI, here the word 'aesthetic' is used to imply the look and feel of the interfaces. From the literature study done above, it is understood that the users' sensory channels generate an aesthetic response almost instantaneously and last for long influencing other experiences with the system (Tractinsky, 1997; Tractinsky et al., 2000). In affective experience the existing theories of emotions, such as theory of basic emotions and their categorizations have been kept in view. It is posited here that by analysing the reported affect felt during the interaction, along the lines of basic emotions, one can ascertain the efficiency of the technique used for gathering affective experience data. By intellectual, the constructivist notion of self in relation to the environment around has been meant. Involvement of the user with the system in context of task at hand is not in isolation from the immediate environment that he/she belongs to. Meaning of the interaction and satisfaction emergent from it occurs on the background of related social and personal concepts. The user intellectually invests in order to arrive at the meaning and thus the satisfaction. In contrast to the aesthetic and affective experiences, the intellectual experiences are felt after considerably longer duration of

interaction with the system. It is a very rational thinking process which is involved in assessing the system. There is much more cognitive processing involved in arriving at the intellectual experiences.

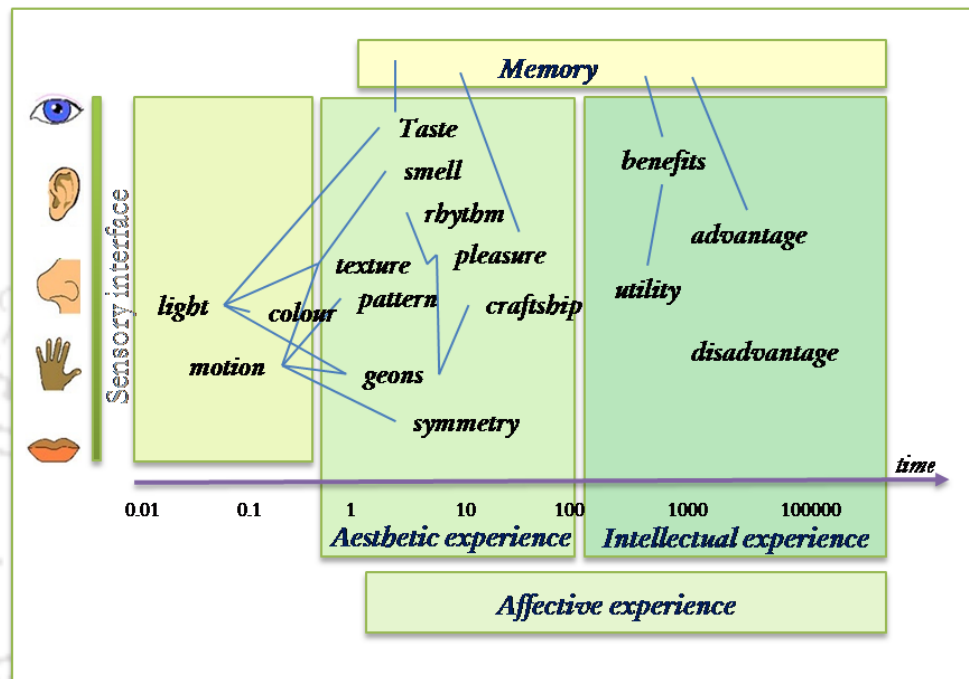


Figure 3. 4: Temporal positioning of experiences
(Based on Ulrich and Eppinger, 2000)

Further, the aesthetic and intellectual experiences can be found to have separate and identifiable temporal identities as theorised by Ulrich and Eppinger (2000). The aesthetic responses are more immediate and are likely to occur within the first 100 seconds. The intellectual experiences occur after the analytic processes of mind operate upon the received stimuli in context of the concepts already stored in memory. Author has extended Ulrich and Eppinger (2000) model to add affective experiences in it, as prevalent throughout, shaping and being shaped by the intellectual experiences (fig 3.4).

Affective experiences, identified here as one of the three categories of experiences will be used for validating semantic differential technique's ability to gather experiential data in chapter 4 (section4.7). For use of affective experiences in experiments in this thesis, the cognitive perspective in study of emotions, the 'peripheralist view' also called the 'bottom-up' approach has been adopted (Norman, 2005). Under this view, emotions are constructed under the influence of the stimuli observed from outside the person.

As mentioned in section 1.2, in this thesis, users' experiences pertaining to the interaction with digital products only, like softwares and websites, has been focussed at. Users' experiences with the company or its services, which are associated with the interactive product, are not the focus of study in this thesis. Hence the proposed user experience model exhibited above should be seen with the focus on users' interaction with computer based systems only. Though this model has the possibility of being extended into other domains of users' experiences as well but that has not been focussed here.

The user model presented in fig 3.3 has been used in this thesis to investigate suitability of the techniques for experiential data gathering. It is posited that the technique which can bring forth the experiential data along the aesthetic, affective and intellectual experience dimensions would be suitable for the design process. Thus, after having recognized the type of data needed for a data gathering technique to be capable of eliciting, in order for it to be a suitable technique, it is now needed to identify data gathering techniques for experimental investigation.

3.6 Influence of culture on the proposed model

Culture has been found to influence not only the social and organizational setups (Hofstede 1991,2001) but also the very cognitive processes underlying all

observable behaviour (Nisbett, 2003; Nisbett et al, 2001) Need for consideration of cultural diversity of users, designers and evaluators in HCI design process has been emphasised strongly (Khaslavsky 1998 ; Marcus, 2000 ; Hertzum & Jacobsen, 2001 and Nielsen,1990). Need for understanding and accommodating 'culture' factor in HCI design process has become important because of expansion of the system design market. Today, globally distributed HCI design processes are in practice. Often a designer comes from one culture while the user belongs to another. And the cultures are not only geographically and historically separated from each other but have known differences in value systems, rituals, social practices and symbols. These differences are likely to shape the users interaction with the system. Also the designer's understanding of the users is likely to be influenced by designer's culture. The interaction between the interviewer and the user during data gathering process will also thus be influenced by culture. Hence the technique that is used to gather data from the users has to be sensitive enough to elicit cultural data form users in order to bridge the gap between users and designers. Also the technique should be considerate of the social cultural settings that the users come from in order to be applicable across cultures for collecting data.

3.6.1 Cultural sensitivity of data gathering process

The cultural differences shape the way users perceive and interact with the system and hence the systems have to be created with cultural considerations. The data gathering techniques which are meant to aid the designers' decision making process by supplying information on users' experiences should be sensitive enough to capture the differences in user groups belonging to different cultures. The ability of the data gathering technique to capture cultural differences in users' interactions has been called 'cultural sensitivity' of the technique. It has been

posited here that a data gathering technique to suitable for experiential design process should have good cultural sensitivity. It should be able to mine the data pertaining to the cultural differences in the way users experience a given system.

3.6.2 Cultural suitability of data gathering process

One of the manifestations of culture is at the level of an individual, influencing the way one makes meaning of things around and is addressed in the cultural sensitivity of the technique. Another manifestation of culture is at of the level of interaction between individuals. At this level, culture shapes the way one communicates, gesticulates, maintains personal space etc.

Data gathering techniques, already in use in HCI, have been reported to be influenced by culture. For instance, in usability testing situations, difference in cultural backgrounds of users and evaluators has been accepted as a variable affecting the test outcomes (Hertzum & Jacobsen, 2001). Researchers have reported differences in users and evaluators behaviours when they belong to different cultures. Researchers have observed that the differences in behaviours are specific to the culture they belong to (Yeo 1998; Yeo 2001; Clemmensen & Goyal 2005; Vatarapu & Pérez-Quñones 2006). These behavioural differences have further been found to affect the outcome of the data gathering process itself. For instance, Vatarapu & Perez-Quinones (2006) reported that when the interviewers' and users' cultural backgrounds were same (both Indian) more usability problems were found as compared to when cultural backgrounds were different (Anglo-American). Such research studies indicate that the cultural backgrounds of the participants do seem to have an influence on quality of the data gathered from the users.

Alternative data gathering techniques suitable to particular cultures have also been suggested. For example, Chavan (2004 & 2005) has suggested a '*Bollywood method*', a data gathering technique culturally suitable to Indian culture. Indians have high power-distance index according to Hofstede (1991), which suggest that cultural factors such as hierarchy due to authority and age (elders) play a role in social communications. As data gathering process often involves communication between an interviewer and a user which takes place in a socio-cultural setup.

This thesis looks at the culture as an influencing at several levels which need to be considered in HCI design process. As illustrated in fig 3.5, interaction between the system and user is one of the influences that culture exerts. This influence can be accommodated by gathering data related to the differences in users' interaction with systems and designers can make more informed design decisions to create culturally suitable systems. Another influence of culture is on the users' and designers' way of perceiving and making meaning of things around them. This influence is the cause of the interaction related differences and is a concern for HCI designers, as they need to accept this fact and learn to bridge the gap. Culture's influence on users and designers way of thinking is not a direct issue related to the data gathering process and hence is not the subject of study in this thesis. Culture's influence on the way users and designers (or the person who is gathering data on behalf of designer) interact during the data gathering process is the subject of study here and is being called cultural 'suitability' of the technique in this thesis. It is posited here that the techniques used for gathering experiential data have to be culturally suitable in order to be able to successfully gather experiential data. Especially this factor has been known to play a role in a cross-cultural data gathering situations involving participants from different cultural backgrounds (Dray and Mrazek 1996).

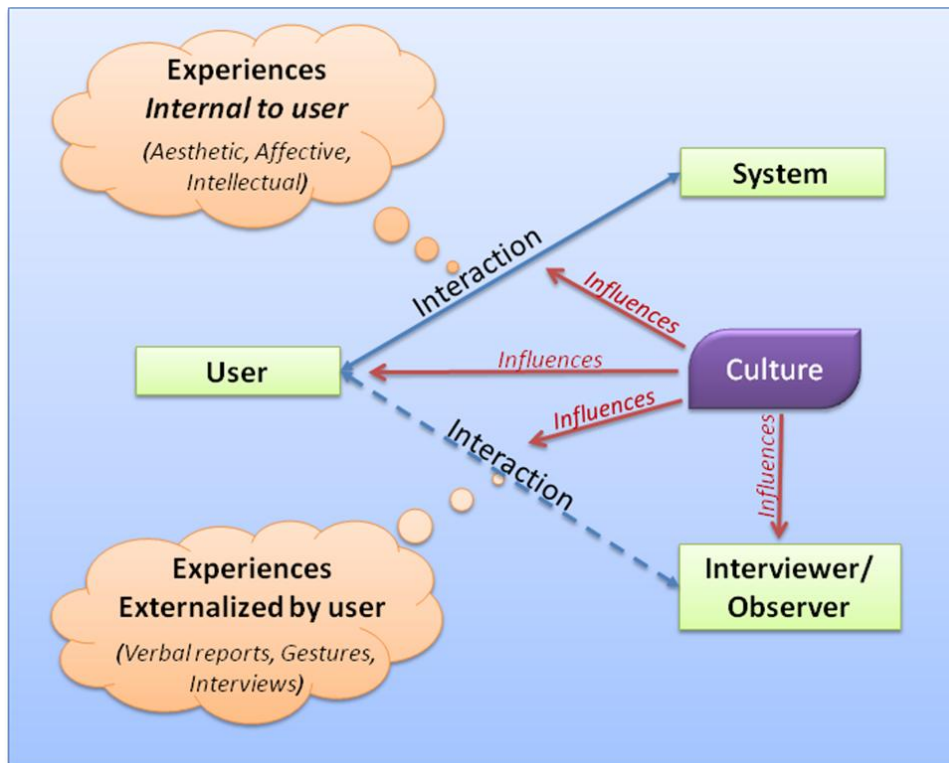


Figure 3. 5: Influence of culture in data gathering process in HCI.

This influence of culture both on the user's value system and the social system has deep connotations for gathering data from them. The user model proposed in section 3.5 for use in experiential design process also needs to accommodate for the cultural influences. As the proposed model is to fix the criteria for identifying suitable data gathering techniques in experiential design process, the cultural influence on this entire process cannot be overlooked. After all the data gathering process occurs in a cultural setup and the gathered data has to be used in designing interaction which are culturally suitable. Hence the data gathering technique has to be sensitive enough to identify cultural influences on the reported experiences of the user in order to aid making design decisions catering to the cultural nuances of the user. With this in mind, a schematic diagram of the

probable experiential data gathering process in cross cultural framework has been outlined in fig. 3.6. Interaction between the user and interviewer, who is gathering data from the user, is situated in cultural contexts. The interviewer responds with empathetic cues in order to facilitate elicitation of experiential data form users. The user having a trust in the interviewer's ability to understand his/her experiences, uses language as a medium to communicate his/her experiences. The experiential data gathered form users in this process, be it aesthetic, affective or intellectual is coloured in the cultural lenses that user belongs to. The technique has to be sensitive enough to identify the cultural colourings in the experiences. Further, as the technique itself is applied in a cultural context, it therefore has to be suitable for application in socio-cultural setups.

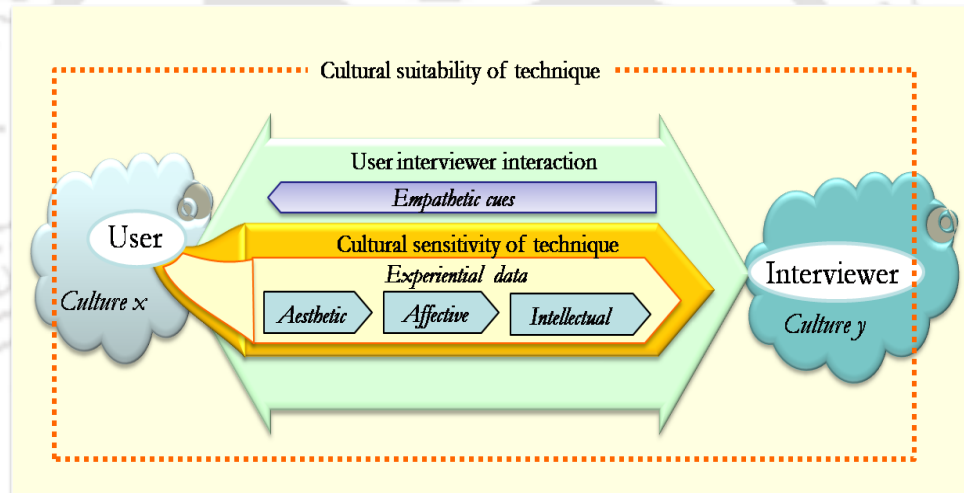


Figure 3. 6: User and interviewer dynamics in culturally situated experiential data gathering process.

3.7 Conclusions

This chapter has proposed a user model for use in experiential design. This model will be used to identify the suitable data gathering techniques for experiential design process. The identified aesthetic, affective and intellectual experiences will be used as categories of experiences that a suitable user data gathering technique should be capable of gathering data about. The technique which in cultural context is able to gather experiential data from users along these three categories and is suitable for application in different cultural setups will be identified as useful in experiential design process.



SELECTION OF EXPERIENTIAL DATA GATHERING TECHNIQUES

4.1 Introduction

As chapter 1 presented the basic area of investigation in this thesis and chapter 2 presented literature survey regarding the designers design cognition and available users' models in HCI. A gap was identified in the present body of knowledge in the form of unavailability of a suitable user model for use in experiential design framework. A user model for use in experiential design process was thus proposed in chapter 3. As mentioned in chapter 1, section 1.3 and further elaborated in chapter 2, section 2.4, the designers' and users' mental models differ and the designer needs information from users in order to bridge the gap between their mental models. The case of experiential design process needs further more sensitive selection of the techniques by which experiential data from users can be gathered. The need to identify the proper techniques for gathering experiential data has been argued in this thesis to be instrumental to the user experience design process. In this chapter, literature study done in order to identify the suitable techniques for the experiential design process is being presented.

Before this chapter presents the discussion on the prevalent data gathering techniques and systematically identifies the suitable candidates for experimental validation later in this thesis, this chapter identifies the criteria for the selection of the data gathering techniques. As has been discussed in section 1.3 and further in section 2.4, the data gathering techniques are required to gather the data for the

purpose of aiding the designers to make appropriate design decisions. Hence the information gathered from the users using the techniques under study should suit to the needs of the designers. In order to understand what type of data is needed by the designers during the interaction design process, it is first required to understand what types of design decisions that designers have to make during the design of interactive systems. Section 4.2 first presents the studies done towards understanding the types of design decisions that designers have to make in a typical interaction design process so as to be able to understand the type of data that they would require from the users. Section 4.3 presents the analysis done towards understanding the prevalent data gathering techniques in HCI and allied fields while simultaneously zeroing in on the four techniques selected for experimental validation in chapter 6. Section 4.4 introduces in detail the four techniques selected for experimental validation.

4.2 Designers' design decision categories in HCI design process

Designers have to make decisions about the interactive interfaces during the design process. These have been referred to here as 'designers design decisions' and this section tries to identify if there are any 'types' or 'categories' in the decisions that the designers make in a typical interaction design process.

The human computer interaction design is a highly complex task, consisting of stages of design, it is expected that the kinds of decision that are made by designers can be categorized in some broad categories. A designer is not expected to make entire gamut of design decisions regarding the menus, the information structure, the look and feel, the page transitions etc. all at once. And also it is unlikely that the kinds of data that designers would use to make those decisions would all be same. For instance, the data needed about users experience of icons

on the interface would be different from the users experience about the link clicking and a page appearing subsequently.

On the users' front, the users' experience is a conglomerate of instances of experiences which occur due to interaction with different aspects of the interaction. Each instance contributes to the whole of the experience. Fig 4.1 schematically presents this idea of temporal spread of instances where positive or negative experience was felt by the user during the interaction. We do not know how these instances contribute to the overall reported experience of the user but surely it can be safely assumed that the overall experience that the user has felt has been contributed by the several instances of individual experiences that the user had with the interactive system. Fig 4.2 elaborates one such fragment from the users experience with the interactive system. An instance of aesthetic appreciation would contribute positively to the users experience with the system while an instance of a cryptic error message would contribute negatively to the users experience to the system.



Fig 4. 1: A visualization of users' experiences with an interactive system as a function of time

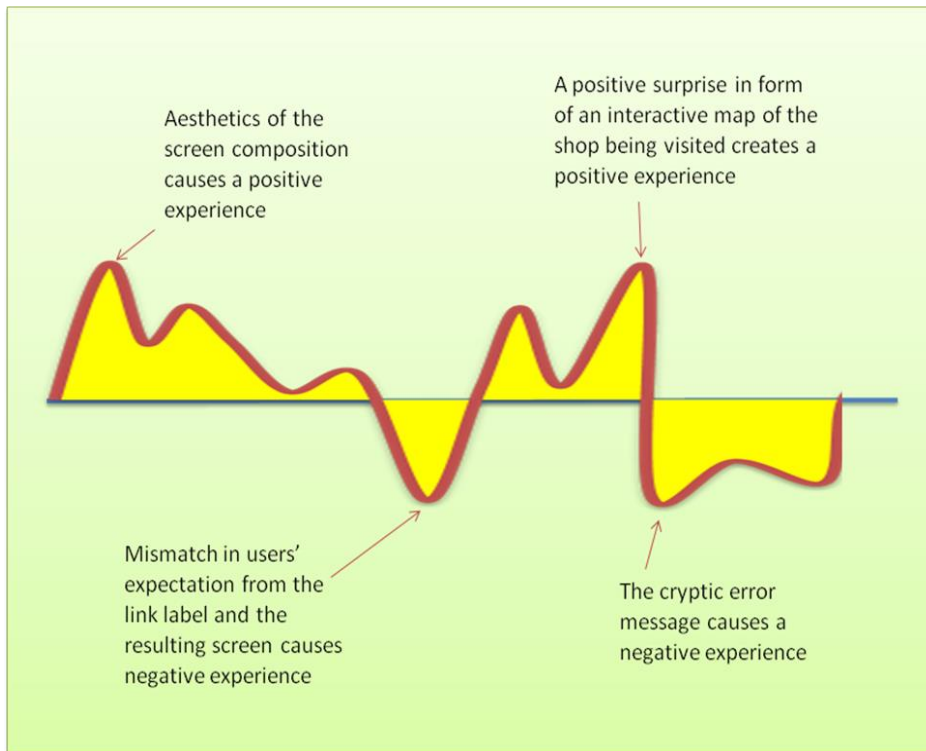


Fig 4. 2: Contributions from instances of user's experience to the overall experience with the system

From interaction design perspective, a designer needs to know all such instances that have contributed positively or negatively to the users' experience with the system, in order to make any decision to improve the users experience with the system. The designers would need to know how each aspect of the interaction has affected the users experience with the system, in order to make decisions regarding each one of those elements. In order to study suitability of a given technique for gathering experiential data, it hence, becomes imperative that the technique being studied, be applied to gather experiential data pertaining to the particular stage of design and hence the particular design decision that designers have to make. The technique is thus applied to gather data from particular design

stage and in context of a particular design decision to be made. Hence, literature was studied to identify kinds of design decisions that designers have to make in a typical HCI design process.

In literature, several design decisions that designers make have been mentioned. Also stages in design process where different kinds of data are gathered have been mentioned. As mentioned earlier, the HCI design process is an iterative process where a design is incrementally refined through user involvement and by collecting data from users to help make the design decisions (Nielsen, 1993). James Garrett (Garrett, 2006) has proposed a five tier model for interaction design where as the project progresses from the bottom layer to the top layer, more concreteness is arrived at in the project. A simplified model of Garrett model has been depicted in fig 4.3. In this model, the functions have been treated separate than the interaction and the final, uppermost layer is the visual design. However in the data gathering process from users, especially with respect to the users' experiences, some concrete form of the interaction has to be present before the users with respect to which they can elicit their experiential data. The interaction under design has to be presented to the users in order to elicit any affective, aesthetic or intellectual experiences. Hence this model though constructed from an actual project progress point of view, is not helpful in deciding when and how to gather data from the users. Further this model is not from the designers design decision perspective, for the functional meaning as appearing to the users is not quite independent from the users' perceptual meaning of the interface present before him/ her. It is the meaning in the components of the visual artefact in front of the users that the experience of the interaction is much dependent upon. Hence a different approach to decomposing the interaction design process based on designers' decision making categories needs to be done.

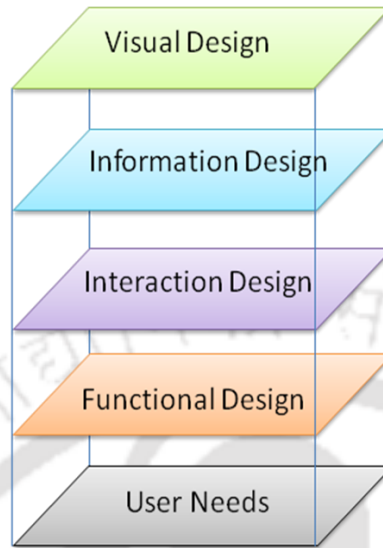


Fig 4. 3: A simplified version of 'Elements of User Experience' by James Garrett (Garrett, 2006)

Though the interaction design process is an incremental process but on the basis of the stimuli used for data gathering, design process can be categorised into two stages. The conceptual or formative design stage, where no prototypes or low fidelity prototypes are used and summative design stage where high fidelity working prototypes, beta versions or finished products are used. Purpose of data gathering at the conceptual stage is to aid the designer in conceiving the design ideas and help validate the rudimentary design concepts. Conducting interviews to understand users' general experiences with the system from the domain or using quick and dirty/ basic paper prototypes to validate some initial ideas are some of the stimuli used to gather data from users at this stage. In the later stage, functional prototypes with higher fidelity are used as stimuli to gather data from users. In both the stages, the data gathering concerns are different and hence the number of items on the stimuli which is mock up of some part of interfaces is different. In the initial stage, it is mostly the task flow which is the concern and

hence bare interfaces of poor visual quality are used for they cost less and users feel more free to criticize them thereby giving more data.

Turning to the types of design decisions, during the course of development of design of interactive systems, designers have to make decisions about: colour theme, layout, icons, menu items, navigation, content, graphics elements, aesthetics etc. These design decisions have been identified uniformly in HCI design literature (Nielsen, 1993; Lindgaard, 1995; Dix et al, 1998; Shneiderman, 2000; Preece et al, 2003). Dix et al have recognised the icon design, interface design and interaction design explicitly as the design activities associated with HCI design process. Nielsen identifies icon design very explicitly as a challenging task in depicting the metaphors (p126) and its role in internationalization of HCI systems (p. 239, Nielsen 1993). Graphic consistency in screen design as a design heuristic has also been identified by Nielsen (p 132). The term 'screen design' has been used consistently by Nielsen to refer to the composition of various graphic elements on the interface. Nielsen also identifies the need for 'screen designs' to have graphic clarity and 'interactions' to be as per expectations of the users (p121). Emphasis on screen designs to follow gestalt laws in structuring information has been made and need for good graphic design for success of interactive system has been iteratively made in Nielsen's references. On categorization of these design decisions, a clear recognition of three aspects of design, icons, screens and interactions is evident in Nielsen's foundational book on *usability engineering* (Nielsen 1993). Lindgaard (1995) lists a set of design issues which need to be looked in HCI design process. They are, navigation, screen design, terminology, feedback, consistency, modalities, redundancies, user control and match with user tasks (p. 33). Out of these, 'screen design' can be seen as the composition of the screens, 'terminology' as an element on the screens and rest items in the list relate to the transitional or holistic level of the system. Shneiderman (2000) identifies font sizes, colour, blinking, graphic layout,

nomenclature of menu items titles etc. as the elements of the screen to be paid attention in design process (p. 81, p 257).

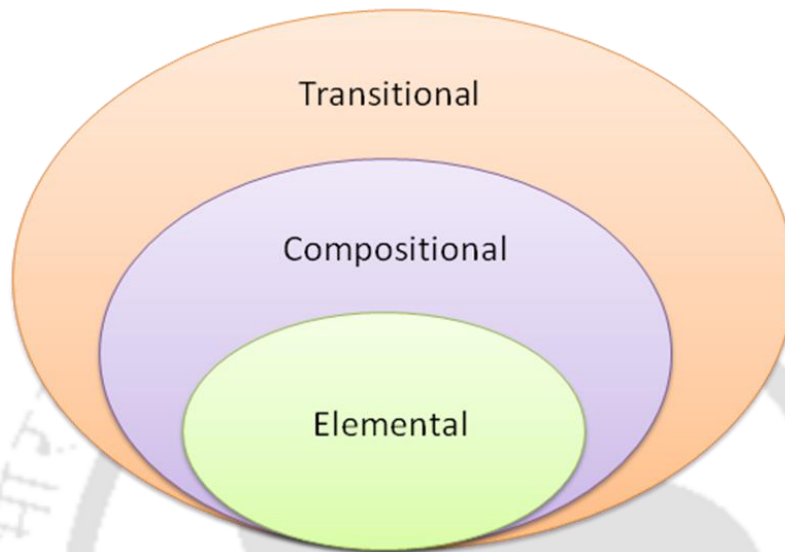


Fig 4. 4: Onion model of designers design decision categories

As evident in the discussion above, one can safely categorize the design decisions made by HCI designers in three categories. The categories have been named in this thesis as, 'Elemental', 'Compositional' and 'Transitional'. Where 'Elemental' refers to all the elements that make a screen like, icons, menu items, colour, graphic elements etc. and 'Compositional' refers to the arrangement of elements on the screen, while, 'Transitional' refers to the subsequent appearance of screens upon user actions, like new screens or error messages etc. These levels of design decisions are not independent of each other; rather they hierarchically constitute each other starting from the elemental to compositional to transitional. This has been depicted in an onion model in fig 4.4. These design decisions may not necessarily be sequential in the design process. Sometimes, standard solutions at one level may start guiding the rest of decisions. For instance, if a transitional

level solution already exists and is known to work best with the users group in focus then the designer may not invest in finding a new solution but rather select the existing one and thereafter the transition level decisions will influence the elemental level decisions regarding the menu items, the graphic style etc.

4.3 Identifying Data Gathering Techniques for Experiential Design

Data gathering techniques already in practice in HCI and other allied fields has been studied to identify techniques which can cater to experiential data gathering needs for further investigation. For this, first HCI literature was studied to understand techniques used in HCI and then literature of allied fields were also looked into. Four techniques in all for further study have been identified through literature study as described in section 4.3.1 and 4.3.2. Next section, section 4.4 presents the detailed literature on these techniques separately.

4.3.1 Prevalent users' data elicitation techniques in HCI

The most recommended design process for HCI design is User Centred Design (UCD) process. Iterative design with involvement of users and incremental prototyping is at the core of UCD process (Mayhew, 1999). The involvement of users generally is to gather data from them regarding their behavioural responses to the prototypes or the final system designs. Several variants of the UCD process exist in practice in HCI Filed. One of the most prevalent practices is of Usability Engineering. In Usability Engineering practice, the measures of usability are identified and criteria for a successful design are fixed in terms of the measures of usability. The system is designed iteratively till the design meets the predetermined criteria (Nielsen, 1993). In this process, evaluation of system is done using techniques which are called usability evaluation methods (UEM).

Several UEMs are in practice today. These techniques are nothing but a way of gathering data from the users. They gather behavioural data from the users. These techniques have been studied in detail and a body of literature is available to aid in their understanding.

Nielsen and Molich (1990) have discussed four categories of UEMs. These categories are automatic, formal, empirical, and heuristic methods. According to Nielsen and Molich, automated approaches have been in limited use and are mostly used in a few primitive computerized checks of interface elements. What has been called by Nielsen and Molich as formal methods has been termed 'user models' in this thesis and these according to Nielsen and Molich include cognitive modeling approaches such as GOMS (Card, Moran, & Newell, 1983), Cognitive Complexity Theory (Kieras & Polson, 1985), and the CE Model (Polson & Lewis, 1990). Empirical methods focus on observing users as they perform tasks and include usability testing, field testing, and attitude questionnaires. Heuristic methods attempt to reduce the time and costs associated with evaluation and include such methods as heuristic evaluation and guideline reviews. It is the empirical methods in UEMs that are of interest here as it is hypothesised that some of these techniques may be capable of eliciting experiential data from the users.

Another classification of UEMs has been proposed by Wixon and Wilson (1997). They suggest five dimensions along which usability methods can be classified. The five dimensions include: (1) formative versus summative, (2) discovery versus decision, (3) formalized versus informal, (4) designer involvement versus user involvement, and (5) complete and component. While the formative methods are used in the initial stages of HCI design process, the summative methods are used in the later stages. The prevalent HCI design practices use a number of both formative and summative UEMs in the process. However, it is at

the summative levels that there seems a consensus of UEMs in use (Boren and Ramey, 2000). Also it is the first dimension of five proposed by Wixon and Wilson that is often used in differentiating the UEMs.

From the point of view of type of data obtained, Whitefield, Wilson, and Dowell (1991) categorised UEMs in four: (1) analytic methods, (2) specialist reports, (3) user reports, and (4) observational methods. While the specialist reports do not involve users and hence are of not much use to this study. While observational methods and user reports could have users' experiential components but it is the analytical methods are of interest here as they would give scope of analysing the users' experiential data.

Another way of categorizing the UEMs is by the type of data elicited is of quantitative versus qualitative types. The quantitative data gathering techniques are typically used in calculation of metrics that assess the usability criterion of system (Dumas and Redish, 2000; Ivory and Hearst2001). Though the quantitative methods are easier in evaluation and provide results which can be statistically validated but they provide less expressive data (Constantine and Lockwood 1999, Dumas and Redish ,2000). The quantitative methods do not give rich data which can be used to understand the internal processes of the users. The quantitative data gives more of counts of 'what happened' rather than 'why something happened'. The details of the structure of the event and the mental processes involved with them are not present in the quantitative methods. Complexity of the experiential data augurs for consideration of qualitative methods rather than quantitative methods. It is hypothesised that techniques which can give both quantitative and qualitative data would ideally suit the experiential design process and a search will be made here for such a candidate technique.

Based on the above categorizations done to understand the types of prevalent data gathering techniques in use in HCI, we fix here the search criteria for suitable techniques. The techniques that will be identified and experimented in this study will be formal techniques which can be recommended for use in the experiential design process. Techniques applicable to both formative and summative stages of design would be searched as a typical experiential design process would consist of these stages. There would be greater emphasis on the analytical methods rather than observational methods as the experiential data would have narrative structures which can be captured more in the analytical methods. The observational methods would merely tell about the outcomes of the internal processes at the action level in the user, which is not of much interest in the experiential framework. After having decided on the criteria for search it would be pertinent to first take a look at the most practiced data gathering methods in HCI to look for suitable candidates for experimental study.

According to a recent survey; usability testing, expert evaluation and interview-type investigations are among the most used user data gathering methods (Troost et al., 2006). Among these, the usability testing and interview type investigations are of interest here for the reason that expert evaluation does not involve users and hence no experiential data could be gathered in these.

In usability testing, Think Aloud is the most prevalent technique in use (Boren and Ramey, 2000). Think Aloud Technique is also called TA in short and this short form will be used in this thesis often hence onwards. TA is the process of concurrent verbalisation, where the user keeps '*thinking aloud*' that is, keeps verbalizing the thoughts as they occur to the user. This method was popularized by Ericsson and Simon (1993) by establishing verbal protocols data as a scientifically valid form of data. Newell (1972) also had earlier argued for its use in HCI. In TA technique user keeps interacting with the system fulfilling given

task/s and user keeps on speaking aloud whatever thoughts that come to the mind. The evaluator, also called the moderator, keeps reminding the user to keep thinking aloud when the user forgets to do so. The user is discouraged to ask for help or answer any other questions. TA seems to be a good candidate for experimenting for its capabilities for experiential data gathering. It is so not only because it is the most popular method in use and hence would save much effort in shifting the design process from usability to experiential design but also because it gathers data directly from the users and has a verbal report data with a somewhat narrative structure. Detailed description of TA technique will be taken up separately in section 2.8.1 in context of further investigation of this technique.

Among the other popular techniques used in usability data gathering in HCI, as described by Ivory and Hearst (2001), is the 'coaching method'. In 'coaching method', unlike the TA technique, users ask questions to the expert and experts help them. This technique cannot be considered for the experiential purpose because the interference of the user-expert dialogue would hinder the internal experiential processes. The users' internal processes of dynamic appraisals and motivations would get influenced by the external input received from the experts. For the same reason, two other methods in the Ivory and Hearst (2001) study, the 'teaching method' and 'Co-discovery learning' method would be ruled out. In teaching method expert instructs the users in how to do the task and in co-discovery two users help each other out. Another potential technique for experiential data gathering from the list by Ivory and Hearst is 'Retrospective Testing'. Earlier, retrospective verbalisation has been doubted to be a reliable technique for data gathering due to the fragile nature of human memory, especially on account of the interferences by the subsequent events (Ericsson and Simon 1993). But if the ability of recall be improved by some mechanism like the replayed video of the interaction, it is hypothesised here that the user would be able to give rich accounts of the experiences he/she underwent. Retrospective

verbalisation would be considered for the experimental study in this thesis for its capability in eliciting experiential data and detailed description of this technique would be given separately in section 2.8.2. Among the other Inquiry methods being used in HCI, as identified by Troost et al. (2006), the 'field observation' and 'focus groups' techniques can be easily ruled out for experiential data gathering. Field observation consists of merely observing the users in their own environment and it does not comprise of mechanisms to understand what goes on inside the user. Observing users external behaviour cannot help us much in understanding the experiences that the users undergo during interactions. On the other hand, the Focus group technique is a group method, where no direct experiences of the users can be identified reliably. The other technique of direct Interviews could be a potential technique as it gives rich data but an interview conducted long after the actual interaction with the system is over would not give any reliable account of what happened during the interaction. Indeed interviews can help in gathering background experiential data related to the system in general but it will have limited use in extracting experiential data pertaining to a prototype or a running version of a system under use. It is posited here that interview technique may be combined with other methods to be able to extract such data. Also surveys and questionnaires would not serve the purpose as the data gathered from them would be too lean to help in identification of any interesting experiential accounts by the user. Again it is posited here that the questionnaires could be combined with other methods to get initial demographic data and help focus the effort for gathering psychographic and experiential data. But questionnaires alone would not be able to get rich experiential data from the users.

After having identified two data gathering techniques, namely Think aloud and Retrospective verbalisation, from the prevalent HCI practices, other bodies of literature were also searched for any suitable techniques.

4.3.2 Users' data elicitation techniques in allied fields

Among the allied fields of study, it is the field of Psychology which has traditionally dealt with scientifically understanding human experiences in different circumstances. Several schools of thought have existed in the field of psychology and several threads of debate still continue regarding reliability and validity of the techniques used for understanding human experiences among different schools. For instance, psychoanalysis, which originated with Sigmund Freud, uses a specialized technique to mine individual's experiential accounts and relate it to one's psychological problems. By drawing out the participants, encouraging them to speak out the deep feelings and beliefs they had associated with different events in their life, Freud tried to piece together the complex psychological puzzle of understanding the individuals' experiences with different events and its likely impact on the way one behaved in present. Using hypnosis as a technique to do this initially and later shifting to free associations, Freud found many a followers of this approach. Freud's used theories of personality structure and personality dynamics, to aid him in understanding the psychological puzzle of individuals. Though the theoretical frameworks used by psychoanalytic remain under debate, merits of the technique used to mine the deep feeling level data have been accepted in specialized interview techniques. Some of the core ideas in the psychoanalytic techniques are being used in gathering experiential data in HCI too (Schaffer and Weinschenk, 2008). Patient listening in a casual comfortable environment, with directed probes have been found to help gather deep beliefs and feelings of the users in context of the use of the system. But in this technique the user is not involved in any interaction with the system. It is more an attempt to gather the psychographic profile of the user rather than gathering experiential data pertaining to a complete interaction that has taken place. The image of an interactive system is used as a stimuli rather than allowing the user to interact with the system and have the experience of using it. This technique does

get good data about the beliefs and feelings of the users but it does not give the data related to the experience of having used a system in context of a task. Further gathering data related to aesthetic experiences is not a focus of the technique. Also, several other techniques for gathering data from users exist under different theoretical frameworks in the field of psychology. The psychological tests, for instance, are also ways of gathering data from users. But these tests, like achievement tests, ability tests, aptitude tests, personality tests etc. are focussed solely on the user's capabilities, independent of the context of the interaction with computer. It is more to know the psychological makeup of the users rather than to understand the experiential process in the context of interaction with computers.

Among other theories in psychology, there also exists a theory of personal constructs psychology which seems to be of interest in experiential design framework. George Kelly (1955) proposed the theory that individuals are like scientists who make an individualistic meaning of the world around them. They do so by creating constructs which are very personal to individuals and hence name of the theory 'personal construct psychology. Kelly emphasised that the individual's constructs need to be elicited in order to understand the 'psychological space' of individuals (Gaines and Shaw, 1992). Kelly also developed a technique of repertory grids to aid in eliciting personal constructs from individuals. Kelly (1969) rejects the idea that these personal constructs are merely cognitive. This is because he suggests that the "cognition-emotion" distinction is of little use to psychological science. Kelly prefers to move towards a more holistic orientation which views behaviour; thought and emotion as the result of a process that involves the construction of meaning (see Mancini & Semerari, 1990). Kelly also offers a framework to understand role of meaning in emotions and in decision-making process which has been discussed under the topic of users as decision makers. Kelly emphasises that the individual's

constructs have profound effect on how one constructs the view towards environment around. This in turn triggers the emotional program in the individuals which affects the decision making process. Kelly's personal construct theory on the individual's internal psychological processes is very close to the user model in experiential framework suggested above. For this reason, Kelly's repertory grid was taken up as one of the techniques to be experimented with for experiential data gathering and detailed description of this study will be subsequently presented in section 2.8.3.

So far, three techniques for experimental investigations have been recognised; think aloud, retrospective verbalisation and repertory grid technique. These techniques elicit qualitative data having verbal reports of users. It was felt that having one technique which could be on the quantitative side would help in cross checking across the techniques for consistencies in experiential data. Further, as we have discussed earlier in the user models sections that users are meaning makers and also have recognised in the user model for experiential design that meaning is central to the users' internal experiential processes. Indeed it's the meaning received by the users that has to be central in the HCI experiential design thinking process. Also, since "*Humans do not see and act on the physical qualities of things, but on what they mean to them*" (p 47, Krippendorff, 2006) and also that these "*meanings that artifacts acquire in use, are largely framed in language (p 147)*" and thus "*the fate of all artefacts is decided in language (p148)*", hence it would be suitable to have a technique to measure meanings through language. Osgood (1952) had proposed a technique for method of measuring meaning. In '*The Measurement of Meaning*' (Osgood et al, 1978) a semantic differential technique for measurement of connotative meanings has been detailed out. Meaning has been recognised as "*a representational mediation process, a complex reaction divisible into some unknown but finite number of components (p 31, Osgood et al, 1978)*". Semantic differential acts as a "*combination of controlled association and scaling procedures*" (p 20) to exhaust the

dimensionality of the semantic space by constructing semantic scales through the semantic space. The 'association value' of materials and meaningful terms is capitalized by constructing dimensionality in the semantic space. Even affect has been recognised as a process mediated by meaning and thus has a psychological representational process. As a psychological representational process has psychological 'association values' with other meaningful words, hence even affective meanings can be measured using the semantic differential technique (Osgood et al, 1978). Semantic Differential has been used earlier in measuring affective meanings (Bradley and Lang, 1994; Skrandies and Chiu, 2003). Even satisfaction measures in usability have been done using semantic differential technique (Chin et al., 1988). Hence semantic differential was selected to be one of the techniques for investigating its suitability and applicability in experiential design process. Detailed description of semantic technique will be given in section 4.4.4.

The researcher acknowledges that there could be more data gathering techniques in use in HCI or allied fields which have not been studied in this section and that some of those techniques may be capable of eliciting the experiential data from users. However, the author has tried to look into the available techniques with the availability of literature on the technique, its applicability to HCI field and the resources available to conduct experimental observations using the technique. Another criteria for selection of techniques for experimental study was that the techniques being studied should cover the range of design decision levels and should together provide data for all the levels of design decisions. It was felt that as the designers do not need only one type data during the design process for interactive systems hence it would be good to study the different levels of data that can be gathered for experiential design process. For instance, having data only from the system level will not help the designer in making design decisions regarding the icon or graphic designs hence designers will also need information

on the elements of design during the formative stages of the design development. Hence experimenting with techniques which can be experimentally validated for gathering data from across the design decisions levels will facilitate not only comparison across the different data types needed for different levels but would also help in coming up with design heuristics for designers to be used in experiential design process. The type of data elicited by the techniques was also an important factor in selection of the techniques. It was felt that having techniques which range from their ability to mine data both in the form of qualitative and the quantitative data would facilitate the comparative study of the techniques. It was felt that part of the problem of gathering experiential data was also lying in the factor whether the data gathering technique was eliciting data in qualitative or quantitative form. Hence a mix of qualitative and quantitative data gathering techniques was selected.

4.4 Data gathering techniques selected for experimental investigation

The four selected techniques for experimental investigations for their suitability to the experiential design process are Think Aloud, Retrospective Verbalization, Repertory Grid and Semantic Differential. Here each technique will be introduced in brief and the procedure for application will be described. Also the plan of experimental investigation will be set for each technique.

4.4.1 Think Aloud Technique

In line with the concept of human cognition as information processing, verbal protocol was argued as a reliable source of data by Newell and Simon (1972). Later verbal protocol analysis as a technique for understanding human problem solving process was detailed by Ericsson and Simon (1993). Protocol analysis

argues its validity on the basis that verbally coded chunks of information is retrieved directly from Short Term Memory during concurrent verbalisations and hence there is no subjective interference in the data thus obtained.

Traditionally, the verbal data has been treated as 'soft data' as it is subject to the subjective interpretation by the coders and analysts. Generally data is called 'hard' if there is inter-subjective agreement over the observed behaviours. Generally the behavioural data is considered to be 'hard' in comparison to the verbal data which is more 'soft'. Ericsson and Simon (1993) argue that the after invent of recording facilities has helped preservation of the original verbal report and hence helped shifting the verbal data towards more 'hard data' type. Further Ericsson and Simon argue that with recognition and acceptance of the information processing model of human, the verbal behaviour can be treated as a type of recordable behaviour and hence can be treated as hard data.

In the information processing model it is assumed that the information processing happens as a sequence of internal states successively transformed by different cognitive processes. An important assumption in information processing model with respect to verbal data is that the information recently attended is stored in Short Term Memory for a very short duration and is directly accessible for verbal processing (fig 4.5). Once the information passes into the Long Term Memory, it has to be retrieved before verbally reporting. This additional processing can involve transformation on the information through cognitive processes involved in the process that the data may not remain reliable.

Ericsson and Simon recognize two kinds of verbal reports which are concurrent in nature. 'Talk aloud' where the vocalization does not involve any verbal coding and 'Think Aloud' where information heeded is symbolically present and is translated into an appropriate overt form. Ericsson and Simon claim that both of

these are direct and level 1 verbalization where cognitive processes are not modified in the process of verbal reporting but are merely verbally externalized in its actual state (p16).

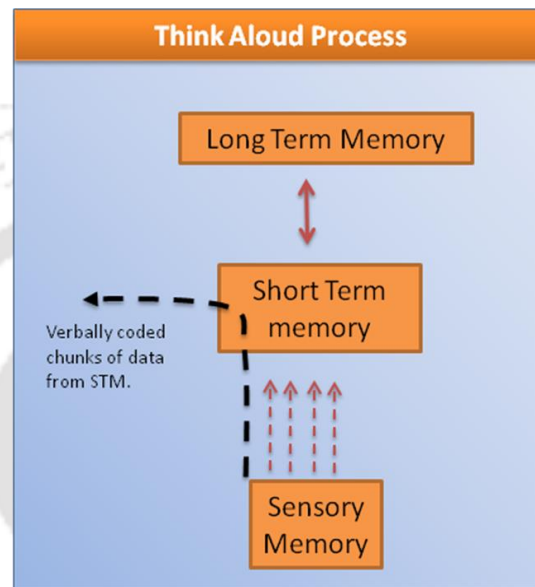


Figure 4. 5: Think Aloud Verbalizations from STM (after Ericsson and Simon, 1983)

Over years of its existence in practice within HCI, think aloud, has been recognized as the single most used Usability Testing technique (Boren and Ramey, 2000). In its current form in HCI, users are asked to “think aloud” while performing a task on the system. It is believed that the sequence of thoughts is not changed by the additional instruction to think aloud (*preface*, Ericsson and Simon, 1993). An evaluator sits beside the user throughout the interaction and the role of evaluator is to keep reminding the user neutrally to ‘keep thinking aloud’. As per the classic instructions, the evaluator has to abstain from conversing, suggesting or interacting with the user during the task fulfilment. The evaluator has to have a neutral attitude towards the task fulfilment activity and

has to merely remind the user to keep thinking aloud in case the user stops thinking aloud. Often the user is first taken through a practice session where user is demonstrated the think aloud technique and is made to practice 'thinking aloud'. Recorded videos of the task fulfilment session are coded and analysed for usability criteria.

The data thus obtained provide the analyst with records of verbal accounts of what users see and think. The analyst also correlates the observed interactions, the users' behaviour with the verbal accounts. Ericsson and Simon (1993) suggest two ways of analyzing the verbal data. In method one, verbal data are merely 'categorized' into pre-agreed upon categories and no attention to meaning or context of verbalization is given. It is like mechanical counting of the terms and phrases without attention to what they mean and in which context they were spoken. The second analysis method consists of consideration for meaning. The encoding of verbal data is done by selectively considering the intent of the verbalization rather than the merely counting terms and phrases. Less formal methods have also been recognized which do not depend on any prior coding scheme and the search for interpretations run in parallel to search for a coding scheme.

At attempt has been made in this thesis to gather experiential data using 'think aloud' technique and the results obtained have been analyzed for the technique's strengths and weaknesses in experiential design framework. In this thesis both methods of analyzing data as mentioned above, have been used to understand capability of think aloud technique in gathering experiential data. The methodology used for the experiments has been described in the next section. An abbreviated form of 'Think Aloud' Technique, 'TA' has been used hence forth at places for brevity.

4.4.2 Mind Tape Technique

Another form of verbal report, retrospective verbalization has also been in practice (Ivory and Hearst, 2001) and in research in HCI (Van den Haaket al, 2003). In this technique users are asked to report sequence of their thoughts after the task is over. Though doubts over reliability of retrospective reports have been raised, its benefits over concurrent verbalizations have also been outlined (Brinkman, 1990). Ericsson and Simon (1993) have raised caution in use of retrospective verbalisation due to the temporal separation between the initial heeding of thoughts and their reporting. It is suggested that for tasks lasting between 0.5 second to 10 seconds, subjects would be able to retrospectively verbalization accurately if they are asked about the sequence of thoughts immediately after the task is over but for tasks beyond that time the interference due to cognitive processes is feared. As in the case of HCI, the tasks take much longer, the retrospective verbalization method has not been in much use.

Most of the doubts and objections to retrospective verbalization have been related to the inability of recall and interference with subsequent cognitive activities. In spite of these objections, the richness of data one gets from the retrospective recall was hypothesized to be of much importance in experiential design process. Hence a variant of direct retrospective recall has been developed as part of this thesis work. In the variant method, the recall has been cued by the replayed video of the screen recorded during task fulfilment. This recorded video is pause and played during the retrospective reporting process which takes place immediately after the task fulfilment is over (fig 4.6). An interview technique using formalized probes has also been developed to extract experiential data during the retrospective reporting. This variant of the direct retrospective verbalization has been called 'Mind Tape' (Nielsen and Christiansen, 2000; Nielsen et al., 2003) and is used in this thesis. The term 'Mind Tape' has been used to imply that the mind during recall acts as a tape under the influence of the

stimuli of the recorded screen (Nielsen et al., 2003). The term Mind Tape has been used hence forth in the thesis to imply this variant of the retrospective verbalization and also the abbreviated form of 'Mind Tape', MT has been used frequently for brevity.

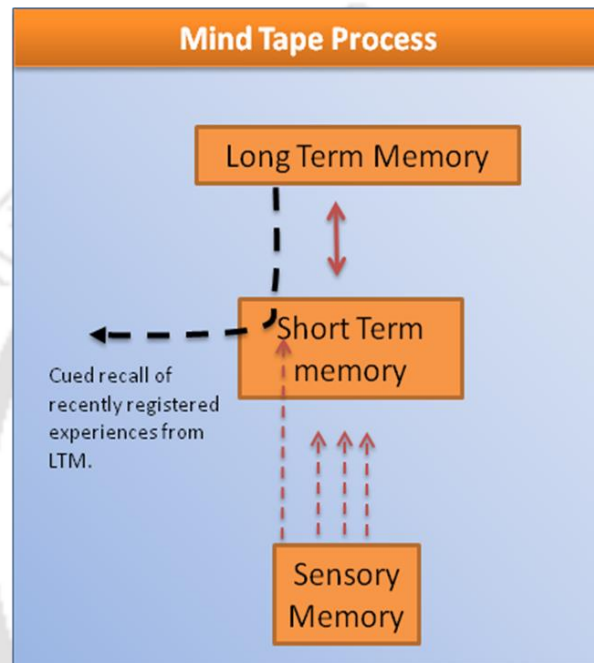


Figure 4. 6: Mind Tape Process as an improvised retrospective recall

In MT, the recorded screen of interaction is replayed immediately after the interaction and the user is interviewed under the stimuli of recorded video by playing and pausing when required. Though there has been some validation researches for this technique (Van et al., 2003; Zhiwei et al 2006), it is not a widely practiced technique in HCI yet. In this research this technique has been researched with a hypothesis that this technique would be suitable in experiential design process. It is hypothesized that MT would not only be able to elicit experiential data but also would be a culturally suitable technique, capable of

being accepted across cultures. The cultural differences in social settings also are a variable in application of a data gathering technique. The difference in value systems across cultures surface out in terms of the language usage, symbols used and social settings for communication. The data gathering technique needs to suit the socio-cultural setting in order to be truly efficient. Further, that data gathering technique also needs to be a sensitive tool to bring for the data related to the cultural differences in the user experiences. It is hypothesized that the MT technique would be not only a culturally suitable but also a sensitive tool to bring for the experiential data. As MT technique is capable of probing into deeper level cognitive processes, it is also hypothesized that it will be able to bring forth the deeper level of feeling. As MT does not interfere with task fulfilment by users it would further be easy to apply and will have more validity in experiential framework. Also it is expected that MT technique would provide with much more rich data hence having greater usefulness in aiding the designers design decision making process for it will tell the designer not only 'what user did' but also 'why user did' it. The research methodology used for MT technique has been described below and the experimental setup has been described in chapter 3.

4.4.3 Repertory Grid Technique

The Repertory Grid is a technique designed by George Kelly to capture the structure of personal meaning and is based on Kelly's (1955) Personal Construct Theory. The Personal Construct Theory premises that individuals have their own, very personal ways of understanding the world around them. Individuals give meaning to their experience in their own terms and build implicit theories of understanding the world. The Repertory Grid Technique (RGT) is an instrument to explore the structure and content of these personal meanings and implicit theories through which individual perceive, act and experience (Bannister &

Fransella, 1986; Dalton & Dunnet, 1992; Landfield & Leitner, 1980). Kelly sees every human being as a scientist who creates hypothesis in interpreting and understanding the world around. These hypotheses are bipolar in nature like scientific hypotheses. These hypotheses, also called as personal constructs, help categorize new meanings by accept or reject a new notion on the basis of similarity or differences with other ones. It creates a dimension of meaning that allows two things (events, people etc.) to be similar in some respect and a third one to be different. These constructs are used to segment the psychological space of a person (Fig 4.7).

In contrast to the traditional "investigator centred approach" where the investigator's theoretical constructs (e.g., extroversion vs. introversion, internal vs. external locus of control, etc.) are used to describe the psychological space of an individual, a more "person-centred approach" is used in Repertory Grid Technique where the person is understood in terms of one's own theories called as 'personal constructs' (Hampson, 1982). The person's idiosyncratic categories used in meaning construction process are given priority over the theoretically derived categories. It believes that all individual constructs are necessarily influenced by the active construing processes of the person who has elicited them (Neimeyer, 1993). Also the data obtained from RGT can be rigorously analyzed mathematically which makes it an excellent tool for the scientific study of personal meaning. This technique is also flexible and hence can be used in variety of forms like using structured interviews, paper and pencil or computerized interactive forms.

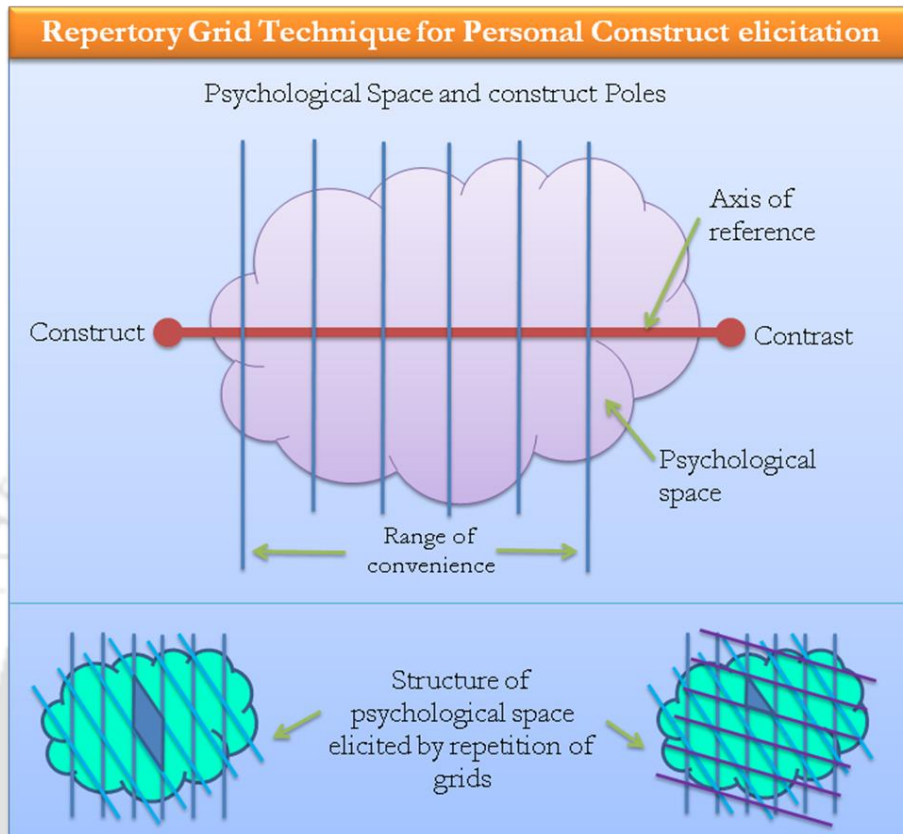


Figure 4. 7: Schematic representation of construct elicitation process.

A repertory grid consists of (a) a series of *elements* that are representative of the sample of things like events, people etc. In present research, interactive systems have been taken as elements, (b) a set of *personal constructs* which users use to compare and contrast these elements, (c) a *rating system* which evaluates the elements based on the bipolar arrangement of each construct and (d) *a number of grids* to iteratively create triads of elements for construct elicitation and rating. Selection of elements and constructs, the rating system to be used and the number of grids to be administered are decided depending on the aim of data collection. In RGT, constructs can be elicited by the participants directly at the

time of interview or they could be predetermined by conducting a series of pilot tests identifying the relevant constructs prior to the main study (Neimeyer, 1993). In the present research, direct construct elicitation method was selected for its capability of eliciting diverse set of constructs which could give experiential data from the users through the use of constructs. Also a seven point rating scale has been used for all the experiments conducted in this study. Details of the research methodology followed have been described in the next section.

4.4.4 Semantic Differential Technique

Semantic differential technique as a tool in for 'measurement of meaning' was introduced by Osgood (1952). Osgood identifies meaning as a representational mediation process (p 5, Osgood et al, 1978). Meaningless stimuli become meaningful signs by partial association with existing 'wired in' meanings. An incremental association with existing meaning of known stimuli due to partial similarities in the responses helps develop meaning of a new sign and even after acquiring the meaning of its own, the sign continues to have meaning related associations with other stimuli. Earlier, such associations have been analytically studied between colour, emotions and musical experiences (Odbert et al, 1942). Results have shown that cross modality stimulus equivalences exist. Stimuli from modalities like visual, auditory, emotional and verbal, share meanings and have a continuity in dimensions of experiences (Karwoski et al, 1942). Further, language has been identified as an 'index of meaning'. Though in naturally occurring overt conversation, encoding of the meaning internal to speaker may be difficult in expression but given a choice of linguistic variables that is words, the encoding and hence expression of internal meaning becomes easy and explicit. A carefully selected sample of alternative verbal responses representative of the possible

variations in the meaning is applied across participants in semantic differential to recognise the aforementioned associations between existing meanings. Semantic differential is essentially a combination of controlled associations and scaling procedures. The subject is provided with, a concept, to be differentiated and a set of adjectival scales against which to do it.

Similar to the personal construct psychology of Kelly where a concept of psychological space is used which is rich with meaning and needs to be dissected with construct-contrast pairs, Osgood uses concept of a semantic space which the straight line of semantic scales pass through and thereby create multidimensionality in the semantic space (p25, Osgood et al, 1978). Thus, Osgood defines semantic space as of known dimensions and Euclidian in character which reveals its dimensionality through the straight lines of different semantic scales.

Semantic differential technique has been used in various fields in measurement of meanings. For instance, semantic differential has been used in measuring attitude change (Wolfinger, 1955), effects of advertising (Mindak, 1955), meanings in colour (Tannebaum and Osgood 1952 in Osgood et al 1978), meanings in pictorial signs and symbols (Tannebaum and Kerrick, 1952 in Osgood et al 1978) and aesthetic judgement (Tucker, 1955). In the context of design as well, Krippendorf (2006) has argued that the meanings acquired during interaction with systems are largely framed in language and language used directs attention and frames perception, hence semantic differential has been suggested at a tool to assess the character of an artifact through sets of adjectives attached to it using products or product prototypes (p 232, Krippendorf, 2006).

Semantic differential technique has been used to measure the emotional experiences as well. Osgood has recognised emotional experiences as one of the

several modalities which have shared meanings (p21, Osgood et al, 1978). Thus a possibility of eliciting affective experiences through the associated adjectives as semantic scales in semantic differential technique exists. Skrandies and Chiu (2003) have also identified correlations between neural activation and affective states using semantic differential technique to assess the affective meanings in stimuli. Using electrocardiogram in conjunction with the semantic differential technique, Skrandies and Chiu (2003) have reported similar neural activations in participants across different cultures and languages under similar affective experiences, which show not only that the affective experiences are universal in the way they are felt physiologically but also that the semantic differential technique can be applied universally for gathering affective meanings and thereby the affective experiences. Affective meanings have been measured using semantic differential technique in several other places as well (for detail see Bradley and Lang, 1994). In HCI, Semantic differential has been in use for measuring satisfaction of users in usability tests in several different prevalent protocols (Chin et. al, 1988; Lewis, 1995).

Osgood has used a seven point scale throughout his studies for it appears to be the 'natural' grid. Further Osgood's semantic scales are Bipolar in structure consisting of opposite pairs of adjectives. The seven point scale gives the central point which is the meaningless point from which the participants can chose to deviate in any one the two directions. In case of this study unipolar seven point scale has been used. The adjectives used here have been representative of the most commonly accepted affective experiences. It was decided to do away with the pair of opposites as linguistic terms representing affective experiences opposite to each other was difficult to find and also it made the task of participants tougher. Unipolar scales helped identify extent to which an affective experience was associated with the given stimuli. The research methodology for semantic differential technique experiments has been described in Chapter 4.

4.5 Conclusions

This chapter has identified the probable techniques for the experiential data gathering these techniques will be further investigated through experimentation for their suitability in gathering experiential data in cross cultural situations in chapter 6. Choice for the techniques was not very straightforward as many other techniques could also have been selected for experimental validation. The four techniques selected were on the basis of their description found in literature and authors personal interpretations of the techniques presented in various literatures. Quick pilot studies also helped in assessing the resources required for the experimental validation of the techniques.



EXPERIMENTAL FRAMEWORK AND RESEARCH DESIGN

5.1 Introduction

This chapter presents the research framework and research design employed for experimental investigations with the four techniques. The experiments were conducted with an aim of identifying strengths and weaknesses of each technique for their adaptability within the experiential design process and the research methodology applied for each technique depended on the type of data the technique was capable of eliciting. The choice between the qualitative and quantitative research methodologies for experiments depended upon the technique under study and the type of data elicited by them. The various experiments conducted as part of the research reported in this thesis had mutual influences on them and as temporally one experiment followed the other one, the findings of one experiment had an influence on the others. The research methodology and the research design for experiments with each technique have been discussed in sections 5.2 and 5.3 subsequently.

Earlier in chapter 4, section 4.2, it was discussed that the users' experience during interaction with computer based systems was composed of different instances involving different aspects for the interactive system and that the designers needed information about those instances, in order to make design decisions about them. It was also derived from the literature study that the designers design decisions can be categorised into three categories, namely those pertaining to, elemental, compositional and transitional aspects of the interaction. As the users'

experience with an interactive system is with respect to certain aspect of the interaction, hence for collecting experiential data form users for experimental purpose using the three techniques it is imperative to also identify the aspects of interaction with respect to which the data can be collected. In order to experimentally validate the data gathering techniques' ability to gather experiential data pertaining to these different design decisions levels, it is also essential to identify the suitable stimuli in response to which the experiential data can be gathered. For this purpose, section 5.6 introduces to the various stimuli selected for the experimentation with the selected techniques at all the three levels of design decisions.

5.2 Research Methodology

Two broad research methodologies exist in literature for gathering and analyzing users' data, namely quantitative and qualitative research methodologies. Whereas quantitative research relies exclusively on analysis of numerical or quantifiable data, qualitative data focuses on the meaning in the communication. While quantitative data is in form of numbers which can be statistically analyzed, the qualitative data comes in many forms, including text, sound, still images, and moving images having rich meaning in them. The focuses of the quantitative and qualitative research practices are also different. While quantitative research focuses does thin slicing of a natural phenomena to be able to count the instances of it, the qualitative research involves an in depth understanding of human behaviour and the reasons that govern human behaviour. In quantitative methodology, the aim is to classify features, count them, and construct statistical models in an attempt to explain what is observed, whereas in the qualitative methodology, the aim is a complete, detailed description of the phenomena. The qualitative research methodology allows a certain amount of fuzziness in what is

being observed in the research process. The clarity in the conclusions and findings emerge often through cycles of data gathering, analysis and re-gathering of data as depicted in fig 5.1. On the other hand, the quantitative research methodology demands that researchers should be clear about what they are looking for in the phenomena under observations, or in other words, the researchers should have a clear hypothesis before embarking on the research (fig 5.2). The qualitative research methodology, on the other hand allows the researchers to discover the aspects of interest in phenomena during the study itself. Also, there is a level subjectivity in the interpretations that the qualitative research is tolerant about whereas the quantitative research methodology seeks precise measurements and analysis of the target concepts. Unlike quantitative research, qualitative research relies on reasons behind various aspects of behaviour. It investigates the why and how of decision making, as compared to what, where, and when of quantitative research (table 5.1). Hence, qualitative research needs smaller but focused samples rather than large random samples, which are suitable for quantitative research as categorisation of data into patterns is the primary basis for organizing and reporting results (Miles and Huberman, 1994; Creswell, 1998).

Researchers too differ about the value of two research methodologies and whether they are inherently two separate methodologies at all. Some researchers take one extreme position and believe that "All research ultimately has a qualitative grounding" (Donald Campbell in Miles & Huberman, 1994, p. 40) while others take the other extreme and proclaim, "There's no such thing as qualitative data. Everything is either 1 or 0" (Fred Kerlinger in Miles & Huberman, 1994, p. 40).

Table 5. 1: An overview of Qualitative and Quantitative research methodologies

| Qualitative | Quantitative |
|---|---|
| Answers Why? How? | Answers How many? When? Where? |
| Data are “rich” and time-consuming to analyze | Data are more efficient, but may miss contextual detail |
| Research Design may emerge as study unfolds | Research Design decided in advance |

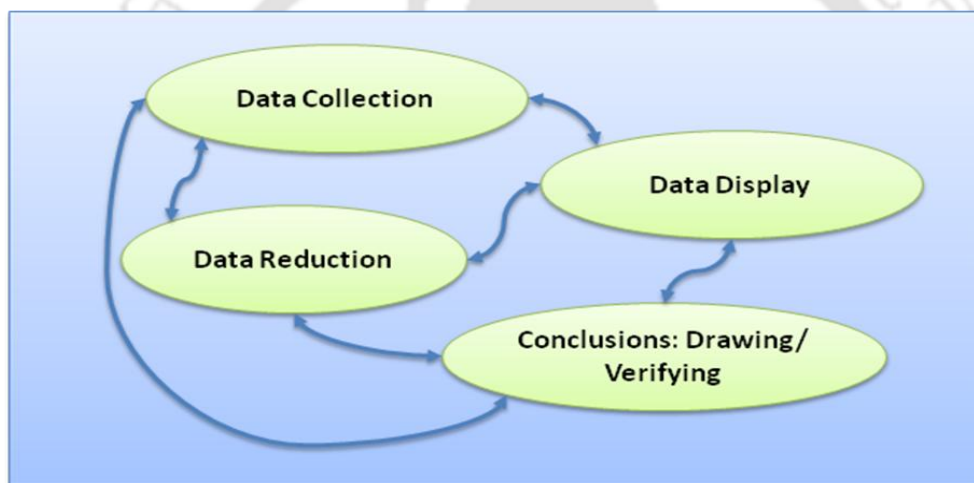


Figure 5. 1: A typical qualitative research methodology (from Miles & Huberman, 1994)

However, in HCI both quantitative and qualitative research methodologies have been used and recommended (Newell & Card, 1985). It has been argued that HCI as a field should employ both the quantitative and qualitative research methodologies as it is an emerging field which needs to integrate different bodies of applicable knowledge (Newell & Card, 1985; 1986; Carroll & Campbell, 1989).

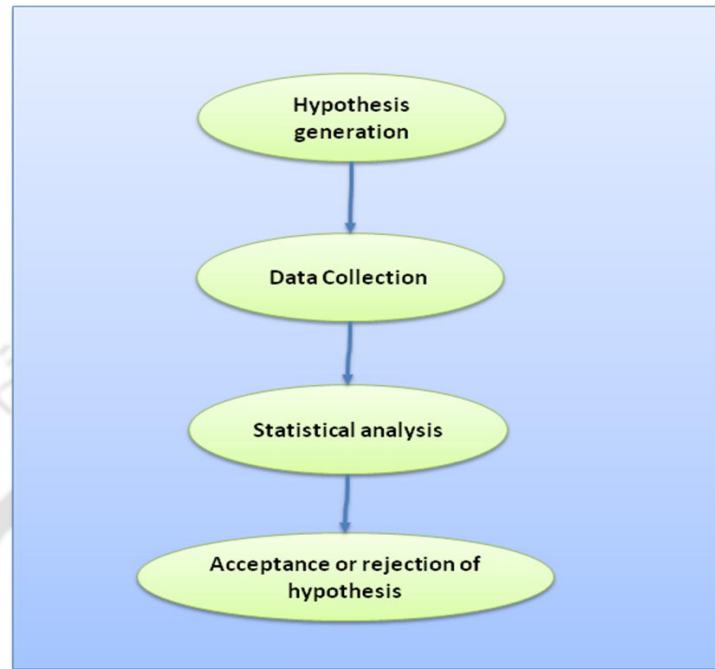


Figure 5. 2: A typical quantitative research methodology (after Balnaves and Caputi 2001).

Especially, in the experiential design framework, user data which answer ‘why’ and ‘how’ about the users’ experiences are welcome as they would furnish richer accounts of what happened to the users during the interaction. Hence qualitative methodology has been used to analyse the meaning in users’ verbal elicitations. Analysis methods in qualitative methodology have been developed which can fathom the meaning in the conversations of the users. Such methods will be useful to the experiential design framework as the users’ experiences are deep within the users which need to be dug out through narrative verbal structures. These narrations or elicitations of the experiences are filled with rich meaning in them which need to be analyzed to arrive at design conclusions by the designers. On the other hand, the quantitative methods are sometimes less resource

expensive in terms of analysis time needed and hence are useful for the validations of experiences across the user groups.

In this thesis the quantitative and qualitative research methodologies have been opportunistically used depending upon the type of data elicited by the techniques under study. The qualitative method has been used wherever data gathered from techniques would be found to be rich in verbal meaning. On the other hand, the quantitative analysis method has been used to count the instances of the particular episode of an experience that any user has elicited. The choice of research methodology has been guided by specific techniques abilities to mine the data and the research design for the specific investigations carried out in this thesis.

In the end, comparison between the four techniques, namely, Think Aloud (TA), Mind Tape (MT), Repertory Grid Technique (RGT) and Semantic Differential (SD) on the basis of qualitative richness versus quantitative robustness has been reported in chapter 7.

5.3 Research Design

As described in section 1.4, need to identify data gathering techniques which could inform the designers about the users' experiential processes in context of interaction with computers was felt. This need led to study of existing literature which has been reported in chapter 2. From literature study, a gap in available user models was identified. In absence of suitable user model for use in experiential design process, validating the data gathering techniques would be difficult. Hence, a user model for use in experiential design process has been proposed in chapter 3. The proposed user model also contains the criteria for evaluation of the data gathering techniques' ability to mine the experiential data

along aesthetic, affective and intellectual experiences. With having set the criteria for identification of the suitability of data gathering techniques, the investigative experiments were carried out.

5.3.1 Research design for experimental study of Think Aloud Technique

Think aloud is an established technique being used in HCI for usability testing. TA is being used across the globe during evaluation phase of the system design. Hence, as depicted in fig. 5.3, first a survey of the existing TA practice in Industry was done across three countries namely, India, Denmark and China to observe how this technique is being applied. After having observed the cultural acceptance and prevalence of TA, participants from each of the three cultures above were observed in experimental TA sessions over given set of tasks. Videos of the TA session were recorded and analyzed both quantitatively and qualitatively.

Total of 30 participants (age group 21-25 years; Students on HCI course at bachelor and master levels), from 3 different cultures were given a set of tasks to be performed on known software (fig 5.4). They were asked to think aloud simultaneously. The video of user's behaviour was recorded. The videos (total 30 in number) were coded using Grounded theory approach (Glaser, 2004) for verbal reports of user experiences during the interaction with software. Further, videos were coded for gestures used by participants (as gestures were seen as a source for experiential data). The coded videos were statistically analysed. This technique was used for collecting data from 10 participants each, from India, Denmark and China. Further, Think Aloud technique was also used during paper prototype test with 31 Indian users (age group 21-25 years) and where 10 users were facilitated by an American evaluator and rest 21 were facilitated by Indian

Evaluators. Difference in reported satisfaction and verbal behaviour were also observed along with the quality of verbalisations during paper prototype with respect to the fully functional prototype test.

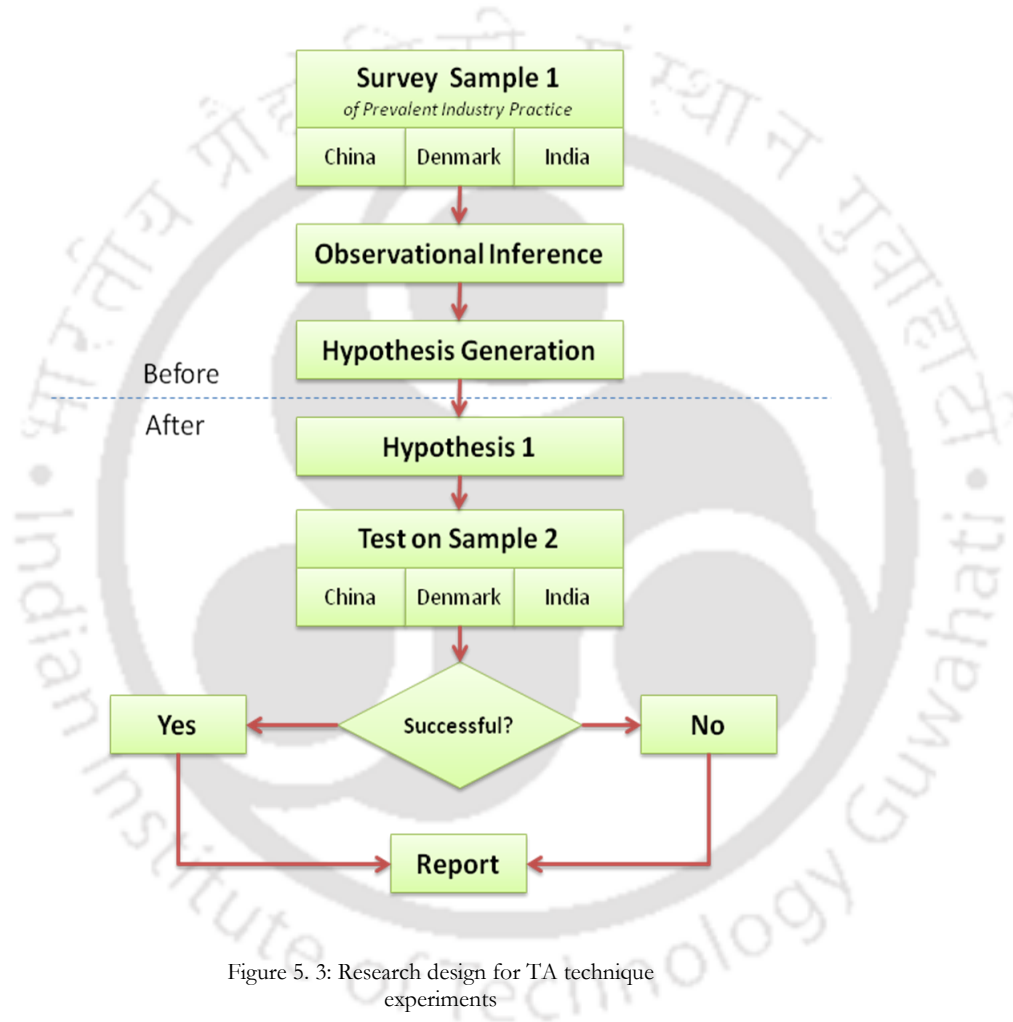


Figure 5. 3: Research design for TA technique experiments

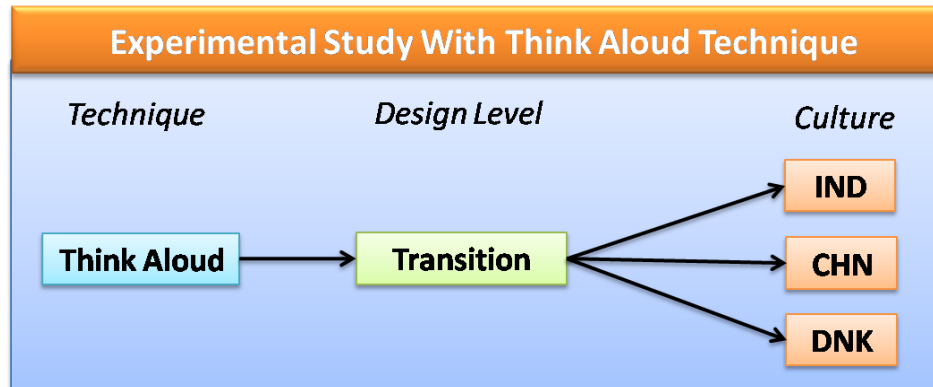


Figure 5. 4: Research Design for cross cultural TA investigations along the design decision categories

5.3.2 Research design for experimental study of Mind Tape Technique

After observations from the TA technique it had become evident that the concurrent verbalization methods had several drawbacks which constrain the experiential data collection using it. Hence Mind tape technique as an improvisation of the retrospective verbalisation was developed and employed for data collection. As depicted in fig 5.5, the mind tape technique was applied on another sample of participants to collect experiential data from the two cultures. As depicted in fig 5.6 the MT technique was used to gather the data only at transitional level of the interaction design.

Participants (total of 21, 7 in each culture; age group 21-25 years) were given a set of tasks to be performed on three information websites. The screen activities during task fulfilment were recorded. After the task fulfilment session the screen recording was replayed. The participants were interviewed using stimuli of the recorded videos. The interview voice over was recorded over the screen videos.

The videos were coded for verbal reports of user experiences during the interaction and were both qualitatively and quantitatively analysed.

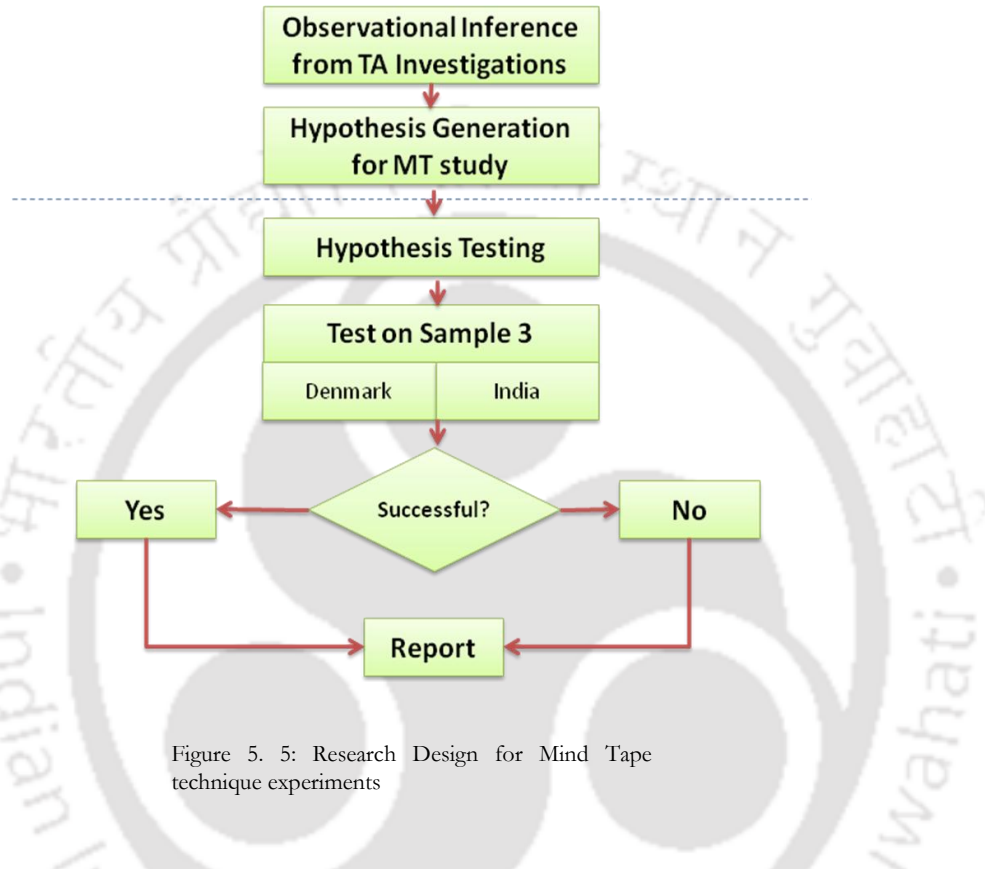


Figure 5. 5: Research Design for Mind Tape technique experiments

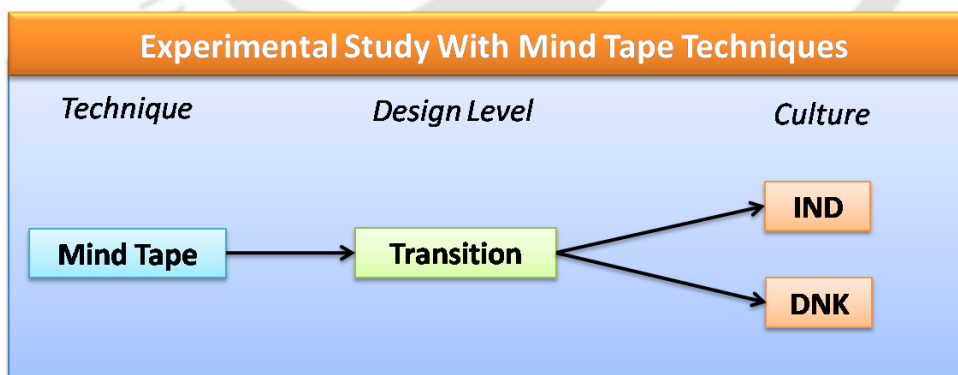


Figure 5. 6: Research Design for cross cultural MT investigations along the design decision categories

5.3.3 Research design for experimental study of Repertory Grid Technique

After having observed the TA and MT techniques' ability to gather data at the transitional level, RGT technique was experimentally observed for its ability to gather experiential data. Due to flexibility of the repertory grid technique, as it can yield data from both experiences based in memory as well as at the moment, it was found by this researcher that it can be applied at all the three levels of design decisions, namely, elemental, compositional and flow. For experiments at three levels, three different setups were used for eliciting data at three levels (fig. 5.7 and fig 5.8).

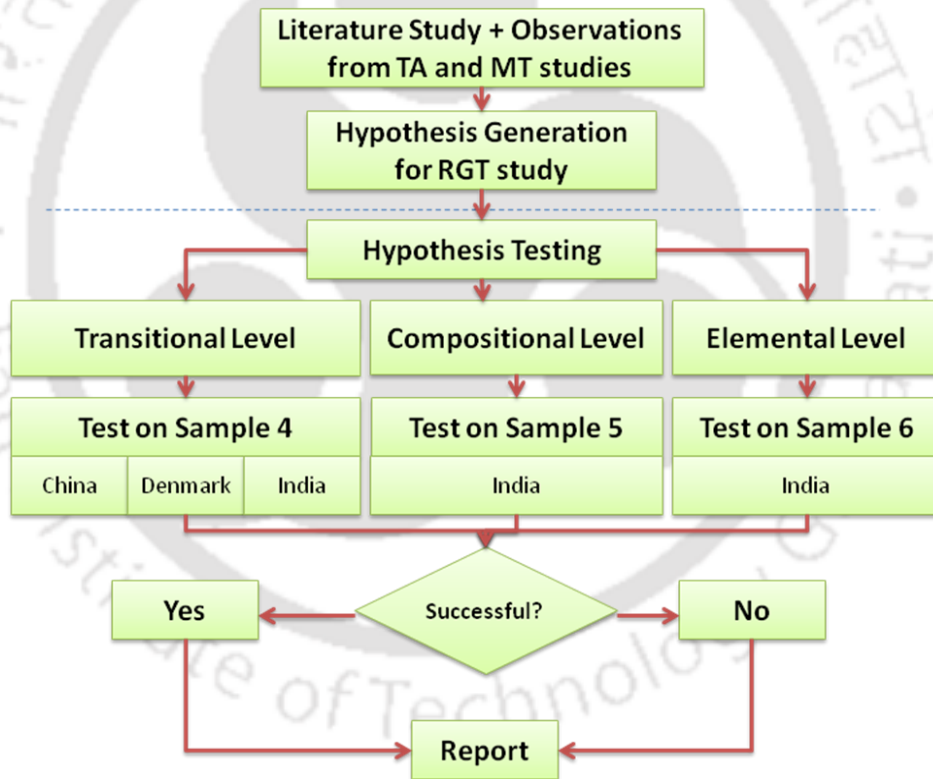


Figure 5. 7: Research design for RGT technique experiments

At transition level, participants were asked to select 6 software systems they have used under given 6 categories. From the software systems selected by the participants, three systems were selected at a time and were presented to the participants. Participants were asked to find any two similar systems in the given set of 3 systems. The 'construct' that made them similar were noted down. The 'contrast' that made the third one different was also noted too. Participants were then asked to rate all the other software systems on a 7 point scale using 'construct' and 'contrast' as poles. This process was applied for all the possible sets of software systems taking three at a time, till participants stopped coming up for new constructs consecutively for 3 next sets. Total of 72 participants were interviewed using this technique having 24 participants each from three countries namely, India, China and Denmark.

At elemental level, stimuli of icons were shown to participants, three at a time and participants were asked to pick any two similar in their opinion. The 'construct' that made them similar were noted down. The 'contrast' that made the third one different was noted too. Participants were then asked to rate all the other stimuli images on a 7 point scale using 'construct' and 'contrast' as poles. This process was applied for all the sets of images taking three at a time, till participants stopped coming up for new constructs persistently. This study was done with 33 participants.

Same process was repeated for the compositional level also, except that stimuli images of compositions of screen shots were used in place of images of icons. This study was also done with 33 participants.

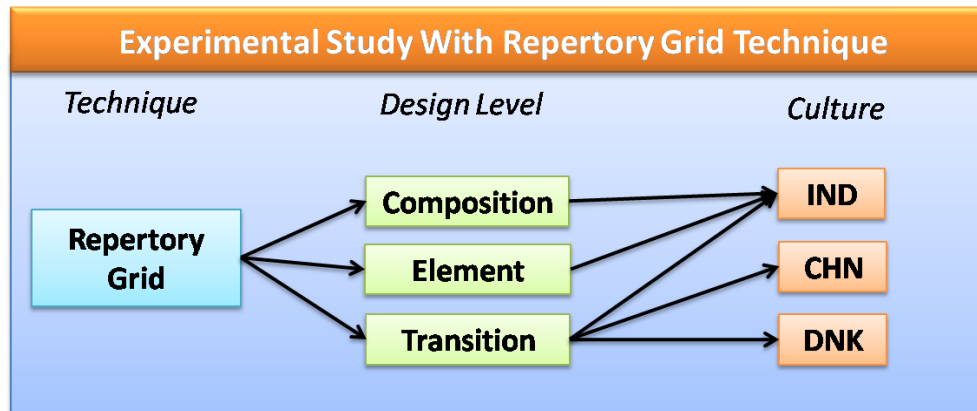


Figure 5. 8: Research Design for cross cultural RGT investigations along the design decision categories

5.3.4 Research design for experimental study of Semantic Differential Technique

Semantic differential was used at elemental and compositional levels. Only difference between the two levels was the stimuli used. Stimuli of images of icons were used at the elemental level and images of screen shot of layouts were used at compositional level (fig 5.10). In each case, participants were shown stimuli and were asked to rate each of the images along 9 uni-polar emotional categories on 7 point scale. The ratings were analysed and compared with the results of RGT method. The semantic differential study was repeated with the same participants using the same stimuli in same order of presentation after a gap of 18 months to investigate the consistency in ratings.

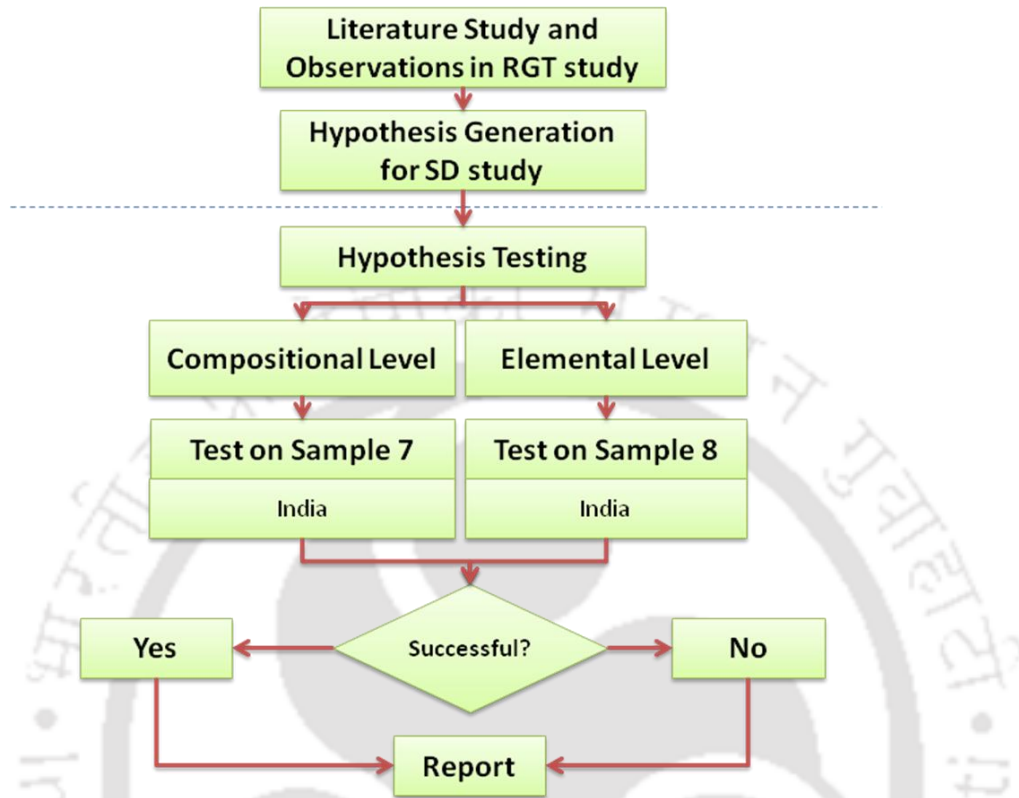


Figure 5. 9: Research design for SD technique experiments

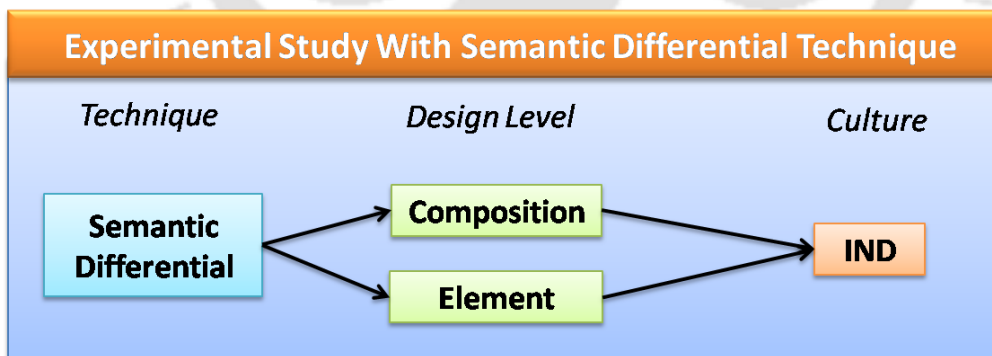


Figure 5. 10: Research Design for cross cultural RGT investigations along the design decision categories

5.4 Overall experimental framework

Apart from the experiments with the four identified techniques which involved attempts to gather experiential data using the techniques, designers design cognition in presence and absence of the data was also observed. Designers were initially observed under a given design task in absence of any user data and then they were observed again when user data collected form one of the techniques was presented to them. All the experimental studies were interconnected as illustrated in fig. 5.11. The flow of experiments was set in order to set a frame for 'before' data was introduced and 'after' data was introduced to the designers design decision making process.

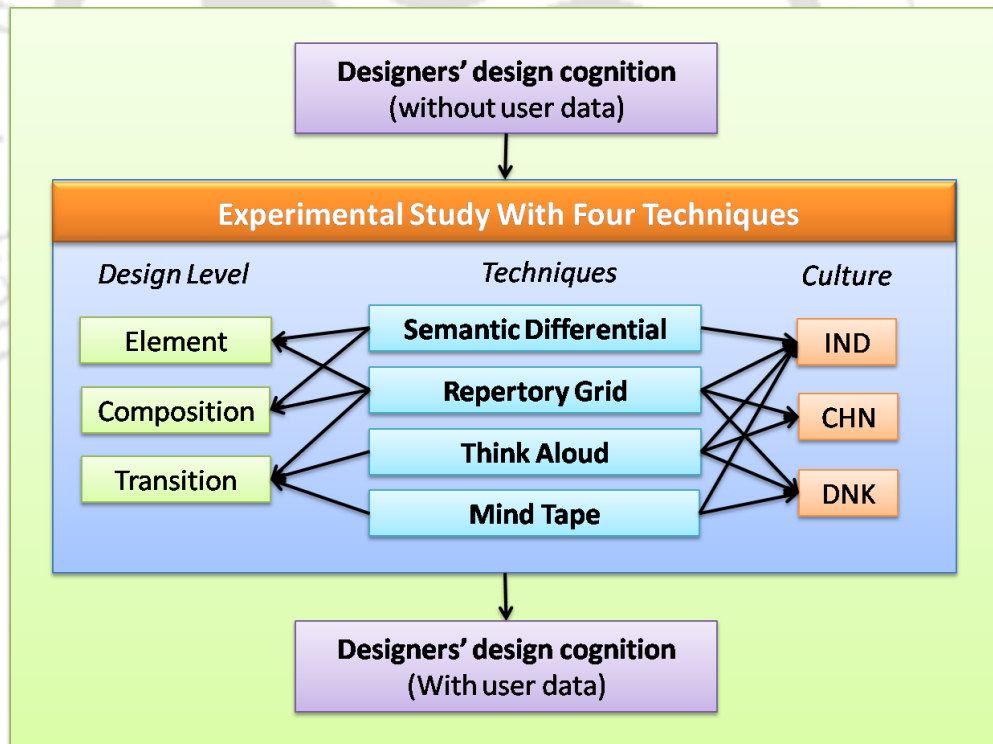


Figure 5. 11: Overall research framework

The experimental study began with observing the designers' design decision making process in absence of the user data. Once having observed the need for user data by designers in order to make confident and safe design decisions, the four data gathering techniques were used to gather data from users. The four techniques were opportunistically used across the three design levels and across three countries as described below in fig 5.11. Think Aloud (TA) and Mind Tape (MT) techniques were used only at transitional level across three cultures. Semantic Differential (SD) was used at elemental and compositional levels in only one culture. This was done as cultural suitability of SD is known and the cultural sensitivity could be predicted on the basis of earlier research studies. RGT was applied at transitional level across three cultures and at elemental and compositional levels in one cultural. This was done as the cultural suitability and sensitivity of RGT was already known at the transitional level hence RGT was used with participants of only one culture at elemental and compositional levels. Finally the data gathered from one of the techniques, namely, from semantic differential, was given to the designers under a given design task. Designers design decision making process was observed under the influence of user data. Variations of data presentations to the designers and their efficiency in aiding the design decisions were observed.

5.4.1 Temporal relationship between the experiments

The experiments with four data gathering techniques had progressed somewhat sequentially. Not all the experiments were running in parallel because the different research methodologies were being tried out and were simultaneously being compared, hence the findings from one experiment influenced the experiment design and implementation of the experiments. The research began with a survey of the industry practice of TA technique which was done to identify

the practical implications of using the TA technique in interaction design process. This was followed by the TA experimentations with the sample participants participating in TA experiments in cross cultural setups. After realising the shortcomings of the TA technique in gathering experiential data, a variant of the retrospective verbalisation, MT was tried with. Having observed satisfactorily rich experiential data from MT at the transitional level, techniques RGT and SD were tried at the elemental and compositional levels. Recognising the ability of RGT technique to gather data from all the three levels of design, RGT was also tried at the transitional level of design decisions. Designers were then observed under a design task where they made design decisions without use of any user data. Finally the data gathered from SD was given to the designers and observations regarding the change in their design thinking process were made (fig 5.12).

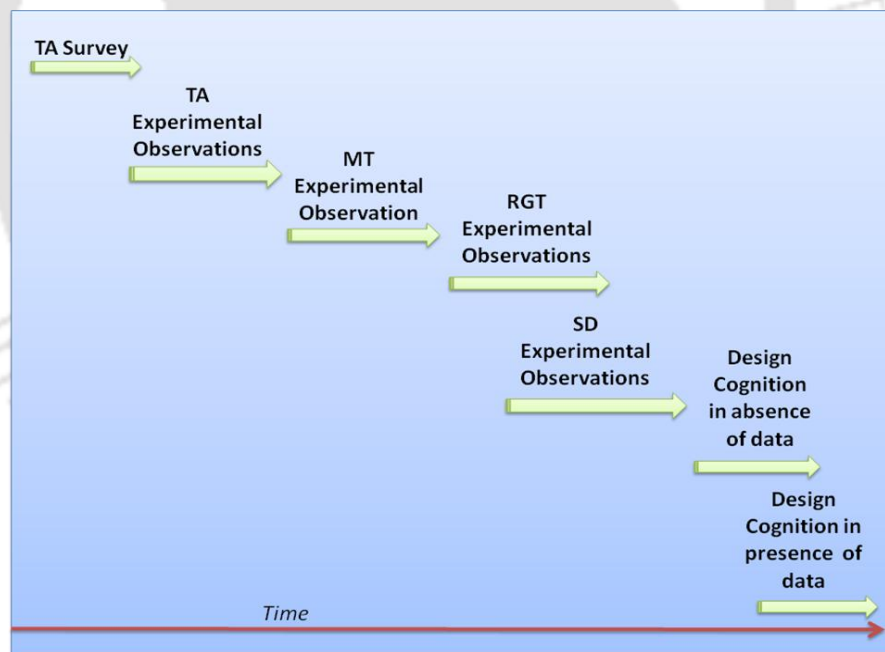


Figure 5. 12: Temporal association between the experiments

5.4.2 Mutual influences between experiments

As the experiments progressed with the four data gathering techniques, there were influences from the findings of one technique onto the other technique's experimental setups and hypothesis. The mutual influences from one technique onto another has been depicted in the fig 5.13. As the experimental investigations began with TA observations, TA experiments set the tone for the rest of the investigations and the findings from TA guided the other experiments too.

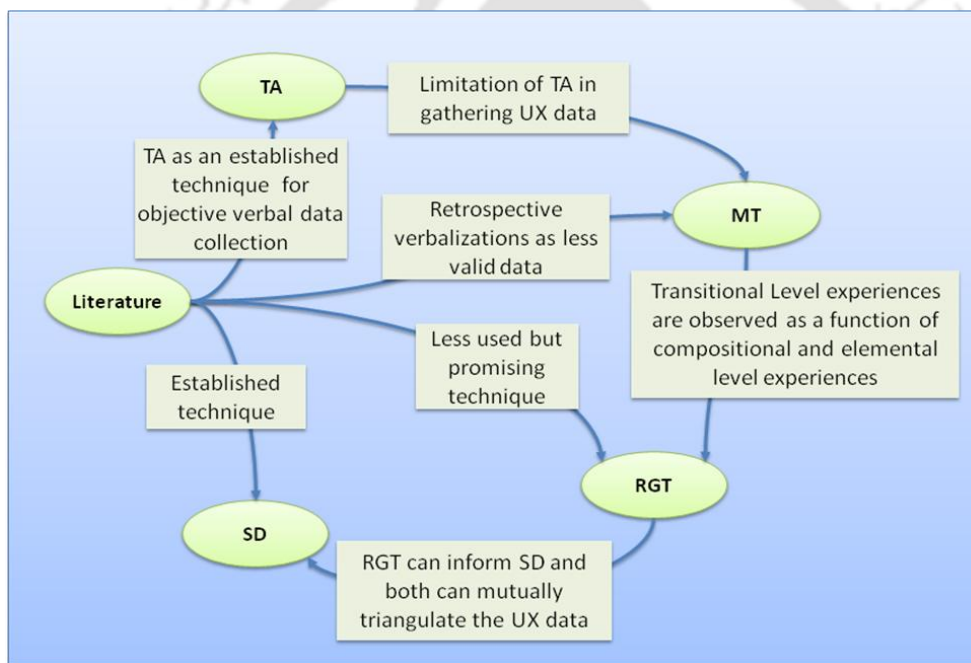


Figure 5. 13: Mutual influences of the experiments on each other

Observing the limitations of the concurrent verbalisations in form of TA induced the idea that the interference of the data gathering technique itself in the gathered experiences of the users would be a major issue in concurrent techniques. Hence retrospective methods were preferred for rest of the experiments. TA technique

also led to the idea of MT. The observations at MT gave rise to the idea that the experiences at the overall level with the system are composed of instances of experiences with the elements and the screens of the interactive system. Hence the RGT and SD techniques were preferred for investigations at the elemental and compositional levels.

5.5 Stimuli selected for experiments with the four techniques

In order to investigate ability of the four techniques to gather experiential data, appropriate stimuli for each of three design decision levels, namely, elemental, compositional and transitional were identified. The stimuli for each level are being introduced in following three subsections.

5.5.1 Stimuli for elemental level

As identified above elemental level design decisions consist of deciding about icons, menu items, colour themes, graphics items like lines, textures, backgrounds etc. Among these icons are the most challenging and expressive ones to design as they are rich in meaning and have to be very crisp in expression using minimum graphics. Their experiential value is also very high as they elicit rich meaning to the users at several levels, including aesthetic, intellectual and possibly emotional as well. Hence icons were selected as stimuli at the elemental level investigations. In order to select the type of icon to be used for experimental purpose, HCI literature was studied.

In context of HCI, Nielsen has categorised icons after Lodding (1983) and Rogers (1989) in three categories (p. 239, Nielsen, 1993). They are

Resemblance icons: A physical object as a direct resemblance. Like, showing a dustbin in windows to represent storage of unwanted/ deleted files.

Reference icons: Using an analogy to represent a concept. Like, using picture of clamp to show file compression.

Arbitrary icons: Showing arbitrary shapes that have meaning due to convention. Like, warning triangle from traffic for a warning message in computer.

Further, it has been reported that the icons that have least semantic distance from the intended meaning and are most familiar are recognised fastest (Isherwood et al., 2007). As resemblance icons have least semantic difference for they represent the same object that the icon depicts, it can be safely assumed that resemblance icons will have the maximum ease in recognition. For this reason a resemblance icon, 'dustbin' was used as stimuli at elemental level.



Figure 5. 14: Sample stimuli used at elemental level

From a set of 50 randomly selected dustbin images that could serve as dustbin icons, 21 images of dustbin icons were selected by 3 designers by mutual consensus for variety and range of graphic elements they contained. Also, cultural

representativeness was kept in view while selecting the range of dustbin images for cross cultural investigations. The selected stimuli have been exhibited in appendix A, section A.1. A sample of three stimuli images from the set of 21 images used in the experiments has been exhibited in fig 5.14 for reference.

5.5.2 Stimuli for compositional level

At compositional level, the design concern is about the ‘arrangement’ of various elements like icons, text, graphics, images etc. on the screen so as to give aesthetic and emotional meanings to the interface as a whole. It is the screen layout and composition that elicit aesthetic and affective meanings to the user. Hence at compositional level, screen shots of online interactive systems were selected as stimuli for experiential data elicitation. For this purpose, official tourism websites of different countries were chosen.



Figure 5. 15: Sample stimuli used at compositional level

From randomly selected official tourism websites of 25 different countries 10 screen shots of home pages of websites were selected by mutual consensus among three designers. The goal kept in mind for selecting the screenshots was

expected range in experiential elicitation. These screen shots were used as stimuli at compositional level experiential data gathering. The selected stimuli have been exhibited in appendix A, section A.2. Thumbnails of three of the 10 screen shots used at compositional level have been exhibited in fig 5.15 for reference.

5.5.3 Stimuli for transitional level

The transitional level design decisions involve deciding about the transitions or more articulately, the subsequent appearance of screens during the interaction. It consists of decisions on what follows the users actions on the given screen items. As this is the level of complete interaction, the experiential data elicitation has been with respect to the systems used by the users. Hence, the stimuli used at transitional level has been the software systems such as MS word, already used and experienced by users over a period of time (in case of RGT experiments) or the systems given to the users to use during the experimental sessions (in TA and MT experiments). There was no control about the choice of systems in case of RGT experiments as it depended on the users, whatever systems they had used in past, only broad categories were provided to them to select from. In TA and MT experiments, national tourism websites of 3 countries were used by users under given tasks and experiential data was collected. Also TA and MT experiments used Microsoft Word in a variation of the experiment to cross check data gathering techniques' ability with offline systems in comparison to online systems. In these experiments, the experimental setup detail has been reported along with the experiments in next chapter.

5.6 Conclusions

This chapter has introduced the research methodologies employed for experimental validation of the data gathering techniques for their ability to gather experiential data from users in cross cultural settings. This chapter has also introduced the stimuli used for experimental data gathering using the four selected techniques at the three design decisions levels. The next chapter, chapter 6 reports the experiments conducted with the four techniques and the findings from each experiment. Finally, chapter 7 will present the comparison between the findings from each technique and propose heuristics for their usage in an experiential design process.



EVALUATING THE FOUR TECHNIQUES THROUGH
EXPERIMENTS

6.1 Introduction

This chapter is organised in eight sections. The next four sections, from section 6.2 to 6.5 describe the experiments and observations done with each of the four techniques and the section 6.6 describes the experiments on the designers' design thinking process in presence and in absence of the user data collected from one of the techniques. Different studies were conducted for each technique and have been described as separate subsections under sections 6.2 to 6.5. Experimental setups, details of participants, procedure for each experiment are presented in each subsection sequentially. Inferences drawn from each study has been presented in the study subsections. Overall inferences drawn from each technique's strengths and weaknesses have been discussed in the end of each section.

Table 6.1 presents an overview of the experiments conducted as part of this thesis. The main experiments have been reported in this chapter while ancillary experiments have been reported in Appendix A to G. This has been done in order to maintain the flow of arguments while still referring to them as and when needed during the discussions. Table 6.1 also lists the objectives of each of experiment alongside the sections in which they have been reported.

Table 6. 1: An overview of experiments conducted in this thesis

| | <i>Experiment</i> | <i>Objectives</i> |
|-----------------------------------|---|--|
| Think Aloud | 6.2.1 Industry survey of TA practice (52 hours of video across 7 companies across 3 cultures) | To understand the current practice of TA in industry |
| | 6.2.2 Experimental TA sessions across cultures (28 participants, India, China and Denmark) | To identify strengths and weaknesses of TA for experiential data gathering |
| | B.1 Gesture Analysis on TA Video (Videos from 6.2.2) | To identify experiential cues in gestures elicited during TA sessions |
| | B.2 TA at Paper prototype level (31 participants, India) | To identify TA's ability to gather data at paper prototype level |
| | 6.3 Experiments with Mind Tape | To investigate MT's ability to gather experiential data across cultures |
| RGT Experiments | 6.4.1 RGT at transitional level (72 participants, India, China and Denmark) | To investigate RGT's ability to gather experiential data across cultures at transitional level design decisions |
| | 6.4.2 RGT at compositional level (31 participants, India) | To investigate RGT's ability to gather experiential data at compositional level design decisions |
| | 6.4.3 RGT at elemental level (32 participants, India) | To investigate RGT's ability to gather experiential data at elemental level design decisions |
| Semantic Differential Experiments | 6.5.1 SD at compositional level (33 participants, India) | To investigate SD's ability to gather experiential data at compositional level |
| | 6.5.2 SD at elemental level (59 participants, India) | To investigate SD's ability to gather experiential data at elemental level. |
| | 6.5.3 Identifying categories in affective experiences (data set from 6.5.2) | To investigate if affective scales have mutual associations in themselves. |
| | 6.5.4 Identifying categories in stimuli images (data set from 6.5.2) | To investigate ways of presenting the SD data to designers. |
| | D.2 Investigating semblance in affective experiences of users (data set from 6.5.2) | To seek answer whether the different users have similar affective experience with a given set of stimuli. |
| | D.3 Longitudinal study of affective experiences (repeat 20 participants from data set in 6.5.2) | To investigate if affective responses to stimuli remains consistent over a period of time. |
| | D.5 Differences in affective responses between genders (data set from 6.5.2) | To find if there are any differences between the affective responses of the two genders. |
| | 6.6 and G.1 Study with designers design thinking process (20 novice designers) | To investigate how designers think in absence and in presence of user data and how designers make use of the users data. |

6.2 Experiments with Think Aloud technique

This section Reports the experiments conducted with TA technique. Think Aloud (TA) is the most practiced usability testing technique in HCI (Boren and Ramey, 2000). TA has been used across cultures to gather data from users in usability engineering practice. While universal usage of TA is acknowledged, little is reported in literature about any cultural variations in which the TA sessions are conducted. While studies in culture have revealed differences in the way different cultures treat artefacts and social relationships. For instance, Honold (2000) observed that culture manifests itself in artefacts and institutions. Hence it is posited here that interactive systems being digital artefacts of today's world are affected by culture. TA sessions can also be seen as an institution in the sense of it being practiced regularly within different companies situated in and affected by surrounding culture. Hence it is likely that TA sessions would also be affected by the culture they are being practiced in. Other studies have established that the social and organizational setups are affected by culture they are geographically situated in (Hofstede, 1991; Honold, 2000). It is therefore likely As a data gathering technique in HCI deals with a given digital artefact and the data is gathered from the users in a social and organizational setup, hence it is hypothesised that culture would have procedural affects on data gathering techniques like Think Aloud. With this hypothesis firstly an observational survey was conducted across companies in three cultures. Having observed the effects of culture on TA practice, experimental TA sessions were conducted across three cultures with cross cultural user and evaluator pairs. Videos of TA session were recorded and analyzed for users' behaviours and user- evaluator relationships. After observing lack of experiential data in TA verbalisations by users and noticing use of gestures by users during verbalisations, a gesture analysis of the TA videos was done. It was observed that the gestures are being used aplenty by users during the TA verbalisations but it is still difficult to gather detailed

experiential clues from them which could be useful for designers design thinking. Finally, TA was experimentally observed for use in gathering experiential data at the prototype level, for gathering data early enough would facilitate the experiential design process better. Both mono cultural and cross cultural user-evaluator pairs were observed under task fulfilment with paper prototypes. All these studies done with TA technique have been elaborated in this section. Each subsection describes one study in detail with inferences from the study. Finally the overall conclusion with respect to use of TA technique for experiential data gathering has been described at the end of this section.

6.2.1 Industry survey of TA practice across three cultures

Aim: To observe TA practice in industry and identify any cultural influences on TA practice.

Introduction: TA is practiced in industry in different cultures. To understand practice of TA technique with respect to its cultural sensitivity and suitability, TA session observations were done at companies that did professional user testing.

Research Question: What are the cultural variations in Think Aloud Technique applications? What cultural issues are involved in gathering data using Think Aloud technique?

Hypothesis: Culture would have affect on procedure of Think Aloud technique in HCI.

Research Design: A sample of companies was selected from each culture on the basis that all of them were clearly independent in their operations and that they did not have any cooperation among them. Further they were professional

companies which conducted TA tests on a regular basis. In each company, field observations were conducted and recordings of TA usability test session were done with video cameras. After the TA sessions got over the evaluators and the test users were interviewed. A team of three observers, one Indian, one Danish and one Chinese, did the field observations. It was ensured that at least two of the three, including one observer from the culture where the observations were being done, were present at all observations. This was done in order to cross check any cultural connotations involved with the proceedings. It was made explicit that the TA tests were conducted in the normal way that the company did otherwise. In cases when it was not possible to observe a routine TA test, paid by a customer, request to the company was made to redo a recently run TA test. Total of 52 hours of observation from three cultures across seven companies were obtained. Team of researchers shared their notes at the end of each session or at the end of the day. Together, data from the interviews were analysed using a grounded theory approach (Glaser, 2004). Recurring and salient themes were identified from the data.

Place of observation: China, Denmark and India.

Number of observations: 52 hours of TA tests in normal settings inside 7 companies.

Research method: A request for observing actual and full TA tests conducted by company was sent to several companies in three countries. From the responses received, 7 companies were selected and visited. The company staff conducted TA tests inside their test labs while researchers observed the test sessions from observer room and took notes. Researchers observed the tests from observer room during the test and took notes. Later the users, evaluators and managers were interviewed by researchers.

Observations: The physical test setups used across cultures were similar. Each test set up had user-evaluator pairs in the evaluator room and note takers, observers, stakeholders and managers in observer room. The two rooms were separated by one way mirror to facilitate observation. Monitors in the observation room showed the screen of the users screen and the entire test was video recorded.

However, there were variations in the way tests were conducted across the cultures. Indian and Chinese cultures being more hierarchical in social structure with greater power distance (Hofstede, 2001) had age and gender issues in the way tests were conducted. In India, it was important that the evaluator was younger in age so that the user could freely share their feelings. Managers in Indian company assessed that evaluator was supposed to act as a student, 'learning' about the errors from the users, while the user acted as a design critic. It was preferred in Indian culture that the evaluator is of the same gender as the user and especially in case of a female user from traditional background the evaluator strictly had to be a female.

TA tests were observed to be more like an interview rather than pure 'think aloud' tests in all the three locations. Evaluators asked questions like in an interview throughout the tests in all three cultures where. Chinese evaluators in particular, asked more retrospective questions like "what were you thinking just now" and the users gave more retrospective explanations like "I was looking for ..". The Chinese evaluators felt that when users are silently doing tasks it is OK and "there is no need to disturb the user when the user takes the correct steps....". The test protocols were found to be very elaborate in Danish tests while Indian tests did follow a test protocol strictly which introduced the tasks with help of a scenario and asked users to think aloud. Chinese tests had less strict protocols and were meant to appear informal. Chinese evaluators reported

that "...if you have many protocols it will scare the user, make the user very nervous, uncomfortable". A detailed report of this study has been presented in HCI conference 2007 (Clemmensen et al, 2007b).

Table 6. 2: Some of the key observations
From TA field study

| | China | Denmark | India |
|--|---|--|--|
| Gender and age issues in user evaluator pairs | Opposite genders in user-evaluator pairs preferred. | Same gender, age and professional background preferred. | Same gender preferred for traditionally minded/rural users. Strictly female evaluators required for female users. Relatively younger evaluators preferred. |
| TA technique variations | TA and interview combined. More retrospective explanations by users. Retrospective probes used. | Instead of TA interview was observed for most of the time. | Detailed probes to dig deeper into the think aloud. Ultimate aim of TA data was to help improve the design. |

| | | | |
|------------------------------------|--|--------------------|---|
| User-Evaluator relationship | Evaluator not given any attention, almost as if not there. | Equal relationship | Evaluator to act like a student learning from the user. |
|------------------------------------|--|--------------------|---|

Discussion: Observed TA sessions had deviations from classic TA technique as described by Ericsson and Simon (1993). Ericsson and Simon have listed a set of ‘think aloud instructions’ and ‘think aloud reminders’ from the literature as a suggestion towards a standard protocol for TA. Most of the think aloud instructions listed aim at clarifying to the user what TA means and what they have to do. For instance, Krutetskii (1976) has reported using initial instruction to the user as, *“Do not try to explain anything to anyone else. Pretend there is no one here but yourself. Do not tell about the solution but solve it.”* Silveira’s (1972) instruction says *“Don’t plan what you say or speak after the thought, but rather let your thoughts speak, as though you were really thinking out loud”*. Such instructions clearly identify two issues which are in contrast to the observed TA protocols in use. First is of not explaining but of merely speaking out and second is of assuming that there is no one around and one is speaking to oneself only. It was observed in all the three cultures, in the companies that TA observations were done, that not only presence of the evaluator was very much part of the users think aloud behaviour but actually an interview mode was existing through the test sessions in all the three cultures. Explanations were observed to be very much part of the TA sessions and in Chinese culture especially the evaluators accepted the retrospective explanations as legitimate and asked users to explain when the segments of tasks got over and user had not spoken during the time. Chinese evaluators for instance, used phrases like “you have finished the task, what did

you think just now” which is actually asking to retrospectively explain the thoughts instead of thinking aloud.

Verbal explanations have been recognised as level 3 verbalisations which are not merely recoding the information already present in the STM, explanations require intermediate inferences which may or may not need represent correctly the actual motives or the actual causes linking thoughts in the user. Explanations also need directing attention to ones mental procedures, thus changing the structure of thought process and hence having less validity (p 80, Ericsson and Simon, 1993).

Further, literature says that in case reminders are needed, neutral reminders like “keep talking” or “what are you thinking about?” should be used (p 83, Ericsson and Simon, 1993). Also, the evaluator can as well be completely absent from the user’s room to create a more natural setting for task fulfillment (Klinger, 1974).

The actual reminders observed in the TA sessions, differed widely from the suggested protocol. For instance, Indian evaluators used phrases like “you just said right”, “did you notice that?”, “why is that”, “what is the information you are looking for right now?” and Chinese evaluator said “which input method are you using now?”. These reminders are far from being neutral or attempting to make the user feel that he or she is alone and the evaluator is merely to remind them to think aloud. These reminders make evaluator appear as an active participant in the test rather than a passive observer.

The above motioned conflict between theory and practice is an intriguing observation in context of the experiential design process under discussion in this thesis. On one hand is the theoretical concern of the validity of the reported data and on another is the practical concern of gathering useful and relevant data. TA as a technique has its validity in non interference to thought structures and access to coded chunks information directly from STM. Concern of the theoretical TA

protocol is not to obtain the structure of thought as it is and it seemed that concern of the TA practice in HCI is to get meaningful chunks of information from user about what is going on in his/her mind. Presence of an interview mode in TA sessions in all three cultures assesses this need. From interviews with Indian evaluators it surfaced out that the prime concerns in TA sessions were to 'make the user comfortable' and to understand the users' reflections on the system design. In light of the observations made, it was hypothesised that the probes used by evaluators, like "why is that", were rather aimed at understanding the users' actions more deeply than the TA verbalisations were meant to provide and that the TA is not capable of giving the deeper level understanding of users that evaluators were seeking. This need of understanding the users, beyond mere 'think aloud' on task procedures and immediate intention-action loops, is specifically important in experiential framework as users' experiences run deeper than the surface level procedural verbalisations obtained in TA sessions. In order to test the hypothesis made from observations, the next level of experiments were conducted.

Also, it was observed that the evaluators made very lively gestures while trying to communicate to the user. Users also used gestures while communicating in TA sessions. From this observation, it was hypothesised that gestures could give more experiential data as they are tacit and rich in meaning. An elaborate experimental study was carried in next level to make sense of users' gestures for experiential clues.

It was also interesting to observe Indian and Chinese users digging deeper by asking questions to users during the test. Does the dialectical characteristic of east Asian individuals (Peng et al , 2000) and their collectivist social structure require them to converse and communicate more ? Does the mechanical verbalisations

of think aloud does not satisfy the evaluator and/ or the user? These are some questions that were raised for further explorations in experimental study.

Also, cultural variations in the way the evaluator-user relationship formed and evolved during the test were also observed. For instance the nods evaluators used had cultural connotations like, '*han*', '*hoon*' sounds were used by Indian evaluators, which are very cultural and mean 'yes, go on'. It also helped create a rapport with the user which the evaluators reported was very important for the test to be successful. Often a sharing of some light instance during the test was observed to ease out the user and the intensity user verbalisation increased after that. Giggle or smile shared between the evaluator and user also affected the rate at which users gave think aloud reports, especially in Indian culture. These observations augur for deeper currents of relationship that were formed between the user and evaluator as a factor in the quality and quantity of data shared by user. This was found to be more in Indian culture. In Indian culture the physical distance between user and evaluator was also observed to be dependent upon the gender both belonged to. Physical distance between the user and evaluator was greater when they were of opposite genders than when they were of same gender. Even after being asked by the manager the evaluator did not feel comfortable to sit closer to the user of opposite gender. The distance may have deeper connotations with respect to the relationship formed between the user and evaluator and the data shared by the two, this issue needs to be probed deeper.

Inferences: Think Aloud protocol as suggested in theory is not being practiced in its pure form. Users are not only 'thinking aloud' during the TA sessions but are also 'asking', 'explaining', 'retrospectively reporting', 'justifying' and 'arguing'. Cultural variations in the user evaluator relationship like use of cultural nods, gender and age influences between the user and evaluator relationship, need of feeling the shared experience between the user and evaluator were factors

towards the quality and quantity of data gathered. More detailed study need to be done to identify the reasons for variations in test protocols and affect of culture on the same.

Limitations of study: This study was limited to three cultures only and also total of seven companies, which is a small sample. Further, the selected companies were among the leading ones in their own cultures and were therefore expected to be much more organized in their approach to usability testing than others in the same cultures comparatively. Therefore these companies might not be true representatives of the way tests are conducted in other companies situated in that culture. Also presence of observers who were known to be observing for TA specially might have interfered with the way these tests would be conducted normally. Also it is expected that more variations may be observed across other cultures and also some observations could be more consistencies across other cultures as well.

6.2.2 Experimental TA sessions across cultures

Aim: To understand cultural sensitivity, cultural suitability and experiential data gathering ability of TA technique.

Background: From observations of TA tests in companies, certain hint towards the cultural issues involved in data gathering in general and with TA techniques in particular were identified. Thereafter TA tests were decided to be conducted to gather data from users by giving those tasks and asking them to think aloud while fulfilling the task.

Research Questions: Do the user evaluator pairs interact differently during the TA tests when they belong to the same culture vs. when they belong to different cultures? What are the differences observed in different user evaluator pairs? How does this impact the quality of data gathered through the TA sessions? Does TA produce any experiential data pertaining to aesthetic, affective and intellectual categories?

Research Hypothesis: a) Evaluator's behaviour will interfere with the users experience during the TA sessions. b) TA will not be conducive to the users' experiential data elicitation due to absence of narrative structure from the TA data.

Research Design: Total of 28 TA sessions were conducted. 7 in China, 9 in Denmark and 12 in India. As described in Table 2, in Chinese tests, 3 out of 7 evaluator pairs were foreign-local pairs which mean that the evaluators came from a different culture than the users. Rest 4 evaluator-user pairs were from same cultures. In Indian tests 6 out of 12 evaluator-user pairs were Foreign-local pairs, and in Danish tests, 3 out of 9 were foreign-local pairs. Rest pairs were all local-local pairs.

All the evaluators had background in Usability. Some of them were professionals while others had taken courses in usability prior to the tests and were well familiar with usability testing. Users were given task to design a Birth Day card in Denmark while in India and China they had to design a wedding card. Evaluators introduced the tasks and introduced Think Aloud practice. Users were then given tasks one by one and were also asked to Think Aloud while they performed the given tasks.

Table 6. 3: Evaluator-User pairs in TA tests

| Chinese Tests | | Danish Tests | | Indian Tests | |
|---------------|---------------|--------------|---------------|--------------|---------------|
| Local-Local | Foreign-Local | Local-Local | Foreign-Local | Local-Local | Foreign-Local |
| 4 | 3 | 6 | 3 | 6 | 6 |

Videos of the interaction between evaluators and users were recorded. Later videos were coded for the user's and evaluator's behaviours. The data was analysed for the cultural issues involved in conducting think aloud sessions. Data was also analysed for the content of think aloud verbalisations. The cultural sensitivity and suitability of the TA sessions were thus assessed and TA's capability for experiential design was also evaluated in light of the data.

Materials and methods: Microsoft word was used as the application on which tests were conducted. In Denmark Tests, users had to design a Birth Day card using MS word's clipart application. This task was chosen as it is a common practice to give Birth Day invitation cards to friends and family in Denmark. While in India and china, users had to design marriage invitation cards, as the practice of inviting marriages is a more suitable practice to these cultures. The clipart icons were selected from a pool of images and were imported into the MS Word's clipart section so as to make it operational. In each culture and depending on the task, some suitable and some unsuitable icons were placed in the clipart section. This was done in order to induce some errors and effort in selection process of the icons as it would provide more TA data and would also enable opportunities for user evaluator interactions during the test thus providing data for analysis. Figure 6.1, 6.2 and 6.3 give a glimpse of the way clipart sections looked for the three cultures to the users.

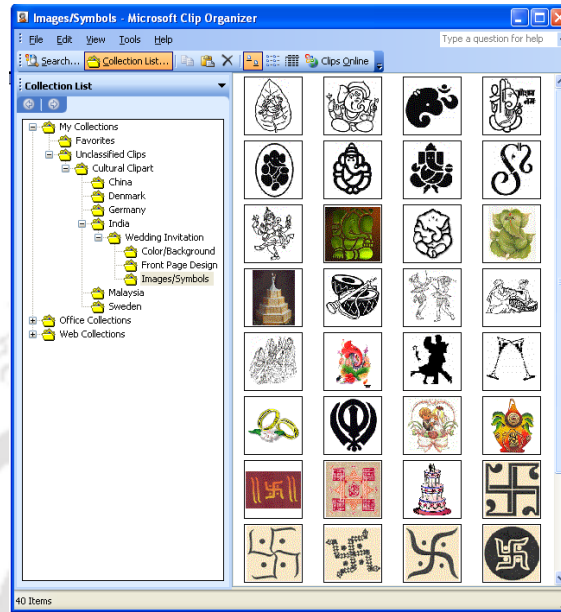


Figure 6.1: Clipart Icons for Indian tests



Figure 6.2: Clipart Icons for Chinese tests

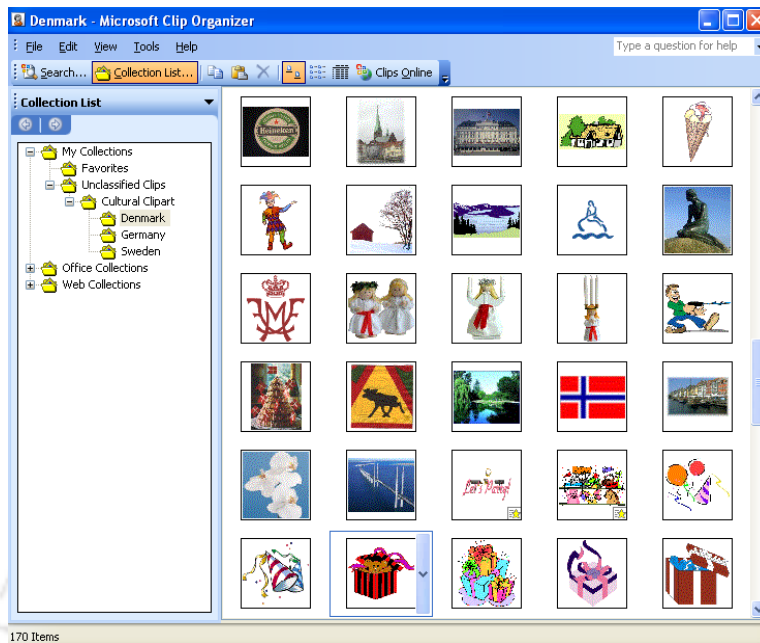


Figure 6.3: Clipart Icons for Danish tests

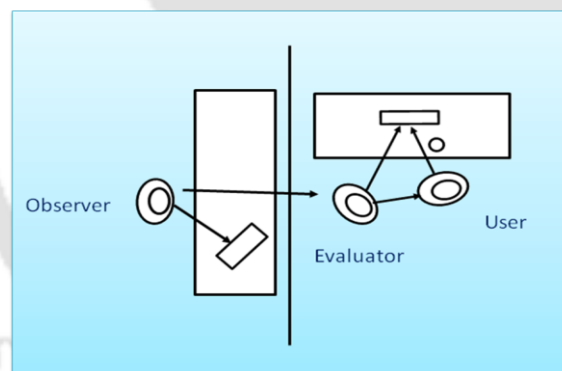


Figure 6.4: TA experiment Setup

These tests were conducted in a normal TA setup (Fig 6.4) where the evaluator sat beside the user throughout the test. An observer observed from an observation room or a similar setup. Observer also took notes of the Session. Video of entire TA sessions were recorded. The recording was done at such an angle that both the user and the evaluator could be seen in the video. The recorded videos were then coded and analysed.

Users were given one task at a time on a piece of paper. The list of tasks given to users in Danish tests has been listed in Table 6.4 and list of tasks given to users in Indian and Chinese tests has been listed in Table 6.5.

Table 6. 4: Tasks for users in Danish Tests

1. *Design a Danish birthday invitation for your son's birthday*
2. *Please write the text that you want to appear on the Invitation.*
3. *Please choose the appropriate font(s) for the text.*
4. *Please choose the appropriate style(s) for the text.*
5. *Please choose the colour(s) for the text.*
6. *You are free to choose any kind of formatting and layout that you require for this text.*
7. *Now using the Cultural Clipart sub-folder in My Collections folder in Microsoft Clip Organizer, add some images and graphics so that its looks like Birthday invitation.*
8. *Please make this invitation look happy, colourful, and joyful as this is for birthday.*
9. *Since primarily all your guests are from Denmark and are Danes, make this invitation look Danish*

Table 6. 5: Tasks for users in Indian and Chinese Tests

1. *Design your own 'Indian wedding invitation' task*
2. *Please write the text that you want to appear on the Invitation. (You can either choose from the pre-designed invitation wordings or u can build your own). Compose or place the text on the page as you want it.*
3. *You are free to choose any kind of composition and layout for the text matter.*
4. *Now using the Cultural Clipart sub-folder in My Collections folder in Microsoft Clip Organizer add some motifs/ images and graphics so that its looks like Indian Wedding Invitation.*
5. *Choose an appropriate front page design for the invitation.*
6. *Choose the paper/ color/ background for the invitation.*
7. *Choose from the list provided of other possible additional in*
8. *Information regarding invitation/ dinner/ timings or any other information you feel you want to convey.*

Table 6. 6: TA test Participant Profiles

| Evaluators in Chinese Test | | | Users in Chinese Test | | |
|----------------------------|--------|---------|-----------------------|--------|---------|
| Age | Gender | Culture | Age | Gender | Culture |
| 34 | F | China | 31 | F | China |
| 37 | F | China | 25 | F | China |
| 45 | M | Danish | 27 | M | China |
| 25 | F | China | 29 | F | China |
| 27 | M | Sweden | 27 | M | China |
| | | | 24 | F | China |
| | | | 23 | M | China |
| Evaluators in Danish Test | | | Users in Danish Test | | |
| Age | Gender | Culture | Age | Gender | Culture |
| 52 | M | Danish | 26 | M | Danish |
| 45 | F | Danish | 34 | M | Indian |
| 20 | M | Indian | 30 | M | Danish |
| 38 | F | Danish | 27 | M | Indian |
| 42 | M | Danish | 32 | M | Danish |
| | | | 35 | F | Danish |
| | | | 28 | F | Danish |
| | | | 33 | M | Danish |
| | | | 35 | M | Danish |
| Evaluators in Indian Test | | | Users in Indian Test | | |
| Age | Gender | Culture | Age | Gender | Culture |
| 53 | M | Indian | 22 | M | Indian |
| 23 | F | Indian | 23 | M | Indian |
| 42 | M | Danish | 21 | M | Indian |
| 37 | M | German | 23 | F | Indian |
| 23 | M | Indian | 22 | F | Indian |
| 22 | M | Indian | 22 | M | Indian |
| | | | 21 | M | Indian |
| | | | 20 | M | Indian |
| | | | 22 | F | Indian |
| | | | 20 | M | Indian |
| | | | 21 | M | Indian |
| | | | 22 | M | Indian |

Participants: Total of 28 users participated in the tests across all the three cultures. A total of 16 evaluators participated in all the tests. Some evaluators conducted 2 or more TA sessions. List of all the participants has been tabulated in table 6.6. As all the evaluators had a prior HCI knowledge and were either

professionals or had taken some course at the university level. All participants were volunteers and were not compensated monetarily.

Procedure: First evaluators were briefed about the research by the researchers. It was ensured that they knew about the TA practice. The recording cameras were set and the computer system with MS word having intended clip arts were set up in the testing rooms. The users were invited into the test rooms and were briefed about the tests by the evaluators. The users were given tasks one subtask at a time on a printed piece of paper. Users were reminded to think aloud by the evaluators. After completion of each subtask, the evaluator kept handing out the next subtask till all the subtasks were over.

The recorded videos of the interaction between user and evaluator were coded according to the scheme detailed in Table 6.7 and 6.8. Statistical analysis on the codes were performed which are reported in next subsection.

Table 6. 7: Coding Scheme for user's behaviour during the TA sessions

| Code | User Behaviour |
|--------------------------|---|
| <i>Think aloud</i> | When user is thinking aloud. |
| <i>Silence</i> | When user is silent and doesn't say anything for considerable time duration. |
| <i>Explanations</i> | When user tries to explain something. |
| <i>Cultural Comments</i> | When user is making a comment which is about some information related to the culture user belongs to. |
| <i>Help Out</i> | Evaluator helps the user in task fulfillment. |

Observations from the Think Aloud tests: There were three foci of observation in the experimental tests. First were the observations on user's verbal responses. Purpose of observing the verbal response was to identify the experiential data in them. As per the user model and research framework created

in section 3.5, it was posited that the techniques which will be able to gather along affective, aesthetic and intellectual categories of experiences can be considered for use in experiential design process. Second focus of observation was the user-evaluator relationship. It was pointed out by Ericsson and Simon (1993) that the evaluator - user interaction during the task fulfilment should be minimal and neutral. One of the intentions in this investigation was to observe whether the user evaluator relationship is neutral in practice and if not what could be the consequences if TA is used in experiential design process. It is likely that if the evaluator's behaviour is found to be interfering to the users' interaction with computers then it would impact the very experiences the user is undergoing in the interaction process. And this would defy the purpose of conducting such interviews with users in experiential design process. The third focus of observation was the users comfort level with this technique. With these three foci, the video were coded and observations were made.

Table 6. 8: Coding Scheme for Evaluator's behaviour during TA sessions

| Code | Evaluator Behaviour |
|--------------------------------|--|
| <i>Interrogative reminders</i> | When evaluator asks the user to explain his thoughts, e.g.: What are you doing? Etc. |
| <i>Affirmative Reminders</i> | Evaluator sends a message of agreement or communicates that he/she is listening, e.g.: Yeah, Ok, Hmmm, Mm Hmm etc. |
| <i>Neutral Reminders</i> | These are classic Ericsson and Simon Think Aloud reminders, e.g.: keep thinking aloud. |
| <i>Answer Questions</i> | Evaluator helps clarify a doubt of the user or answer any questions. |
| <i>Comment</i> | Evaluator says something which is neither a reminder nor any help. |
| <i>Help Out</i> | Evaluator helps the user in task fulfilment. |

User evaluator relationship was found to be interfering with the users' task fulfilment and hence with the experience that the user was having in interaction

with the system. As shown in fig 6.5, several of evaluator's behaviours were observed throughout the TA sessions. Evaluators giving comments (6.5, a), helping out (b), evaluators answering questions of users (d) were persistently found throughout the TA session. User was also giving cultural comments during the TA session 6.5 (c). It is stated here that such interactions between the user and evaluator during the task fulfilment interferes with the experience of the task being fulfilled. Hence TA sessions were not encouraging towards further consideration of TA for experiential data gathering purpose.

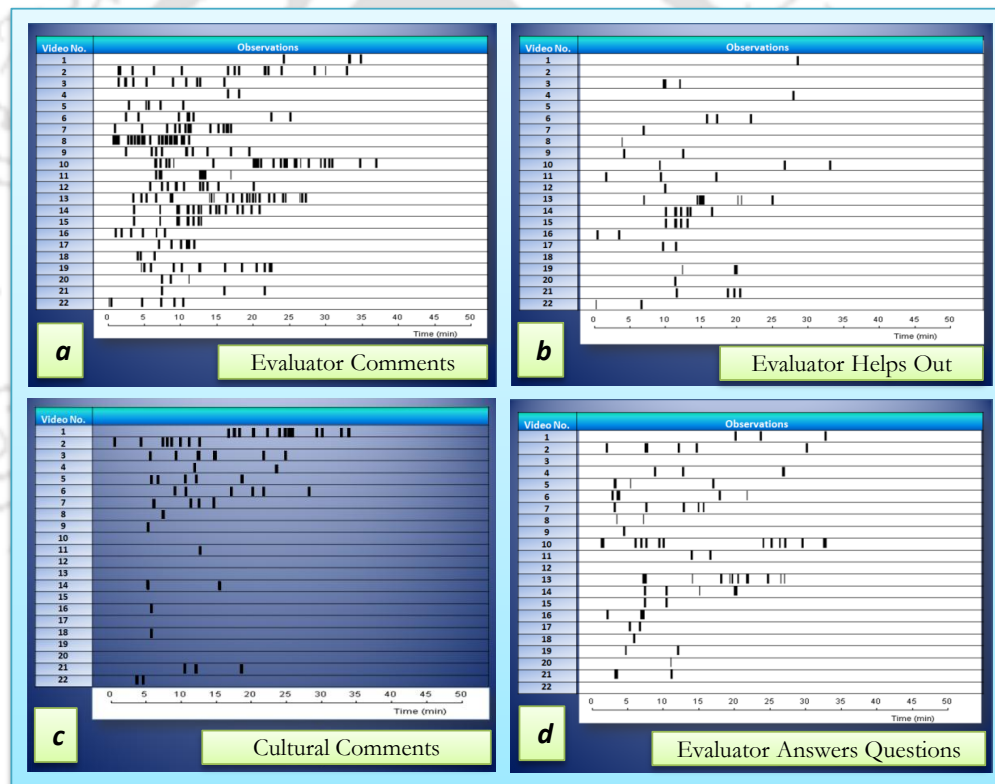


Figure 6.5: Temporal location of evaluator and users behaviours

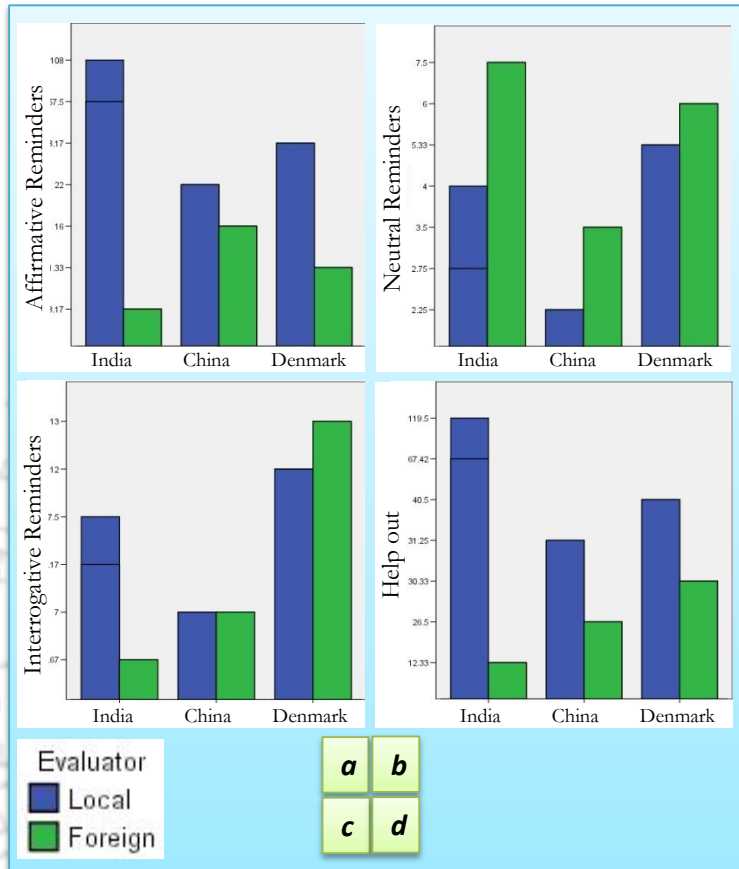


Figure 6. 6: Evaluator's behaviours in TA tests

Cultural influences on the application of TA tests were also observed. As illustrated in fig 6.6 (a), in Indian culture the affirmative reminders were used with relatively higher frequency between the Indian user-Indian evaluator pairs rather than Indian user and foreign evaluators. The converse was also found to be true, that the neutral reminders were used mostly by the foreign evaluators in comparison to Indian evaluators in Indian tests (fig 6.6, b). The helping out tendency of Indian evaluators was also high in comparison to the foreign evaluators with the Indian users (fig 6.6, d). In general, there was greater interaction noticed between the Indian evaluator and Indian user than other pairs.

Also, in general, affirmative reminders were given more frequently among the same culture pairs than the foreign-local culture pairs (Fig 6.6, a). Conversely, the neutral reminders were more noticed between the foreign local pairs than the local-local pairs (fig 6.6, b). Though these results were statistically not significant but they do give an indication of the kind of cultural influences that the data gathering techniques undergo.

Further, as illustrated in fig. 6.7, Indian users were less silent when there was an Indian evaluator conducting the tests (6.7, a) and cultural comments were highest by the Indian users. Interestingly, the Chinese participants were most silent participants while Danish participants lay in the middle. It needs to be further explored into the reason how culture has affected the sharing of the experiences during the TA tests. What made the Chinese participants quieter than others? Was it the language issue, culture issue or is it an issue with the test setups being more incongruent with the social setup prevalent in the culture. While these questions are being raised here, in light of the observations, it is also evident that the purpose of inquiry here, the assessment of a likely influence of culture on the TA technique, has been achieved and there are indications towards the cultural variations in the users behaviour during the tests, which can interfere with the finding of tests themselves.

Further investigating how the evaluator's behaviours influenced the users' responses during the TA sessions, a lag sequential analysis on the various behaviours between evaluators and users has been done. As exhibited in table 6.9, the evaluators' behaviours form the left most column and the corresponding users' behaviours are exhibited in the next two columns. Within 60 seconds of evaluators' affirmative reminders, the users have started talking aloud 25.5 times on an average and they reported an error with the system 10 times. This demonstrates that the users were silently engaged in the task when the evaluators

had to remind them think aloud. Within 60 seconds of the reminder that users reported errors or started thinking aloud. This could indicate the involvement the users were having with the system and were silent during that time, and as soon as a reminder was given, under the compulsion to think aloud the errors were shared with the evaluator. The number of instances of think aloud behaviour per session was counted. It was observed that on an average 35 times TA behaviour had occurred during the TA session (table 6.11). Silence was observed to be 25 times and evaluator had interrupted 40 times on an average. It therefore also means that TA reminders are provoking behaviours in users which are not natural to them during the interaction and hence it poses serious questions on usage of TA in experiential framework.

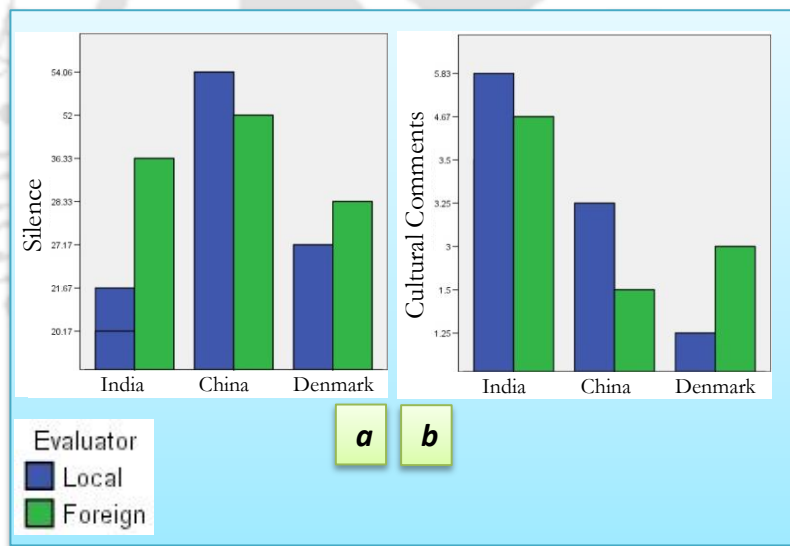


Figure 6. 7: User's behaviours in TA tests

Further, the time used in think aloud behaviour as a percentage of total time of the session was calculated. As can be seen in Table 3, an average of 3.34% of the entire session was used in Think Aloud behaviour. This means that Think aloud technique is giving a very small window into the cognitive processes of the user. There much happening which probably is getting lost. Especially from the point

of view of collecting experiential data this becomes abysmal as the experiential data needs to be rich in nature, giving an account of all the twists and turns that has happened to the mind during the session.

Table 6. 9: Lag sequential Analysis of behaviours (within 60 seconds)

| | Think Aloud | Problem Reported |
|------------------------|--------------------|-------------------------|
| Affirmative Reminder | 25.5 | 10.0 |
| Interrogative Reminder | 4.9 | 1.9 |
| Neutral reminder | 2.6 | 1.4 |
| Answer Questions | 3.4 | 1.3 |
| Comment | 10.4 | 3.9 |
| Instruction | 2.8 | 1.4 |
| Help Out | 2.3 | .8 |
| Comment | 4.4 | 3.8 |

Table 6.10: Lag sequential Analysis (within 60 seconds)

| | Explanations |
|----------------------|---------------------|
| Affirmative Reminder | 2.5 |
| Think Aloud | 1.8 |
| Silence | 1.9 |

Table 6.11: Frequency of TA behaviour in videos

| | Mean | Std. Deviation |
|------------------------|-------|----------------|
| Thinking Aloud | 34.58 | 19.782 |
| Silence | 24.63 | 15.405 |
| Evaluator interruption | 40.33 | 42.692 |

Table 6.12: Duration of TA as a percentage of total observation

| Video No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Observation | 3.56 | 2.72 | 4.38 | 4.18 | 2.04 | 1.48 | 3.62 | 2.61 | 1.66 |
| Video No. | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| Observation | 3.61 | 4.75 | 3.86 | 0.51 | 4.54 | 3.75 | 6.75 | 2.73 | 0.60 |

Qualitative Observations:

1. **Language issue:** In Chinese tests, some of the tests were in Chinese language while others were in English language. No difference was observed in the amount of questions, descriptions and confirmation done during the tests. So for users, whatever language they spoke, it didn't affect their conversation content and behaviour.
2. **No explanations:** None of the users' think aloud verbalisations explain how they thought during the task fulfilment and why they picked a certain picture to create the card and not other pictures. The users only spoke about what they were doing on the screen. They merely described their screen operations to evaluator.
3. **When reading the text:** As it has been pointed out several times (Ericsson and Simon, 1993), when doing tasks that are cognitively loaded, the TA behaviour goes down. This is unfortunate for the designer as the most critical; pressure points in the interaction are not captured by this method.
4. **Initial few minutes of the interaction:** Though there are lots of expectations and initial reactions on the side of the user, which are very important for the designer to know about, but the user doesn't speak much at this point as he/she is heavily investing the cognitive resources in making sense of the interaction. Both, the data related to the aesthetic experience of the user, which is the first kind of experience aroused (within 200 milliseconds) is never recorded in Think Aloud.

When scanning an image or the webpage: As the image scan or page scan involves taking a quick look and the TA behaviour goes down. It is posited here that the verbal coding of the task of scanning of images does

not take place as other tasks. The sensory information from the visual channel does not get verbally coded in the processing phase at STM hence making it difficult for the subjects to verbalise data relating to the images seen. This is very crucial to the designer as one of the strongest tools in the hands of designer to build meanings into products is through the visuals and it is difficult to get visual data in TA.

Mechanical to keep verbalizing: Several Indian participants complained of the absence of a context for thinking aloud. Normally one speaks when one has an audience and in the TA context we do not have any reciprocation from the audience making it very boring and meaningless.

Interference with task: TA has been accused of interference with task fulfilment when the task is cognitively loaded (Ericsson and Simon, 1993). It doesn't keep the environment natural which is very essential for capturing experiential data.

Mostly silence: The users, while performing tasks needed to focus on the tasks and were thus mostly silent during the interaction. This devoid the evaluator from understanding what was going on in user's mind during the silent durations of the interaction.

6.2.3 Ancillary experiments with TA Technique

During TA experiments it was observed that the users were making lively gestures, during thinking aloud and otherwise as well. It was felt that possibly experiential information could be gathered from the gestures which are being made by users so often during the TA sessions. With this motive gesture analysis on the recorded TA session videos was done with help of three independent coders. Details of the experiment have been described in Appendix B, section B.1. It was observed during the gesture analysis that though there are plenty of gestures are being elicited by the users during the TA sessions (fig 6.8), it is not

easy to decipher their meaning for direct usage in experiential design process. Probably with help of any automated gesture recognition apparatus a designer may get clues about the users' experiences but by the arduousness of the manual analysis would be too heavy on resources for it to be practically applied in experiential design process.

Another experiment with TA was conducted at the paper prototype level. It was felt that TA still is a useful technique at the low level prototype testing data collection phase. Mind tape due to its need of a recorded set of actions for the interview to be performed cannot be applied effectively at the paper prototype level. While the on screen activities can not only be recorded easily in Mind tape technique but also when replayed, appears 'natural' to the user, hence facilitating easy recall of the events just preceded in the interaction. TA could still be useful to the experiential design process at the paper prototype level where the functional prototype made out of printed or sketched designs on paper are introduced to the user and manual interaction with the prototype is facilitated, replicating the effect of on screen responses with a system. Details of the experiment conducted with TA technique at paper prototype level are reported in Appendix B, section B.2. Cross cultural TA interviews, where one foreign evaluator conducted TA sessions with 10 local users, was compared with same culture TA interviews, where 21 different local evaluators conducted TA sessions with 21 participants. Results show that there was significant difference between the percentage of ideas verbalised by users between the foreign-local and local-local pairs. The users verbalised on an average 81 % ideas when in TA session with local evaluator in comparison to 62% when they were with foreign evaluators (table 6.13). Also, the participants were more critical to the prototype under experimentation when the evaluator was from the same culture (table 6.13). This finding though difficult to generalise due to small sample size, but has significant indications for the way TA sessions need to be carried in cross cultural

situations. The evaluators need to be more acclimatised to the users' environment and vice versa in order to facilitate more sharing of experiential information. This goes in correspondence with theory of experience sharing through shared trust in understanding of experiences between the speaker and listener as put forth by Krippendorff (2006) and as discussed in chapter 2, section 2.5.9.

6.2.4 Inferences from experiments with TA Technique

TA technique was found to be good at obtaining the users thinking process concurrently. However it did not yield deeper level data from the users. TA could only tell what is 'going on' it did not give the reason for the users actions. No experiential components were observed in the users' verbalisations. There were no affective or aesthetic responses observed in the verbalisations from the TA technique. Though in form of gestures some affective data was observed but it was found difficult to mine that data from TA tests.

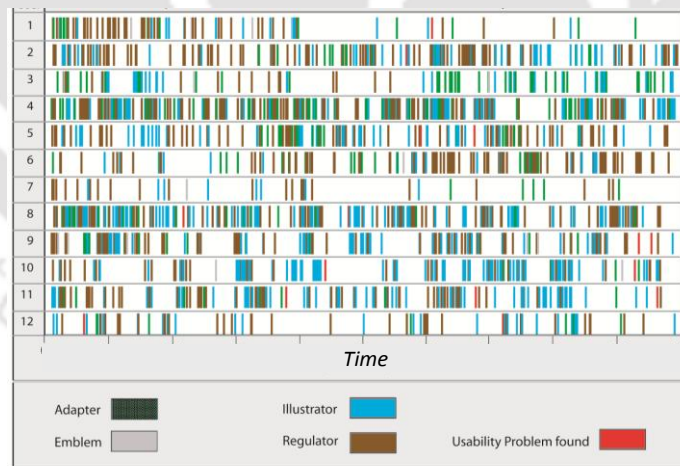


Figure 6. 8: Spread of gesture occurrences for 12 users in the first 10 minutes of the video.

Table 6. 13: Responses to the prototype

| <i>Evaluator</i> | | <i>Easy/ Difficult</i> | <i>Enjoyable/ Not Enjoyable</i> | <i>Percent of Ideas Verbalized</i> |
|------------------|-------------|------------------------|---------------------------------|------------------------------------|
| <i>American</i> | <i>Mean</i> | <i>3.30</i> | <i>2.60</i> | <i>61.88</i> |
| <i>Indian</i> | <i>Mean</i> | <i>4.71</i> | <i>5.13</i> | <i>80.86</i> |

6.3 Experiment with Mind Tape technique

Mind Tape technique as described in section 2.8.2 is a form of retrospective verbalisation where the recall is facilitated by replaying the recorded screen of the interaction. Mind tape technique was selected for its likely capability in eliciting users' experiential data from deeper cognitive layers. As identified in section 2.6, the users' experiences are never a priori to the interaction but are dialogically created in process of interaction. Also the impossibility of sharing an experience except through narrative use of language, where a trust in the empathetic listener gives a motivation to the experience to share the experience has been acknowledged in same section. The expectation of being understood helps in sharing the experience and only when shared, the experience 'settles down' (Krippendorff, 2007). Mind tape technique has been used to gather experiential data here with dialogical nature of experience in mind. The evaluators were described the process of empathetic interviewing in order to make this technique a success.

While the most prevalent technique for gathering user data in HCI, TA has been criticized of sharing the cognitive resources of the user with task fulfilment (Preece et al, 1994; Branch, 2000), MT offers a good alternative. TA has been reported to be incomplete as some thoughts are difficult to translate verbally

(Schuck and Leahy, 1996). It has also been argued that the mental process is faster than the verbalisation speed, making it difficult to get continuous data on thought sequences in the verbalisation (Brainbridge, 1999). For all the above reasons, Mind Tape seems to be a better options for the gathering data from users in general, and experiential data in particular.

Theoretical basis for effectiveness of Mind Tape technique is the 'Level Processing Theory' (Craik and Lockhart, 1972; Cermak and Craik 1979). This theory proposes that people analyze stimuli at a number of different levels. Shallow levels involve analysis in terms of physical or sensory characteristics and deep levels involve analysis in terms of semantics which consists of associations, images and past experiences in relation to the stimulus. Shallow level memory traces can be quickly forgotten whereas deep level traces are more durable and therefore more reliable. Craik and Lockhart's (Craik and Lockhart, 1972) hypothesis that deeper level processing produces better recall has been widely tested (Baddeley, A.D.1990; Craik and Tuving, 1975).. The Depth of processing approach posits that greater the depth of processing, richer the meaning a person extracts from a stimulus.

Mind Tape method belongs to the category of Retrospective Verbalisation (RV). RV has been accused of subjective reporting and memory loss due to time lag between actual thinking process and reporting (Ericsson and Simon, 1993; Teague et al., 2001; Russo et al 1989). However, the validity and reliability of data obtained through SRV has been established (Zhiwei et al, 2006) and the quality of SRV data have also been reported in comparison with Think Aloud (TA) [Gapra, 2002; Van der Haak, 2003; Branch, 2000]. The stimulation used in Mind Tape during recall ensures the reliability of the recall data.

The Mind Tape method uses Stimulated Retrospective Verbalisation (SRV), which involves the use of a stimulus such as recording of computer screen activity captured to act as a trigger and refresher for the memory of the user. The stimulus acts as cue to enable the recall of reasoning behind a particular activity / action/ non action during the test. Retrospective replay is adopted with the assumption that, certain secondary and deeper level cognitive processes can be pulled up to the surface without loss or bias of afterthought. Under the influence of the stimulus mind acts as a tape and unwinds the memory, thread by thread. By appropriate interviewing, each thread can help trace back deeper level reasoning.

In order to structure the recall process and to improve the reliability of verbalised data, users in Mind Tape are asked to synchronise the mouse movement with the eye movement on the screen during the task fulfilment stage. The replayed cursor movement over the interface screen during the Mind Tape interview helps users structure their recall and verbalisation. This 'hand-eye coordination' which yields synchronised data on eye movements acts as a low cost substitute to the Eye Tracking equipment. The replayed capture of the cursor movement along with the background of the interface screen helps the user recall the threads of activities in sequence. The users are asked questions on why's and how's of the activities performed during the Mind Tape interview and a voice over video is created. The benefit of data collected in this way is that it is rich in content and thus can be analysed in various ways to answer different questions pertaining to future design activity.

Aim: To observe Mind Tape techniques capability in gathering experiential data from users. Ancillary aims were to investigate

1. Effectiveness of Hand-Eye coordination in the Mind Tape, employed as a cuing tool in recall process.
2. Suitability of Mind Tape in cross-cultural settings.
3. Effectiveness of Mind Tape method in observing differences and similarities in users' cognitive processes cross culturally.
4. The investigations and results obtained in response to these questions have been discussed in the following sections.

Hypothesis: Narrative structure of conversations in the MT technique will be conducive to the experiential data elicitation.

Tasks and Test Apparatus: Online official tourism websites of three different countries namely India, China and Denmark were used as sample systems for evaluation. The web sites were:

1. India: <http://www.incredibleindia.org>
2. Denmark: <http://www.visitdenmark.com>
3. China: <http://www.cnto.org>

The Scenario narrated to the users was as follows: “You and your friends dream of going on a holiday together. You have not decided where to go, but you have imagined different possibilities and during your talks three countries came up. You have access to computers and network so you promised others that you would check up on the countries to get inspired”.

Users were given two tasks

1. To explore the three websites so as to get an overview of places of tourist interest.

2. To find one place of interest in each of the countries and gather data to be able to give your friends an impression of the culture and idea of what a holiday could be in that place.

Screen recording software and an attached webcam was used to capture the activities on the screen as well as users gestures. An attached micro- phone was used to record the interview as voice over. Danish participants conducted the tests on laptops having satisfactory net speed and processing speeds. Indian participants conducted the tests on an LCD monitor with matching computer processing speed and internet connection speed. The tests took around one hour and forty minutes for each on average.

Participants: The experimental studies were conducted with total of 28 participants from Denmark and India consisting of 14 users and 14 evaluators. 7 user-evaluator pairs were from Denmark and the study was conducted at Copenhagen, Denmark. 7 user-evaluator pairs were from India and the study was conducted at Guwahati, India. All the 28 participants from Denmark and India were enrolled for HCI courses and had knowledge of interaction design issues and HCI design practices. The test was conducted in English at both the places and the participants were conversant in English. The mean age of Indian participants was 21.57 with standard deviation of 0.73 while the mean age of Danish participants was 26.14 with standard deviation of 2.29. None of the participants had explored the websites extensively. A few of them had chance visits to the websites of their native countries but had not explored it. The selection of participants and place of study was conveniently sampled so as to study the effectiveness of Mind Tape technique in cross cultural settings.

Procedure: Participants were initially briefed about the Mind tape technique. In Denmark, the users and the evaluators both were familiar to the hand eye coordination method and had used it in experiments earlier. In India, the users

and evaluators were taught about the hand eye coordination method and made to practice a few times, couple of days prior to the tests.

The evaluators and the users were given detailed instructions in the first session. Users were reminded about the hand eye coordination and were told to be free and natural during fulfilment of tasks. The evaluators on the other hand were informed to refrain from interfering in the task fulfilment by the user. Once the task fulfilment was observed to be over, the evaluators were to save the screen recording. For the Mind Tape interview, the evaluators were suggested to encourage free flow of thoughts during verbalisation. The evaluators were instructed to show attention and acceptance to the users' verbalisation through nod, gestures, phrases of acceptance and body language. The importance of users being able to recall by supportive listening and free verbalisation was duly emphasised.

Stages in experiment

1. **Task fulfilment stage:** The evaluators started the websites and the screen recording. Scenario was narrated to the user. Tasks were introduced to the user. Request was made to explore each website for about 15 minutes and decide upon one place of tourist interest in each website. The evaluators watched quietly as users fulfilled the tasks and they took notes of the interaction behaviours which had importance in their viewpoint.
2. **Mind Tape interview stage:** The just recorded screen capture of the interaction was replayed. The evaluators conducted interviews using stimulus of screen recording being replayed, pausing and replaying when needed. Users were asked

- a. *“what were you looking for?” whenever the user’s mouse had wandered around for sometime without clicking at anything*
- b. *“what were you expecting?” whenever the user clicked at something. The researchers, in the meanwhile, observed the process and took notes of important evaluator-user behavioural characteristics.*

3. **Semi-structured qualitative interview stage:** Finally, a semi - structured qualitative interview on the overall impression of the three websites was conducted. The users were asked to give overall rankings to the websites along the parameters ‘website most liked’, ‘website easiest to use’, ‘website having most pleasing interface’. The users were asked to elaborate upon the reasons for the reported Likeness, Friendliness and the most Pleasing interface in the interview. Ratings for the website on a 7 point scale under criteria of Attractive, Exciting and Friendly were collected.

Analysis and discussion: Mind Tape data collected in above experiment can be analysed in variety of ways such as tabulation, chronological displays, cause effect matrices, relationship and networks. It is source of rich verbal descriptions and explanations of cognitive processes. It is observed that the data preserves chronological flow helping the investigators identify which events led to which consequences. Serendipitous findings are also likely to emerge in different contexts of analysis.

As the present study is more focused on arguing for Mind Tape as a useful method in experiential data gathering, especially in cross cultural context, only one way of the ways of analysing the Mind Tape has been explored. Using Grounded Theory principles (Miles and Huberman, 1994), the replayed voice over videos were transcribed and important observations were tabulated chronologically. Researchers drew inferences from the Mind Tape verbal data of

the users in context of the online activity being displayed and jotted down the inferences by the side of the observations. By mutual agreement of the researchers some of the inferences were identified to be of importance in the redesign context. The qualitative interview data helped in triangulation of the findings. Statistical data was used to get a glimpse of the overall picture in the two groups of users while their individual responses about the overall experience of the websites was used for internal verification of their verbal reports.

Though the main aim of this study was to investigate the suitability and acceptability of this method, some interesting observations have also resulted which have been discussed categorically in section 5.4 below.

A segment of the user wise, tabulated Mind Tape data, with researchers' inferences, has been exhibited in table 6.14. In light of the data in table 6.14 it is argued here that Mind Tape data is much richer in terms of descriptions and explanations. The users' understanding of certain terms like 'project', 'heritage', 'regions', 'culture', 'inspiration' etc., identified as possible causes of conflict between the users mental model and that of the interaction design, is difficult to identify in other methods like TA. A designer can analyse the data depending on the direction one wishes to take, to suit the required need. Table 6.15 and 6.16 display an instance of the statistical data from the overall rankings and ratings of the websites. This data has been used for triangulation and cross validation in the following sections.

Effectiveness of Mind Tape: Mind Tape method was found to be effective in terms of quality of explanations provided by the users and also in terms of quantity of the verbal data. No user from the pool of 14 participants, reported difficulty in recalling the mental processes that accompanied the events

during the interaction. The effectiveness of stimulation of recorded screen being used to aid the recall process became evident. The quality of the explanations provided by the users was found to be of a level that was satisfactory to both, the evaluators and researchers. Also, there were 6 instances when the users reported that they were able to explain things which they were not aware of at a conscious level during the interaction activity. The users also reported that there was no interference with task fulfilment during the test as evaluators watched silently. Thus it is being posited here that Mind Tape technique is capable of yielding sufficient amount of quality data from deeper levels of cognitive processes which will be useful to HCI designers.

Suitability of Mind Tape in cross cultural settings: It has been argued earlier that the data gathering techniques need to be sensitive to the cultural nuances of test setups, users comfort levels, evaluator user relationships during test etc. In light of this theoretical framework, the participants were observed from both Danish as well as Indian cultural backgrounds during the test to be comfortable with the Mind Tape method. No participant reported physiological discomfort due to constant verbalisation which has been observed in TA sessions. On the contrary, the users were observed to be quite involved in the Mind Tape verbalisation. A possible explanation, which was submitted by one of the users for this, could be that the presence of a listener made verbalisations more natural in comparison to the TA method where the user verbalizes most of the time looking at the screen. The conversation setting between the user and evaluator, even though the evaluator uses silent nods and gestures mostly, makes this method more involving and satisfying to the user in comparison to the TA method. Sometimes users also divulged personal information that they were reminded of during the interaction. Indian users participated more voluntarily and divulged more information on their own and provided logical explanations than the Danish participants. Indian users were found to speak more elaborately

about what their expectations and outcomes during the interaction were. On the whole, the Mind Tape data was richer in terms of explanations in case of Indian users than Danish users.

Since, no negative observations regarding suitability of Mind Tape method in cross cultural settings was made by the researchers and the evaluators and positive reports regarding the comfort level were given by the users, suitability of the Mind Tape in cross cultural settings is posited here.

Effectiveness of Hand-Eye coordination: As the hand eye coordination was used to help cueing the recall process in Mind Tape, it was essential to also validate effectiveness of this tool through observation and user report. There was a mixed response observed to the hand-eye coordination tool from the users. Of the 14 participants altogether, 3 Danish participants reported 'no problem' using the hand eye coordination and that it was 'natural', 2 Danish participants reported that it was difficult when 'scanning the pages' and that 'the eye moved faster than the hand'. 4 of Indian participants reported the difficulty in 'scanning the page' and 2 said 'it was natural while reading'. From the above observation, since majority of the users across cultures were positively oriented about the hand-eye coordination in case of menu viewing, scrolling, text reading and searching, it is posited, that it is an effective tool for later cueing the recall process without interference to the task or causing discomfort to the users. The effectiveness of the hand-eye coordination was observed to be less in case of picture viewing and quick perusal of WebPages. This may be so because eye moves faster than the hand and in cases of unstructured tasks, it is expected to be more chaotic, making the coordination between the two more difficult. This tool needs to be further investigated for effectiveness and possible interference in task.

Effectiveness of Mind Tape in observing cross cultural differences: Though this study was focused on investigating suitability of the Mind Tape method, the experiment itself revealed suggestive data towards similarities and differences in the cognitive processes of users cross culturally. This finding is being reported here to help intensify the argument in favour of Mind Tape on one hand and on the other to argue the need to consider the cultural nuances of cognitive processes for interaction design.

Table 6.14: Mind Tape verbalisation by participants

| Users' Observed Interaction behaviour | User's Mind Tape Interview response | Inference/ Hypothesis |
|--|---|--|
| Mouse wanders in the beginning of interaction with Indian Tourism website, checks the menus. | Looking for 'Tajmahal' for I have heard of only that from India. | Posit: Danish People/ In general people search by what they already know on an unfamiliar website |
| Clicks 'Heritage' link | Expected that it will give me some pictures of Tajmahal. | Pictures are what information can be quickly and richly availed. |
| Picture of Tajmahal comes on screen. Expression of dissatisfaction on the face of subject. | Got only one picture with little text so I started looking for some other link where I can get more info. | Need of many pictures. |
| Text of info comes | I am looking for pictures; I am not going to read 10 pages of text. | Lot of texts is not preferred on a tourism website. |
| Danish Site: Beginning... mouse wanders around | I am looking for something interesting | Posit: When the person is well aware of the place then one looks for something interesting (does it mean not known earlier)! |
| Clicks link named 'inspiration' | I am looking for something interesting so I guess here is something... | The word 'inspiration' promises for new and exciting on a tourist website. |
| Further sub menus come upon clicking inspiration - sub menu - culture | I am not looking for so specific information when I click culture, I want a general picture. | There is a threshold of detailed information that one seeks while looking for a tourist place, at least initially. |

| | | |
|---|---|--|
| Chinese site: Beginning... Mouse wanders... | I thought Hong Kong is part of China, I am not able to get it. | Again search by know place on a less known site. |
| Indian Site: Mouse static in the beginning. | Looking for some pictures to see what all places to visit in India, I do not know much about India. | Pictures as means of getting an image of the place. |
| Selects Beaches of India - Goa | Because it has pics of beaches so I can go there | Probably familiar locations interest more |
| Selects places to visit | I do not know anything about India so may be this is a good place to begin with. | Cognitive tools that aid in beginning to search is not names of places for they are unknown but the categories that represent them. This could possibly be a universal phenomenon. |
| a list of places is shown | I do not know any of the places so this list doesn't give me desired information. | Further categories of places and then the list might have helped probably. |
| After a lot of trials on menu items | The purpose of this website is not clear... whether it is about introducing me to the culture.... Or it is also to help me get there... | Could it be much talked about- holistic thinking in east Asians.... Trying to get the bigger picture? |
| Looks at an image | It looks like from my very own place | Does this cultural identity phenomena relevant more to this individual or to the \ community? |
| Gets a submenu filled with known items except one | These I know...OK... but what is this?.. let me click | Posit: In known territories, people explore the less known to them item. |
| State wise organization of info | Why is it done state wise? I am interested not in states but the kind of holiday I want to have. | Information architecture to suit the motivation of the user was observed in user's of both the cultures. |
| Highlights the text while reading | I always do it while reading, it helps me identify the text from rest | Cognitive tool used by most of the Indian participants while reading to focus on the text being read. Is it a cultural phenomenon? |

Table 6.15: Participants' rankings of websites
(I= Indian, D= Danish)

| Rk | Indian Website | | | | | | Danish Website | | | | | | Chinese Website | | | | | |
|----|----------------|---|------|---|-------|---|----------------|---|------|---|-------|---|-----------------|---|------|---|-------|---|
| | Liked | | Easy | | Looks | | Liked | | Easy | | Looks | | Liked | | Easy | | Looks | |
| | I | D | I | D | I | D | I | D | I | D | I | D | I | D | I | D | I | D |
| 1 | 5 | 3 | 4 | 2 | 2 | 1 | 2 | 3 | 1 | 4 | 5 | 5 | 0 | 1 | 1 | 1 | 0 | 1 |
| 2 | 1 | 2 | 2 | 2 | 4 | 4 | 4 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 3 |
| 3 | 1 | 2 | 1 | 3 | 1 | 2 | 1 | 1 | 4 | 0 | 0 | 1 | 5 | 4 | 4 | 4 | 6 | 3 |

Table 6.16: Participants' ratings of websites

| | Attractive | | Exciting | | Friendly | |
|-----------------|------------|-----|----------|-----|----------|-----|
| | Ind | Dan | Ind | Dan | Ind | Dan |
| Indian Website | 5.4 | 5.0 | 5.4 | 3.6 | 4.5 | 4.5 |
| Danish Website | 4.7 | 4.3 | 4.0 | 4.0 | 4.7 | 5.0 |
| Chinese Website | 3.5 | 3.8 | 3.4 | 3.6 | 3.2 | 3.1 |

Observations suggestive of cultural differences in cognitive processes

Observation 1: Danish users were observed to indulge much less in reading texts on the web pages compared to their Indian counterparts. The Danish users emphasised more on the need of images (Table 6.14, row3) on the websites than the Indian participants. The Danish participants also stayed a lot less amount of time on each webpage as compared to the Indian users. Some Indian participants also commented on the composition style of the text (Table 6.14, row 9) and complained about the inappropriateness of the style of writing for the site, which was not observed in any Danish user. 4 of 7 Indian users also exhibited a peculiar habit of highlighting the text while reading which was not exhibited by the Danish users. This observation was in accordance with the observation of their reading habit. The hypothesis generated thus, "Danish users are willing to

read less in comparison to Indian users” could be tested further for generalization.

Observation 2: Indian participants’ tendency to get a holistic impression of the site before actually fulfilling the task was more prominent as compared to the Danish participants. Even though both the groups of users, Indians as well as Danish, were unfamiliar about their counter-part country’s tourist places, the Danish users started with more specific queries like, Tajmahal, Tigers, Beaches etc. (Table 6.14) in comparison to Indian users who went about first getting a general picture of the place by browsing through contents. Apart from a number of other possible reasons, this phenomena could also be due to a more holistic thinking approach by the east Asians than westerners, as reported by Nisbett et al (2007).

Observation 3: Indian website was liked more by Indian users than by Danish users (Table 6.15). 4 out of 7 Indian users identified themselves culturally with Indian website (verbal expression of one such participant is exhibited in Table 6.14, row 10) whereas no such accounts were observed from Danish users for Danish website. This could indicate presence of stronger cultural identity in Indians which may affect tacitly the overall impression of the websites reported by them. Though bright colours of the Indian website was reported to be ‘attractive’ to both the Danish and Indian users (Table 6.15) they made the Indian users feel more ‘at home’ due to traditional cultural graphic elements. This could be a reason for Indian users rating the Indian site as more ‘exciting’ (Table 6.16) compared to the Danish users who found their native country’s site (Table 6.16) more exciting. Both the group of users reported that it was ‘easier to use’ their own native countries website (Table 6.15). Such cultural differences in the cognition of interfaces due to difference in

strength of cultural identity thrown up by Mind Tape technique can become inputs for interaction design in cross cultural situations.

Observation 4: Though the Information was categorised geographically on both websites, most Indian users (6 out of 7) were critical of information categorisation on Indian website in comparison to the Danish website. One of the possible reasons for differential thinking by Indian users could be, that Indian users, who were aware of the greater seasonal variation in Indian subcontinent, thought of holidaying in the context of seasons. Indian users expected and expressed the need for a 'season wise' (Table 6.14, row 11) categorisation of the tourist information instead of geographical. This could be cultural phenomena which the cross cultural HCI designer will need to take into account.

Observations suggestive of similarities in cognitive processes:

Observation 1: Participants from both countries while searching in unfamiliar territory, tended to order their search from more known to lesser known places. For instance, Danish participants exploring Indian website, started their search from looking for 'Tajmahal'. This search by familiarity in unknown places was significantly observed in both groups of users. Upon probing they replied that they knew only famous tourist spots so they explored them first. The complementary phenomena of prioritising search by choosing unfamiliar places in known country were also observed. Users while searching for places of interest in familiar set of places, when confronted with a previously known set of places, clicked on items less known to them. Upon probing they replied that they were curious to explore the lesser known. This observation could be critical for the information design in scenario of cross cultural usage. It would help designer

to prioritize the sequence of appearance of information for greater satisfaction of culturally different users.

Observation 2: Almost all participants (6 out of 7) were critical of lack of images on websites. They articulated the need to get a feel of the place which in their opinion was only possible through images. They quit webpages with no images more quickly and rated such websites lower. Users also preferred to read the text accompanying pictures more than other instances.

Observation 3: Both the groups of users found the Danish website almost equally attractive and exciting. The explanations given for this by both the groups of users were 'it had a clean and simple look' and 'Information looked organized'. This observation is in concordance with Nasar's observations in earlier studies done across American and Japanese cultures. Nasar had reported perceptions of orderliness, diversity and novelty remain the same across cultures (Nasar, 1984). Though Nasar had investigated aesthetic perceptions in the context of architectural and spatial settings, it is interesting to find a similar observation in the context of interaction design as well. From this observation, it is posited here that the visual cues associated with 'simplicity' and 'cleanness' of the website layout, are similar in perception across cultures, especially with relevance to the Danish and Indian cultures.

6.3.1 Inferences from experiment with Mind Tape technique

The Mind Tape technique was found capable of mining data from deeper layers of the users' information processing. It yielded sufficient information on users' aesthetic, affective and intellectual experiences to suggest that this technique would be useful for the experiential design process. The sensitivity of Mind Tape

method in surfacing out the cultural cognitive differences and similarities for direct usage by designers has been observed.

The cultural suitability of the Mind Tape Method was found to be more prominent in case of Indian users in comparison to Danish users. This could be attributed to relational, dialectical and personal characteristics of the east Asians (Peng et al, 2000). Further development of the Mind Tape method could make it a useful tool in HCI profession.

6.4 Experiments with Repertory Grid technique

As described in section 2.8.2, Repertory Grid technique was developed by George Kelly (1955) to elicit personal constructs which are used by individuals to make sense of the world around them. Personal construct psychology propounds the idea that individuals make sense of the world by creating constructs. These constructs are very personal to the individual. Every individual has a unique way of experiencing the world and hence has unique constructs. Every individual's psychological space consists of a web of lines which are created by the construct-contrast pairs and Repertory Grid is the technique to elicit these constructs and contrasts.

In context of interaction design, knowledge of the way a user makes sense of the interaction is critical to the design process. It would not only help the designers make informed decisions about the users, but use such knowledge to constantly validate the design ideas during their development process. As it is not easy to gather data from deep down the users psyche, any tool which augurs for it is welcomed by the designer. For this reason, RGT has been studied here to identify its capabilities in gathering experiential data from users. Fortunately, because of the kind of stimuli RGT needs for gathering the data from users, it can be applied

at all the three levels of design decisions. In this section, firstly experiments done at the transitional is described and discussed which is followed by description of experiments at the compositional and elemental levels respectively. Cultural suitability and sensitivity of RGT has also been investigated alongside in the experiment at transitional level.

6.4.1 RGT Interviews at transitional level across three cultures

Aim: To identify RGT's ability to mine experiential data form users and also to find out the techniques cultural suitability and sensitivity.

Background: Repertory Grid technique requires triads of stimuli or objects under discussions for the technique to be applied. Any three objects or experiences could be taken at a time to facilitate identification of constructs and contrasts in users' psychological space by using this technique. At the transitional level, prior experiences with systems used by users have been used as the *elements* (see section 2.8.2, under heading 'repertory grid technique').

Research Design: There are several stakeholders to the HCI design process. Users, HCI designers and developers are three most important ones directly connected to the HCI system development process. The way these stakeholders experience the HCI systems will have an impact on the way systems would be designed. Hence, this research focuses on gathering experiential data from these three stakeholders from across three cultures backgrounds to investigate any differences in the way their experiences differ. This experiment would help establish both the cultural sensitivity of the technique as well as its ability to gather experiential data.

Materials and methods: RGT interviews were conducted by three researchers in three different cultures. The three researchers came from the three cultures that where the interviews were conducted. In order to ensure that all the interviews were conducted in same way by all the three interviewers, some activities were performed. First, an interview manual was written with step-by-step instructions about how to conduct the interviews. Second, each interviewer conducted a pilot interview using the manual while other two researchers observed the conduct of interviews. Third, experiences gained from the pilot interviews were discussed with two more researchers who had prepared the manual and suggestions were incorporated in the manual. The outcome of these preparations was the final version of the interview manual and a common understanding among the interviewers about how to conduct the interviews.

Participants: Total of 72 participants was interviewed using RGT across three cultures and three stakeholder groups. 8 participants per stakeholder group per culture, amounting to total of 24 participants in each culture and 24 participants in each stakeholder groups were interviewed over a period of 6 months. The Chinese participants were interviewed in Beijing, the Danish participants in Copenhagen, and the Indian participants in Bangalore, Guwahati, Hyderabad and Mumbai. Table 6.17 summarizes the 72 participants' gender, age, and IT experience. The participants had average to excellent English skills.

Procedure: Participants were interviewed individually by a person with the same cultural background as the participant. First, the study was described to the participant and the repertory-grid technique explained. Second, participants filled out a questionnaire about their background and signed an informed-consent form. Then, participants tried to elicit constructs with the repertory-grid technique on a couple of training tasks. After these preparatory steps, the actual

repertory-grid interviews were conducted. They consisted of two steps: selection of systems and elicitation of constructs.

Table 6.17: participant's profiles for RGT experiment at transition level

| <i>Group</i> | <i>Gender</i> | | <i>Age (years)</i> | | <i>IT experience (years)</i> | |
|---------------------------|---------------|---------------|--------------------|-----------|------------------------------|-----------|
| | <i>Male</i> | <i>Female</i> | <i>Mean</i> | <i>SD</i> | <i>Mean</i> | <i>SD</i> |
| Chinese developers | 5 | 3 | 31.5 | 1.9 | 10.6 | 1.7 |
| Chinese users | 5 | 3 | 27.3 | 1.9 | 8.4 | 1.9 |
| Chinese HCI professionals | 5 | 5 | 26.6 | 3.2 | 9.7 | 2.4 |
| Danish developers | 5 | 3 | 36.6 | 5.8 | 19.3 | 5.8 |
| Danish users | 5 | 3 | 36.8 | 6.2 | 16.9 | 3.6 |
| Danish HCI professionals | 3 | 5 | 32.5 | 4.5 | 18.6 | 6.0 |
| Indian developers | 8 | 0 | 29.6 | 1.7 | 9.9 | 2.5 |
| Indian Users | 5 | 3 | 29.0 | 4.0 | 7.0 | 2.1 |
| Indian HCI professionals | 7 | 1 | 29.8 | 1.5 | 9.5 | 2.6 |

In selecting systems, the participant was asked to consider “the array of computer applications you use for creating, obtaining, revising, managing, and communicating information and documents in the course of your day-to-day activities.” This included applications the participants use regularly but excluded applications they had only used once or twice and applications they merely know of. On this background participants were asked to select a system within each of six categories: my text processing system, my email, a useful system, an easy-to-use system, a fun system, and a frustrating system.

In eliciting constructs, the participant was successively presented with groups of three of the selected systems and asked: “Can you think of some important way in which your personal experience using these three systems makes two of the systems alike and different from the third system?” Having indicated the two similar systems, the participant wrote down a short phrase that told how these two systems were alike – the construct – and another short phrase that told how the third system differed – the contrast. Then, a seven-point rating scale was

defined with this construct-contrast pair as its end points, and the participant rated all six systems according to this rating scale.

This procedure was repeated for all twenty combinations of three systems, in random order, or until the participant was unable to come up with a new construct for two successive combinations. The interviews were conducted in the participants' native language, if participants preferred that, or in English. Constructs and their contrasts were always recorded in English. In accordance with cultural customs, Danish and Indian participants received no compensation for their participation in the study while Chinese developers were paid 200RMB for their participation and Chinese users 50RMB. Each interview lasted about 1.5 hours.

Data Analysis: Repertory Grid Technique yields data that has both qualitative and quantitative dimensions. In data obtained through RGT interviews, we get construct-contrast pairs, which are subjective descriptions aspects of interaction experience important to the users in textual format, often a short phrase. These constructs and contrasts phrases are rich with meaning personal to the users. These phrases can be analysed qualitatively to identify recurring concerns/experiences among users. The other form of the data obtained is the ratings to the systems given along these construct-contrast poles. These ratings can be subjected to quantitative analysis. In this thesis, qualitative content analysis has been done on the construct and contrast phrases to identify recurring categories in them. Further, statistical analysis has been done using Multi Dimensional Scaling (MDS).

Firstly content analysis will be described. The content analysis involved two steps. First, two of the researchers who had not been conducting repertory-grid interviews, collectively made an affinity diagram of first 661 elicited constructs

from the user and developer groups of the interviews. This resulted in 51 categories; each category was described by a sentence. Second, to assess the reliability of the categories the three authors who had been conducting the interviews individually classified all constructs by assigning each construct to one category. The researchers are being referred to as 'judges' here. Each judge was trained on a selection of 30% of the constructs, during which they twice received feedback on their classification. Different training sets were randomly selected for each judge. Some minimal changes were made to the descriptions of the categories as a result of the judges' classifications. Then each judge classified the 463 constructs not seen during training. Across the non-training constructs, the Kappa values for the level of agreement between the judges and the categories were .64, .64, and .66, which according to Landis and Koch (1977) represents 'substantial' agreement. As these categories had agreements for categorising the constructs, author rated rest of the constructs along the same categories for the HCI professionals constructs as well. Two new categories also had to be created in order to accommodate the new range of ideas coined by HCI professionals, then all the constructs were re-categorised in 53 categories.

Observations: Total of 976 constructs was elicited by 72 participants. Break up of number of constructs per group has been given in Table 7 below. These constructs were categorised into 53 categories as described above. These categories can further be broadly grouped into three groups. Table 8 gives details of the breakup of constructs in each group. First group of categories were found to be pertaining to the system characteristics and total of 398 constructs were found in this group. This also is the highest number of constructs in any group. This means that mostly people have reported differences among the systems they use on the basis of the system characteristics like, internet connectivity, proneness to viruses, vendor that provides that software etc. It is also noteworthy that during the RGT interviews it is difficult for the participants to elicit data

consistently along rich experiential lines hence there is also a tendency to give superficial constructs like physical differences in systems and differences in characteristics etc. The next broad category was of constructs pertaining to users experiences. Total of 259 constructs were observed in this category. This means that RGT is a good technique to gather users' experiential data. Participants have elicited constructs like 'I can't share my ideas with friends', 'Can get other people's feeling or emotion', 'I never worried about being attacked by virus' under the experience category which are very useful for the HCI designer involved in experiential design process.

Table 6.18: Number of constructs obtained from each group of participants

| <i>Group</i> | <i>Culture</i> | <i>No. of Constructs</i> |
|--------------------------------|----------------|--------------------------|
| <i>Developer</i> | China | 122 |
| | Denmark | 97 |
| | India | 98 |
| | Total | 317 |
| <i>User</i> | China | 124 |
| | Denmark | 100 |
| | India | 119 |
| | Total | 343 |
| <i>HCI Professional</i> | China | 125 |
| | Denmark | 98 |
| | India | 93 |
| | Total | 316 |
| <i>Total</i> | China | 371 |
| | Denmark | 295 |
| | India | 310 |
| | Total | 976 |

Four of the systems used to elicit constructs are defined in terms of user experience, namely systems that are easy-to-use, frustrating, fun, and useful. The construct/contrast pairs on which these systems are given extreme ratings of one

or seven can help characterize those systems. The easy-to-use systems are often associated with being of utility (10 extreme ratings, e.g., “Job-essential”), predictable (4 extreme ratings, e.g., “No unpleasant surprises/Unpredictable”), comfortable (4 extreme ratings, e.g., “Can get pleasure from using it”), easy to install (4 extreme ratings, e.g., “Small, easy to install/ Large tool, install takes much time”), and non-frustrating (3 extreme ratings, e.g., “Happy to use/Annoying to use”). Unsurprisingly, easy-to-use systems also receive many extreme ratings on construct/contrast pairs about ease of use (7 extreme ratings). It should be noted that the easy-to-use systems are not directly related to construct/contrast pairs categorized as reflecting a distinction between simple and complex (4 ratings at one end of the scale, 3 at the other).

Table 6.19: Overview of kinds of constructs

| <i>Kind</i> | <i>All</i> | <i>Cultural background</i> | | | <i>Stakeholder group</i> | | |
|-------------------------------|------------|----------------------------|---------------|---------------|--------------------------|-------------|-----------------|
| | | <i>Chinese</i> | <i>Danish</i> | <i>Indian</i> | <i>Developer</i> | <i>User</i> | <i>HCI Prof</i> |
| <i>System characteristics</i> | 398 | 154 | 119 | 125 | 139 | 155 | 104 |
| <i>User experience</i> | 259 | 107 | 72 | 91 | 80 | 84 | 123 |
| <i>Task or use context</i> | 240 | 99 | 69 | 72 | 77 | 92 | 71 |
| All | 976 | 371 | 295 | 310 | 317 | 343 | 316 |

The frustrating systems are mainly characterized by a lack of comfort (4 extreme ratings), by not being easy-to-use (7 extreme ratings), by being non-inspiring (3 extreme ratings, e.g., “Interesting/Monotonous), and by being slow. Unsurprisingly, extreme ratings on construct/contrast pairs relating to frustration

are frequent and consistent (8 extreme ratings). None of the construct/contrast pairs challenge the common understanding of frustration. As mentioned earlier, ratings for the frustrating system is also negatively correlated with ratings of the easy to use system and the fun system.

For the fun system, the extreme ratings relate to ease of use (7 extreme ratings), whether a system is inspiring and interesting (6 extreme ratings), simple (6 extreme ratings), aesthetic (4 extreme ratings, e.g., “Beautiful interface/Earthly interface”), and comfortable (4 extreme ratings). As expected, the fun system is also related to construct/contrast pairs about fun/frustration (6 extreme ratings). Fun systems do not appear to be related to predictability as they are both rated as predictable and unpredictable (2 and 3 extreme ratings, respectively). Efficiency is also not related in any clear way to fun (5 constructs in either direction). Thus, construing a system as fun seems to be orthogonal to construing it in terms of efficiency.

The useful system is associated with ease of use (6 extreme ratings), fun (as opposed to frustration, 5 extreme ratings), and inspiration (4 extreme ratings). Note that usefulness is neither related in a clear way to efficiency, nor to simplicity. Furthermore, the notion of usefulness varies in the construct/contrast pairs mentioned: four pairs mention a lack of necessity to use, and four other pairs construe the useful system as essential and important.

Finally, let us mention some observations from the data on user experience that we find surprising in relation to the HCI literature. First, several constructs discuss installing and updating software; a topic rarely discussed on its own in the usability literature (7 constructs, e.g., “Large tool, install takes much time/ Small, easy to install”). Second, the infrequency of construct/contrast pairs relating to consistency—an often discussed notion in human-computer interaction—is also

surprising. Only three construct/contrast pairs about consistency were found (e.g., “Look and feel is same”). Third, it is noteworthy that when users are asked to speak broadly about their personal experience of using systems, they talk to a lesser degree than might be expected about traditional usability attributes. Only 22% of the construct/contrast pairs were classified as concerning user experience. This might suggest that other facets of personal experience matters more to participants.

Table 6.20: Details of constructs obtained from participants

| China | Denmark | India | Developer | User | HCI Prof | Total | | |
|-------------------------------|---------|-------|-----------|------|----------|-------|-----------------------|---|
| System Characteristics | | | | | | | | |
| 16 | 24 | 25 | 17 | 32 | 16 | 65 | Internet connection | Systems that require internet or network connection to work correctly |
| 2 | 0 | 9 | 1 | 10 | 0 | 11 | Need for installation | Distinguishes pre-installed systems (or those that require no installation) from those that must be installed to work |
| 8 | 1 | 3 | 4 | 5 | 3 | 12 | Virus | Systems that easily get infected by virus as opposed to those that do not |
| 15 | 10 | 2 | 6 | 9 | 12 | 27 | System updates | Concerns the frequency and nature of system updates such as new versions |
| 0 | 5 | 5 | 3 | 4 | 3 | 10 | Tailorability | Concerns the flexibility of systems, in particular the degree to which they may be tailored |
| 11 | 0 | 0 | 4 | 5 | 2 | 11 | Generic vs. specific | Distinguishes systems that work across domains/tasks from systems tasks that are specific to a certain domain/task. |
| 6 | 1 | 1 | 5 | 2 | 1 | 8 | License | Systems that are free versus those that require a license |
| 4 | 10 | 9 | 8 | 8 | 7 | 23 | Microsoft | Systems that are made by Microsoft as opposed to other vendors |
| 13 | 16 | 9 | 16 | 11 | 11 | 38 | Alternative suppliers | Systems are available from alternative suppliers or in alternative versions |
| 7 | 0 | 0 | 4 | 2 | 1 | 7 | Reliable | Distinguishes systems that are |

| | | | | | | | | |
|----------------------------|----|----|----|----|----|----|------------------------------|--|
| | | | | | | | | reliable (stable) from those which are not |
| 4 | 1 | 0 | 1 | 4 | 0 | 5 | Text vs. graphics | Distinguishes systems using mainly text from those using graphics or visual contents |
| 11 | 1 | 1 | 5 | 4 | 4 | 13 | Integration vs. stand | Distinguishes systems that work on their own from systems that are alone integrated or a subsystem |
| 14 | 9 | 14 | 12 | 8 | 17 | 37 | Numbers vs. words | Systems that use or concern numbers as opposed to using mainly words |
| 0 | 5 | 7 | 4 | 8 | 0 | 12 | Keyboard vs. mouse | Distinguishes systems where a keyboard is used from those operated mainly by mouse |
| 6 | 3 | 1 | 3 | 3 | 4 | 10 | Specific functionality | Concerns systems with a specific functionality or requirement (e.g., search, history, memory) |
| 5 | 4 | 0 | 7 | 1 | 1 | 9 | Popularity | Concerns the uptake or popularity of systems |
| 2 | 1 | 0 | 1 | 2 | 0 | 3 | Local language | Concerns whether or not systems provide support for local language, e.g. Chinese |
| 4 | 1 | 1 | 3 | 3 | 0 | 6 | Up-to-date | Concerns whether or not a system's content is up-to-date |
| 0 | 3 | 1 | 1 | 2 | 1 | 4 | User-initiated vs. automatic | Distinguishes systems or functions that are automatically available or always enabled from applications/functions the user must initiate |
| 19 | 20 | 24 | 24 | 20 | 19 | 63 | Multiple vs. single | Distinguishes systems that can work on multiple documents or windows from systems that cannot |
| 7 | 4 | 13 | 10 | 12 | 2 | 24 | Overview | Concerns whether or not a system provides an overview |
| Task or Use context | | | | | | | | |
| 31 | 25 | 36 | 30 | 38 | 24 | 92 | Work or leisure | Systems related to work/business or to leisure/private concerns |
| 12 | 12 | 10 | 10 | 9 | 15 | 34 | Unwind | Systems that actively help users unwind and relax as opposed to systems that do not or are stressful |
| 6 | 4 | 8 | 8 | 3 | 7 | 18 | Support for learning | Systems that support learning, in particular through training, exploration, and trial-and-error |
| 0 | 4 | 0 | 1 | 3 | 0 | 4 | Availability of system | Systems that are available only at one particular place or everywhere |
| 3 | 2 | 0 | 3 | 2 | 0 | 5 | Creativity | Systems that support being creative and getting ideas |
| 24 | 9 | 4 | 11 | 16 | 10 | 37 | Frequency of use | Systems that are used frequently or with which the user is familiar as opposed to those that are rarely used |

| | | | | | | | | |
|------------------------|----|----|----|---|----|----|------------------------------|--|
| 5 | 7 | 10 | 5 | 8 | 9 | 22 | Privacy | Issues relating to passwords, pin codes, and other privacy matters |
| 4 | 1 | 0 | 1 | 2 | 2 | 5 | Communication | Systems that support communication with others; often in contrast to systems for manipulating contents |
| 5 | 0 | 0 | 2 | 2 | 1 | 5 | Particular domains | Concerns systems that provide support for programming, planning, and applications courses, presentation, literature, and other specific domains and applications |
| 1 | 2 | 3 | 2 | 3 | 1 | 6 | Modifiability | Distinguishes systems where users may modify the content (save/write/store) from those that cannot be modified |
| 4 | 1 | 1 | 1 | 3 | 2 | 6 | Use vs. produce | Distinguishes whether a system supports using information/services or producing content |
| 4 | 2 | 0 | 3 | 3 | 0 | 6 | Push vs. Pull of information | Distinguishes systems that require the user to request/pull information from systems that push information |
| User Experience | | | | | | | | |
| 5 | 2 | 0 | 4 | 3 | 0 | 7 | Convenience of installation | Distinguishes systems that are easy to install and require few system resources from systems that are hard to install and require many system resources |
| 16 | 4 | 5 | 8 | 9 | 8 | 25 | Predictable | Systems that are predictable as opposed to systems that surprise |
| 0 | 3 | 5 | 5 | 0 | 3 | 8 | Utility | Distinguishes systems that are seen as useful, urgent to use, or of utility to the user from those which are not |
| 6 | 10 | 8 | 8 | 7 | 9 | 24 | Time efficiency | Distinguishes slow from fast systems |
| 2 | 2 | 2 | 1 | 3 | 2 | 6 | Trust | Concerns how well a user trusts a system or how transparent its interface is |
| 7 | 8 | 13 | 8 | 6 | 14 | 28 | Ease of use | Distinguishes easy-to-use and helpful systems from difficult-to-use systems |
| 19 | 3 | 7 | 4 | 6 | 19 | 29 | Efficiency | Distinguishes systems or operations that require few steps from those which require many steps |
| 17 | 4 | 14 | 10 | 2 | 23 | 35 | Simplicity | Distinguishes systems that are simple (e.g., have few features) from those which are complex |
| 4 | 4 | 8 | 7 | 6 | 3 | 16 | Clear menu structure | Concerns whether or not a system's menu structure is easy to understand |
| 0 | 3 | 8 | 2 | 5 | 4 | 11 | Aesthetics | Concerns the visual appeal of a system's interface |

| | | | | | | | | |
|------------|------------|------------|------------|------------|------------|------------|-------------------------------------|---|
| 4 | 8 | 5 | 5 | 5 | 7 | 17 | Comfortable | Concerns whether a system is pleasant to use, that is, comfortable, friendly and affective |
| 14 | 4 | 11 | 7 | 9 | 13 | 29 | Inspiring and interesting | Concerns systems that are inspiring, engaging, or the interesting to the user |
| 2 | 1 | 2 | 4 | 0 | 1 | 5 | Fun vs. frustrating | Distinguishes systems that are fun or likeable from those which are frustrating or annoying |
| 1 | 3 | 0 | 3 | 1 | 0 | 4 | Intuitive vs. focused effort | Concerns systems that are intuitive to use as opposed to systems needed that requires a focused effort |
| 2 | 1 | 2 | 1 | 2 | 2 | 5 | Powerful | Concerns powerful or expressive systems |
| 1 | 6 | 1 | 3 | 5 | 0 | 8 | Consistency | Concerns whether or not systems are consistent |
| 2 | 5 | 4 | 1 | 7 | 3 | 11 | Specialist vs. non-specialist users | Distinguishes systems that require specialist/knowledgeable users (primarily technically knowledgeable) from systems that make no such requirements |
| 2 | 7 | 6 | 0 | 0 | 15 | 15 | Pleasure | Describes systems that have other affective dimensions like pleasure etc. |
| 3 | 1 | 0 | 0 | 0 | 4 | 4 | Template/format | Describes systems that have a template to do work |
| 11 | 28 | 12 | 20 | 20 | 11 | 51 | Others | |
| 371 | 295 | 310 | 317 | 343 | 316 | 976 | | |

At software level the RGT interviews obtained a total of 976 ratings from 72 participants across three cultures and three stakeholders in each culture. The constructs and contrasts were qualitatively analysed for their meanings. All the 976 construct-contrast pairs were coded for affective, aesthetic or intellectual experiences. Number of elicited affective experiences was observed to be maximum in RGT interviews and HCI professionals had maximum constructs related to affective experiences followed by users. Developers had more of intellectual experiences reported in their constructs (table 5) . Significance level of

these differences was observed to be high ($\chi^2 = .000$). The difference in types of experiences reported across cultures was not significant though (table 6).

Table 6.21: Difference between stakeholder groups in use of experiential constructs

| | | Group | | | Total |
|------------|--------------------------------|-----------|------|------------------|-------|
| | | Developer | User | HCI Professional | |
| Experience | <i>Affective Experience</i> | 115 | 186 | 193 | 494 |
| | <i>Intellectual Experience</i> | 170 | 134 | 84 | 388 |
| | <i>Aesthetic Experience</i> | 32 | 23 | 39 | 94 |
| Total | | 317 | 343 | 316 | 976 |

Table 6.22: Difference between cultural groups in use of experiential constructs

| | | Culture | | | Total |
|------------|--------------------------------|--------------|----------------|--------------|-------|
| | | <i>China</i> | <i>Denmark</i> | <i>India</i> | |
| Experience | <i>Affective Experience</i> | 159 | 150 | 185 | 494 |
| | <i>Intellectual Experience</i> | 159 | 125 | 104 | 388 |
| | <i>Aesthetic Experience</i> | 53 | 20 | 21 | 94 |
| Total | | 371 | 295 | 310 | 976 |

Statistical Observations from RGT: One of the ways of doing quantitative analysis on the RGT data is using Multidimensional Scaling or MDS. MDS is a statistical technique that displays the structure of distance-like data as a geometrical picture. It creates the perceptual maps of the distances between the

images as reported by the users through ratings of the elements (in this case, 6 systems). MDS uncovers underlying relationship between the given objects based on a series of similarity or distance calculations. It takes an input matrix giving dissimilarities between pairs of items and outputs a coordinate matrix whose configuration minimizes a loss function called strain. (Kruskal and Wish, 1977). In order to interpret the findings of Multi Dimensional scaling, scatter plot of linear fit of the MDS data is used to determine the goodness of fit of the model to the data. In a perfect model, the scatter plots of linear fit forms a straight 45-degree line (Kruskal and Wish, 1977).

As in factor analysis, there is ambiguity in the labelling of axes in MDS. Subjective procedures use subjects and/or experts to "eyeball" the perceptual maps and infer dimension labels. Each object or event is represented by a point in a multidimensional space. The points are arranged in this space so that the distances between pairs of points have the strongest possible relation to the other similarities objects. That is, two similar objects are represented by two points that are close together, and two dissimilar objects are represented by two points that are far apart. As Kruskal and Wish (1977) suggest "The most common way of interpreting the multidimensional solution is to look for lines in space, possibly at right angles to each other.". As the Dimension do not signify anything except providing us with poles to compare along with, looking at the opposite ends of the dimensions and then comparing the images at diagonally opposite ends of the rectangular scatter plot, one can see the relationship between the images.

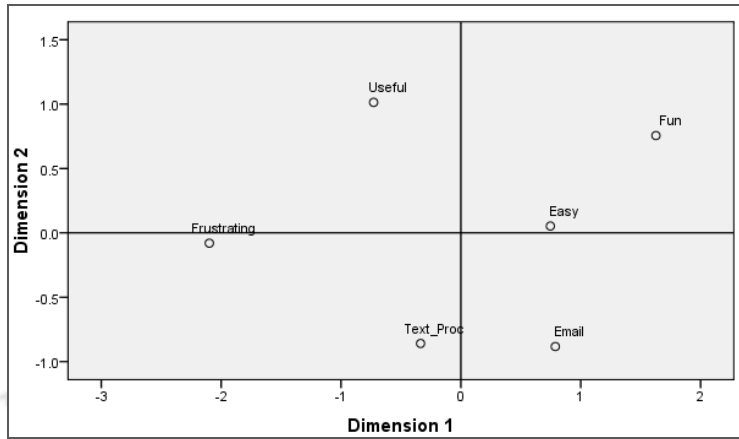


Figure 6.9: MDS on overall constructs

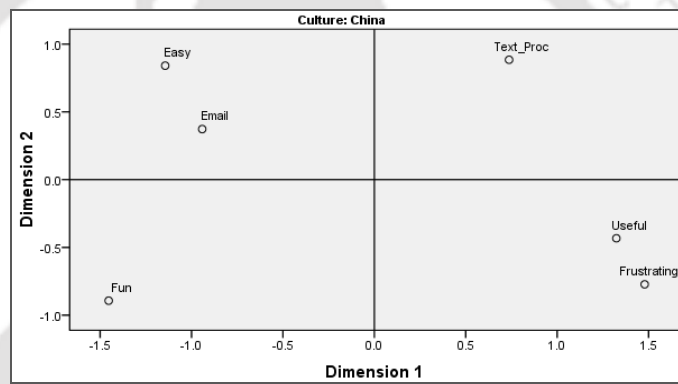


Figure 6.10: MDS on constructs from Chinese participants

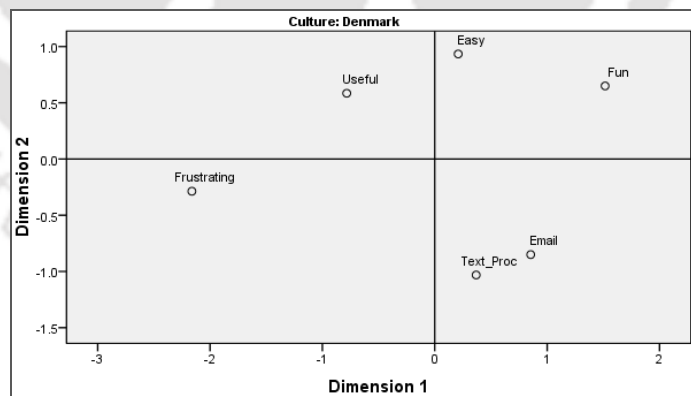


Figure 6.11: MDS on constructs from Danish participants

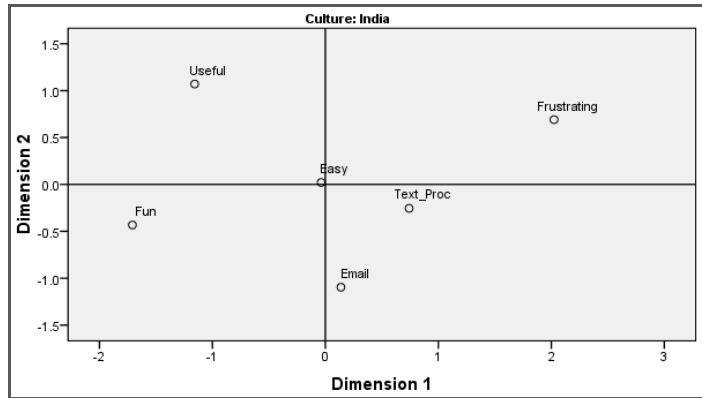


Figure 6.12: MDS on constructs form Indian participants

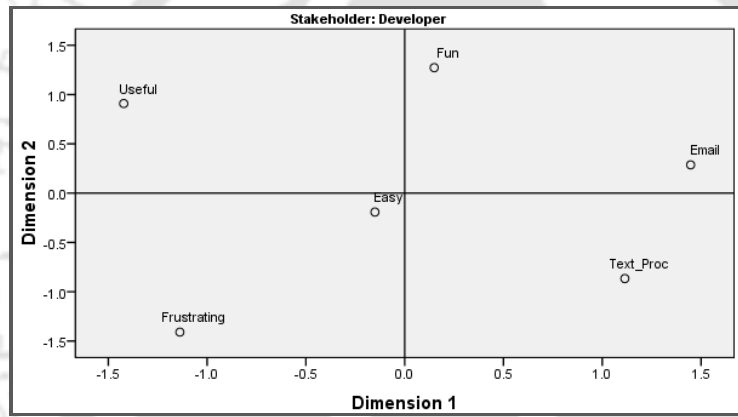


Figure 6.13: MDS on Developer's constructs

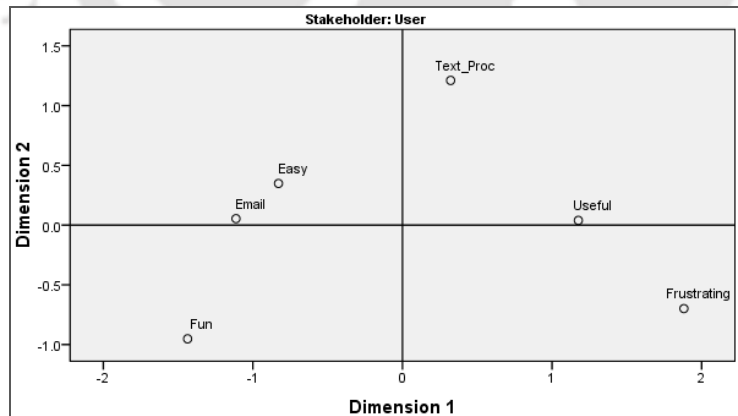


Figure 6.14: MDS on User's constructs

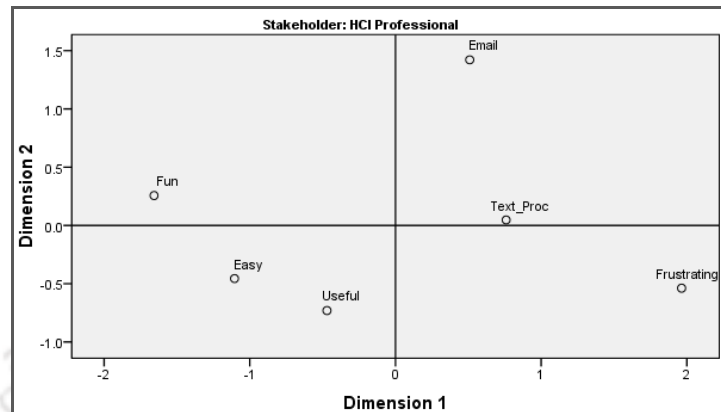


Figure 6.15: MDS on HCI Professional's constructs

6.4.2 RGT Interviews at compositional level (in one culture)

Aim: To study RGT's ability to mine experiential data form users at the compositional level of design decisions.

Background: Repertory Grid Technique requires triads of stimuli for it to operate. In the transitional level, as described in section 6.4.1, the triads were taken as memory based experiences, as the interaction level experiences are temporal and are accumulated over a period of time, which the experiment tried to elicit data from. At the composition level the temporal aspect on experience is not as strong as the transition level. A designer designs a screen; the composition of the screen gives a visual impression and creates an experience due to its presence. Ability of the RGT technique to gather data pertaining to experiences evoked at the compositional level has been investigated here.

Experiment Details: Total of 31 participants were interviewed using the RGT. The average age of participants was 20.6 years (std. dev. 1.6) and all were students at IIT Guwahati. All the participants were from a homogenous group of regular website users. They were shown 10 screen shots of different websites, taken three

at a time. One of the triads used for experiment has been exhibited in fig 6.16 for illustration, rest of the triads have been exhibited in appendix A, section A.4. From the given triad of screenshots, participants were asked to select any two similar screenshots in any respect as experienced by them. They were then asked to name the 'construct' by which the selected two were similar. The participants were then asked to give the 'contrast' by which the other screen shot was different. They were then asked to rate all the other screen shots on a seven point scale where the construct meant '1' and the contrast '7'. After they had rated, again a different set of three screenshots were presented to them and the same requests were repeated. This was done for all the different triads created from the 10 screen shots. They were constantly requested to give new constructs with every triad they were presented with. The interviews were stopped when the participants stopped coming up with new constructs. Total of 267 construct-contrast pairs were obtained from 31 participants at an average of 8.61 construct per participant. The obtained data was subjected to a number of qualitative and quantitative analysis techniques.



Figure 6.16: Stimuli used in RGT experiment at compositional level

Observations: As RGT data has both the constructs and the ratings of elements along those constructs hence both qualitative and quantitative analysis are possible on the RGT data. While the qualitative and quantitative analysis can be

performed separately but they reinforce and inform the inferences from each other. For instance, statistical techniques of clustering and scaling on RGT data help identify themes in the experiences elicited. The statistical grouping of constructs or elements helps identify the experiential similarity or differences among the elements as well as the different constructs. For instance hierarchical clustering of the constructs yields a pattern of response from users, as an example, fig. 6.17 displays one of broad clusters obtained from the analysis of constructs. The emergent experiential theme in the cluster displayed in fig 6.17 is 'strong and vivid graphics' which some users have experienced as 'shouting' and 'trying to sell something' while others have found as 'kiddish' and 'glaring'. These constructs carry deep experiential meanings and clustering those helps identify similar themes within the set of clusters. Together they are capable of informing the designer about the trends in the way users have experienced a given interface.

The 267 constructs were studied for the different types of constructs by looking at the meaning of each construct. Mostly the constructs were found to be related to the feel of the interface. Words often used to describe the compositions were cluttered, colourful, heavy, light, crowded, promoting culture or food, clarity in information presentation, clean layout, also affective constructs were observed. Constructs like, 'positive feelings'-'negative feelings', Fresh feeling, Friendly feeling, warm feel, cool feel etc. were also observed.

Some constructs had a much deeper connotation, in terms of the feel that they speak about the screen, for example, 'commercial/non reliable'. The user is saying that on end of his pole is 'commercial' and the other end is 'non reliable'. So does this mean that looking commercial is also synonymous with being professional? These become good questions to further probe.

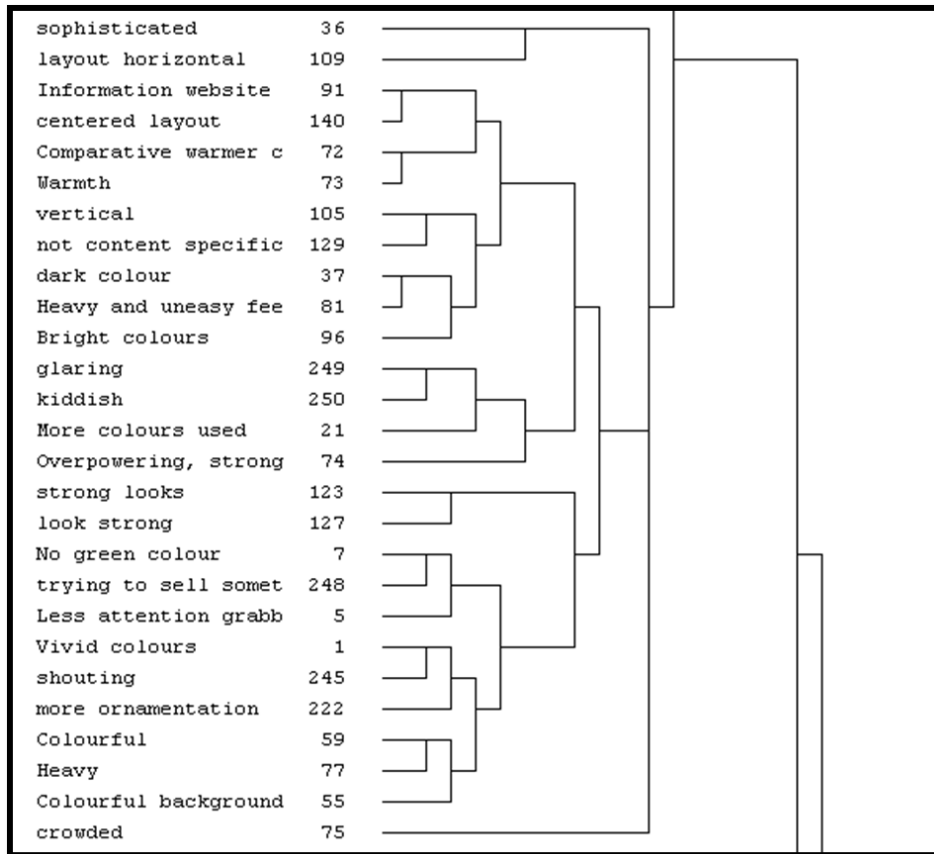


Figure 6.17: Cluster analysis on RGT data

When users report construct-contrast pairs like 'boring place'/'thrill and adventure' merely by looking at a screen shot, it becomes a good starting point for designers to look into the impression that the site is creating. Putting this data by side of the commercial concerns of the site, this becomes vital information towards improving the experiences of users. For instance, screen having 'more information' was also experienced as 'courageous and pinching', 'focused at promotion', and 'not attractive'. So should the stakeholders of the site dare to put more information at the cost of appearing un-attractive?

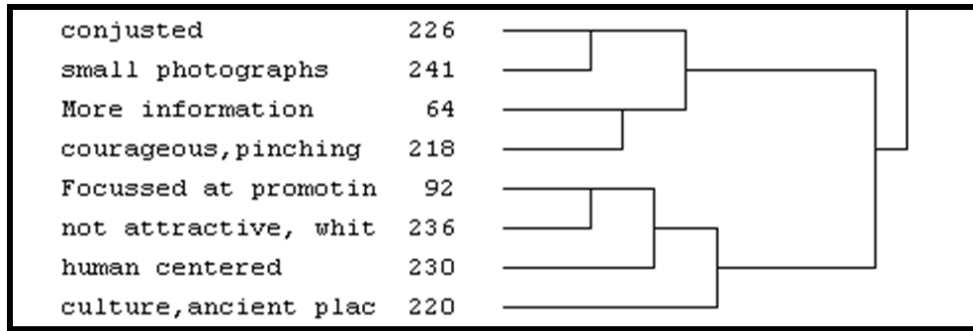


Figure 6.18: Digging deeper into users' psyche through cluster analysis in RGT data

Cluster analyses on the elements of the RGT experiment, the screenshots themselves, reveal how they were experienced by participants. As illustrated in table 6.19, the screen shots numbered 6,9 and 7 (table 6.23) were seen similarly and they were seen as vivid in colour, attention grabbing, attacking and not soothing or relaxing. Screen nos. 8, 10 and 5 (table 6.24) were seen as another closely associated group and they were felt to be full of advertisements, not daily life stuff, as promoting culture and tourism, too ethnic and professional but looking cluttered and shouting.

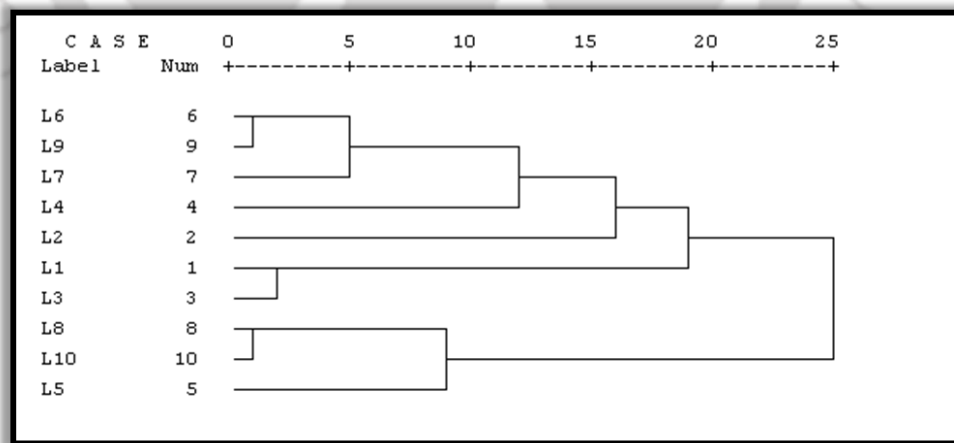


Figure 6.19: Dendrogram on the stimuli images

Table 6. 23: Analysing the stimuli with respect to constructs depicted in fig 6.19




| Screen no 6 | Screen no 9 | Screen no 7 |
|---|---|--|
|  |  |  |

Table 6.24: Analysing the stimuli with respect to constructs 6.19

| Screen no 8 | Screen no 10 | Screen no 5 |
|---|---|--|
|  |  |  |

Inferences: RGT was able to gather experiential data at the compositional level and provided wealth of information on the different ways in which people look at the screens.

6.4.3 RGT Interviews at elemental level (in one culture)

Aim: To study RGT's ability to mine experiential data from users at the elemental level of design decisions.

Background: Ability of Repertory Grid Technique to mine experiential data has been investigated at transitional level in section 6.4.1 and compositional level in section 6.4.2. After having observed the capability of RGT to mine deeper level experiential constructs from users at transition and compositional levels, investigations into its capability at gathering experiential data at the elemental level were conducted. Using the stimuli selected for elemental level experiments, triads were formed and were given to users during the RGT interviews.

Experiment Details: Total of 32 participants were interviewed using the RGT at elemental level data gathering. The average age of participants was 21.2 years (std. dev. 1.8) and all were students at IIT Guwahati in bachelor level programs. They were shown 21 dustbin icons, taken three at a time. For illustration, one of the triads used for experiment has been exhibited in fig 6.19, rest of the triads have been exhibited in appendix A, section A.3. From the given triad of images, participants were asked to select any two similar screenshots in any respect as experienced by them. They were then asked to name the 'construct' by which the selected two were similar. The participants were then asked to give the 'contrast' by which the other screen shot was different. They were then asked to rate all the other screen shots on a seven point scale where the construct meant '1' and the contrast '7'. After they had rated, again a different set of three screenshots were presented to them and the same requests were repeated. This was done for all the different triads created from the 21 screen shots. They were constantly requested to give new constructs with every triad they were presented with. The interviews were stopped when the participants stopped coming up with new constructs.

Total of 212 construct-contrast pairs were obtained from 32 participants at an average of 6.62 construct per participant.



Figure 6.19: Stimuli used at elemental level RGT experiment

Observations: Initial constructs obtained described the superficial look and feel of the images rather than deep experiential constructs. Initial constructs were like, ‘circular’, ‘box like’, ‘colourful’ etc. With further probing and participating in the interview, participants did divulge some deeper experiential constructs. Participants used constructs like ‘has an urban feel’- ‘has a rural feel’, ‘looks casual’- ‘looks professional’; ‘bubbly’- ‘traditional’; ‘adult like’- ‘childish’; ‘artistic’- ‘not expressive’, ‘traditional’ - ‘modern’; ‘raw’- sophisticated; ‘masculine’- ‘feminine’ ; ‘stylish simple’; ‘Modern’ – ‘classic’. These give a very deep insight into the kinds of meanings users associate with any given image.

The RGT interviews were observed to be more difficult with the elemental level stimuli than the compositional level stimuli. The participants consistently came out with more superficial constructs than the experiential constructs. This could be due to the elemental level stimuli being less rich visually, having less expressive elements in them, was not evoking the affective, aesthetic or intellectual experiences strongly enough in the participant so as to elicit deep level constructs.

While this could be a weak point in usage of RGT at elemental level, but given that it does elicit some experiential constructs which are otherwise difficult to gather through other techniques, it is recommended here that RGT be used at elemental level data gathering as well.

6.4.4 Inferences from experiments with RGT

Foremost observation is that RGT can be used at all the three levels of design decisions. It provides access to the user's personal constructs. Users have unique way of observing the interfaces and interactions. They use their own terminology to describe their experiences.

It was comparatively more difficult to gather experiential data using RGT at the elemental level than at the compositional level and further it was easier at transitional level. Participants had difficulty in eliciting experiential and deeper level constructs in general but it was more observable with the elemental level data collection. The interviewer has to be patient in the interview technique, as the participants take longer to come out with experiential constructs. Sometimes, even an issue in expressing the experience through a construct was noticed, in that case interviewer has to help the participant by carefully maintaining a neutral stand.

6.5 Experiments with Semantic Differential technique

Semantic differential is an established technique for measuring connotative meanings. It has been used to measure affective meanings too. Here, semantic differential technique has been used to elicit affective experiences from the users.

The constructivist view presented in section 3.5 will be used here to elicit emotional experiences with images using semantic differential technique with affective scales. Nine emotional categories from Nāṭyasāstra (Chākyār, 1975) has been taken in this experiment as the nine measurement scales for semantic differential. The same emotional categories have been found to be also persistent across other lists of basic emotions as well (Ortony and Turner, 1990). These scales were used to measure participants' responses on a 7 point rating scale. Semantic differential technique was used to gather data at the compositional and elemental levels of design decisions.

All the data gathered using SD technique were done with Indian participants only and no cross cultural studies were involved. The reason for not doing any cross cultural studies is that SD is an established technique and has been in use across cultures for measurement of meaning. Cultural suitability of the technique is not an issue with SD technique for it involves very objective rating of the stimuli and there is not much scope for a dialogue or conversation between the interviewer and the participant. Only when there is likeliness of influence of the interviewer's and user's cultural backgrounds on the process of data gathering and hence affecting the quality of data gathered that a cross cultural study for cultural suitability of the technique has been conducted as a part of this research. Further, identification of cultural sensitivity of the technique is also not an issue with SD. Cultural sensitivity of the SD technique, which is its ability to mine data pertaining to cultural differences from the users with respect to affective experiences would be automatically assessed if the SD is able to gather affective experiences from users effectively. The differences in the affective experiences across cultures would thus be reflected in the data gathered from different cultures.

6.5.1 *Gathering affective data at compositional level using SD.*

Aim: To identify issues in gathering experiential data for composition level design decisions.

Research Questions: how do users give affective responses to the compositions when they are used as stimuli?

Background: As elemental level design decisions are concerned with the design decisions pertaining to the elements of the interaction like menu items, icons, graphic elements etc, the compositional level is concerned with the arrangement of the elements on interfaces, namely, menu items, icons and graphic elements on the screen. Experiential at the compositional level may be a little more than just summation of the experiences with the elements, the visual balance of the elements in relationship also expected constitute to the felt experience.

Research Design: 33 participants rated 10 layout compositions on 7 point affective scale. The nine affective categories were used as scales in this experiment too. The 10 layout images were screenshots of 10 national tourism websites of different countries.

Observations: ANOVA table (table 6.25) reveals that the agreement between participants on emotions elicited by the layouts was statistically significant for consideration of this data for further use by designers.

A sample of elicited data by users has been displayed in fig 6.20. The entire set of graphs representing the affective responses against the stimuli used has been displayed table D.1 of appendix D.

Table 6. 25: ANOVA on SD data at composition level

| | | <i>Sum of Squares</i> | <i>df</i> | <i>Mean Square</i> | <i>F</i> | <i>Sig.</i> |
|-----|----------------|-----------------------|-----------|--------------------|----------|-------------|
| L1 | Between Groups | 259.845 | 8 | 32.481 | 11.350 | .000 |
| | Within Groups | 824.182 | 288 | 2.862 | | |
| | Total | 1084.027 | 296 | | | |
| L2 | Between Groups | 164.896 | 8 | 20.612 | 7.125 | .000 |
| | Within Groups | 833.212 | 288 | 2.893 | | |
| | Total | 998.108 | 296 | | | |
| L3 | Between Groups | 81.603 | 8 | 10.200 | 3.394 | .001 |
| | Within Groups | 865.455 | 288 | 3.005 | | |
| | Total | 947.057 | 296 | | | |
| L4 | Between Groups | 420.121 | 8 | 52.515 | 18.204 | .000 |
| | Within Groups | 830.848 | 288 | 2.885 | | |
| | Total | 1250.970 | 296 | | | |
| L5 | Between Groups | 110.532 | 8 | 13.816 | 4.852 | .000 |
| | Within Groups | 820.121 | 288 | 2.848 | | |
| | Total | 930.653 | 296 | | | |
| L6 | Between Groups | 394.182 | 8 | 49.273 | 13.228 | .000 |
| | Within Groups | 1072.727 | 288 | 3.725 | | |
| | Total | 1466.909 | 296 | | | |
| L7 | Between Groups | 359.818 | 8 | 44.977 | 16.873 | .000 |
| | Within Groups | 767.697 | 288 | 2.666 | | |
| | Total | 1127.515 | 296 | | | |
| L8 | Between Groups | 206.545 | 8 | 25.818 | 9.254 | .000 |
| | Within Groups | 803.515 | 288 | 2.790 | | |
| | Total | 1010.061 | 296 | | | |
| L9 | Between Groups | 122.364 | 8 | 15.295 | 4.860 | .000 |
| | Within Groups | 906.364 | 288 | 3.147 | | |
| | Total | 1028.727 | 296 | | | |
| L10 | Between Groups | 703.279 | 8 | 87.910 | 34.628 | .000 |
| | Within Groups | 731.152 | 288 | 2.539 | | |
| | Total | 1434.431 | 296 | | | |

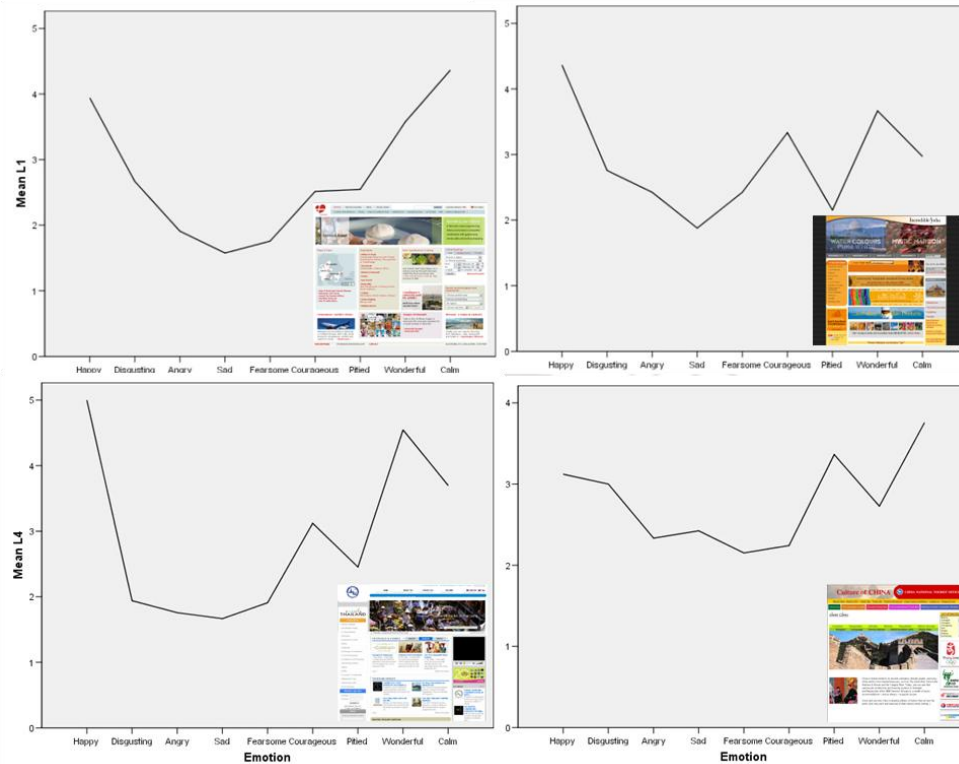


Figure 6. 20: Affective responses using SD at composition level

6.5.2 Gathering affective data at elemental level using SD

Relevance: After having confirmed that the group of participants in general agree to the affective experiences the stimuli images have generated, it becomes of interest to the designer to recognise the features and characteristics of each image that could have caused the affective responses from the users. It is posited that this understanding would help the designer in designing intended affective experience in icons and images.

Materials and methods: The data collected using the SD technique from 59 participants with 21 images was statistically described with respect to each images stimulus.

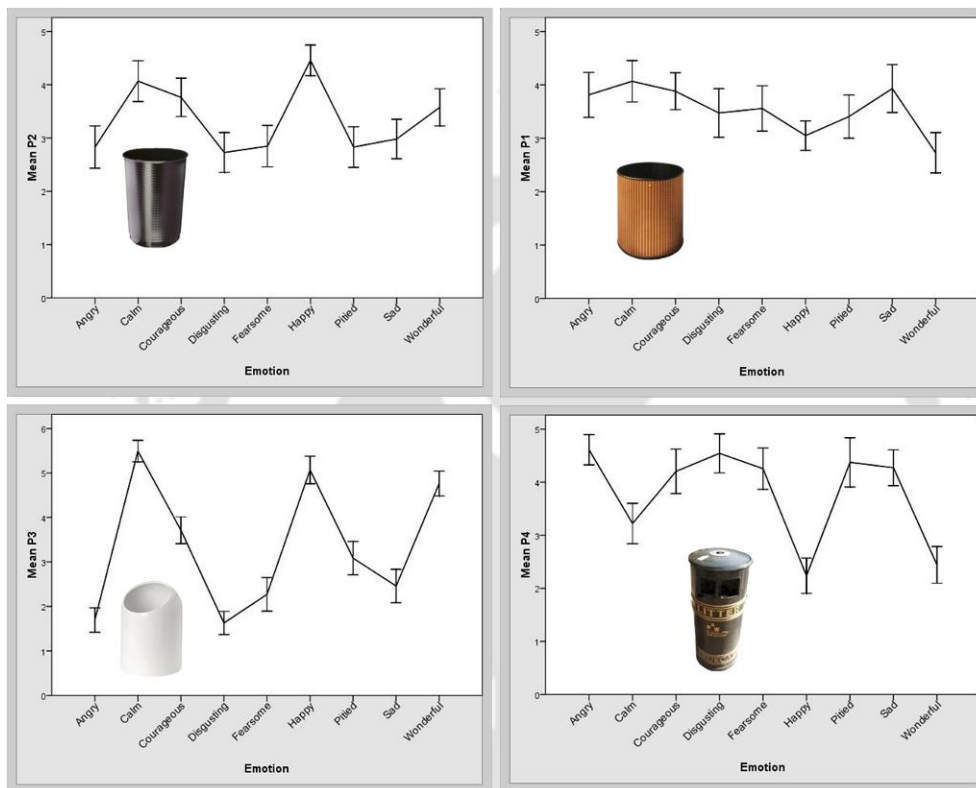


Figure 6.21: Affective data from SD at elemental level

Observations: A sample of the affective responses obtained using semantic differential technique with stimuli at elemental level has been displayed in fig 6.21. The entire set of graphs describing the affective responses along the nine emotional categories for all the 21 images has been displayed in Table D.3 in appendix D. 95 percent confidence intervals of each mean rating has been shown on the mean plots. Scales used on each image are different due to truncation of empty spaces in the charts on the top. The images have been numbered starting with alphabet P followed by the image number.

Image numbers 3 and 15 have received the maximum positive ratings on positive emotions while image numbers 1 and 4 have received the maximum ratings on negative emotions. A detailed analysis of the features responsible for the affective responses has been done in section F.1 of appendix F.

6.5.3 Identifying categories in affective experiences

Aim: To study how different basic emotional categories are related to each other.

Background: Emotions research talks about valence in emotions. This means that emotions can be categorized as positive or negative. In this study, emotional categories have been identified from Indian dramatics treatise and though the basic emotion categories from this list have maximum recurrence in other lists too, there is curiosity to find whether these categories show any groupings like valence theory in Emotions research.

Materials and methods: The data collected using the SD technique with 21 images was analysed with two statistical processes. One is multidimensional scaling and the other is cluster analysis.

Observations: As depicted in fig 6.22, in results of cluster analysis, emotions 'happy' and 'wonderful' were found to be very close. Also 'angry' and 'fearsome' are observed to be very close. Also results from multidimensional scaling show the same pattern. This means that the participants have reported experience of happy and wonderful in similar ways. Stronger grouping of emotions 'happy', 'wonderful' and calm one end and 'angry', 'fearsome', 'disgusting', and 'sad' on another, revalidate the valence theory in a way observing that the first group is the group of positive emotions and the second group is negative ones. 'Courageous' and 'pitied' are on opposite ends of dimension 1 in the MDS (fig

6.23) but are not strongly grouped with either of the groups. This means that they are not neutral emotions but they do not strongly belong to the two valences of the emotions that is positive and negative emotions.

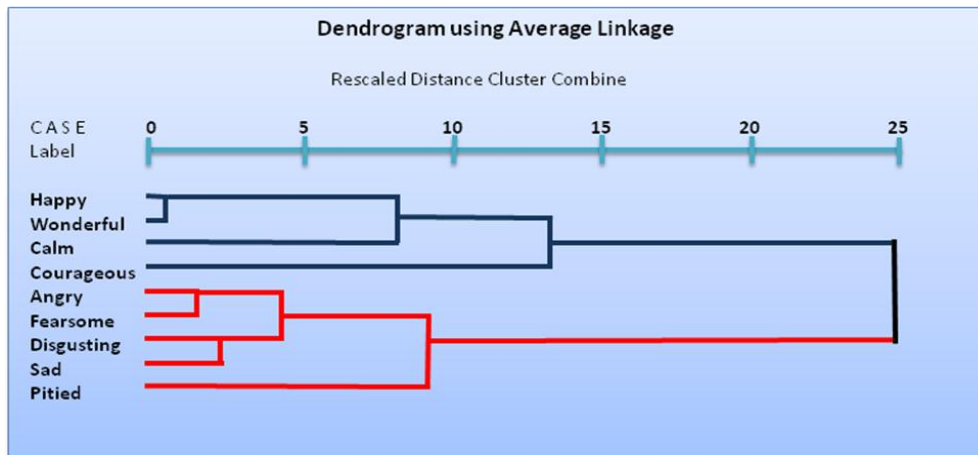


Figure 6.22: Dendrogram of emotions to identify categories in the nine emotions

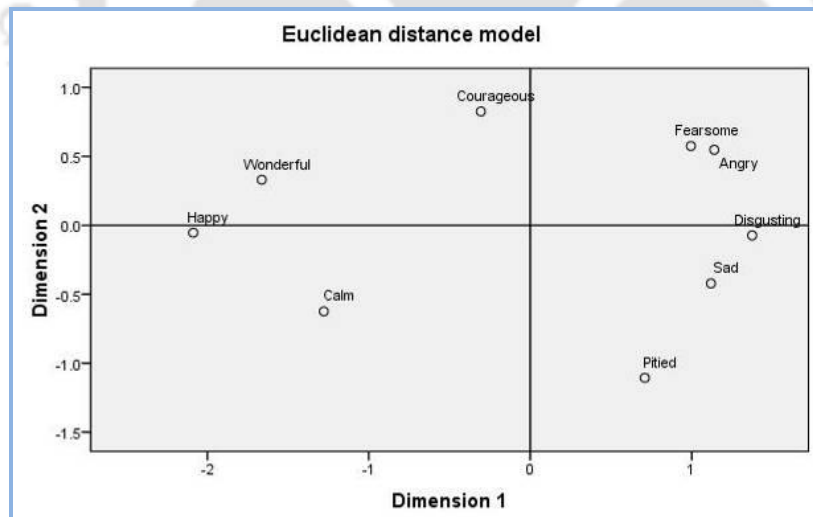


Figure 6.23: MDS on emotions showing relationship between them.

Inferences: Semantic differential technique is able to gather experiential data from the users pertaining to their emotional responses and it is capable of showing the valences in emotions which could be useful to the HCI designers.

6.5.4 Identifying categories in stimuli images with respect to emotion elicited

Aim: To investigate if the images used for experimentation show categories on the basis of emotions elicited by them.

Background: The stimuli images were selected for maximum variation. This is a statistical attempt to see how varied the different stimuli were. This observation would be of good help to designers who are visual people (Malamed, 2009) who think and act in visual media. A visual presentation of categories in the stimuli can help them think in terms of the possible visual reasons for elicited emotions which they could further into the design thinking.

Materials and methods: The data collected using the SD technique with 21 images was analysed using multidimensional scaling.

Observations: The goodness of fit achieved in the Multidimensional scaling (fig 6.25) shows almost a straight line at 45 degrees to the base. This means that the data was fitted satisfactorily to the distance model created in fig 6.24. As depicted in fig 6.24, from the results of multidimensional scaling it is evident that Image 4 which was seen as the most fearsome, most disgusting, most angry and most pitied among the group of 21 images stand out of the group at the extreme right on dimension 2. Image 15 and image 3 were the most happy, most wonderful and most calm among the group, stands out on the extreme left of dimension 1.

Images 19 and 21 seem to have neutral affect values as they do not elicit any emotions almost.

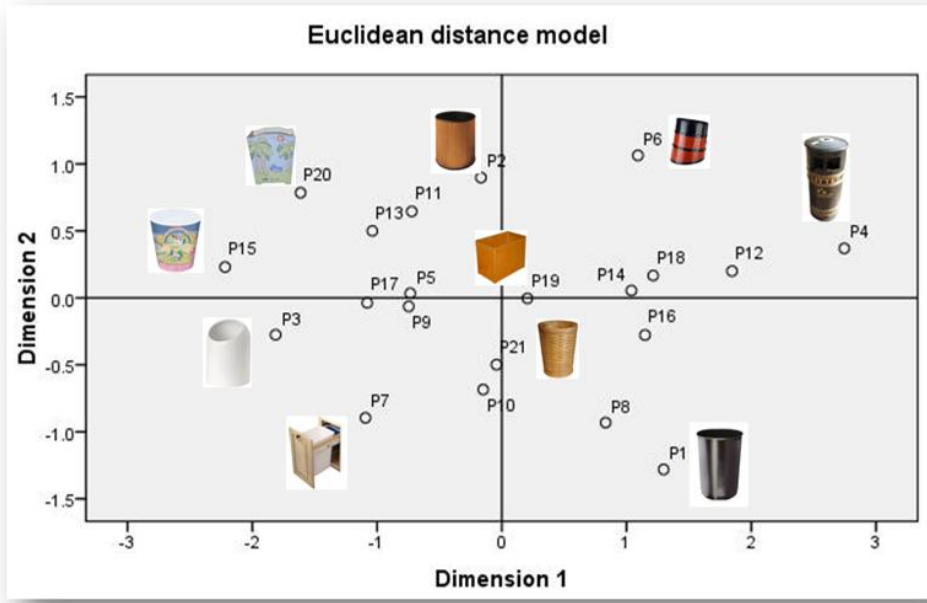


Figure 6.24: Multidimensional scaling on images used as stimuli.

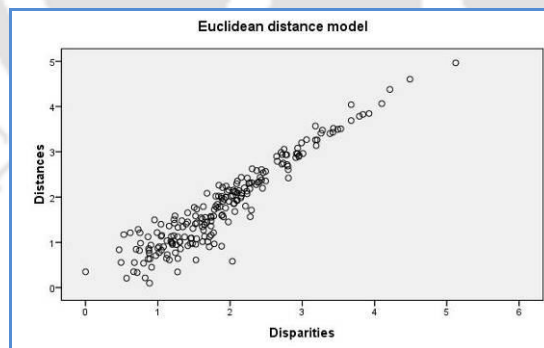


Figure 6.25: Goodness of fit for MDS on stimuli images

Scaling techniques like MDS, can help identify the features in images that lead to certain emotional elicitations. This perceptual presentation of affective data with respect to stimuli images can be very helpful to designers design decisions at elemental levels as they can clearly see the affective valence in images.

The distance measure used in MDS for this analysis was the classical model or principal component analysis. Mapping was done using the rectangular matrices of 9 emotions by 21 images at a time. This revealed the comparative spacing between the images taking into consideration the emotions they were being compared for. The result has been displayed in fig. 6.24. The goodness fit curve (fig 6.25) shows that the MDS is representing a fairly accurate picture of the distances between the images as felt by the participants.

6.5.5 Ancillary experiments with SD

Semantic differential technique proved to be a very quick and efficient technique of gathering affective data. Participants responded confidently to the semantic scales. Author observed them to be clear in their mind about what emotion was elicited by which image and about how much to give them the rating. No behavioural indication of uncertainty or doubt towards the ratings was observed in participants. Though the imageries associated with stimuli images as reported by participants in process of rating differed from participant to participant, fair amount of consistency was observed in the reported ratings along the nine emotions.

Observing the similarity in reports of different users, statistical test to confirm the semblance was done. Details of investigation into finding similarity between participants' affective responses have been presented in section D.2 of Appendix D. It was observed that the participants mutually agree in the category and

intensity of emotions felt in a given icon. The affective responses to the stimuli presented were not arbitrary. Further, the responses of participants on affective scales to the stimuli presented had consistency over a period of time. Participants did not change their opinion about the emotions felt in the icons even after a gap of 18 months. Details of the longitudinal study with icons as stimuli are presented in section D.3 of appendix D.

From the above two observations, the semblance of affective responses across participants and consistency of these responses over time, it is inferred here that it is possible to design for users affective experiences which can meet a prefixed criteria. This idea will be taken forward in next section, section 6.6, which briefly describes experiments done with designers design decision making process in presence of user data on affective experiences.

6.5.6 Inferences from experiments with semantic differential

Semantic differential was observed to be a quick technique to gather experiential data of affective nature. Participants found it easy to elicit affective responses along the affective scales created by the experimenter. Semantic differential gives quantitative data which can be statistically analysed. The stability of the affective responses over time has also been confirmed in the longitudinal study done and the semblance of affective responses was statistically found to be high. It is thus posited here that semantic differential could be a useful technique in gathering experiential data when the semantic scales along which experiential data has to be gathered already exists. Though deep mining into the causal and effectual relationships of the experiences is not facilitated by the SD technique but due to its resource efficiency, both in terms of users' time needed and interviewer's effort required, it can be effectively used to validate any experiential constructs

across a range of users quickly. SD needs visual stimuli for ratings and unlike the RGT technique there is no restriction on the minimum number of stimuli required for conducting SD based data gathering. However SD technique can be applied to gather data pertaining to only the elemental and compositional level design decisions as it can efficiently handle the moment based experiences with a given static stimuli. SD technique was tried at transitional level with a couple of participants but the experiment was discarded after observing that when asked to rate along the affective scale, their experience with an interactive system, they gave inconsistent . For instance, when asked to rate their experience with MS word usage though they gave a rating

6.6 Experiments with designers' design thinking process

The user data gathered in Semantic differential experiment at elemental level, using dustbin icons, was given to designers' under a prescribed design task. A before-after research design was followed for this study. Designers were asked to design a dustbin icon in absence of user data. They were asked to design a 'happy' looking dustbin.

In absence of user data, the novice designers created direct analogies of 'happy' onto the dustbins, like pasting a smiling face on the front of it or creating a morning sun on the dustbin to say, that mornings are happy (fig 6.26). Designers were then given user data tool which had all the statistical charts created from the affective data gathered by using semantic differential technique in section 6.5.2. Designers found it hard to comprehend the charts to infer from the charts the necessary clues for design decisions. Designers were then given user data having qualitative verbalisations along with the quantitative charts. This time the designers found it useful and reported high on satisfaction of use of the tool.

They felt confident in their design decisions when they used the user data tool (a tool created from sequentially arranging the image stimuli along with the users' responses on slides as depicted in fig 6.27). But it was found that the designers, who were novice, were directly influenced by the images already present in the user data tool. The tendency to copy the features appreciated by users into the design they were creating was observed (fig 6.29). Novel design solutions were not observed. Hence a fuzzy Inference based tool was developed which was based on rules derived from the user data. Perceptual rules mapping the surface features of the icons to the emotions elicited were fed into the fuzzy inference system and after checking it for accuracy, was given to the designers to use as an aid in design thinking. This time novel design solutions with accuracy in emotions elicited were observed. Expert designers' opinions were sought and they reported the design solutions as better than the previous ones (fig 6.30). Details of these experiments are presented in appendix G. The fuzzy inference system creation process has been described in appendix F and the User data tool given to designers has been exhibited in appendix E.



Figure 6.26: Design cognition in absence of user data

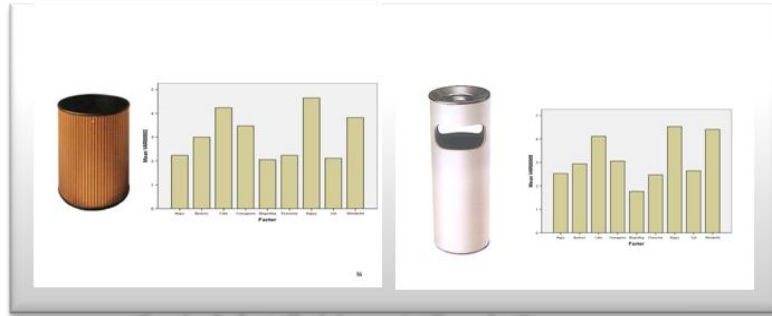


Figure 6.27: User data tool with statistical charts

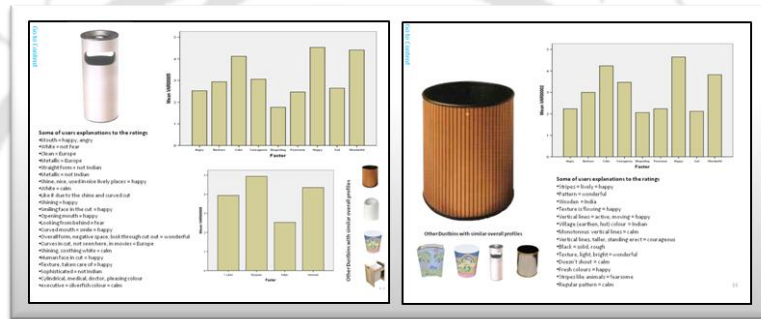


Figure 6.28: User data with qualitative reports added



Figure 6.29: Design cognition in presence of user data

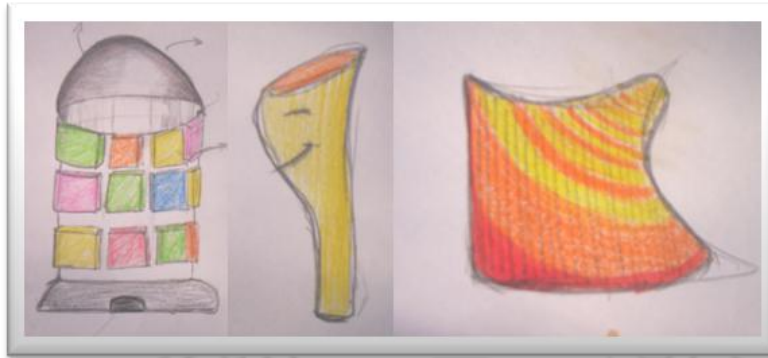


Figure 6.30: Design cognition with help of Fuzzy Inference System

6.7 Conclusions

This chapter has presented experimental investigations done with the four techniques. This chapter has also presented the experiments investigating influence of user data on designers' design cognition. It was observed that while the Think aloud technique does not yield sufficient experiential data on users' interaction with the computers, Mind tape comes good at this. But both these techniques can be applied only at the transitional level of design decisions. At the compositional and elemental levels of design decision making, Repertory Grid and Semantic differential techniques were found to gather useful experiential data. Repertory Grid technique was found to not only gather data at all the three levels of design decisions, but was also found capable of mining deeper level experiential data as well. Cultural suitability of Mind Tape was observed to be higher than the cultural suitability of think aloud technique as the dialectical nature of east Asians demanded a more 'natural' and 'conversational' technique which MT fulfilled in place of 'mechanical' verbalisations which TA was observed to be. Cultural sensitivity of MT and RGT was found to be good as they were

able to bring forth data on cultural differences in the way users experienced the interactive systems.

Each of the four techniques was also found to have its own merits and limitation. These observations have been collated and discussed in chapter 7, through description and comparisons of findings from investigations with each technique.





COMPARITIVE STUDY OF THE FOUR TECHNIQUES AND THEIR
INTEGRATION INTO THE EXPERIENTIAL DESIGN
METHODOLOGY

7.1 Introduction

This chapter discusses the findings from the investigations with four techniques and compares them for their ability to elicit experiential data from users at the three design decision levels. The four techniques identified from literature as promising candidates for experiential data gathering in HCI Design, namely Think Aloud, Mind Tape, Repertory Grid and Semantic differential, were experimentally investigated by collecting data from users using the techniques. The experiments and their findings have been reported in chapter 6. This chapter summarises the findings by discussing the results from experiments using each technique and by making comparative analysis of the abilities of each technique.

As identified in chapter 1, the user centred design process employed for HCI design involves iteratively collecting data form users in order to inform design decisions of the designers. Literature survey helped identify gap in HCI literature where the need for designing for experience of users has been iterated but the process for designing for users' experiences has yet not been identified and universally agreed upon as presented din chapter 2. In order embark on the experiential design process, it was realised that a working model of users in HCI is needed to understand the experiential processes within the users. A user model for use in experiential design process was proposed in chapter 3 and on basis of

the model, criteria for adjudging data gathering techniques which will help gather experiential data from users was also identified. Chapter 5 reported the research framework and the research design for each of the experiments conducted with the identified techniques. The user model created in chapter 3 and research design created in chapter 5 guided the conductance of investigations reported in chapter 6. As outlined in Chapter 1, the purpose of conducting the reported experiments was to identify if the selected techniques elicited experiential data and whether they were suitable for application in cross cultural data gathering situations. This chapter discusses the observations and inferences from the investigations and proposes an experiential design process wherein these four techniques could be appropriately used for gathering data from users.

First, strengths and weaknesses of each technique as observed through the studies are discussed in section 7.2. This is followed by comparative studies between the techniques. The techniques are compared for the quality of data elicited, resources used and levels of design decisions they are suitable for. On the basis of conclusions drawn from each of the experiments, recommendations for further studies have been suggested.

7.2 Inferences from observations on each technique

This section describes the inferences drawn from the studies done with each technique with respect to their applicability in experiential design framework. As reported in section 6.2 to 6.5, several experiments with each of the four techniques were conducted and observations regarding their ability to gather experiential data were made. Several ancillary experiments supporting the main studies were also conducted which have been reported in the appendices B to F and have been cited during the course of discussion in chapter 6. While the

reports on each experiment, presented as subsections of each section from 6.2 to 6.5, described the findings and inferences from each individual experiment, here the overall inferences from the experiments for each technique is being presented.

7.2.1 Observations on Think Aloud technique

From industry survey conducted across three cultures, it was identified in section 6.2.1 that Think Aloud technique, in spite of being practiced universally in HCI design process (Boren and Ramey, 2000), does not have a standard format. Culture has an influence on the way TA is practiced across cultures. Accounts of retrospective verbalisations, explanations and conversation were noticed which are not as per the standard protocol for TA (Ericsson and Simon, 1993). The relationship between user and evaluator was also observed to be culturally modified. For instance, the hierarchy of Indian culture demanded that the evaluators do not talk as equal to the user but act as a subordinate in order to ensure that the user feels in control to share sufficient information which could be useful to the designer. The conflict between theory and practice of the TA observed in the survey is intriguing. After all what causes the practice to drift away from the theory? On the basis of observations made during the industry visit, author posits here that it was the need to get 'more meaningful' data from the users and the need to appear 'more natural' by the users that a conversational mode was observed. On one hand, the evaluators need to get a good understanding of what is happening in users mind and on the other hand users want to do the task before letting the evaluator know what he/she is doing. This mutually shared need facilitates a conversational mode during TA. The problem with respect to these conversations, in context of the experiential design framework, is that the experience of users with the system gets modified in the

very process of gathering the user data. If the interviewer becomes an entity in the interaction of users with computers, then the experience with interviewer will also become part of the gathered data and the data would be biased about the experience user had with the system. Hence need for a better technique in experiential design framework was felt during the industry survey.

During the Think Aloud experimental tests that were conducted across three cultures (section 6.2.2), the following set of observations were made: a) One of the observations critical to the experiential design framework was long durations of silence during the TA tests. It has been mentioned in literature that the TA verbalisation slow down or turn into silence when cognitively loaded tasks are undertaken by users (Ericsson and Simon, 1993). From experiential perspective, it is important to know what the user 'felt' during that time, as process of experience is a continuum where each preceding event affects the experience of one following it (Dewey, 1988; McCarthy and Wright, 2004). Unfortunately in TA session, there is no way one can probe or get to know what these silent moments meant to the user in terms of experience without disturbing the user during interaction with the system and interference with system would again mean an interference in the experience that the user is undergoing in its relationship with the system. b) Particularly, silence was recurrent among participants when the user was trying to make sense of interface in initial phases of interaction. As mental processes critical to influencing the entire succeeding experiences occur during this time, like the aesthetic appreciation and initial opinion formation, it is imperative that data pertaining to this phase of interaction be gathered. While following TA protocols it is not possible to achieve this. c) Further, Indian participants had reported the mechanical and artificial nature of TA, wherein a person having to keep speaking without any colloquial response, found it boring. It was reported that the act of continuous verbalisation was 'not fun'. Further the quality of data elicited during the TA sessions was not rich. They

contained accounts of what the user was ‘doing’ rather than what the user was ‘feeling’. It is thus stated here that TA would not be a useful technique for gathering data in experiential design framework.

7.2.2 Observations on Mind Tape technique

Mind tape technique was observed to be efficient in facilitating a narration of experiences with users after the task was fulfilled (see section 6.3, table 6.14). Users reported satisfactory recall of the events just completed during the task fulfilment. Further this technique was found to be culturally suitable as it resembles an ethnographic interview technique in style and intent. It allows the user to participate as one would naturally do in any social set up. This technique was found to be especially helpful in East Asian set ups, like India, which has a relational and dialectical social characteristic. The users found it ‘natural’ and ‘enjoyable’ as it let them unwind and talk about their feelings. A receptive listening was found to be engaging enough to share one’s deep level experience. Due to these reasons, it is posited here that Mind Tape would be suitable technique in experiential design framework.

Mind tape technique caters to the philosophical traditions of ‘embodied mind’ and ‘phenomenology’, which negate the sole dependence of human experiences on the mental processes alone. The emphasis on understanding human experiences in terms of the “implementation details” rather than merely through the mental processes is well accommodated in the Mind tape technique as the verbal expressions of users’ experiences are situated in the context of the interaction just finished and the interviewer forms an understanding of this context through prior observation of the interaction.

However, Mind tape can be used to gather data only pertaining to the transition level design decisions. It requires a complete working interactive system to be applied. Also, this technique is resource consuming and takes more than double the time that a normal TA session would take for the same task. Also analysing the Mind tape data is resource consuming, for the data comes in forms of dialogues and conversations. Unlike statistical analysis the text requires longer periods of time to analyse and the findings are subject to interpretation to a greater degree than most of statistical reports. For this reason Mind Tape should be used judiciously in the interaction design process.

One of the sensitive characteristic with Mind tape technique is development of an empathetic yet neutral interviewing style by the data collector. The ability to pull out the experiential data from deep within the users, with minimal nudges, both through language and through non verbal cueing, is an art which will be required for an efficient Mind tape interviewer. This art can be perfected through training and practice. Though this kind of qualitative and open ended interviewing technique is not new to the different faculties dealing with human understanding, yet it is required to be developed by the interaction designers in order to practice Mind tape interviewing efficiently.

7.2.3 Observations on Repertory Grid technique

Repertory Grid was found to be a very versatile technique which could mine experiential data from deep within the users at all the three design decision levels. Both qualitative and quantitative data are obtainable through the RGT interviews. In a way, the two types of data reinforce the findings of each other, and guide richer interpretations, catering to the need of the experiential designers. As described in section 6.4, in context of various experiments conducted, RGT data

was found to afford multiple analysis techniques, helping the experiential designers in inferences suitable to their need. Some statistical processes, like scaling and clustering have been used in this thesis and qualitative analysis methods like content analysis have also been attempted on the results of RG experiments. It was found that the unique ability of RGT technique to both collect qualitative data and also be in a position to validate findings quantitatively is helpful to the experiential design process. Hence, it is posited here that RGT can be used as an effective data gathering technique in experiential design process. However, the data gathered from RGT can serve as a good starting point for further explorations into the user psyche, as RGT only gives pointers to the experiences that are unique to individuals and not give the entire structure of the experience. On one hand, the associations and actions causing and forming the experience can be further explored in detail with a qualitative technique and on the other hand the elicited constructs can be validated through statistical techniques across a class of users. RGT data gives an indication to deep individual experiences that a person has undergone in interaction with a digital product and user elicits it through personal constructs.

A personal construct is a unique experience that the user had with an interactive system under study and that the experience was an important element in the relationship of user with the interactive product. This information needs to be validated further. As illustrated in fig 7.1, one of the ways to do this would be to mine deeper into the fabric of that particular experience so as to understand the web of actions, associations, causes and effects of that experiences with respect to the relationship with the interactive system. A second approach would be to take that experience as a scale and validate the ubiquity of that experience with other users in the domain under study. The former effort of mining deeper can be facilitated by Mind tape technique, if the interaction is available for use by user or by any other similar ethnographic style interviewing technique which can

empathetically dig deeper into users' experiences. The latter effort of validating the experience could be done by the Semantic differential technique, which acts in a very objective way, requires less time and effort and is easy to collect data from many users in short time. The experience elicited as a construct during RGT interviews and having identified as an important factor in the users' experience with interactive system under design can be used to construct a semantic scale for validation with other users. The semantic scale can be created keeping the construct contrast poles as the ends of scale and can be applied to a large number of users to validate if one user's experience was also instrumental to other users perception of the interactive product under discussion. In view of the author, both the above directions for search are suggested to be adopted. On one end understanding the users' deep experiences are critical to designing a system that would satisfy him/her and on the other end identifying the needs of the majority of users is critical to the business success. Hence probing 'deeper' as well as validating 'wider' would be a strategy for success in experiential design field.

Selection of elements which can be used in RGT interviews to yield the deep level constructs from users is crucial to success of RGT in interaction design domain. At composition level, either existing products along with the new product being proposed can be used for electing experiential constructs or the different concepts of the new products can be used. Either will identify likely experiential constructs which users will have towards the product being designed. While at the business competitive level, it would help in refinement of the developing, positioning or marketing of the product; at the concept development level it will help identification of the most suitable concept for further development. At the concept development level RGT can also help identify the individual characteristics of each concept found favourable by users. This identification can also guide merger of the elements of each concept to create a better solution having positive experiential qualities. The same applies to the

elemental level as well. Different icons, graphic elements can be compared, to identify the most suitable ones for a given graphic user interface.

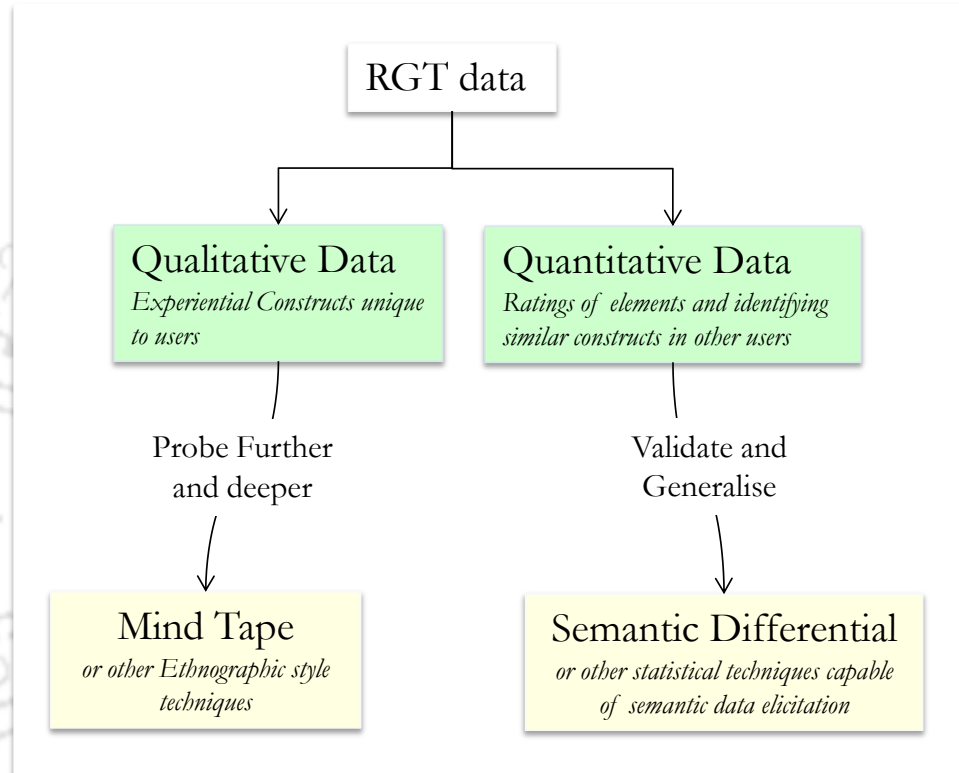


Fig 7. 1: RG T data as a starting point in data gathering process

One of the weaknesses of RG T is that it requires prior use of the interaction for data to be gathered at transitional level design decisions. It also requires that there be several 'kinds' of those experiences which can be compared and contrasted for the constructs to be obtained. While this holds good for data gathering where competitive analysis of experiences among competing products is involved, it becomes difficult to gather data when there are no competitors.

7.2.4 Observations on Semantic Differential technique

Semantic differential is an established technique for gathering semantic data, especially with respect to the connotative meanings associated with any artefact. In this thesis, ability of semantic differential to mine affective data from users for use in interaction design field in the experiential framework was investigated. It was found to be a quick and efficient way of gathering affective data pertaining to elemental and compositional level design decisions.

Data obtained from application of Semantic differential technique at the elemental level of design decisions was also given to the designers, and their design decision making process was observed. It was found that though at the level of validation of experiences SD was an efficient technique, it generated only statistical data which the designers found it difficult to infer any design related conclusions from. SD was found capable of eliciting affective data in terms of the ratings along the given affective scales. This data though having high validity about the users' experiences lacks practical usage in design decision making process as observed in the experiment with designers design decision making (see section 4.8 and appendix G). SD only tells what experience users felt and to what extent but it is not able to elicit data on the structure of those experiences, as in what caused those experiences and what are the causal or effectual capabilities of those experiences in context of the interaction with systems. In absence of the richness of information on the felt experiences designers found it difficult to use this data. However, when SD data is collated with the verbal accounts of users then it is observed that it becomes a good guide to design decisions making process (appendix G, Section G.1, step 1). Hence it is posited here that the Semantic differential technique is useful to the experience design process when used in combination with other data gathering techniques which can qualitatively inform the designers about users' experiences.

7.2.5 Summary of salient observations on the four techniques

Salient observations from investigations with four techniques have been summarised in table 7.1. These findings have already been discussed in the four sections above. It was observed that while TA was giving objective data as there is no interference in the felt accounts of users and there is no loss in memory as the data form users pertaining to the interaction is verbalised concurrently, but TA elicits much less experiential data as the deeper level cognitive processes which are employed in act of experiencing are not easily accessible during the concurrent verbalisations. Hence overall assessment for TA technique in context of experiential design is that the TA technique would not be very helpful to the designers in gathering experiential data form users. MT, on the other hand, was observed to give rich accounts of users experiences during the interaction with the system in a narrative form which was from deeper level of the cognitive processing. Though time consuming MT was found to be effective in gathering experiential data for the transitional level of design decisions.

Table 7. 1: Brief inferences on nature of the four data gathering techniques

| <i>Technique</i> | <i>Strength</i> | <i>Weakness</i> | <i>Effectiveness to Experiential design</i> |
|------------------------------|---------------------------------------|------------------------|---|
| Think aloud | Objective data | Less experiential data | Less effective |
| Mind Tape | Narrative, In depth experiential data | Time taking | Very effective |
| Repertory Grid | Versatile, Depth experiential data | Needs many elements | Effective |
| Semantic Differential | Quick and Easy | Context of experiences | Effective in combination with |

| | | | |
|--|--|---------|------------------|
| | | missing | other techniques |
|--|--|---------|------------------|

RGT was found to be versatile in sense of its ability to gather data from all the three levels of design decisions but it did not give as rich accounts of the users experiences at the transitional level as the MT technique gave. As RGT is a memory based data gathering technique, gathering data from users much after the interaction is over, hence is memory dependent unlike MT where cued recall makes the just finished tasks are recalled much more vividly. A short coming with RGT is that it requires not one stimulus or the design but several of them which can be compared and contrasted in order to elicit constructs form users differentiating them. Overall, RGT can be effective in gathering experiential data if it can be combined with other data gathering techniques to gather experiential data. SD was observed to be a very lean technique, comparatively quicker in gathering data and comparatively easier to analyse. The data elicited by SD did not have much richness but it helped quickly validate the experiential constructs.

7.3 Comparison between techniques on basis of quality of data gathered

In this section, the findings from different techniques have been compared in cases where the stimuli and tasks used for different investigations were same and different techniques were used to gather the data. In light of the inferences from comparison done between data gathered from different techniques over same stimuli and task, inferences about the capabilities of each technique and the possibility of combining them together in a seamless way for use in experiential design process has been discussed.

7.3.1 Comparing Think Aloud and Mind Tape

A sample of verbalisations from Think aloud and Mind Tape techniques have been produced in table 7.2, from the data obtained from experiments reported in chapter 4. Both these sets of verbalisations are from the same task given to different participants. These examples of verbalisations are not extreme cases but are characteristic of the observations made during investigations. In the case being discussed, both participants were given the same task. The task was to identify a suitable place on official tourism website of India where they could visit with their friends. The task and experimental setup details have already been described earlier in chapter 6, section 6.3.

While in the Think aloud experiment, users were asked to verbalise concurrently as they proceed with the task, in Mind tape experiment, they were asked to perform the task as they would naturally do. In Think aloud the evaluator sat by the side of the user and reminded the user to keep thinking aloud as and when needed. In Mind tape experiment also the interviewer sat beside the user but it did not say anything, rather only took notes about the users on screen behaviour.

As it can be seen in table 7.2, which produces a brief transcription of the conversation between interviewer and user during Think Aloud (left column) and Mind Tape (right column), the TA verbalisations of users are much more sparse and superficial in terms of eliciting users' experiences. The user goes into silence often and says words or phrases which are difficult to decipher. For, instance after a period of silence in the mentioned account, user says "Ok...This sounds really good". Now this is a goldmine for an experiential designer to probe and understand 'what' it is that has made the user 'feel' good. But the user again goes into silence as he is involved deeply in making sense of the aspects of interaction.

Table 7. 2: Sample data from Think Aloud and Mind Tape

| Think Aloud Verbalisation <i>(concurrent with task fulfilment)</i> | Mind Tape Verbalisation <i>(Post task fulfilment)</i> |
|--|--|
| <p>Evaluator: <i>Please keep thinking aloud</i></p> <p>First I will check India.. I am looking for something like.. Where can you go Oh beaches of India..that could be cool Oh Lakshadweep.. (user is silent for a long time) OK.. This sounds really good (Silence again. User is working and is focused)</p> <p>Evaluator: <i>keep thinking aloud</i></p> <p>Basically I am reading.. about.. I was thinking something in Jaipur or something like that.... Rajasthan.... (Silence..)</p> <p>Yeah I found my place.. All this Hawa mahal and Jantar mantar.. This sounds like a really good place..</p> | <p>Interviewer: <i>What were you looking for</i></p> <p>Initially I was trying to make out what this site is all about I was looking at different places if I could find But I could not find... I went into History, geography etc.. I did not get what I wanted. I know about India.. So I was looking for places in India that I could visit.. The site was telling me history and culture. How many cultures can I scan through.. There were plenty of choices of cultures and I can't go through...</p> <p>Interviewer: <i>What were you expecting</i></p> <p>I was expecting a map.. And there wasn't anything Related to geography.. There is a picture of mountain and a lot of text which I do not want to read When I entered the site I expected that the site will tell me the best places that are in India But it wasn't telling me anything like that.. I saw five heads.. <i>menus</i> Golden triangle ... Royal Rajasthan..etc.</p> |

7.3.2 Comparing MT, RGT and SD

Screen shots of the home pages of the three websites used for the Mind Tape study were also used for gathering compositional level data using RGT and SD techniques. Hence a comparison between these three techniques ability in mining

the experiential data form users can be discussed in light of the data gathered during experiments.

In the MT interviews, from the post interview questionnaires it is observed that though in overall interaction, Indians *liked* the Indian ‘website’ more but the ‘interface’ of Danish website was *appreciated* more (table 7.4). During the Mind tape interview the reason why it was liked did not surface out whereas it did in the RGT data has brought up.



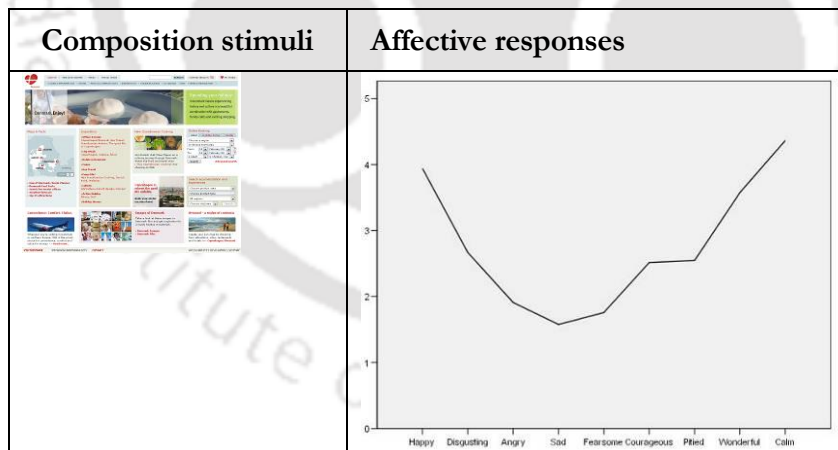
Fig 7. 2: Indian and Danish websites used in experiments

In the RGT interviews, the Indian websites home page (fig. 7.2), was seen as ‘colourful’, ‘depicting culture’, ‘visually heavy’ and ‘cluttered’; whereas the Danish website homepage was seen as ‘having lots of info’, ‘crowded but chunked’, having utilized the space very well, ‘organised’ and ‘having subdued colours’. Comparing the MT data with the RGT data one can see that interface of Danish website was liked because of subdued colours and better organisation of information. The reason for liking the interface of Danish site though the overall interaction with Indian website was felt to be better did not become clear in MT.

It was only through the RGT data that much deeper level experiential information could be gathered.

Though in MT interviews it is possible to go to the deeper feeling level of the user by probing the depth of information that RGT is capable of bringing out is still superior in comparison to MT. The handicap of RGT is that it cannot be applied to gather data from moment based interactions. RGT can gather data from memory based interactions only. The other concern with MT is that one has to be careful during interviewing so as to not disturb the stream of thought that the user is recalling and verbalizing else chances of loss of the experience due to interference with memory may occur. While in RGT the experience of user is deep within the user, it is at the level of concepts that the user has stored those experiences and one can mine that experience at one's ease.

Table 7. 3: SD data on Indian Chinese and Danish sites



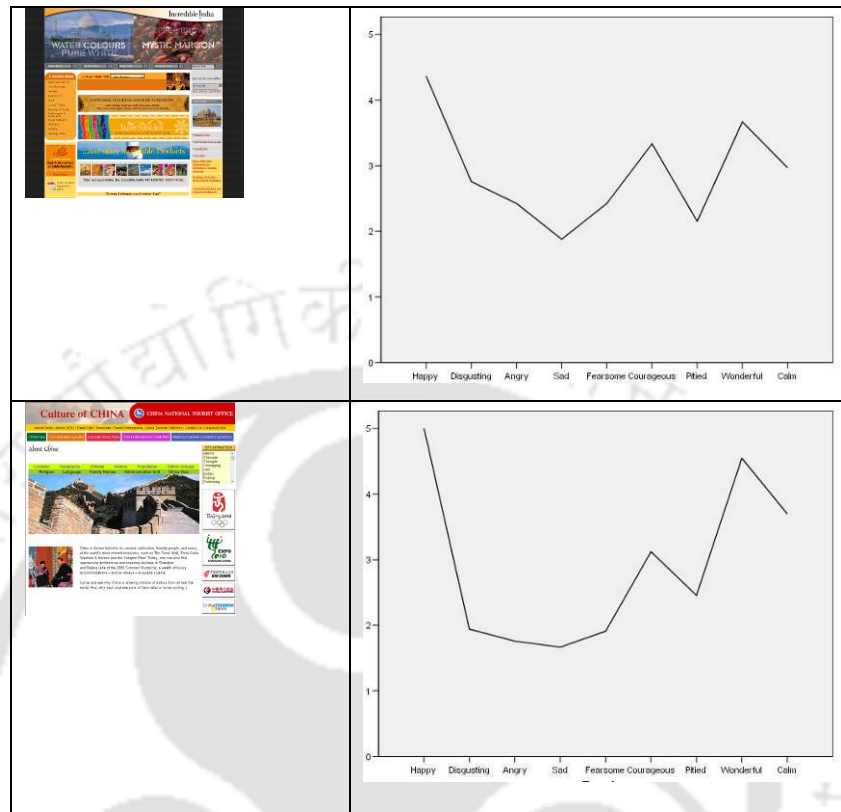


Table 7. 4: MT data on Indian, Chinese and Danish sites

| Rank | Indian Website | | | | | | Danish Website | | | | | | Chinese Website | | | | | |
|------------|----------------|----------|-------------|----------|-----------|----------|----------------|----------|-------------|----------|-----------|----------|-----------------|----------|-------------|----------|-----------|----------|
| | Liked | | Easy to use | | Interface | | Liked | | Easy to use | | Interface | | Liked | | Easy to use | | Interface | |
| | Ind | Dan | Ind | Dan | Ind | Dan | Ind | Dan | Ind | Dan | Ind | Dan | Ind | Dan | Ind | Dan | Ind | Dan |
| 1st | 5 | 3 | 4 | 2 | 2 | 1 | 2 | 3 | 1 | 4 | 5 | 5 | 0 | 1 | 1 | 1 | 0 | 1 |
| 2nd | 1 | 2 | 2 | 2 | 4 | 4 | 4 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 3 |
| 3rd | 1 | 2 | 1 | 3 | 1 | 2 | 1 | 1 | 4 | 0 | 0 | 1 | 5 | 4 | 4 | 4 | 6 | 3 |

Comparing the data gathered through SD technique with RGT and MT now, participants have reported that the Danish interface looked more ‘calm’ than both Danish and Chinese sites but less ‘happy’ than the Indian home page and even

much less 'happy' than the Chinese site. This is quite interesting, because in MT interview nobody seemed to like the Chinese websites interface. Neither the Danish nor the Indian users gave good ratings to the Chinese websites interface. But SD data suggests that the Chinese website homepage has been rated to be happier than the rest two. The anomaly is in the other emotions involved with the sites look and feel. Chinese interface has been rated much more disgusting than both the Indian and Danish sites. So though the Chinese site looks much more 'happy', probably due to use of bright colours, but it is also at the same time looking more disgusting. Hence SD data helps directly avail the affect related data which neither the MT nor RGT can provide. Often emotions being more powerful deciders can overwhelm the other logical processes of mind. Hence use of SD for gathering Affective data could be considered in conjugation with other techniques.

7.4 Comparison between all four techniques

The four data collection techniques yielded sufficient data from various experiments to conclude about their ability to extract experiential data from users and to judge their culture suitability and applicability. The comparison between techniques has been summed up in following tables. Comparisons have been done for the type of data elicited, applicability at different design decision levels and resources needed for each technique.

7.4.1 Comparison between four techniques in type of data elicited

While creating a user model for use in experience design in Chapter 3, which can present a holistic picture of the users' experiences in context of interaction with computer based interactive products, it was discussed that the experiences can be

categorised into three categories, namely, aesthetic, affective and intellectual experiences (Fig. 7.3). Experiments with four techniques revealed each technique's ability to gather the experiential data pertaining to each of the categories. Mind tape was found to be strong in eliciting data pertaining to all the three categories of experiences.

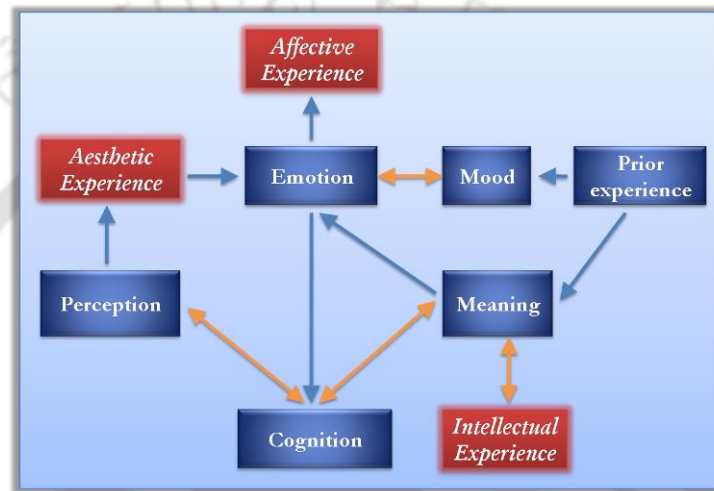


Fig 7. 3: User experience model proposed in chapter 3

Mind tape technique not only elicited the deeper level experiential constructs but also the causal and effectual relationships between the different experiences. For instance, when the users said during the MT interview “I am looking for pictures; I am not going to read 10 pages of text” (table 6.14, row 4), it gives information on the expectation that user has and the experience which is generated upon not meeting it. It clearly shows a causal relationship between the expectation and the experience. MT data also show the effectual relationship between the experiences, as in “because it has pics of beaches so I can go there” (table 6.14, row 10), where an experienced has caused a subsequent action. Details of structures of experience are valuable to the designers to make inferences about the users’ interaction process and the expectations which the designers have to meet through design intervention. As reported earlier, TA was observed to be weak in experiential data while RGT and SD were found to be strong.

Though SD was not tried with aesthetic scales, the observations with the affective data do provide a safe basis for assuming that aesthetic scales would also be able to gather experiential data pertaining to aesthetics of the interfaces. Table 4.20 and 4.21 have listed the aesthetic, affective and intellectual constructs gathered at the transitional level by the RGT technique which is a good point in case about the RGT's ability to mine data with respect to the three categories. Though the aesthetic data gathered from RGT was less in number, but it can be discounted by the fact that RGT being applied on the basis of memory of the systems used, chances that the aesthetic data would have surfaced would be less. As discussed in section 3.5 and exhibited in fig 3.4, the aesthetic experience is the immediate experience on interfacing with the system. With passage of time the deeper level intellectual experiences start occupying the mental space. Hence, while at compositional level and elemental levels the RGT data could generate more constructs pertaining to aesthetic experiences, at the transitional level it could not. It was more due to the limitations of usage of RGT at the transitional level rather than its overall capability. Table 7.5 summarises the each technique's ability to gather data pertaining to each category of experiences.

Table 7. 5: Comparison between techniques in ability to gather type of experiential data

| <i>Technique</i> | Aesthetic Experience | Affective Experience | Intellectual Experience |
|------------------|-----------------------------|-----------------------------|--------------------------------|
| TA | Weak | Weak | Moderate |
| MT | Strong | Strong | Strong |
| RGT | Moderate | Strong | Strong |

| | | | |
|----|--------|--------|----|
| SD | Strong | Strong | NA |
|----|--------|--------|----|

7.4.2 Comparison of techniques in their applicability at design decision levels

As identified in section 2.9 that the complex process of designers design decision making in context of HCI design can be categories broadly as the decisions pertaining to elemental, compositional and transitional levels of designs. During the experimental investigations as reported in chapter 4, the four techniques were employed to gather data pertaining to these design decisions. The findings have been collated in table 7.8 for sake of comparison between the techniques. While RGT was observed to be the most versatile technique capable of gathering data for aiding the designers' design decisions making process at all the three levels, MT and TA were suitable only for gathering the transitional level data. Semantic differential could be applied effectively at the elemental and compositional levels. TA and MT cannot help gather data at the elemental and compositional a levels as there is not temporality involved in the stimuli at these stages. And SD technique is not useful at the flow level. MT cannot be applied at the formative test levels as it is difficult to capture the screen of the interaction for replay and serve as stimulus during recall.

However at the elemental level, collecting experiential data with RGT technique was found to be more difficult than compositional level. Participants came up with more superficial constructs than experiential ones. While using SD technique, users gave the ratings along affective scales very confidently and quickly. It shows that while the RGT technique is able to gather data at the elemental level, the number of experiential constructs gathered is less in

comparison to the compositional level. As mentioned in section 4.6.3, this could be due to the elemental level stimuli being less evocative in terms of visual richness in stimuli. Still due to RGT's ability to gather deeper level experiential constructs, even if few in number, it would be advisable to use RGT to gather these experiential constructs from some users and then validate those constructs through the SD technique, which is easier to apply, across a larger number of users. This way user experiences elicited through constructs in RGT would be used to guide designers design decisions making process instead of designers' scales, which are used in semantic differential.

Table 7. 6: Comparison between techniques in applicability of gathered data in type design decision levels

| Technique | Elemental | Compositional | Transitional |
|-----------|-----------|---------------|--------------|
| TA | No | No | Yes |
| MT | No | No | Yes |
| RGT | Yes | Yes | Yes |
| SD | Yes | Yes | No |

7.4.3 Cultural suitability and sensitivity of the techniques

All the four techniques were found to be culturally suitable in the cultures that they were investigated for. However, Mind Tape was received better in India, as the users reported the technique to support their 'natural' way of talking about experiences. It is posited here that for dialectical cultures like India, MT would be better suited than TA. Further, both MT and RGT was found be sensitive enough to bring forth data on cultural differences in users' experiences. As pointed out in section 6.3, during experiment with Mind Tape, both observations on cultural differences and similarities in the way users experienced the websites

have been mentioned. Similarly in section 6.4, ability of RGT to show the cultural differences in users' experience with interactive systems was observed. For instance, as depicted in fig 6.10, for Chinese users, the useful and frustrating systems were found to be closely related while for Indian users they were furthest apart. One interpretation of this scenario could be that the Chinese users had fewer choices in terms of systems available to them and they had to use a system which was frustrating merely because it was useful. They had to use a system which was not so enjoyable to use but because it helped do some important tasks and there were no alternatives available they had to use it, while this was not the case for Indian users. These findings are only pointers to the possible trends as these constructs require further validations with larger groups. Yet RGT gave very useful data on cultural differences between the users' experiences with systems. SD is a well established technique used in across cultures in different forms. Depending on the kind o scale constructed for use of SD, it is assumed here that it will be able to show cultural differences in users' experiences.

7.4.4 Moment based vs. memory based data

Two approaches to understanding experiences has been suggested by Daniel Kahneman (2003), memory based and moment based. While the moment based approach gathers the experiences as episodes in real time as the user is experiencing the phenomena, the memory based approach gathers it in retrospect. While the validity of memory based approaches have been doubted in literature, still techniques using memory based approaches are prevalent (Kahneman, 2003). Some of the techniques investigated in thesis took the memory based approach to experiential data elicitation while others were moment based. For instance, MT can be categories as memory based but because the video of screen shot during task fulfilled is replayed to cue in the recall, it acts

as if the same experience is relived during the interview. Hence author takes the stand here that the MT technique though being memory based, acts like a moment based technique hence it should be treated as a moment based technique itself.

Table 7. 7: Comparison between techniques in approach to gathering experiential data

| Technique | Moment Based | Memory Based |
|-----------|--------------|--------------|
| TA | Yes | No |
| MT | Yes | Yes |
| RGT | Yes | Yes |
| SD | Yes | No |

TA is purely a moment based technique as it gives concurrent verbalisation on the thoughts being experienced by the user. RGT was capable of eliciting data both 'memory based' as well as 'moment based'. As observed in section 4.6.1, at the transitional level, RGT worked as memory based, as it was gathering data based on the memory of experiences with systems that were used by users and at the compositional and elemental levels it gathered data which was moment based as the stimuli in front of the user was evoking the experience which the users elicited through constructs. SD was purely moment based as it gave responses with respect to the stimuli being provided to the users in real time. Memory based experiences at the transitional levels have deep interconnection, which RGT was found capable of mining out and Mind tape being moment based, captured experiences having causal and effectual interconnections at the transitional level. Table 7.6 summarises the approach to the experiential data gathering process by the four techniques.

7.4.5 Applicability of techniques in different stages of design development

The interaction design process is a developmental process where a design solution evolves through stages. Users' data is gathered iteratively to support design decisions throughout the design development process. Two distinct phases of design development process have been recognised, formative and summative (Black and William, 1998). While at the formative stage of design, data is gathered from users to help accumulate the components of experiential data to help create meaningful whole of the users experiences at the summative level it is more an assessment of the idea that has already been furnished. At the formative stage, the stimuli used is primarily the low level prototypes of specific design ideas while at the summative level more finished prototypes and working models are used. The nature of data sought and the type of stimuli used clearly demarks the techniques that can be used at these stages for gathering data.

Think Aloud has been tried for use at the paper prototype level and it does give good data at transitional levels in spite of the fact that the stimuli used is of very low fidelity. It is a different issue that the data gathered was mostly pertaining to the functional issues with the prototype rather than the experiential issues. It is argued here that even though the TA technique gives more function related data, as the experiential concerns do cover the basic functionality as well therefore when it comes to assessing the basic functionality at the transition level during the early phases, TA can be used with low fidelity prototypes like paper prototypes. This would at least give the functional data related to the interaction being designed. TA anyway is used at the summative level predominantly in the usability field for evaluating designed systems for their usability. Mind Tape has constraints at the formative level of design development. As the Mind Tape requires recorded video of the screen for the interaction just concluded, it is difficult to apply this technique at the formative level where the fully functional computer based prototype may not be available. In cases where the prototype is

based on some computer application like MS PowerPoint, and the interaction is functional, the MT technique can be applied. But observing that the computer based functional prototype occurs fairly late in the design development process, it is difficult to suggest the use of MT at formative level. RGT and SD can both be applied at both formative and summative levels of design development. At the formative level the low fidelity prototypes, like initial sketches of ideas, either screen based or paper based, can be used as stimuli to gather the data from the users. At summative level, again the finished images of the elements or compositions can be used to gather experiential data from users using both SD and RGT.

Table 7. 8: Comparison between applicability of techniques in the interaction design process

| Technique | Formative | Summative |
|-----------|-----------|-----------|
| TA | Yes | Yes |
| MT | No | Yes |
| RGT | Yes | Yes |
| SD | Yes | Yes |

7.4.6 Comparison between four techniques in Resource requirement

One of the parameters influencing the selection of any technique for gathering data in design process is the consideration for the resources it requires. Usefulness of a technique in any given design process decided both by considering the ability of the technique to gather data and the resources it requires. Cost of the data obtained is one of the pragmatic issues in the business environment in which most of interaction design projects are situated. Trade off

between resources required versus usefulness of data obtained is a practical poise in such situations. Comparing the four techniques in the respective resources they require, is one the ways of assessing their usefulness to real experiential design projects. Table 7. 9 summarises the four techniques' resource consumption during the application and data analysis.

RGT and MT techniques which have been found to be the two most useful techniques in collecting experiential data are also the most resource consuming ones. They require comparatively maximum resources during data collection as well during the analysis phase. Mind tape requires the maximum time to collect data as first the users have to complete the task when the video of the task is recorded then the video is replayed, pausing and playing when needed during interview, hence it takes more almost 2.5 times the total time taken for task fulfilment. Though the Mint tape interviews are natural and enjoyable but the time taken during the interview can tire the user. The time taken in MT is much longer than the TA, which takes nearly the same time as the task fulfilment. RGT also takes time depending on the number of constructs that the participants elicit. On an average it was observed that it takes around one hour for 14 to 20 constructs. SD was found to be the easiest to apply and collect data and also to analyse.

On the data analysis front, the MT data is observed to be primarily of qualitative nature, has detailed description of users' experiential accounts and requires more time to analyse. The analysis of MT data is done by identifying the meanings in episodes of experiential accounts by visiting the transcripts repeatedly and deliberating on the interconnections between the spoken words and recurrence of similar accounts. Similar treatment is required by the RGT data which contain verbal accounts of experiential accounts in terms of constructs. The constructs need to be analysed through qualitative content analysis, seeking meaning

recursively in the constructs and creating logical groups in the data. However one advantage with RGT data is that it also contains quantitative information in form of ratings which accompany the qualitative data in form of constructs. Presence of quantitative data makes the analysis of RGT data easier. The quantitative data obtained from RGT technique helps in identifying groups in the qualitative data as shown in the cluster analysis example in section 6.5.2, fig. 6.17 and 6.18. The SD technique elicits purely quantitative format data which is less resource consuming to analyse.

Table 7. 9: Comparison between techniques in their resources required

| <i>Technique</i> | Time required for data collection | Effort required for analysis | Effort required from users |
|------------------|---|---|--|
| TA | Long | Moderate effort, qualitative data availed | Tiring if done on long tasks. Uncomfortable to keep verbalising. |
| MT | Very long | High level of effort required to identify causal and effectual structure of experiences | The interviews are engaging and enjoyable but due to very long duration of interview, could be tiring. |
| RGT | Long to very long (depending on no. of constructs elicited and difficulty in phrasing the constructs) | Moderate effort required (statistical analysis is quicker, content analysis is time consuming). | Needs effort to get right phrase. Interview is time consuming. |
| SD | Short | Short | Puts very little demand on users |

SD technique requires the constructs to be formed by the interviewer and hence is a good tool to validate the experiential data but the data itself does not contain

experientially rich accounts form users. To conclude, the most experientially rich techniques have also been found to be most resource demanding. It is suggested here that a judicious combinations of the various techniques would be suitable to the practical experiential design projects.

7.4.7 Hard vs. Soft data in experiential design

Scientific traditions lay great emphasis on the validity of data whether it be gathered from scientific instruments or from human beings. 'Hard data' is the more preferred data in scientific traditions, and it refers to the type of data which has maximum inter subjective agreements. Validity of hard data is stronger due to easy inter subjective agreement characteristic. In context of design in general and HCI design in particular, the type of data gathered from the users is often in form of verbal reports. Verbal reports are subject to interpretation by the designers who uses these data to draw conclusions about the users' preferences, choices and actions. Hence, verbal data has been treated as soft data due to this subjectivity in interpretations associated with it. On the other hand, behavioural data is a type of hard data. In this thesis, the four techniques which have been studied for their capabilities have yielded both hard and soft data in different circumstances. And there are degrees of hardness which also need to be considered when looking at this data.

The debate between hard vs. soft data is not characteristic of one field; most of the application oriented sciences have faced this issue in some or the other form. For instance, Feinstein (1977) expresses his angst at the over whelming credit given to hard data in clinical psychology "... hard data have been excessively venerated to an extent far exceeding their inherent importance or actual reliability; and soft data have been not merely de-emphasized, but deliberately excluded or eliminated from consideration."

From the experimental studies carried out in this thesis, it has been observed that the choice between hard and soft data lies in the usefulness of the data to designers' design thinking process than the scientific validity of the same. As long as the data supports designers' decision making and it leads in the right direction, it can be said to be valid. The subjective involvement of the designers where they create their own interpretations of users' behavioural or verbal data in the context of usage has to be encouraged for creativity's sake. The designers being constituted of the mental, inter-mental and intra-mental processes, the affective and the cognitive agencies, is the apparatus in which the design decisions happen. Hence, any technique which caters to the designers' design thinking faculty and makes it more confident of his/her decisions should be held as of validity in the interaction design context.

It has been observed in this thesis that Mind tape technique is useful in gathering rich experiential data. Though retrospective verbalization has been accused of subjective interferences due to temporal lag between the experience and the verbalization, its usefulness in gathering the experiential data cannot be undervalued. Actually it is the other way round in case of experiential data gathering process. It is the subjective involvement of the interviewer that is an effective aid in gathering the experiential data. As pointed out by Krippendorff (2006, 2007), it is the faith in the listener's ability to empathize with the experience, that attempt to share the experience is through language is made. In such a context, the very strength of 'hard data' becomes its weakness. It is perceived softness that is leading to not only more useful but also more valid data in context of experiences.

It can be concluded that in context of designers' design thinking process, it is the rich data which they can interpret contextually is of higher value, whether the data be hard or soft quality. A salient example of this from this thesis could be the

comparison between TA and MT data. TA data has greater validity than Mind Tape data due to its concurrent nature where data is coming directly from the Short Term Memory hence not much subjective or temporal interference has happened. But due to its concurrent nature, it is not able to give data from deeper layers of mental processes. One of the reasons being that the thoughts run faster than verbalization speed (Brainbridge, 1999) making it difficult to get continuous data on thought sequences in the verbalization. Further, many mental processes occur at subtler planes which acquire meaning only over a period of time. They are not only difficult to translate verbally but also suffer the danger of interfering with the thought process itself (Schuk and Leahy, 1996). This would mean that the very experience that the TA would try to capture would be shifted due to application of TA. It sounds like the 'Heisenberg uncertainty principle' from physics where measurement of one physical property makes the other one blurry. In other words if we focus too much on the experiences of users then the very experience we are trying to measure will get affected. To conclude, it is argued here that in spite of having soft nature of data from MT technique, it is rich in experiential accounts and hence its use should be encouraged in experiential design process.

To conclude this section, both MT and RGT hold potential to be good for UXD process and both are the least used techniques in HCI as of now. SD and TA could be used to support the UXD process in formative stages of design, especially when the resources are scarce.

7.4.8 Qualitative vs. Quantitative data in experiential design

From observations of designers designing activity, qualitative data was found to be more useful to the design thinking process. Statistical findings only gave a

gross understanding of users' mind. Need for in depth understanding of meanings, into the reasons of those statistical findings, were observed. In the task of icon design, designers found it difficult to interpret statistical charts and diagrams which were prepared from the users data. When verbal reports of users explaining the reasons for their quantitative evaluation of stimuli were presented along with the statistical data, it made more sense to designers.

The school of *interpretivism* in qualitative inquiry provides some explanation for usage of qualitative data in design thinking process. One of the philosophers in long intellectual history of *interpretivism*, Dilthey (1911/1977) has given a defining conceptual perspective to use of qualitative data. His thesis is that human discourse and action cannot be analysed with the methods of natural and physical sciences. The phenomenological way of 'deep understanding' by empathy and indwelling are the ways to understand human action and reason behind them. *Interpretivists* argue that the researchers cannot be detached from their subjects of study. Rather, they have their own conceptual orientations, their own convictions and they are undeniably affected by what they hear and see from the participants (Miles and Huberman, 1994). Decoding the words of information obtained from the subjects of study involves their own contributions to the meaning as well as of the subjects.

The design thinking activity requires internalized information to aid in the design problem solving. Design thinking is 'opportunistic' thinking, shifting and reformulating the 'problem space' and constantly evaluating the ideas generated. To aid in the quick evaluations of the self generated ideas which happens in a quick successions a designer needs a deep understanding of the user. Not only what most of the users prefer but also the reason why they prefer so is required by designers. The interpretivist, phenomenological way of qualitative inquiry hence becomes meaningful to the practice of design.

Quantitative data was found to give a superficial view of how the ‘group of users’ have behaved generally. It is important for the designers to know what the users prefer, for it helps him/her identify the user trends and orient towards it, but it may not be sufficient information for design thinking process. Statistical data tells about the trends and general agreeableness among the users of a system with respect to any feature or characteristic, it fails to elucidate the reasons behind the same, which lurk inside the human user.

Among the four techniques, TA, MT and RGT elicited data of qualitative nature while SD elicited only quantitative data. RGT was in an advantageous position to gather both quantitative and qualitative data.

Table 7. 10: Comparison between techniques in nature of data elicited

| Technique | TA | MT | RGT | SD |
|--------------------------------|-------------|-------------|----------------------------|--------------|
| Nature of data elicited | Qualitative | Qualitative | Qualitative + Quantitative | Quantitative |

7.5 Overall findings from the research

As presented in chapter 1, this thesis has identified the user experience design problem as a problem of bridging the gap between the users’ and designers’ mental models. In order to bridge this gap the designers need to collect data from the users pertaining to the users’ experiences with respect to the interactive system under use by the user. As users are a highly complex system which processes information and arrives at meanings designers need to abstract a working model of users for reference in experience design process. Chapter 3 proposed a working user model for use in experiential design process. Further, designers need suitable data gathering techniques which can elicit the experiential

data from users. Chapter 4 identified four techniques which can be used to gather experiential data from users. Chapter 5 presented a research framework for experimental validation of the techniques for their capability of eliciting the experiential data in cross cultural framework. Chapter 6 presented the details of the experiments conducted with the selected techniques and findings of each experiment. This chapter has discussed the findings from experiments and compared the capabilities of each of the four data gathering techniques.

The research done as part of this thesis has found that the experiential data gathering process has several complexities involved with it which need to be tackled in order to successfully understand users' experiences with respect to their interaction with computer based interactive systems. First of them all is the temporality of the experiences. The users' experiences are in situ with the interaction with computer based systems. Any data gathering process which intends to gather experiential data from users has to bring forth the context of the interaction between the system and the user to help the designers understand the users' experiences. Second aspect of the experiential data gathering is the fear that the data gathering process itself becomes an interference with the gathered experience. Users experiences are a continuum of interpretations and appraisals as discussed in chapter 2, section 2.5.9. Any additional source of influence on the ongoing process of 'experiencing' the interaction may actually change the felt experience itself. Hence the data gathering process has to be non intrusive to the experience as much as possible. Third aspect is the framing of the experiences in language. The felt experiences are buried deep in the users and are integral to the users. Eliciting the experiences through a medium for use externally by the designers involves expression of the experiences in language. Fourth aspect is the cultural settings within which the data gathering technique is being applied. The culture's influence on the interaction design is not only at the level of the cultural meaning in the artefacts of the interaction but also at the level of the social

interaction between the user and the designer. As identified earlier in chapter 3, section 3.6.2, culture increases the gap between the users and designers mental models if the designers and users are from different cultures and above that makes it further difficult for the designers to gather data form users in order to understand the mental models of the users.

7.6 Heuristic guidelines for user experience designer in HCI

From observations on the four techniques studied in this thesis, a user experience design methodology is being proposed in fig 7.4. In case of designing a new interaction aimed at users' experiences, it is suggested that the domain of the application and its existing users should be identified. Users' experiential data pertaining to their use of other similar systems should be gathered so as to guide the initial conceptualisation phase. This can be done with the RGT technique as the existing set of systems from the domain could form the elements, using which users' experiences could be elicited. Mind Tape technique can also be conducted on a given existing system which comes closest in function to the new system being designed. This way deep level experiential data can be availed right in the beginning to guide the conceptual phase of design.

The gathered experiential data can guide conceptualisation of elements of interaction like menu items, icons, graphic elements and a theme can be set around the elements. Conceptualisation of compositions can also run parallel or wait till the elemental level designs are finalised. Then the concepts can iteratively be subject to users as stimuli and experiential responses be gathered about them. At this stage both RGT and SD can be used. For RGT technique to be applied minimum of 5 elements would be needed, so either 5 concepts can be used as elements or screen shots of the existing systems can be used for comparison. SD

can be applied if the semantic scales are already known and if designers are sure which experiential constructs are important to the users. This iteration can be furthered at the transition level, where screen based functional prototype can be used to conduct data gathering with Mind Tape technique or at the low fidelity level, Think aloud can be used.

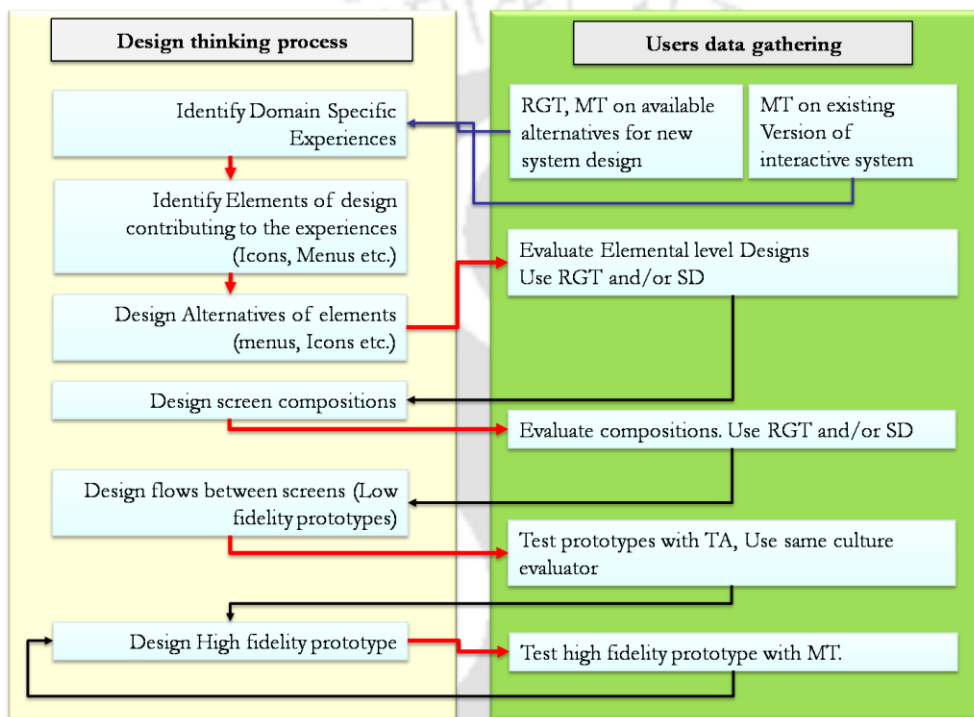


Figure 7. 4: Proposed user experience design methodology

This model proposes a very basic sketch of possible schemes of using these four data gathering techniques in experiential design process. Depending upon the design need and resources available designers can combine techniques or use them solely.

7.7 Contributions of this thesis

The main contributions of this research work are outlined below:

1. This thesis identifies the need of users' experiential data during design decisions making in user experience design process. As experience design is still in its nascent phase of development, experiential data gathering techniques supportive to the design decision making process have not been researched so far. This thesis attempts to fill some of these gaps.
2. This thesis identifies design decision making as taking place at three levels, elemental, compositional and flow. The approach of building an experiential data gathering methodology for user experience design based on the needs of these three levels is a fresh approach in this thesis.
3. This thesis also identified the qualitative user data as useful to designers design decision thinking process and advocates the use of data gathering techniques where the experiences are communicated in narration mediated by language. In light of the experiment conducted with designers design decision thinking process, this thesis identifies the need for combination of qualitative and quantitative data to make the user data useful to design thinking process.
4. This thesis worked towards developing a new variant of retrospective verbalisation technique called mind tape and experimentally demonstrated its usefulness in experiential data gathering process.
5. This thesis identifies the prevalence of Cross cultural design scenarios, where the cultures of users and designers are not the same, and has done experiments to identify the issues involved and suggested cross cultural data gathering techniques.

This thesis also suggests a methodology for user experience design in light of the findings from conducted experiments. The concerns of

designers in user experience have been highlighted and the suitable methodology for the same has also been suggested.

7.8 Limitations of this thesis

This study has been done with only four of the many techniques available in literature. It is likely that experiments with other techniques may yield some more useful insights about users' experiential data gathering process. There may be other techniques that could yield comparable or even better results with respect to gathering experiential data and being useful to designers. Further the studies were conducted in three cultures only. Experimenting in cross cultural data collection across other cultures may bring out some new insights about cultural issues involved with data collection. The designers selected for design decision making investigations had experience of only a couple of projects, experienced designers may have different design strategies which could help orient the data gathering techniques differently. Also the need of experienced designers may be different from the novice designers.

Presentation of the gathered experiential data to the designers to appropriately guide the designers in their design decisions needs to be investigated further. Depending on the type of design decision that the designer has to make, presentation to the designer could be different. The author feels that at elemental and compositional levels, the users' experiential data in terms of static screens of users' reports would be useful while at the transitional level; data would need to be presented in a temporal format. Seeing that still there isn't any significant suggestion on how designers use the users' data and no standard formats for sharing and exchange of user data across design research teams exists, either in industry or in academia, this area needs immediate research attention.

7.9 Conclusions

This thesis has looked upon the Human-Computer interaction design problem as a problem of building experiences for users rather than mere interfaces and their interactions. Though the general design profession has always advocated the need to focus on the user (Alexander, 1964; 1966; 1971; Lawson, 1980), the interaction design profession has the compulsion to do it. With increase in competition in the digital artefact market, focus on experience of the user has increased and so the pressure on interaction designers to understand the users in depth.

Design problems have been identified to be wicked (Churchman, 1967) as there are no unique solutions, has many constraints, requires multi valued thinking and data on which design decisions are to be made are uncertain (Horn, 2001). Designers have to think opportunistically (Hayes Roth and Hayes Roth, 1979; Guindon, 1990; Visser, 1990; Bonnardeletal., 2003) through the data available to make design decisions. One of the suggested ways to make logical and predictable connection between the design problems and their solutions is through analysis-synthesis process (Alexander, 1971), wherein the data is gathered and analysed before synthesis of solutions is attempted. Though this process has been deemed improbable, for analysis and synthesis are intertwined (Gedenryd, 1998), one of the reasons for adopting this process is that the design problems are complex and difficult to manage all at once, hence the complexity of the design problem gets broken into manageable chunks which could be addressed by the human mind (Lawson, 2004). The other approach to solution is the cumulative approach (Page, 1963) which recognises any design problems as connected to many other problems, like window not just being a window on its own but existing in relationship to the entire house and facilitating many functions through this relationship, hence the solution has to emerge not in isolated analysis but in cumulative thinking. In case of experiential design, the

latter view of design process seems closer to the design goals with focus on experience rather than mere functionality. From the experiments conducted on designers design decision making, it is posited here that in experiential design framework, the designer has to cumulatively gather data about the users experiences from deep within, applying as many techniques in combination, complementing or supplementing each other. This ensures a rich account of users' experiences which can be internalised by designers before design solution can happen in their thinking. Analysis of users' experiential data collected using one technique does not have to be in isolation from the data from another technique, but rather it has to cumulatively build upon each other. Experiential design problem though being complex, can be chunked at the level of analysis, applying different specialised data gathering techniques to gather experiential data in parts, but they have to be collated to inform the findings from each other in order to identify an overall holistic picture of the users' experiences. This is imperative in case of experiential design process as the human experiences have been found to be holistic and complex, having both temporal and mesh like structure.

A designer has to choose the techniques to gather data from users', right from the beginning of the project and hence needs to be informed about the available options to choose from. This thesis serves to this end of the designers where they need to make choices from the available techniques, depending on type of problem at hand and the resources available.

The narrative discourse as a mechanism to elicit experiences would be one of the reliable ways to gather experiential data. Eliciting people's experiences through protocol analysis (Newell 1972; Ericsson and Simon, 1993) which is the most current and most widely practiced technique does not help fully in experiential data gathering. Empathetic listening, which has been suggested as a facilitator to

invocation of experiences (Krippendorf, 2006) is absent in the protocol analysis. The meanings created and acted upon at instances of the interaction are subjective in nature which is not elicited by the users due to absence of the sympathetic listener in the protocol analysis. Mind tape has been found to be good at this and hence is being recommended here for use in experiential design process. As meanings are tied with the language, the data elicitation approach which removes the language from the experience elicitation process is likely to fail in gathering experiential data. This thesis advocates a subjective approach, where narration of experiences is facilitated and the temporal quality of experiences is duly recognised, would be a better way to understand users' experiential data. Usefulness and utility of Mind tape data also depended on the interviewer's ability to comprehend integrated linguistic and contextual information in the users' verbalisations to interpret conversational references. It is submitted here that with practice, the interviewer can develop the ability to do Mind tape interviews effectively.





Appendix A

A.1 Stimuli Used at Elemental level



A.2 Stimuli Used at Compositional level



L5



L6



L7



L8



L9



L10



A.3 Stimuli Used in RGT experiments (at Elemental level)



A.4 Stimuli Used in RGT experiments (at Composition level)





Appendix B

B.1 Gesture analysis for identifying experiential cues in TA tests

Aim: To identify user's experiential data in Gestures elicited by users during TA sessions.

Introduction: There is a large amount of rich nonverbal communication that happens during a predominantly verbal user data collection and testing situation that has not been, so far, tapped by design researchers. The study indicates that Non-verbal communications can be relied upon by design researchers for additional interpretation in cross-cultural situations that have issues such as language accents, cultural unfamiliarity and newness for a designer or usability tester. There are optimistic reasons for further probing and studying Users' non-verbal communications during interviews, testing and data collection events.

Though there is rich non verbal data elicited during a verbal data gathering process, however, there is sparse mention in HCI and Design research literature of the effects and nature of non-verbal components of the communication and interaction with the user. The potential of non-verbal components to act as clarifiers and or additional sources of deeper cognitive level data from within the user, has not found adequate attention or mention in designing processes centred on the users.

Ever since Charles Darwin published his scientific study –Expressions of the Emotions in Man and animals in 1872, researchers in disciplines ranging from anthropology to ethnography have probed body language as an outward reflection of a person's emotional condition. Non-verbal refers to all stimuli (except meaningful words excluding interjections such as Oh!) generated for purposes of communication. Such communication may be intentional or unintentional. Body movements such as gestures, facial expressions, eye communication, tactile communication and paralanguage have been identified by

researchers as the principle non-verbal cues. (DeVito, 1989; Leathers, 1989; Kendon, 1983).

In TA testing or user data collection sessions much of the non-verbal communication that is exchanged using body movements and having up to 55% impact according to Mehrabian (1981) can also be gathered along with verbal output. Certain behaviors can be better understood only through the interpretation of non-verbal cues, body movements being the only way of their communication. A few examples are given below:

a) Readiness and enthusiasm: When people are ready to take action, they will often sit forward in their seats or stand with their hands on their hips. They are anxious to get going. They will stand or sit in an erect position. They are alert, with wide, bright eyes. Their body motions are alive and animated. If the evaluator fails to take notice and initiate rapport during this enthusiasm stage the user is likely to become either restive or defensive.

b) Frustration: People are often observed exhibiting gestures such as hand-wringing, running fingers through hair, clenching hands or jaw, an exasperated sigh or touching and stroking themselves. Such gestures are called 'adapters' because the user unconsciously tries to adapt by lowering frustration levels through rhythmic action. If the evaluator were to verbally ask the user about their discomfort the answer would most probably be a denial of their uncomfortable condition while the gestures could indicate the contrary.

c) Nervousness: Nervous people cover their mouths when they speak. Their voices are often high and may even break. Their speech is hesitant, and they use "ums" and "ahs" incessantly. They may clear their throats and wring their hands while looking down at their feet. One may also see their facial muscles twitching. Asking them to continue speaking aloud or responding to a questioner despite

their nervousness may result in non-valid data. Designers need to know about and recognize gesture signs of nervousness. Thus, it can be said that non-verbal cues are a rich source of information on the state and behaviour of the users in addition to verbal content that users communicate.

Types of Non-verbal Cues: Attempts at identifying meaning in non-verbal cues, especially arms and hand gestures have made earlier by Pease et al (2000) and Mahl (Mahl, 1968). Highlen and Hill (1984), working in the area of counselling psychology have identified areas of study in non-verbal behavior as *paralinguistics*, *kinesics*, *facial expressions*, *visual behaviour*, *proxemics*, and *touch*. Later day researchers from cultural anthropology and linguistics have added *oculesics*, *artifacts*, and *chronemics* to the list.

Paralinguistics deal with vocal cues such as pitch, tone, intonation, and modulation that accompany speech. These also include sounds from the throat such as humming or filling silence with sounds such as - 'ummmm' or 'aaaa'. *Proxemics* deal with the study of space element such as distance between people and objects. Edward Hall, an American anthropologist who coined the term, defines proxemics in terms of four zones namely: (a) Intimate - which extends from 0 to 0.5 mts; (b) Personal – 0.5 to 1.2m ; (c) Social -1.2 to 3m; (d) Public – 3m. *Artifacts* has been associated with the study of non-verbal messages sent out by personal accessories such as dress, fashion accessories etc worn / used by the person. *Chronemics* is related to the study of time and its relative understanding by the persons involved. Pauses, silences, response lag during an interaction are some of the issues. *Kinesics* or kinesthetic (both occur in published literature) deals with postures, gestures, head -nodes and leg movements. In this paper we are mainly concentrating on the kinesthetic gestures.

Ekman & Friesen (1969) have further sub-categorised gestures into four types namely *Emblems, Illustrators, Regulators & Adapters*. Emblems are direct translation of culture specific signs like nodding of head for 'yes' or a V sign to indicate victory. Illustrators emphasize action such as banging the table, cutting the air sharply or sketching in the air a circle to emphasize a round geometric shape. Adapters are unconscious actions of body like snapping knuckles, shaking a leg rhythmically, touching the self - stroking h or chin while in deep contemplation, shifting body orientation to get relief from imagined pressure or discomfort. Regulators are used to control the flow of conversation such as nodding the head up and down to indicate agreement and as though signalling the other to continue the conversation.

As seen above the number and type of non-verbal cues that a researcher can observe is large and requires micro level observations of each frame of a video. Most cues occur simultaneously and in clusters necessitating repeated frame rewinding of the tapes during coding. From the pilot analysis done by us using software we estimated that each minute of video requires at least 10 minutes of micro framed observations. In order to reduce complexity and keeping the limitations of time and manpower resources available, it was decided to limit our study only to the kinesthetic gestures involving hand and head movements and code them under the four sub category types namely *Emblems, Illustrators, Regulators and Adapters*.

To seek answers and explore the phenomenon of non-verbal cues such as gestures we analysed contents of videos recorded earlier during a Usability Think Aloud (TA) test wherein data was being elicited from users in three different cultures – India, China and Denmark. A standardized designing task using word processor software was developed and administered in three different countries under a standardized format. In the TA test Users had been given task

of designing a wedding invitation using common word processing software and a collection of cultural clipart embedded in its clip organizer. This TA session was part of an experiment to explore the effects of culture on the interaction between evaluator and test user in a usability test, when the culture of evaluator is different from the user. Phase one of the TA experiment involved a questionnaire, phase two involved composing the wedding invitation clipart by the user as they were thinking aloud. Phase three involved interviewing the user by the evaluator during which the researchers studied the interaction between the evaluator and test user. The entire TA session was video recorded in a standard testing room. It is these videos that have been used for content analysis and coding of non verbal cues reported in this paper.

A total of 120 minutes of videos (12 different videos -10 minutes duration each) were selected randomly from video recordings of Think Aloud Usability sessions conducted earlier in Denmark, India and China. Gestures of a total of 12 users, 4 each from Denmark, China and India formed the sample base.

Keeping in view the total number of gestures per minute a user makes and multiplying them with ten minutes of tape for each user, it was logistically possible to accommodate only four users representative of each of the three cultures.

The language used in all videos was English. Of the two participants featuring in the TA video – the user and the tester, only the user's gestures were analysed for in this research. **Method:** Three independent coders carried out content analysis by visual coding of the occurrences and type of hand as well as head gestures. The coders were male graduate students, 21 years of age, well versed with usability techniques, which they had studied for two years. They were knowledgeable about usability testing and behavioural coding, and they received

additional training on the visual coding and analysis software - Noldus observer™ version 5. **Coding scheme:** The unit of analysis was the user's non-verbal communication behaviour namely hand and head gestures. The coding was done on the user's behaviour and from the user's point of view of the interaction happening in the video. Hand and Head gestures of the user under test were observed and logged every time they occurred in the video. Head gestures were logged as Up- Down; Left- Right and Arch Swing sideways (like when the ears are made to touch the shoulders). The coders classified them according to types namely *Regulators, Emblems, Illustrators, and Adapters*. The coders also keyed in notes, comments and observations against each gesture on the basis of their judgement. The coders also made a note of the presence, if any, of a usability problem in the assigned task along with accompanying spoken words.

Procedure: The procedure for coding the 12 videos was divided into three phases. Phase one was a training phase for the coders to get familiar with the coding software and coding scheme. During phase two coders were asked to individually code a set of three same videos so as to enable calculating the inter-coder reliability. In phase three each coder worked on a different subset of the remaining nine videos. In the training phase one, the coders received feedback on their coding quality twice. The feedback given by the three authors to the three coders focused on clarifying any interpreting differences between them especially in understanding types of gestures and eliminating timing errors that crept in due to lag in pausing the videos while moving back and forth between frames. We emphasized in our instruction to the coders that coding should focus on the user's behaviour and be done from the user's point of view. The rules for distinguishing between categories of behaviour were repeated. Ample rest pauses were incorporated in the coding schedule to minimise the bias of fatigue due to prolonged minute observations that the analyses warranted. In phase two, in order to provide evidence that the coders were not drifting from

their consensus as they continued coding more videos, a 25% overlap between coders was built by having all three coders code the same 3 of the 12 videos and the inter-rater reliability was calculated as shown in Table 1. Table 1. Inter-rater reliability

| | | Indian video | Danish video | Chinese video |
|----------------|---------------------------------|--------------|--------------|---------------|
| Coder A | <i>Summed statistics</i> | Value | Value | Value |
| vs | <i>No. of Agreements</i> | 111 | 69 | 98 |
| Coder B | <i>No. of Disagreements</i> | 54 | 31 | 45 |
| | <i>Proportion of agreements</i> | 0.67 | 0.69 | 0.69 |
| | <i>Consensus (Kappa)</i> | 0.54 | 0.54 | 0.48 |
| | <i>Consistency (Rho)</i> | 0.78 | 0.97 | 0.87 |
| Coder A | <i>No. of Agreements</i> | 137 | 81 | 116 |
| vs | <i>No. of Disagreements</i> | 28 | 19 | 27 |
| Coder C | <i>Proportion of agreements</i> | 0.83 | 0.81 | 0.81 |
| | <i>Consensus (Kappa)</i> | 0.74 | 0.71 | 0.69 |
| | <i>Consistency (Rho)</i> | 0.99 | 0.96 | 0.98 |
| Coder B | <i>No. of Agreements</i> | 97 | 76 | 88 |
| vs | <i>No. of Disagreements</i> | 53 | 17 | 42 |
| Coder C | <i>Proportion of agreements</i> | 0.65 | 0.82 | 0.68 |
| | <i>Consensus (Kappa)</i> | 0.51 | 0.72 | 0.46 |
| | <i>Consistency (Rho)</i> | 0.82 | 0.99 | 0.92 |

Note: Kappa and Rho values were all significant on the <0,001 level

It is observed from table 1 which shows pair-wise frequency sequence based comparisons of coding of nonverbal behaviors in each of the three videos in

phase two, that the inter-rater reliability was significant. Across different pairs of video observations, the three coders showed moderate to substantial *consensus* (Landis and Koch 1977) with Kappa values varying from 0.48 to 0.74, and acceptable *consistency* (Barrett 2001; Stemler 2004) with Pearson's Rho values of above 0.70. This means that there was high agreement between coders about when and which type of nonverbal behaviour they observed. It also indicates that they kept their concentration at uniform levels even as they continued coding more videos. Variations between coders did not introduce systematic bias in the observational data. In phase three, each coder was assigned randomly to code a subset of three of the remaining 9 videos. A total 120 minutes of usability test session video recording was prepared for analysis requiring 36 hours of coding, making the ratio between analysis time and observation time equal to 18:1. Compared to the 2:1 ratio usability professionals normally achieve and the 10:1 ratio common in research-oriented video coding (Fisher & Sanderson 1996; Burr 2006) our coders spent considerable quality time for coding. This effort has yielded high-quality observational data for the further analysis.

Analysis and Results: The observed and coded data is analysed in view of the research questions that were raised earlier. For Q1 wherein it was found out that if users from different cultures exhibit different gesture patterns in terms of their frequency and type, no significant overall difference was found. This is seen in Figure 1 showing frequency averages for users having cultural backgrounds of Indian, Chinese, and Denmark. Figure 2 shows Head and Hand gestures for the three nationalities, and Figure 3 shows each type of gesture (emblem, indicator etc) for each nationality. Our posit that subjects from eastern cultures (Indians & Chinese) use more hand and head gestures - was not tenable. On the contrary - of the three, the Danish, which we label as western culture, had a slightly higher frequency as compared to Indian and Chinese. This is in contrast to popular assumptions in India that Indians tend to use more body actions while

communicating than their western counterparts. However a larger sample size will be needed to come to conclusions.

On the other hand, occurrence patterns of specific *types* of gestures indicate differences between the three groups. *Illustrators* were more used in China where as *Regulators* the least. However, the differences are not significant. Only in the case of '*adapter*' type of gestures the difference, as seen in figure 3 was significant for the three cultures. ($F=4.256$, $df=2$, $p<0.05$).

Further qualitative analysis of the patterns and types of gestures on the basis of their occurrence in each video, regardless of cultural background, wherein the dialogues and interactions noted by the coders were also taken into consideration, (Figure 4) yields the following observations. Though the gestures were spread almost uniformly over the entire recorded TA session videos, (see Figure 7) the frequency and count of these gestures reveal a pattern of importance of each gesture. As seen in Figure.4 *Regulators*, which communicate the users regulation of interaction and activities (turn taking, conversing) (Ekman & Freisen, 1969) were the most prominently observed gestures. These *regulator* gestures become significant in understanding the users' behavior as it speaks of the users need to regulate one's verbalisations. These gestures also communicated the need for the person to focus on the task. The next prominent gesture type - *Illustrators* were found to assist the user in verbalizing (help seek the exact word or emphasise a word) and therefore become additional data to understand the users. Often these *illustrators* were used to depict the quantity ("very small in size"), quality ("attractive looking") or an online action ("I am writing"). These *illustrators* become very profuse at instances of user groping for a word to express his/her actions. The *emblem* gestures, which are culture specific signals as they replace a word by a symbolic gesture, were least in count per video. *Adapter* gestures were found to be fewer in frequency as compared to the other types suggesting that

the users were mostly comfortable in the testing environment. The adapter gesture could thus speak about the comfort level of the user in the testing situations.

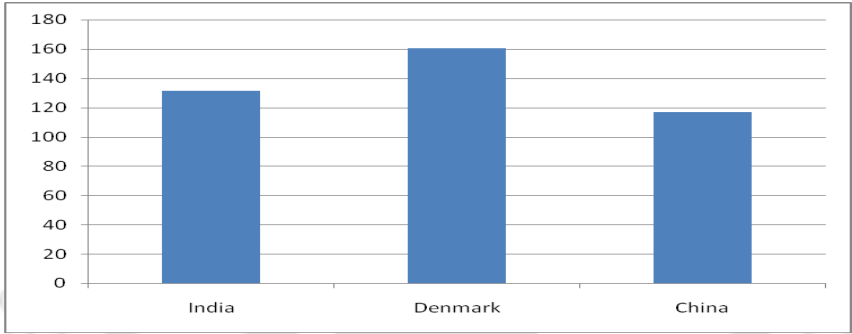


Figure 1. Average of non-verbal gestures in usability tests in subjects from three different cultures

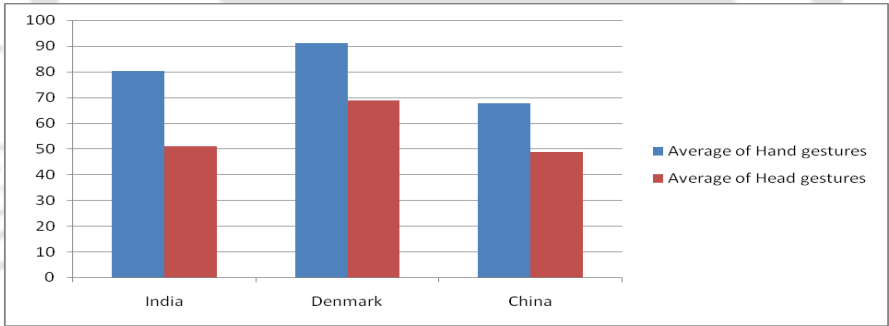


Figure 2. Average of head and hand gestures in usability tests on subjects from three different cultures

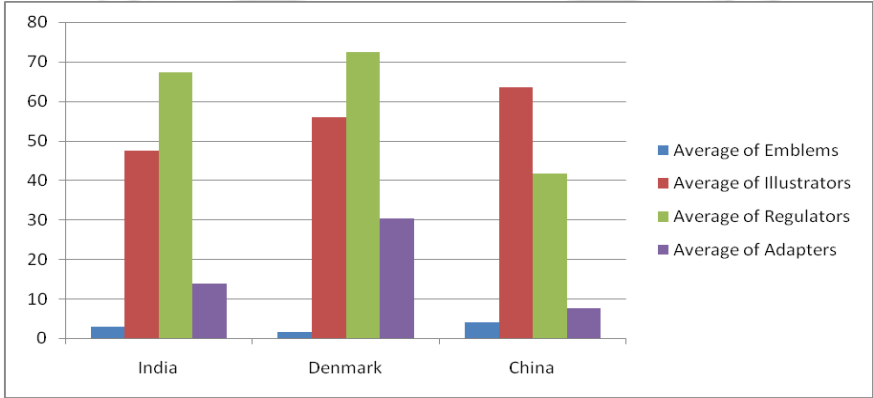


Figure 3. Average of four types of non-verbal gestures for the three different culture groups.

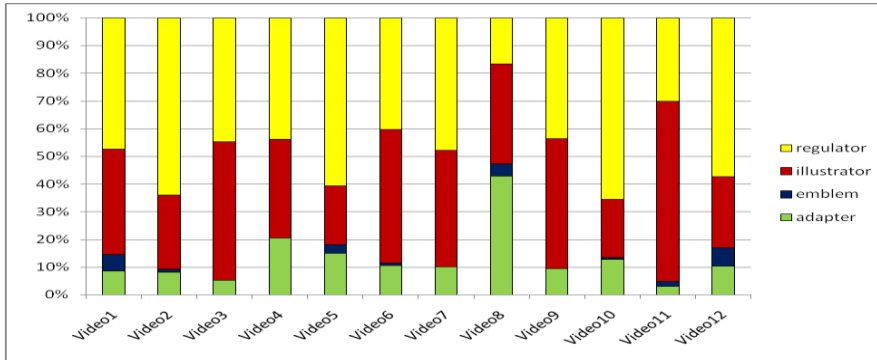


Figure 4. Gesture types distribution across all videos

No significant results were found to the question whether the cultural background of the evaluator being different from that of user influences patterns of gestures. The difference in cultural backgrounds did not seem to matter to the participants. However, more number of gestures occurred when both the user and the tester belonged to the same culture. (Figure 5).

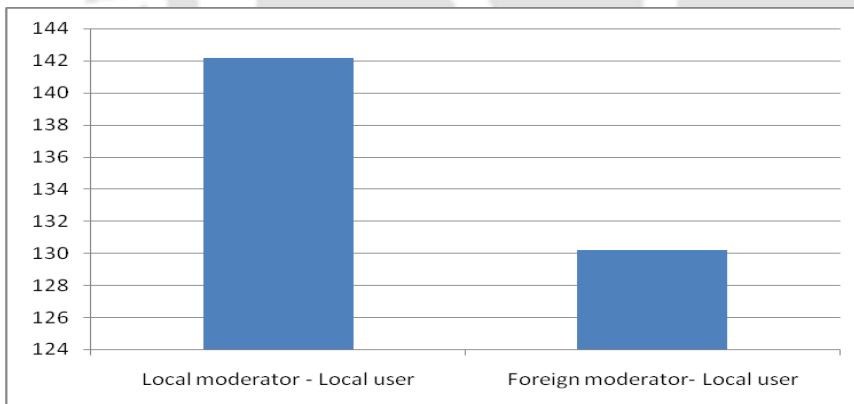


Figure 5: Average of non-verbal gestures for different background pairing of testers & users.

To the question whether frequency of gestures increases in the vicinity of usability problems, we found that the occurrence and frequency of gestures was uniform throughout the 10 minutes of recorded interactions and the presence of usability problems did not influence this spread. Increased frequency of gestures at a point would therefore not necessarily be indicators of the presence of specific usability task problems at that point. However when we analysed the *type* of gestures in the vicinity of a usability problem we observed that the head arch movement and the hand illustrator gesture preceded usability problems in the videos. We did find a significant correlation between the user's use of a head arch swing to illustrate what he or she was saying and the identification of usability problems (N=12, Pearson correlation= 0.555, $p < 0.05$; 1-tailed). Furthermore, a lag sequential analysis showed that of the different type of gestures the *illustrator* gesture is the most frequent predecessor or 'indicator' of a usability problem (see Figure 6).

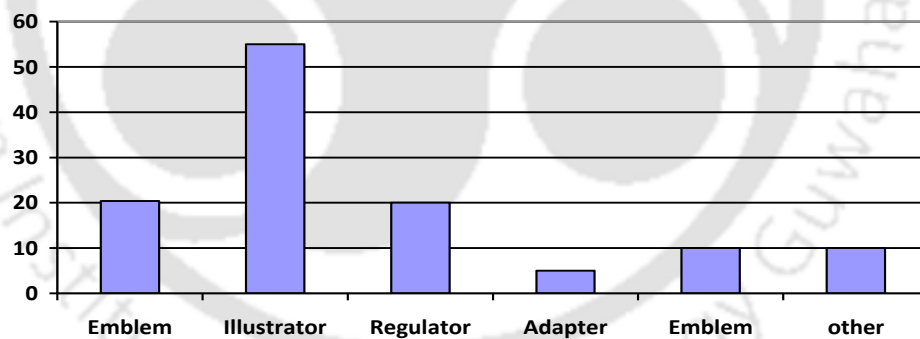


Figure 6: Percentage of Gestures occurring just before a usability problem is found

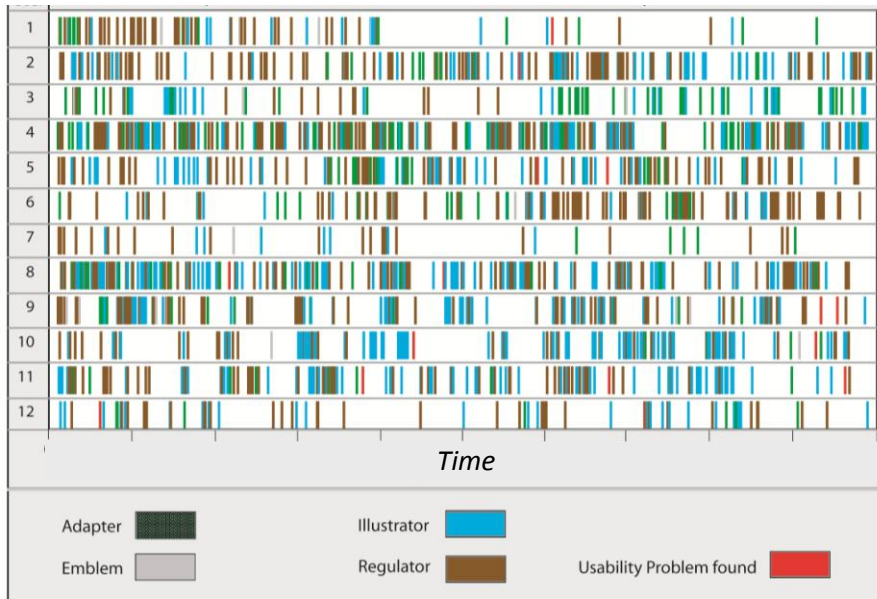


Figure 7: Spread of gesture occurrences for 12 users in the first 10 minutes of the video.

The question postulating that gestures increase in frequency in the initial part of the interaction as an aid to establish rapport is also answered in the negative. As seen in Figure 7 the spread of gestures is uniform throughout the length of the interactive testing session starting at the beginning of the task and ending at the completion of ten minutes of the session.

Conclusions: Analysis of non verbal cues such as gestures showed that there is indeed a rich amount of non-verbal behavioral data that a designer can collect and analyse in conjugation with the verbal data from the user. Non-verbal communication cues such as hand and head gestures occur throughout the interaction with an even spread. Their frequency of occurrence is not influenced by the cultural background of either the user or the evaluator.

The user's communication with 'adapters' was significantly different in the three countries. This indicates that 'adapters' could be culture sensitive in usability

testing situations. Furthermore, gestures of the type ‘*emblem*’ and some ‘*illustrators*’ could also be specific to usability testing in a particular culture. On the other hand, ‘regulators’ seems to be used in similar ways across cultures. In addition, it was observed in lag sequential analysis that the ‘*illustrator*’ gesture is the most frequent predecessor or ‘indicator’ of a problem with the task. Further studies on this can yield non-verbal behavior indicators that can increase a design researcher’s sensitivity to the presence of usability problems in a cross-cultural User testing or data collection situation. A deeper study of gesture types and cultures involving a larger cultural sample base is likely to yield more useful data for design researchers.

The study was restricted to occurrence and type of gestures using a small sample from participants belonging to different cultures. The symbolic, iconic, and metaphoric content of the gestures were not analysed in relation to the accompanying verbal output. A much larger sample base representative of the different cultures, need to be studied.

B.2 TA technique at prototype level data collection

Aim: To observe how TA technique at prototype level can be useful in gathering experiential data.

Introduction: The HCI design process is iterative in nature where data is gathered throughout the design development process. The Initial design concepts are used to gather data from users when the cost of the changes is very low. One of the popular methods used to gather the initial level data from users is with the use of paper prototypes. Not only paper prototypes are less costly to create but also the users find it easier to criticize. It has been observed earlier that with paper

prototypes, users give more frank criticisms. Hence this study was conducted to observe if any experiential data can be gathered by TA technique by using paper prototypes design process. It was relevant to do this study as other techniques selected for study in this thesis cannot be applied at the paper prototype level to gather experiential data under a given task. Though, semantic differential and Repertory Grid techniques can gather data from the sketches created by the designers on paper, but they cannot help gather data effectively when the user is given a task to do on a functional paper prototype. Again in this study, same culture and cross cultural pairs were used to identify any issues in gathering the data when culture is a factor.

Research Question: Does TA yield any useful experiential data at the paper prototype level? Does culture of evaluator affect the data given by users?

Hypothesis: TA cannot gather experiential data at the paper prototype level and culture of evaluator has an influence in data gathering using TA.

Research Design: A foreign evaluator gave three different tasks on a functional paper prototype to likely users. The same prototype was used by five Indian evaluators

Participants: Total of 10 participants, (8 Males, 2 females) were interviewed by the foreign evaluator and total of 21 participants (12 males, 9 females) were interviewed by the same culture evaluators. The participants reported that they used ATM machines on an average 4 times per month. All the participants were bachelor degree students.

Table 1 : Participants' age profile

| Evaluator | Mean | Std. Deviation |
|-----------|-------|----------------|
| American | 21.00 | 1.886 |
| Indian | 20.46 | 1.668 |
| Total | 20.62 | 1.724 |

Research method: Participants sat across a table on which the paper prototype of ATM interactive software was kept. The evaluator introduced the tasks one by one and the asked the users to perform the task by using the paper prototype. As the user interacted with the prototype, depending upon the kind of response expected form the system, evaluator place the responses over the prototype to show the systems responses in return to their actions on the prototype. After fulfilling the three tasks, users were given a questionnaire to fill in based on their experiences. After filling the demographic data, users were asked to fill a set of question related to their experiences with each task. Finally, one set of questions asked for the overall experiences of the users. Same set of questions were asked to the user with respect to each of the tasks that they had performed. Questions asked to the users were:

1. How easy or difficult was it to perform task on this prototype interface?
2. How simple or complex was the process of using this prototype interface for task 2?
3. How enjoyable was performing task on this prototype interface?
4. Generally, how would you rate this prototype interface in its ability to complete task?

Set of questions asked for their overall experiences were:

1. Overall, how easy or difficult was this prototype interface to use?
2. Did the prototype interface behave as you expected?
3. Are the elements within the prototype interface suited for the tasks?
4. How enjoyable was this prototype to use?
5. Overall, how effective was this prototype interface at completing the tasks in the 3 situations?
6. How confident would you feel about using this interface on a real life?
7. What percent of the total ideas that came to your mind during prototype interaction did you report / verbalize?

Users had to respond by rating their responses along a 10 point scale where 1 was the most positive response and 10 was most negative. For instance, for the first question the poles were easy/ difficult, where 1 represented ‘easy’ and 10 ‘difficult’. Similarly for question 2, it was simple (1), complex (10) and so on. Users had to mark the numbers written below the questions to report their experience.

Observations: Significant difference the users’ responses were observed between the evaluators when they were from same culture and when they were from a different culture.

Conclusions: Though no difference in users’ responses with respect to individual tasks was observed but the difference in overall responses had some significant difference between foreign and local evaluators. Users reported greater percentage of verbalisations with same culture evaluators and also criticized the design greater when the evaluator was from the same culture. This finding can be helpful in deciding evaluator selection for a TA test at prototype level. At the paper prototype, the interaction itself is less rich and there is greater role of the evaluator. This increased in interaction between the user and evaluator brings forth the inhibition in users to criticize.

Table 2: Users responses to questionnaire for task 1

| Evaluator | | Easy/ Difficult | Simple/ Complex | Enjoyable/ Not Enjoyable | Satisfactory/ Not Satisfactory |
|-----------|----------------|--------------------|--------------------|-----------------------------|-----------------------------------|
| American | Mean | 4.40 | 3.90 | 4.00 | 4.10 |
| | Std. Deviation | 2.366 | 1.969 | 2.708 | 2.378 |
| Indian | Mean | 3.58 | 4.00 | 4.58 | 3.75 |
| | Std. Deviation | 2.302 | 2.207 | 2.717 | 2.251 |

| | | | | | |
|-------|----------------|-------|-------|-------|-------|
| Total | Mean | 3.82 | 3.97 | 4.41 | 3.85 |
| | Std. Deviation | 2.316 | 2.110 | 2.687 | 2.258 |

Table 3: Users responses to questionnaire for task 2

| Evaluator | | Easy/ Difficult | Simple/ Complex | Enjoyable/ Not Enjoyable | Satisfactory/ Not Satisfactory |
|-----------|----------------|--------------------|--------------------|-----------------------------|-----------------------------------|
| | | American | Mean | 3.50 | 4.20 |
| | Std. Deviation | 2.759 | 2.700 | 2.885 | 2.708 |
| Indian | Mean | 4.63 | 4.58 | 5.08 | 4.75 |
| | Std. Deviation | 2.374 | 2.302 | 2.903 | 2.212 |
| Total | Mean | 4.29 | 4.47 | 4.79 | 4.53 |
| | Std. Deviation | 2.505 | 2.390 | 2.890 | 2.351 |

Limitations of this study: Only one foreign evaluator was involved in the experiment and hence some of the differences observed could have been because of the individual characteristics of the evaluator rather than being representative of the culture. Further, only Indian users' behaviour towards the American evaluator has been observed. India having a strongly hierarchical and collectivist culture, influences the members of its culture to acts in a way where much importance is given to the feelings of others and the strangers specially are much cared for. This may come as a hindrance to the data gathering from users.

Table 4: Users responses to questionnaire for task 3

| Evaluator | | Easy/ Difficult | Simple/ Complex | Enjoyable/ Not Enjoyable | Satisfactory/ Not |
|-----------|----------------|--------------------|--------------------|-----------------------------|----------------------|
| | | American | Mean | 2.70 | 2.70 |
| | Std. Deviation | 1.567 | 1.494 | 1.578 | 1.160 |
| Indian | Mean | 5.13 | 5.25 | 4.96 | 5.46 |

| | | | | | |
|-------|----------------|-------|-------|-------|-------|
| | Std. Deviation | 2.849 | 2.923 | 3.000 | 2.750 |
| Total | Mean | 4.41 | 4.50 | 4.26 | 4.53 |
| | Std. Deviation | 2.754 | 2.820 | 2.853 | 2.788 |

Table 5: Overall responses to the prototype

| Evaluator | | Easy/ Difficult | Expected/ Unexpected | Well Suited/ Poorly Suited | Enjoyable/ Not Enjoyable | Effective/ Not Effective | Confident/ Not Confident | Percent of Ideas Verbalized |
|-----------|-----------|--------------------|-------------------------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------------------|
| American | Mean | 3.30 | 3.80 | 3.20 | 2.60 | 3.00 | 2.70 | 61.88 |
| | Std. Dev. | 1.252 | 2.044 | 1.751 | 1.174 | 1.054 | 1.337 | 19.445 |
| Indian | Mean | 4.71 | 4.67 | 4.83 | 5.13 | 4.63 | 5.13 | 80.86 |
| | Std. Dev. | 2.216 | 2.444 | 2.316 | 2.894 | 2.318 | 2.724 | 17.855 |
| Total | Mean | 4.29 | 4.41 | 4.35 | 4.38 | 4.15 | 4.41 | 75.80 |
| | Std. Dev. | 2.067 | 2.337 | 2.268 | 2.753 | 2.148 | 2.630 | 19.876 |

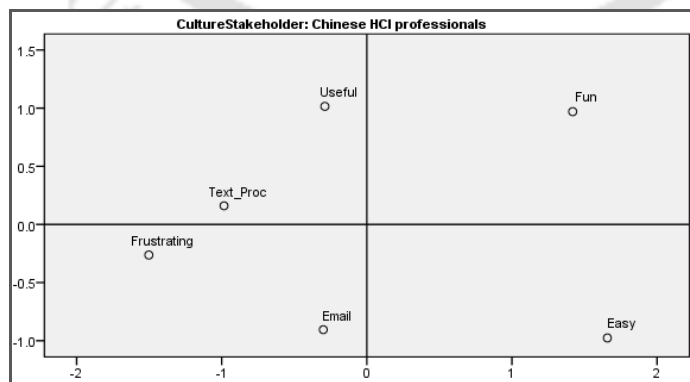
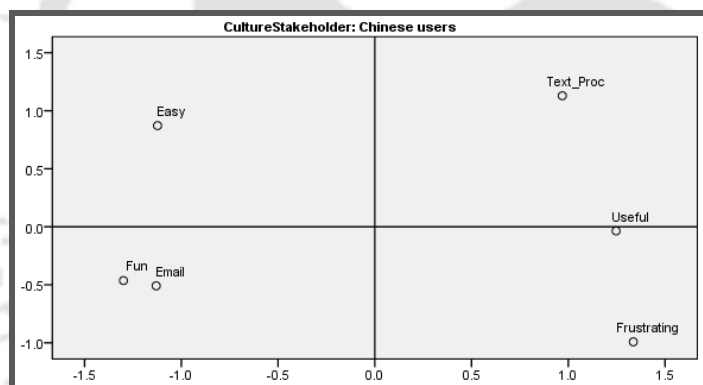
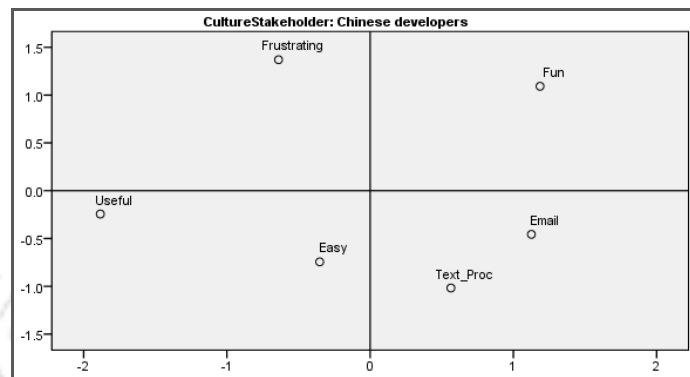


Appendix C

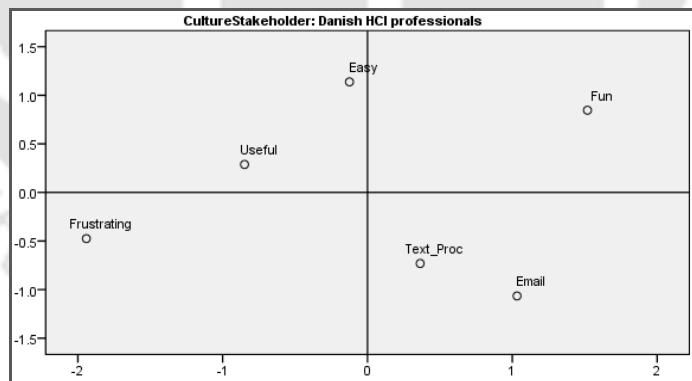
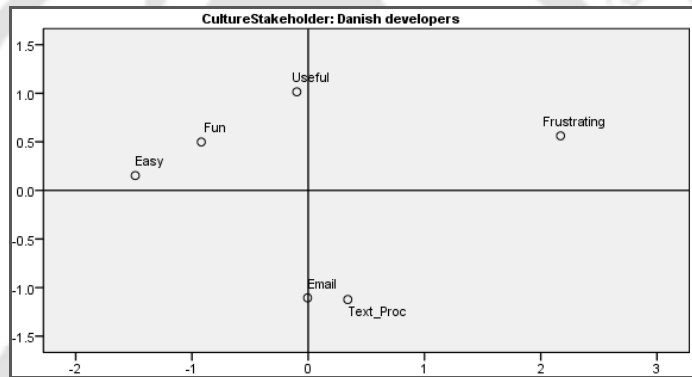
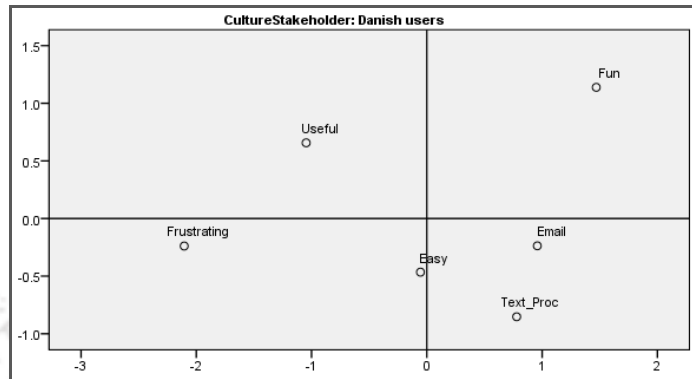
C.1 Findings from Repertory Grid Technique

MULTI DIMENSIONAL SCALING ON THE RGT DATA FROM
TRANSITIONAL LEVEL

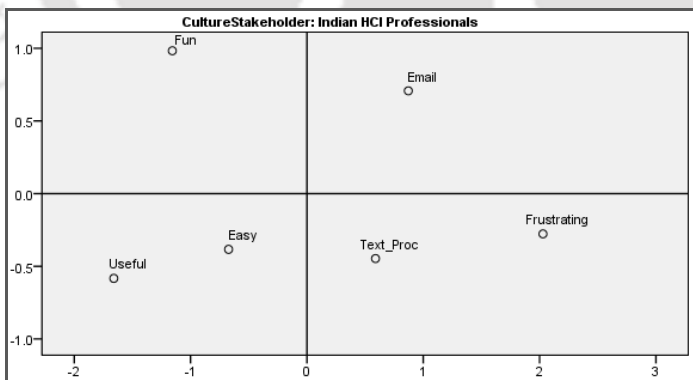
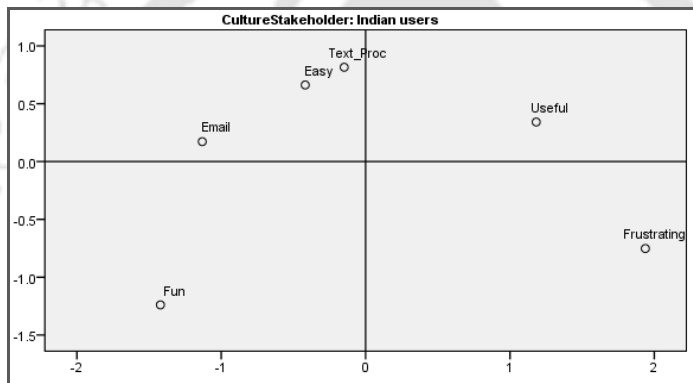
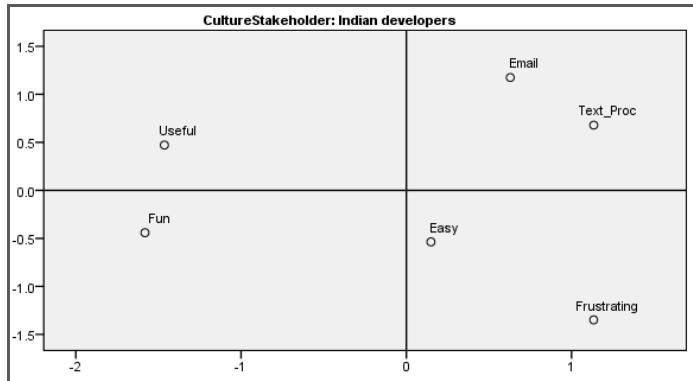
MDS across stakeholders in China



MDS across stakeholders in Denmark



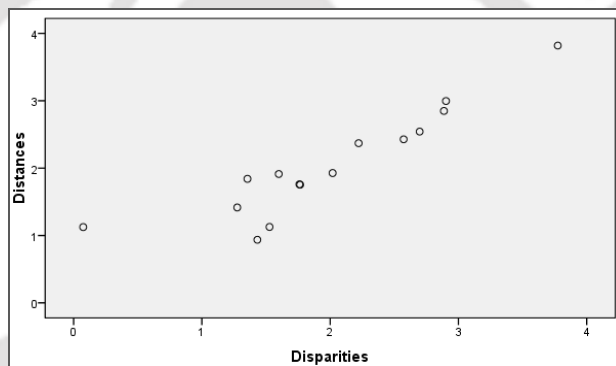
MDS across stakeholders in India



GOODNESS OF FIT OF MULTI DIMENSIONAL SCALING DONE WITH
RGT DATA AT TRANSITIONAL LEVEL.

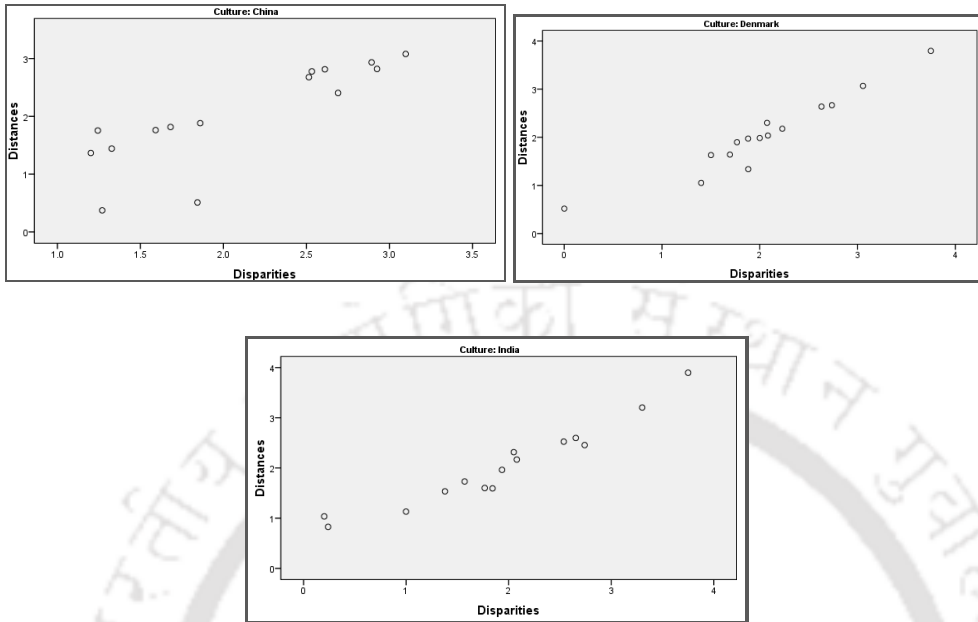
MDS on all the cases taken together

| Case Processing Summary | | | | | |
|-------------------------|---------|---------|---------|-------|---------|
| Cases | | | | | |
| Valid | | Missing | | Total | |
| N | Percent | N | Percent | N | Percent |
| 977 | 100.0% | 0 | .0% | 977 | 100.0% |



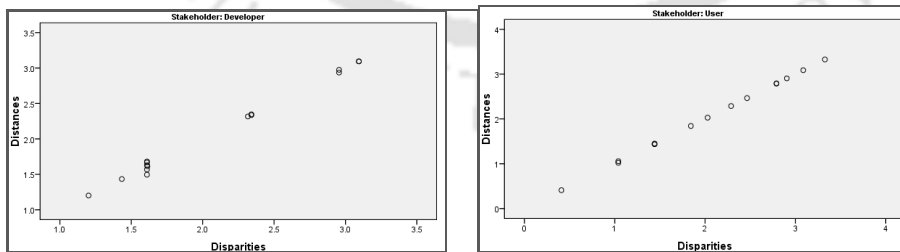
MDS across cultures

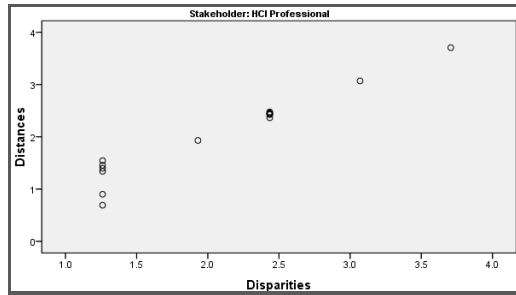
| Case Processing Summary | | | | | | |
|-------------------------|-------|---------|---------|---------|-------|---------|
| Culture | Cases | | | | | |
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| China | 371 | 100.0% | 0 | .0% | 371 | 100.0% |
| Denmark | 296 | 100.0% | 0 | .0% | 296 | 100.0% |
| India | 310 | 100.0% | 0 | .0% | 310 | 100.0% |



MDS across stakeholders

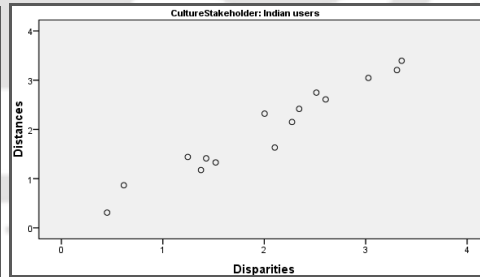
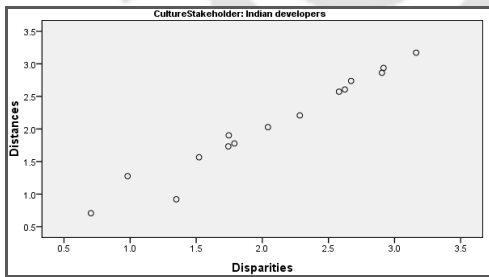
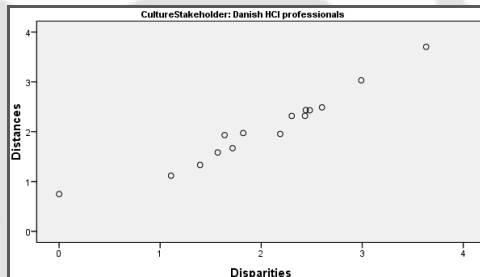
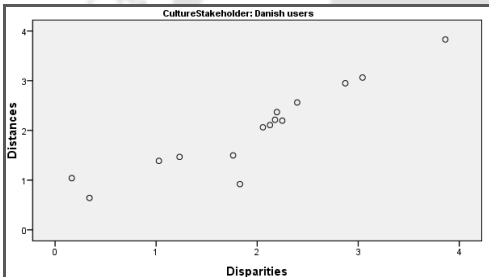
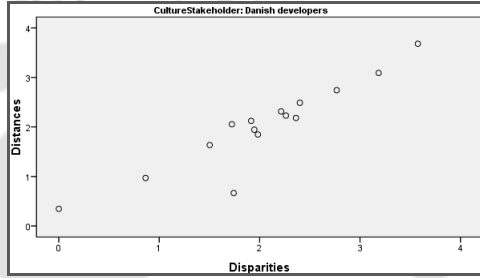
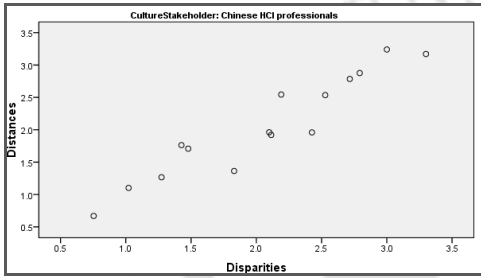
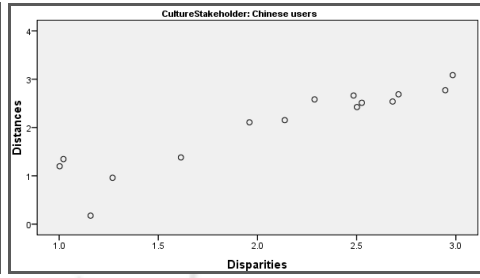
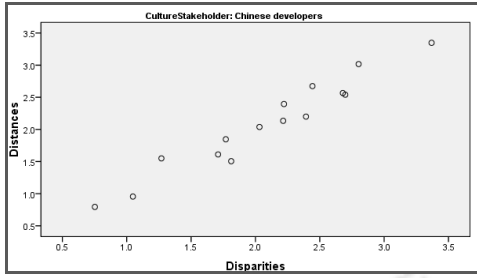
| Case Processing Summary | | | | | | |
|-------------------------|-------|---------|---------|---------|-------|---------|
| Stakeholder | Cases | | | | | |
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Developer | 318 | 100.0% | 0 | .0% | 318 | 100.0% |
| User | 343 | 100.0% | 0 | .0% | 343 | 100.0% |
| HCI Professional | 316 | 100.0% | 0 | .0% | 316 | 100.0% |





MDS across culture and stakeholders

| Case Processing Summary | | | | | | |
|---------------------------|-------|---------|---------|---------|-------|---------|
| Culture Stakeholder | Cases | | | | | |
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Chinese developers | 122 | 100.0% | 0 | .0% | 122 | 100.0% |
| Chinese users | 124 | 100.0% | 0 | .0% | 124 | 100.0% |
| Chinese HCI professionals | 125 | 100.0% | 0 | .0% | 125 | 100.0% |
| Danish developers | 98 | 100.0% | 0 | .0% | 98 | 100.0% |
| Danish users | 100 | 100.0% | 0 | .0% | 100 | 100.0% |
| Danish HCI professionals | 98 | 100.0% | 0 | .0% | 98 | 100.0% |
| Indian developers | 98 | 100.0% | 0 | .0% | 98 | 100.0% |
| Indian users | 119 | 100.0% | 0 | .0% | 119 | 100.0% |
| Indian HCI Professionals | 93 | 100.0% | 0 | .0% | 93 | 100.0% |





Appendix D

D.1 Affective data at composition level.

Users were shown stimuli images of screen shots and the elicited ratings on emotional categories along the nine emotions were analysed. The affective responses elicited by users alongside the stimuli used have been summarised in table. Details of this experiment have been discussed in section 4.7.1. Affective responses elicited by users have been displayed against the stimuli used in table D.1.

Table D. 1: Affective responses of users with the compositional level stimuli

| Compositon stimuli | Affective responses | | | | | | | | | | | | | | | | | | | | |
|---|--|---------|---------|-------|-----|------------|-----|-------|-----|-----|-----|---------|-----|------------|-----|-------|-----|-----------|-----|------|-----|
|  |  <table border="1"> <caption>Mean L1 Data</caption> <thead> <tr> <th>Emotion</th> <th>Mean L1</th> </tr> </thead> <tbody> <tr><td>Happy</td><td>4.0</td></tr> <tr><td>Disgusting</td><td>2.8</td></tr> <tr><td>Angry</td><td>1.8</td></tr> <tr><td>Sad</td><td>1.5</td></tr> <tr><td>Fearful</td><td>1.8</td></tr> <tr><td>Courageous</td><td>2.5</td></tr> <tr><td>Proud</td><td>2.5</td></tr> <tr><td>Wonderful</td><td>3.8</td></tr> <tr><td>Calm</td><td>4.5</td></tr> </tbody> </table> | Emotion | Mean L1 | Happy | 4.0 | Disgusting | 2.8 | Angry | 1.8 | Sad | 1.5 | Fearful | 1.8 | Courageous | 2.5 | Proud | 2.5 | Wonderful | 3.8 | Calm | 4.5 |
| Emotion | Mean L1 | | | | | | | | | | | | | | | | | | | | |
| Happy | 4.0 | | | | | | | | | | | | | | | | | | | | |
| Disgusting | 2.8 | | | | | | | | | | | | | | | | | | | | |
| Angry | 1.8 | | | | | | | | | | | | | | | | | | | | |
| Sad | 1.5 | | | | | | | | | | | | | | | | | | | | |
| Fearful | 1.8 | | | | | | | | | | | | | | | | | | | | |
| Courageous | 2.5 | | | | | | | | | | | | | | | | | | | | |
| Proud | 2.5 | | | | | | | | | | | | | | | | | | | | |
| Wonderful | 3.8 | | | | | | | | | | | | | | | | | | | | |
| Calm | 4.5 | | | | | | | | | | | | | | | | | | | | |
|  |  <table border="1"> <caption>Mean L2 Data</caption> <thead> <tr> <th>Emotion</th> <th>Mean L2</th> </tr> </thead> <tbody> <tr><td>Happy</td><td>4.5</td></tr> <tr><td>Disgusting</td><td>2.8</td></tr> <tr><td>Angry</td><td>2.5</td></tr> <tr><td>Sad</td><td>2.0</td></tr> <tr><td>Fearful</td><td>2.5</td></tr> <tr><td>Courageous</td><td>3.5</td></tr> <tr><td>Proud</td><td>2.2</td></tr> <tr><td>Wonderful</td><td>3.8</td></tr> <tr><td>Calm</td><td>3.0</td></tr> </tbody> </table> | Emotion | Mean L2 | Happy | 4.5 | Disgusting | 2.8 | Angry | 2.5 | Sad | 2.0 | Fearful | 2.5 | Courageous | 3.5 | Proud | 2.2 | Wonderful | 3.8 | Calm | 3.0 |
| Emotion | Mean L2 | | | | | | | | | | | | | | | | | | | | |
| Happy | 4.5 | | | | | | | | | | | | | | | | | | | | |
| Disgusting | 2.8 | | | | | | | | | | | | | | | | | | | | |
| Angry | 2.5 | | | | | | | | | | | | | | | | | | | | |
| Sad | 2.0 | | | | | | | | | | | | | | | | | | | | |
| Fearful | 2.5 | | | | | | | | | | | | | | | | | | | | |
| Courageous | 3.5 | | | | | | | | | | | | | | | | | | | | |
| Proud | 2.2 | | | | | | | | | | | | | | | | | | | | |
| Wonderful | 3.8 | | | | | | | | | | | | | | | | | | | | |
| Calm | 3.0 | | | | | | | | | | | | | | | | | | | | |
|  |  <table border="1"> <caption>Mean L3 Data</caption> <thead> <tr> <th>Emotion</th> <th>Mean L3</th> </tr> </thead> <tbody> <tr><td>Happy</td><td>3.2</td></tr> <tr><td>Disgusting</td><td>3.0</td></tr> <tr><td>Angry</td><td>2.5</td></tr> <tr><td>Sad</td><td>2.5</td></tr> <tr><td>Fearful</td><td>2.2</td></tr> <tr><td>Courageous</td><td>2.3</td></tr> <tr><td>Proud</td><td>3.5</td></tr> <tr><td>Wonderful</td><td>2.8</td></tr> <tr><td>Calm</td><td>3.8</td></tr> </tbody> </table> | Emotion | Mean L3 | Happy | 3.2 | Disgusting | 3.0 | Angry | 2.5 | Sad | 2.5 | Fearful | 2.2 | Courageous | 2.3 | Proud | 3.5 | Wonderful | 2.8 | Calm | 3.8 |
| Emotion | Mean L3 | | | | | | | | | | | | | | | | | | | | |
| Happy | 3.2 | | | | | | | | | | | | | | | | | | | | |
| Disgusting | 3.0 | | | | | | | | | | | | | | | | | | | | |
| Angry | 2.5 | | | | | | | | | | | | | | | | | | | | |
| Sad | 2.5 | | | | | | | | | | | | | | | | | | | | |
| Fearful | 2.2 | | | | | | | | | | | | | | | | | | | | |
| Courageous | 2.3 | | | | | | | | | | | | | | | | | | | | |
| Proud | 3.5 | | | | | | | | | | | | | | | | | | | | |
| Wonderful | 2.8 | | | | | | | | | | | | | | | | | | | | |
| Calm | 3.8 | | | | | | | | | | | | | | | | | | | | |





D.2 Investigating semblance in affective experiences of users

Aim: To identify similarity in affective experiences among members of a homogenous group.

Research Question: Do different people from similar backgrounds have same affective experiences with a given visual stimuli?

Hypothesis: Affective experiences reported by participants of a homogenous group would be similar with same visual stimuli.

Relevance of study: An interaction designer involved in designing for users affective experiences can be sure of success of designing for affective experience only if the members of a homogeneous user group experienced the same visual stimuli in similar ways. Else even if a user group tightly related in some way does not have same experience with a given interactive system, then what could be the purpose of designing for the user experiences itself? Hence this study was to identify if users experienced and rated visual stimuli along similarly and if their ratings were consistent for the group.

Participants: 59 participants who were in their 2nd 3rd or 4th year of bachelor degree education were requested to participate in this experiment. Their age group was 21-24 years.

Procedure: Participants were shown 21 images one at a time, of dustbins collected for maximum variation in eliciting emotional response. The 21 images were selected from a pool of 100 images of dustbin randomly collected from internet by mutual consensus by three designers for maximum variability. The selected 21 images have been exhibited in appendix A for reference. The images were shown full screen on a 17 inch LCD computer monitor at normal viewing distance. The researcher showed the images on screen one by one, asking the user to rate the images along the nine emotional categories. Researcher filled the response sheet using a pen while users kept looking at the screen and speaking out their ratings. This was done so as remove the burden of note taking from the participant. Researcher maintained a neutral relationship with the participant

during the experiment and only uttered name of the emotional categories asking the user to rate on 7 point scale. Total of 11, 151 ratings were thus obtained from all the participants for all the 21 images and all the nine emotional categories.

Data analysis: Analysis of variance was done on the data obtained from 59 participants for 21 images along 9 emotional categories. The ANOVA statistics has been displayed in table D.2.

Results and Discussion: If an affective scale with stimulus image is treated as the independent variable and the ratings as dependent on them. The variance in ratings within the group of emotional category was significantly less in comparison to the variation in ratings between the emotional categories. This means that the ratings were not arbitrary but a pattern did exist among them. The pattern indicated that majority of the participants had similar affective responses to the given stimuli image and the similarity was statistically significant. This is exhibited in the significant value column which shows that all the images were agreed by the participants for their affective responses. Hence from ANOVA it is established that for this research with the given set of images and the very homogeneous group of students, the affecting responses to given set of stimuli were similar. In other words participants in general agreed to the extent to which a given image looked happy or angry or courageous and so on.

Table D. 2: ANOVA on the SD data at elemental level affective responses

| ANOVA Table | | | | | | |
|-------------|----------------|-----------------------|-----------|--------------------|----------|-------------|
| | | <i>Sum of Squares</i> | <i>df</i> | <i>Mean Square</i> | <i>F</i> | <i>Sig.</i> |
| P1 | Between Groups | 131.315 | 8 | 16.414 | 7.321 | .000 |
| | Within Groups | 1170.305 | 522 | 2.242 | | |
| | Total | 1301.620 | 530 | | | |

| | | | | | | |
|-----|----------------|----------|-----|---------|--------|------|
| P2 | Between Groups | 192.738 | 8 | 24.092 | 12.129 | .000 |
| | Within Groups | 1036.881 | 522 | 1.986 | | |
| | Total | 1229.620 | 530 | | | |
| P3 | Between Groups | 1025.891 | 8 | 128.236 | 87.703 | .000 |
| | Within Groups | 763.254 | 522 | 1.462 | | |
| | Total | 1789.145 | 530 | | | |
| P4 | Between Groups | 399.676 | 8 | 49.960 | 24.488 | .000 |
| | Within Groups | 1064.949 | 522 | 2.040 | | |
| | Total | 1464.625 | 530 | | | |
| P5 | Between Groups | 416.072 | 8 | 52.009 | 38.212 | .000 |
| | Within Groups | 710.475 | 522 | 1.361 | | |
| | Total | 1126.546 | 530 | | | |
| P6 | Between Groups | 192.874 | 8 | 24.109 | 12.152 | .000 |
| | Within Groups | 1035.627 | 522 | 1.984 | | |
| | Total | 1228.501 | 530 | | | |
| P7 | Between Groups | 511.492 | 8 | 63.936 | 33.542 | .000 |
| | Within Groups | 995.017 | 522 | 1.906 | | |
| | Total | 1506.508 | 530 | | | |
| P8 | Between Groups | 42.320 | 8 | 5.290 | 2.577 | .009 |
| | Within Groups | 1071.593 | 522 | 2.053 | | |
| | Total | 1113.913 | 530 | | | |
| P9 | Between Groups | 187.642 | 8 | 23.455 | 14.029 | .000 |
| | Within Groups | 872.712 | 522 | 1.672 | | |
| | Total | 1060.354 | 530 | | | |
| P10 | Between Groups | 90.034 | 8 | 11.254 | 7.094 | .000 |
| | Within Groups | 828.102 | 522 | 1.586 | | |
| | Total | 918.136 | 530 | | | |
| P11 | Between Groups | 234.475 | 8 | 29.309 | 14.850 | .000 |
| | Within Groups | 1030.271 | 522 | 1.974 | | |

| | | | | | | |
|-----|----------------|----------|-----|---------|---------|------|
| | Total | 1264.746 | 530 | | | |
| P12 | Between Groups | 295.627 | 8 | 36.953 | 20.158 | .000 |
| | Within Groups | 956.915 | 522 | 1.833 | | |
| | Total | 1252.542 | 530 | | | |
| P13 | Between Groups | 459.254 | 8 | 57.407 | 36.676 | .000 |
| | Within Groups | 817.051 | 522 | 1.565 | | |
| | Total | 1276.305 | 530 | | | |
| P14 | Between Groups | 87.153 | 8 | 10.894 | 7.411 | .000 |
| | Within Groups | 767.356 | 522 | 1.470 | | |
| | Total | 854.508 | 530 | | | |
| P15 | Between Groups | 1199.322 | 8 | 149.915 | 147.483 | .000 |
| | Within Groups | 530.610 | 522 | 1.016 | | |
| | Total | 1729.932 | 530 | | | |
| P16 | Between Groups | 100.610 | 8 | 12.576 | 8.267 | .000 |
| | Within Groups | 794.136 | 522 | 1.521 | | |
| | Total | 894.746 | 530 | | | |
| P17 | Between Groups | 419.288 | 8 | 52.411 | 40.496 | .000 |
| | Within Groups | 675.593 | 522 | 1.294 | | |
| | Total | 1094.881 | 530 | | | |
| P18 | Between Groups | 201.100 | 8 | 25.137 | 17.089 | .000 |
| | Within Groups | 767.864 | 522 | 1.471 | | |
| | Total | 968.964 | 530 | | | |
| P19 | Between Groups | 83.484 | 8 | 10.435 | 6.744 | .000 |
| | Within Groups | 807.763 | 522 | 1.547 | | |
| | Total | 891.247 | 530 | | | |
| P20 | Between Groups | 618.625 | 8 | 77.328 | 38.874 | .000 |
| | Within Groups | 1038.373 | 522 | 1.989 | | |
| | Total | 1656.998 | 530 | | | |
| P21 | Between Groups | 86.241 | 8 | 10.780 | 7.206 | .000 |

| | | | | | | |
|--|---------------|---------|-----|-------|--|--|
| | Within Groups | 780.949 | 522 | 1.496 | | |
| | Total | 867.190 | 530 | | | |

Inferences: Participants did have similar affective experience with the visual stimuli of images. This means that any design aimed at giving an intended experience through HCI design process does have chances of succeeding as a homogeneous group of users do experience same interaction icons similarly.

D.3 Longitudinal study of affective experiences

Aim: To identify if the affective responses elicited by participants are consistent over a period of time.

Research Questions: How consistent are reported experiences of same users over a period of time?

Background: Affective experiences are generally considered unstable and inconsistent over a period of time. It is a general notion that the emotional value of an artefact does vary over time. This is a key concern for the designers who wish to create products with and intended experience value. If the affective responses with the same icons changed over a period of time then it would be far tougher job to ensure that users of an intended system designed for a particular affective experience receive the same for the users might have changed by the time the design reached them. This study was conducted to understand if the affective responses participants gave were consistent over a period of 18 months.

Research Design: 20 of the 59 participants from the study no. D.2 were repeated with the same experiment after a gap of 18 months. 17 of the 20

participants had an abroad visit during this time for a period of about 2-2.5 months. It is assumed here that 18 months is a considerable time period for change in affective responses towards a given icon, especially when we want to ensure that the users remain members of the same user group that the design is intended for. The participants were shown the same stimuli after a gap of 18 months and were asked to rate the images along the same 9 emotional categories. Difference between the two responses was calculated to estimate the difference in the responses.

Observations: As illustrated in fig D.1, standard deviation in differences between ratings of participants was 1.31 with 79.3% participants' reported ratings lying within the difference of 1 on the 7 point scale.

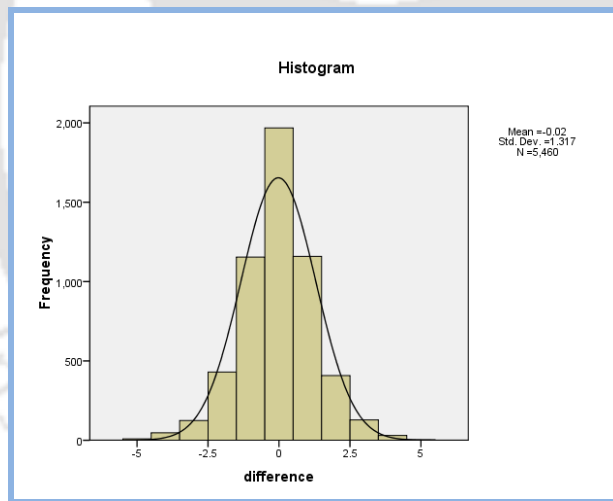


Figure D. 1: Difference in ratings of participants over time




Discussion: This is significantly consistent to conclude that participants' dispositions towards stimuli remain constant over small durations of time.

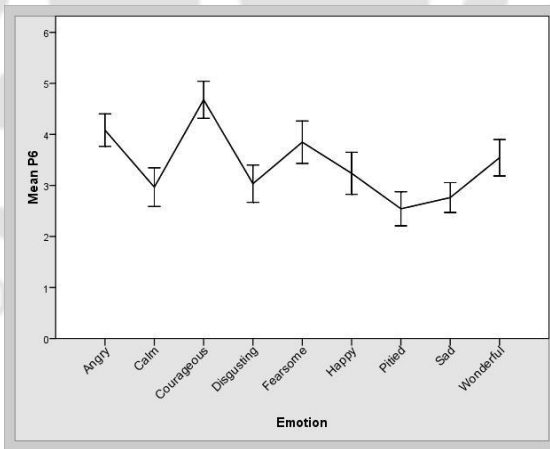
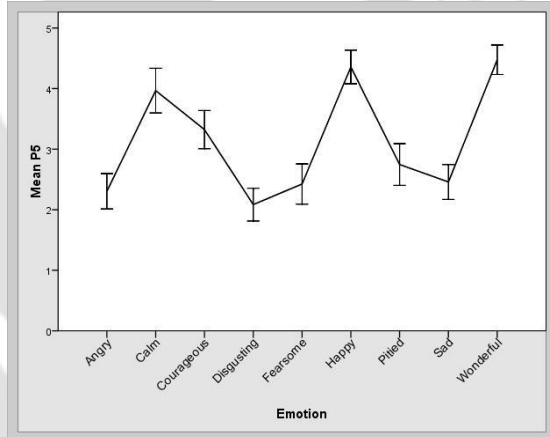
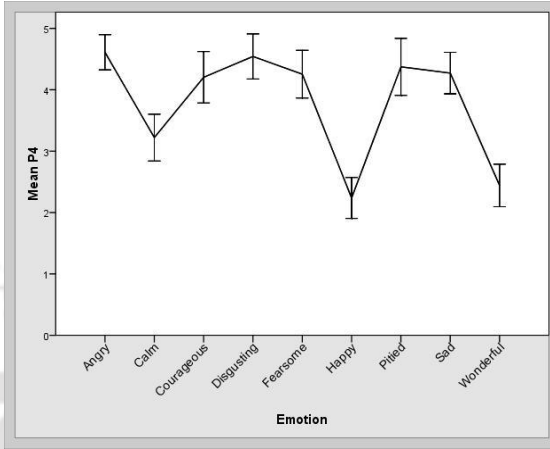
Inferences: Findings from this study have significant implications for the experiential design process. Affective experiences have been seen as fuzzy and volatile which depend upon the individuals and even within the individuals it fluctuates from time to time. This experiment indicates that an individual's disposition towards a given stimuli doesn't change over time that drastically so as to make the whole experiential design process baseless. People do have a fixed experiential response to a given stimuli and that response doesn't change over time. As dispositions influence the affective experiences of the users, the users' experiences with any given interactive system will not change drastically. Though this experiment was elements of interaction designs, namely icons/ images, but with the assumption that the overall interaction is constituted by these elements only, it is safe to assume that the experience generated by the interaction on the whole also will not change over short periods of time. This gives a very firm basis for the experiential design process. The designer can validate a given design whether it meets the experiential criteria set beforehand.

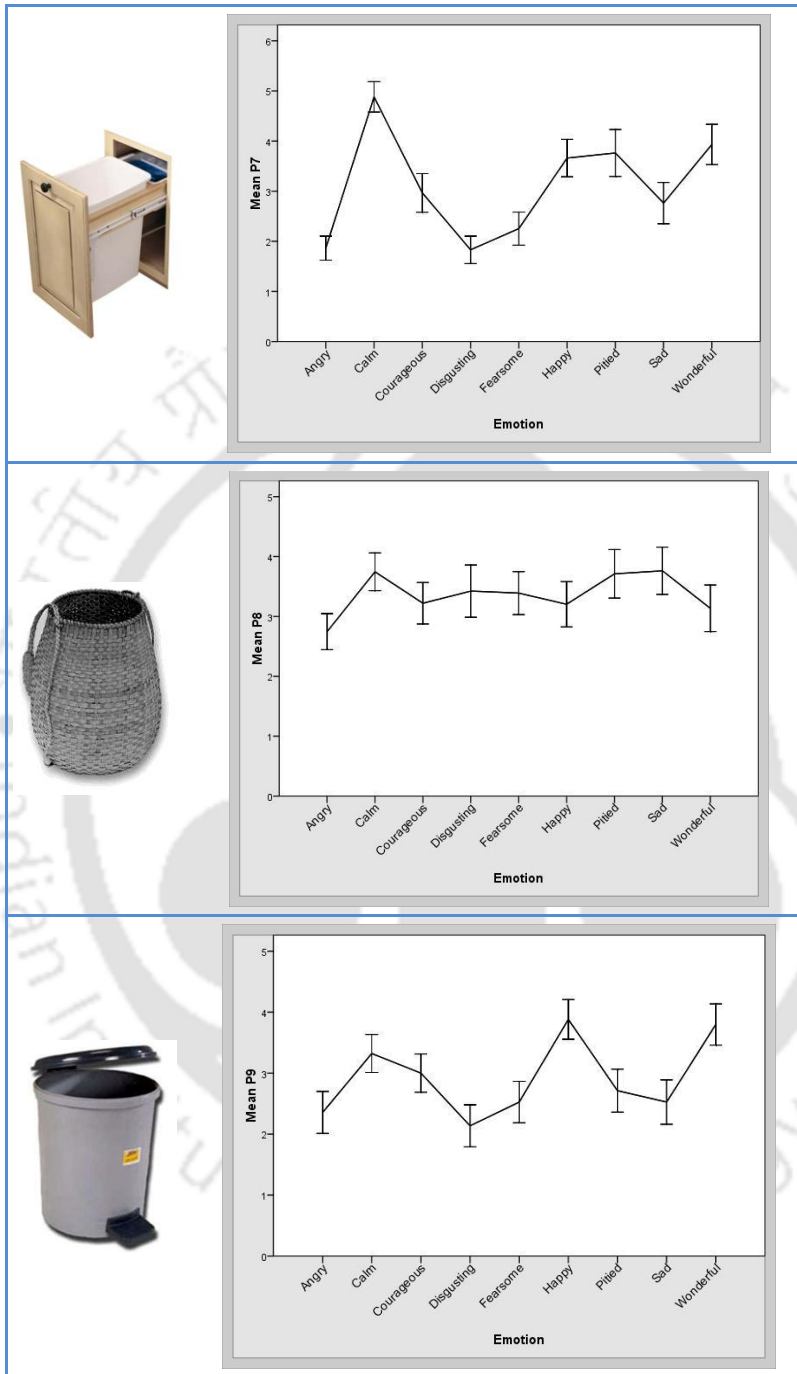
D.4 Affective responses to stimuli at elemental level

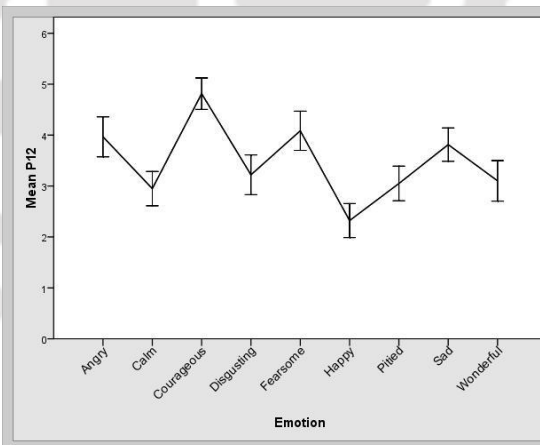
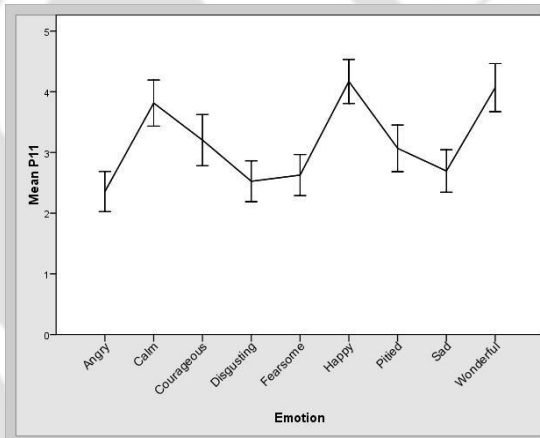
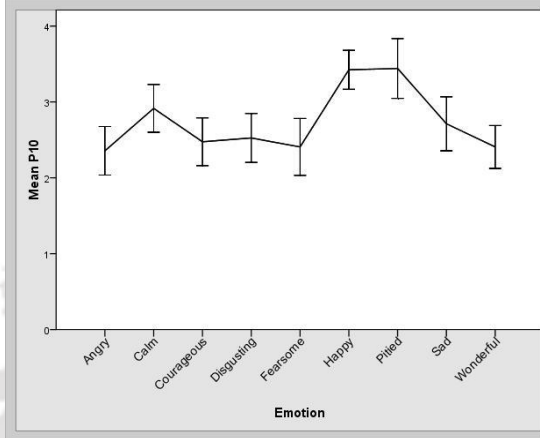
Table D.3 displays the affective responses of users elicited with elemental level stimuli. Details of the experiment conducted are described in section 4.7.2. The bars on the graph show 95 % confidence intervals around the mean value for each emotional category.

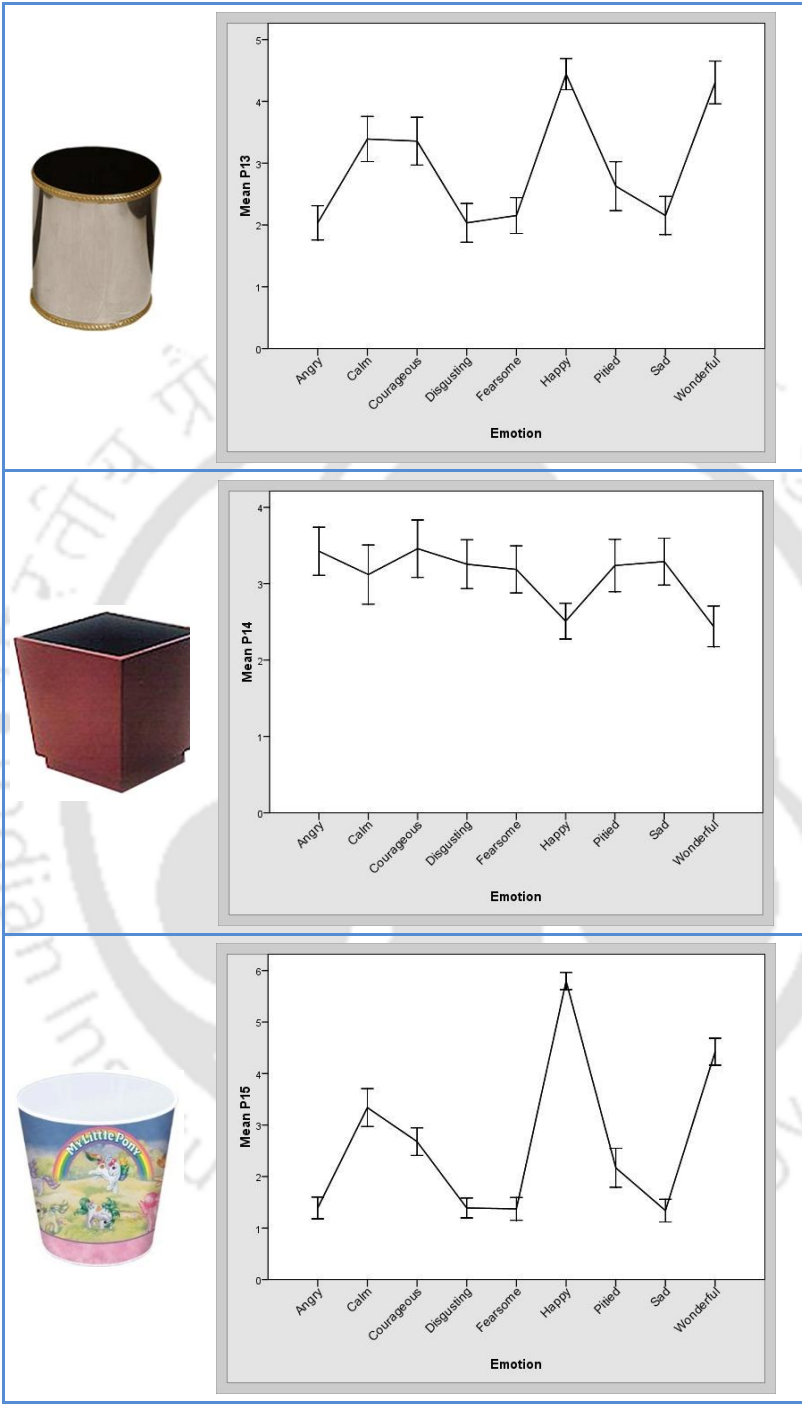
Table D. 3: Elicited affective responses of users at elemental level

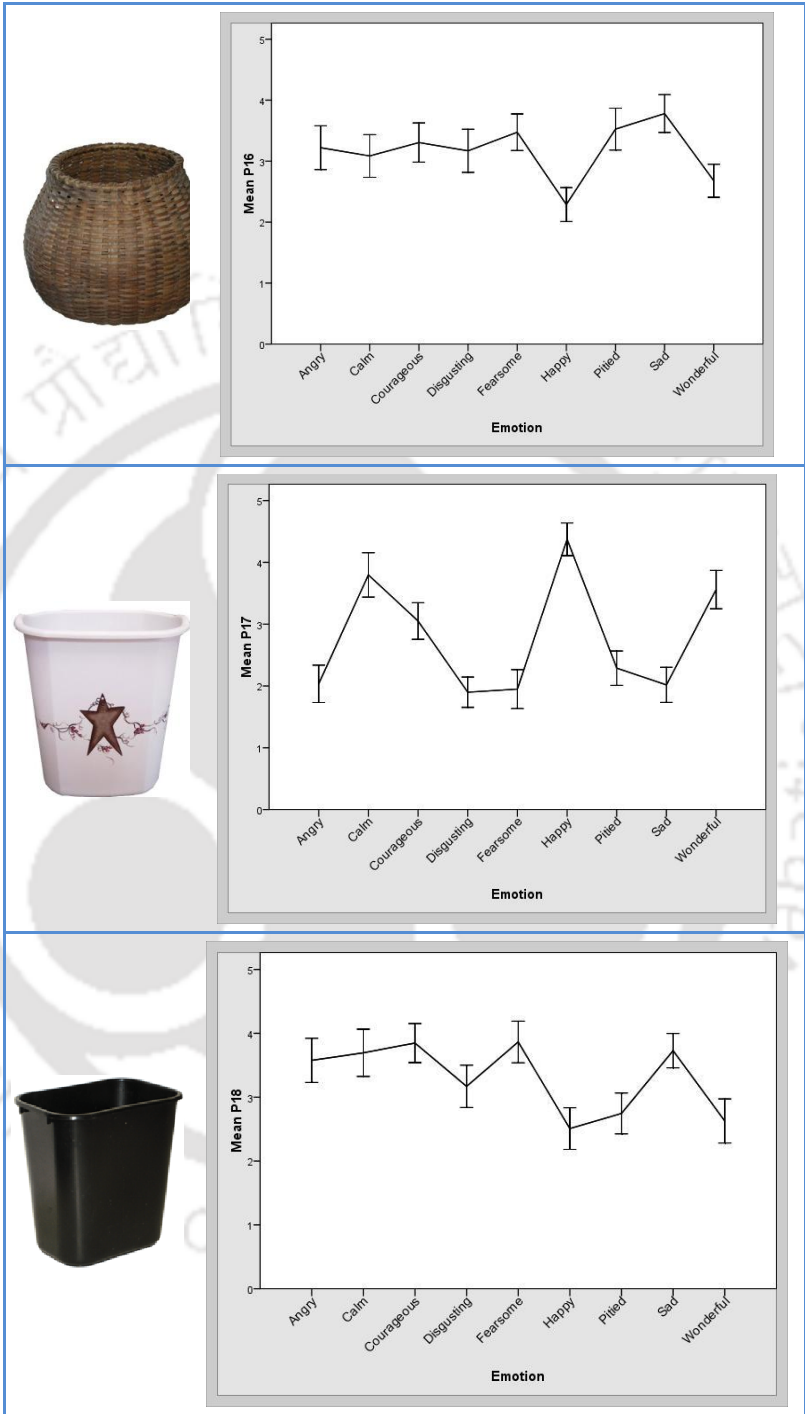
| Image stimuli | Affective responses | | | | | | | | | | | | | | | | | | | | |
|---|--|---------|---------|-------|-----|------|-----|------------|-----|------------|-----|----------|-----|-------|-----|---------|-----|-----|-----|-----------|-----|
|  | <table border="1"> <caption>Mean P1 Data</caption> <thead> <tr> <th>Emotion</th> <th>Mean P1</th> </tr> </thead> <tbody> <tr><td>Angry</td><td>3.8</td></tr> <tr><td>Calm</td><td>4.1</td></tr> <tr><td>Courageous</td><td>3.9</td></tr> <tr><td>Disgusting</td><td>3.5</td></tr> <tr><td>Fearsome</td><td>3.6</td></tr> <tr><td>Happy</td><td>3.1</td></tr> <tr><td>Pleased</td><td>3.4</td></tr> <tr><td>Sad</td><td>3.9</td></tr> <tr><td>Wonderful</td><td>2.8</td></tr> </tbody> </table> | Emotion | Mean P1 | Angry | 3.8 | Calm | 4.1 | Courageous | 3.9 | Disgusting | 3.5 | Fearsome | 3.6 | Happy | 3.1 | Pleased | 3.4 | Sad | 3.9 | Wonderful | 2.8 |
| Emotion | Mean P1 | | | | | | | | | | | | | | | | | | | | |
| Angry | 3.8 | | | | | | | | | | | | | | | | | | | | |
| Calm | 4.1 | | | | | | | | | | | | | | | | | | | | |
| Courageous | 3.9 | | | | | | | | | | | | | | | | | | | | |
| Disgusting | 3.5 | | | | | | | | | | | | | | | | | | | | |
| Fearsome | 3.6 | | | | | | | | | | | | | | | | | | | | |
| Happy | 3.1 | | | | | | | | | | | | | | | | | | | | |
| Pleased | 3.4 | | | | | | | | | | | | | | | | | | | | |
| Sad | 3.9 | | | | | | | | | | | | | | | | | | | | |
| Wonderful | 2.8 | | | | | | | | | | | | | | | | | | | | |
|  | <table border="1"> <caption>Mean P2 Data</caption> <thead> <tr> <th>Emotion</th> <th>Mean P2</th> </tr> </thead> <tbody> <tr><td>Angry</td><td>2.8</td></tr> <tr><td>Calm</td><td>4.1</td></tr> <tr><td>Courageous</td><td>3.8</td></tr> <tr><td>Disgusting</td><td>2.8</td></tr> <tr><td>Fearsome</td><td>2.9</td></tr> <tr><td>Happy</td><td>4.5</td></tr> <tr><td>Pleased</td><td>2.8</td></tr> <tr><td>Sad</td><td>3.0</td></tr> <tr><td>Wonderful</td><td>3.6</td></tr> </tbody> </table> | Emotion | Mean P2 | Angry | 2.8 | Calm | 4.1 | Courageous | 3.8 | Disgusting | 2.8 | Fearsome | 2.9 | Happy | 4.5 | Pleased | 2.8 | Sad | 3.0 | Wonderful | 3.6 |
| Emotion | Mean P2 | | | | | | | | | | | | | | | | | | | | |
| Angry | 2.8 | | | | | | | | | | | | | | | | | | | | |
| Calm | 4.1 | | | | | | | | | | | | | | | | | | | | |
| Courageous | 3.8 | | | | | | | | | | | | | | | | | | | | |
| Disgusting | 2.8 | | | | | | | | | | | | | | | | | | | | |
| Fearsome | 2.9 | | | | | | | | | | | | | | | | | | | | |
| Happy | 4.5 | | | | | | | | | | | | | | | | | | | | |
| Pleased | 2.8 | | | | | | | | | | | | | | | | | | | | |
| Sad | 3.0 | | | | | | | | | | | | | | | | | | | | |
| Wonderful | 3.6 | | | | | | | | | | | | | | | | | | | | |
|  | <table border="1"> <caption>Mean P3 Data</caption> <thead> <tr> <th>Emotion</th> <th>Mean P3</th> </tr> </thead> <tbody> <tr><td>Angry</td><td>1.8</td></tr> <tr><td>Calm</td><td>5.5</td></tr> <tr><td>Courageous</td><td>3.8</td></tr> <tr><td>Disgusting</td><td>1.7</td></tr> <tr><td>Fearsome</td><td>2.3</td></tr> <tr><td>Happy</td><td>5.0</td></tr> <tr><td>Pleased</td><td>3.1</td></tr> <tr><td>Sad</td><td>2.5</td></tr> <tr><td>Wonderful</td><td>4.7</td></tr> </tbody> </table> | Emotion | Mean P3 | Angry | 1.8 | Calm | 5.5 | Courageous | 3.8 | Disgusting | 1.7 | Fearsome | 2.3 | Happy | 5.0 | Pleased | 3.1 | Sad | 2.5 | Wonderful | 4.7 |
| Emotion | Mean P3 | | | | | | | | | | | | | | | | | | | | |
| Angry | 1.8 | | | | | | | | | | | | | | | | | | | | |
| Calm | 5.5 | | | | | | | | | | | | | | | | | | | | |
| Courageous | 3.8 | | | | | | | | | | | | | | | | | | | | |
| Disgusting | 1.7 | | | | | | | | | | | | | | | | | | | | |
| Fearsome | 2.3 | | | | | | | | | | | | | | | | | | | | |
| Happy | 5.0 | | | | | | | | | | | | | | | | | | | | |
| Pleased | 3.1 | | | | | | | | | | | | | | | | | | | | |
| Sad | 2.5 | | | | | | | | | | | | | | | | | | | | |
| Wonderful | 4.7 | | | | | | | | | | | | | | | | | | | | |

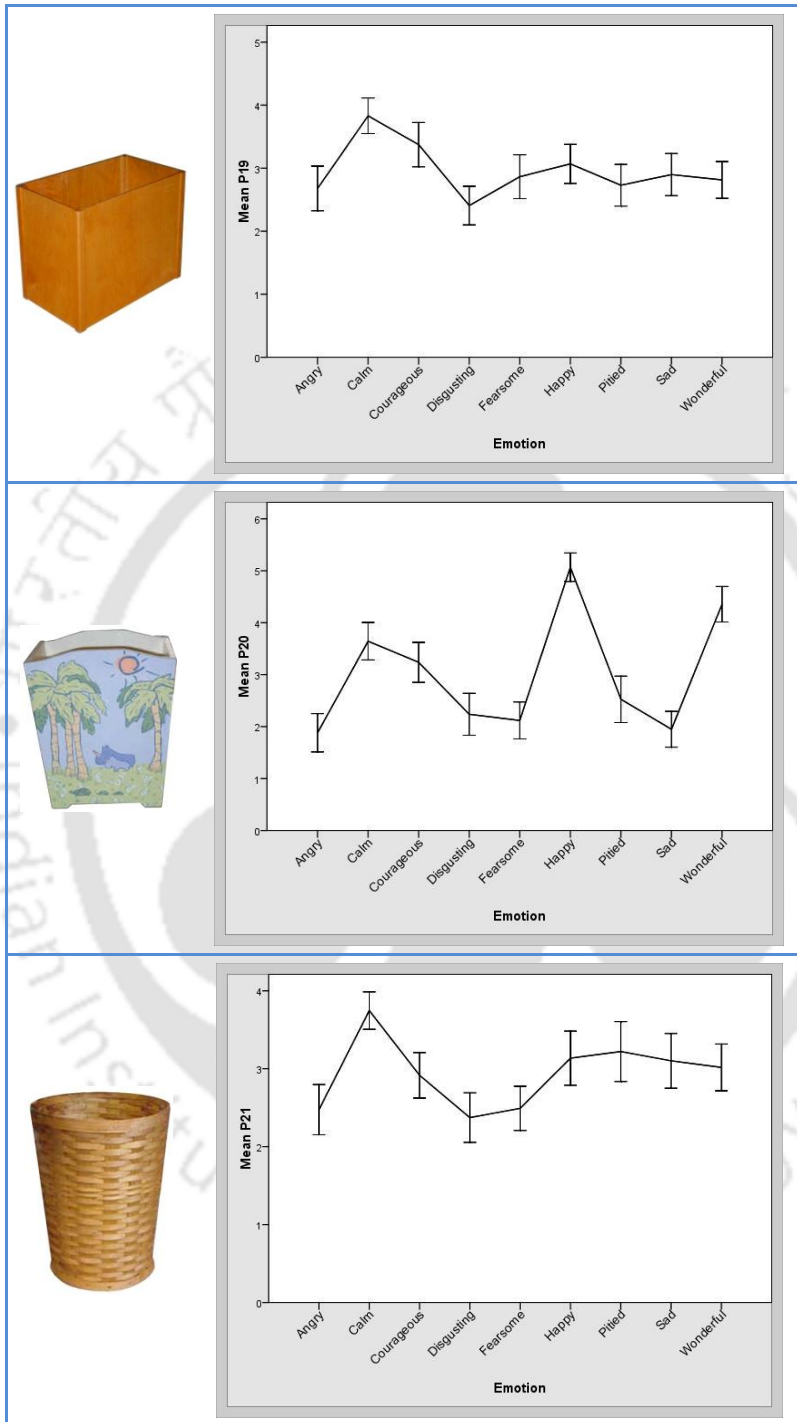












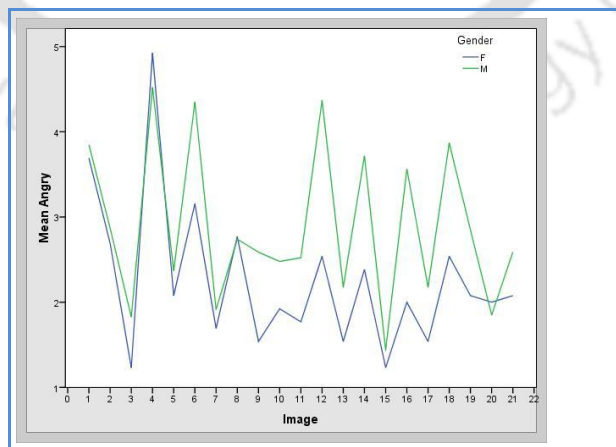
D.5 Identifying differences in affective responses between genders.

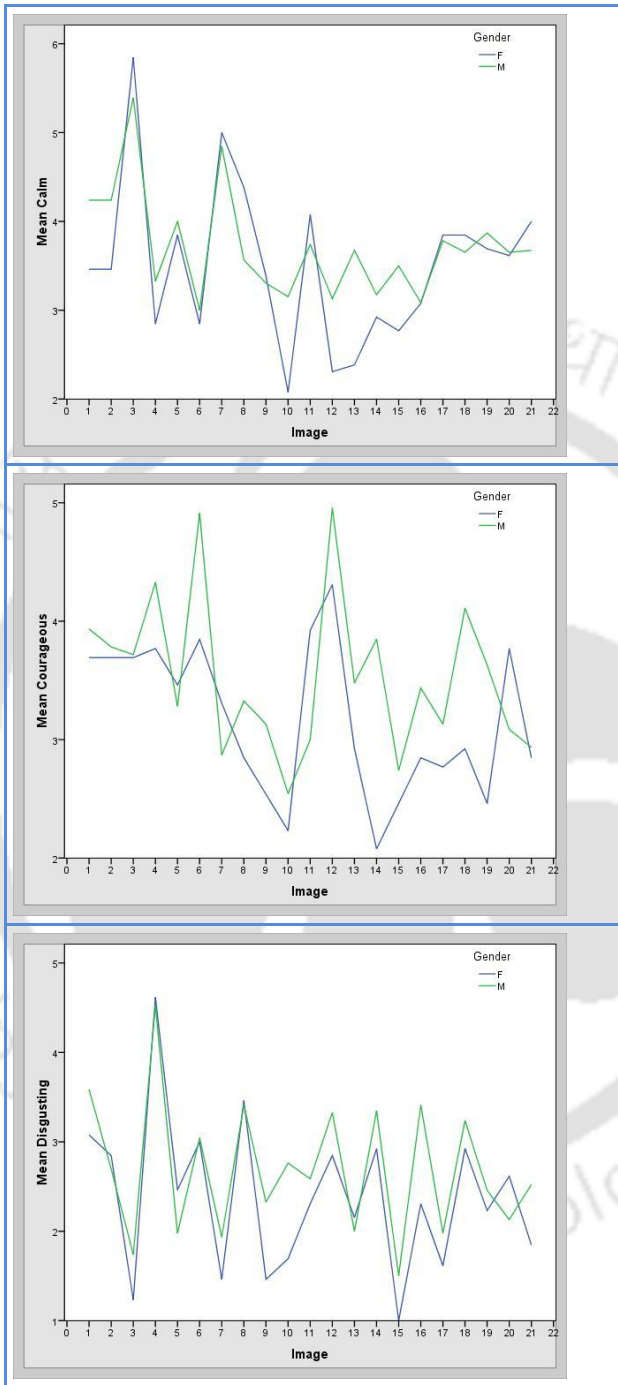
Materials and methods: Among the 59 participants that participated in the experiment, as detailed in section D.2, 19 were females and the rest were males. Though the sample size of female students is very small but a comparison has been made to identify any differences in the emotions elicited across genders. Means of ratings between the genders has been compared in table D.4.

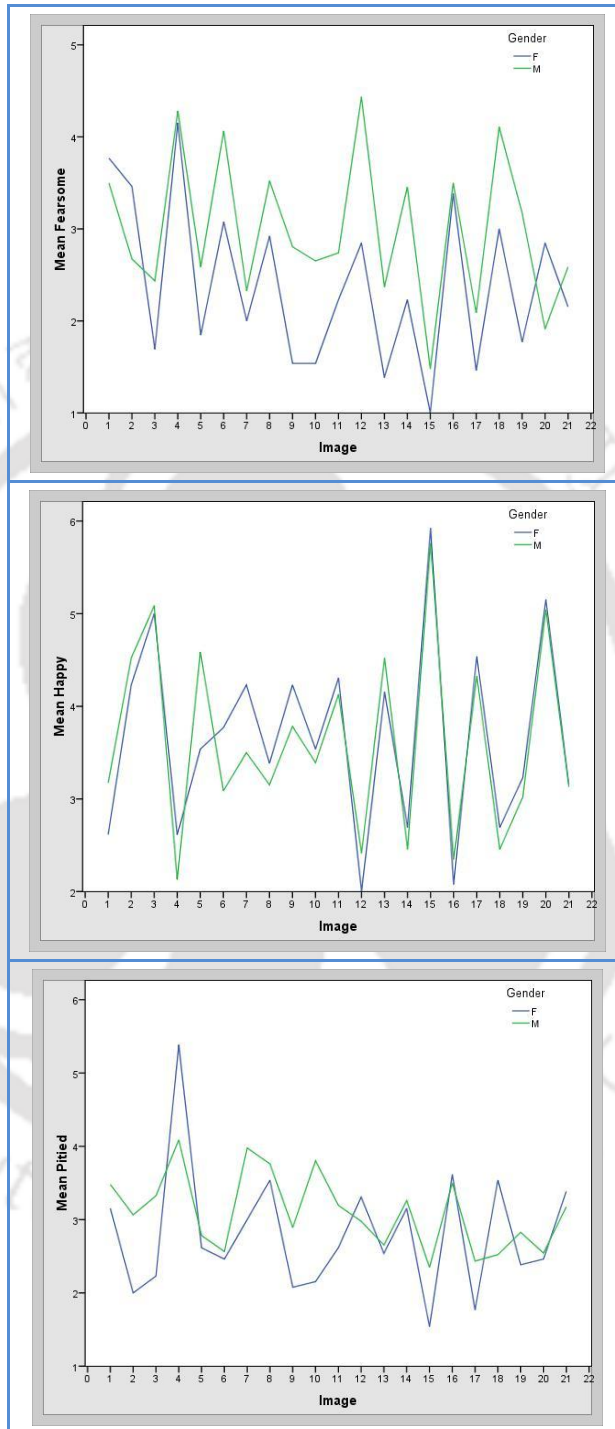
Observations: As depicted in table D.4, no significant difference was observed across the genders in the affective responses elicited. This is true especially with respect to the positive emotions. Both genders have experienced the emotions, happy, calm and disgusting to almost same levels. Some differences in the responses to the emotions, angry, fear and courage has been observed between the genders, females reporting less of these in the same images but it can't be conclusively stated as the sample size is small.

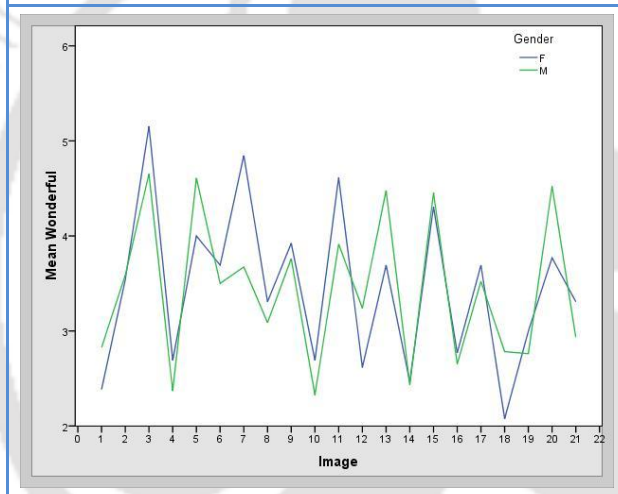
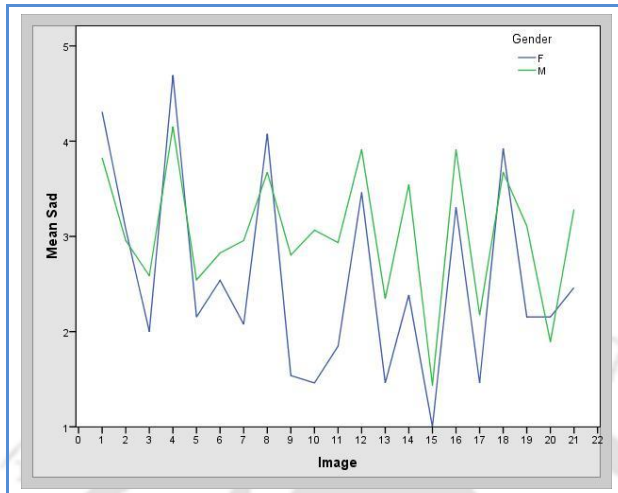
Inferences: Though the sample size is small but this preliminary study suggests that from the HCI design perspective with respect to nine emotional categories no significant differences exist between males and females. It appears from the present study that the positive emotions are felt by both the genders

Table D. 4: Difference in affective responses across gender at elemental level












Appendix E

User data tool slides

Contents of the user data

Please click on the [blue links](#) and [images](#) to go to respective pages

- Most [Liked](#) Dustbins
- Culture wise Rankings of Dustbins
 - [Indian](#)
 - [European](#)
- Emotion wise Rankings of Dustbins
 - [Happy](#)
 - [Angry](#)
 - [Disgusting](#)
 - [Fearsome](#)
 - [Sad](#)
 - [Courageous](#)
 - [Pitied](#)
 - [Wonderful](#)
 - [Calm](#)



1

Go to Content

Ranked from 'Most Liked' to 'Least Liked'
Click on images to see the details



2



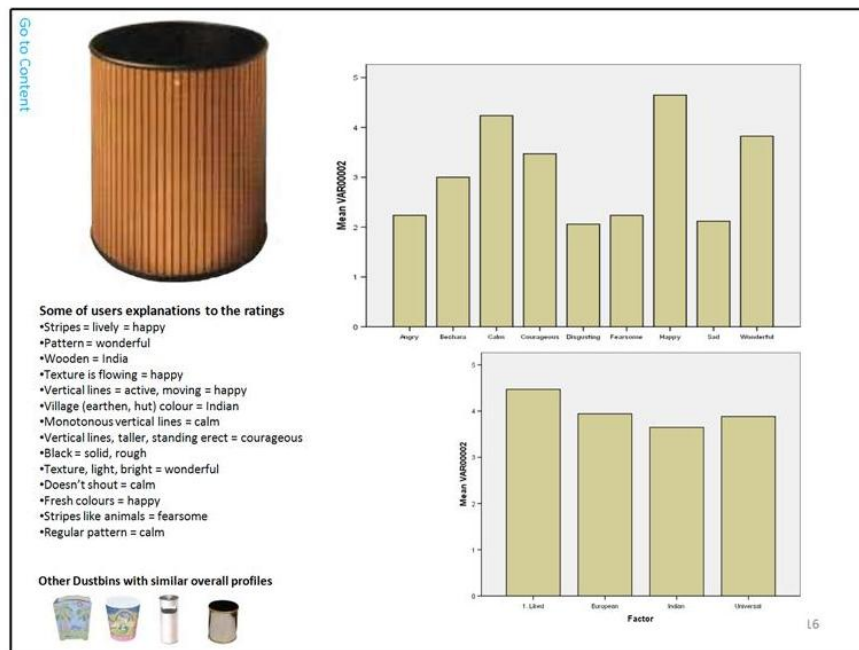
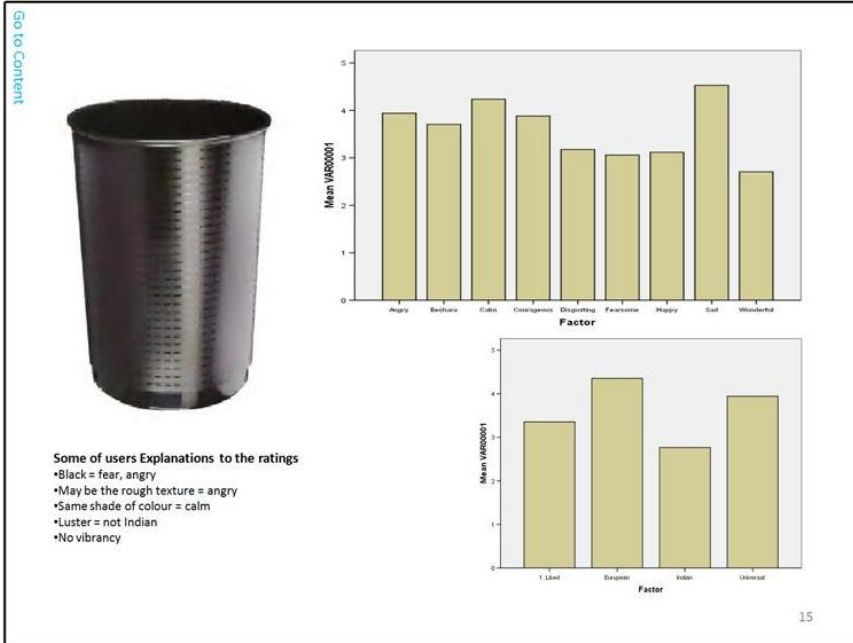


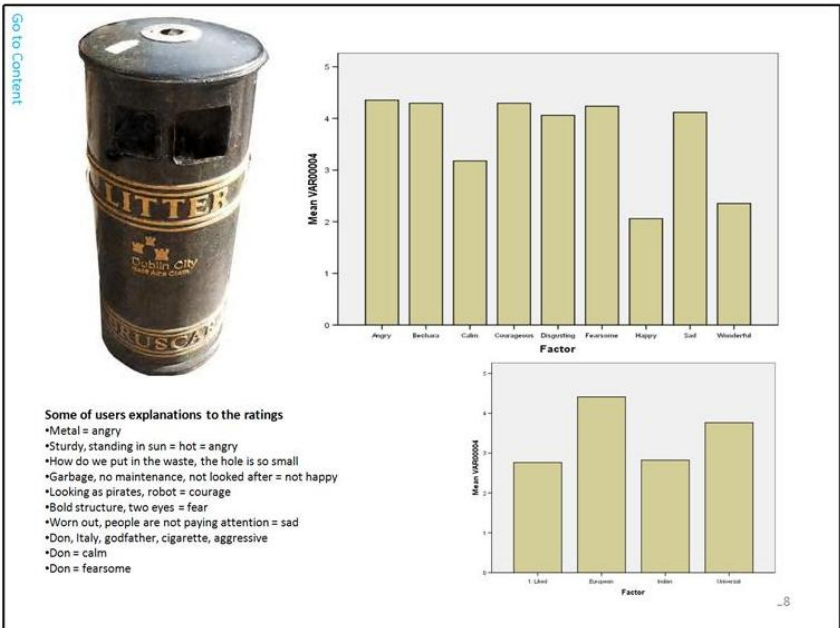
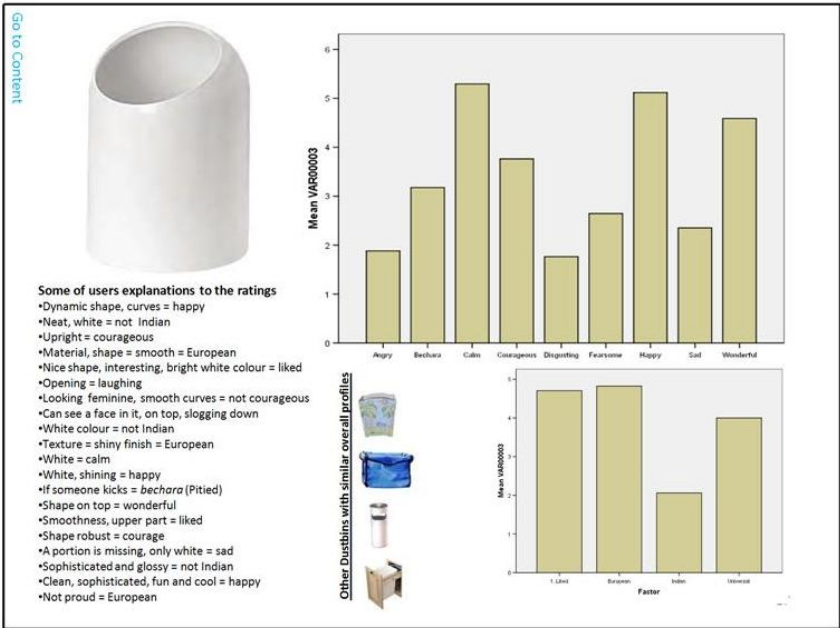










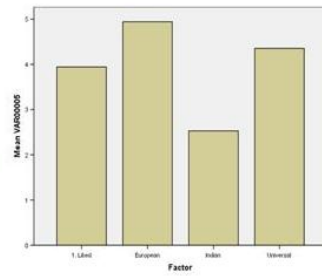
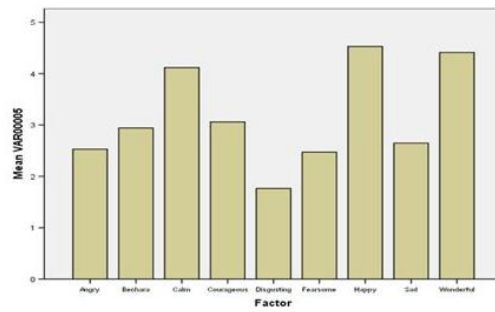


Go to Content



Some of users explanations to the ratings

- Mouth = happy, angry
- White = not fear
- Clean = Europe
- Metallic = Europe
- Straight form = not Indian
- Metallic = not Indian
- Shine, nice, used in nice lively places = happy
- White = calm
- Like it due to the shine and curved cut
- Shining = happy
- Smiling face in the cut = happy
- Opening mouth = happy
- Looking from behind = fear
- Curved mouth = smile = happy
- Overall form, negative space, look through cut out = wonderful
- Curves in cut, not seen here, in movies = Europe
- Shining, soothing white = calm
- Human face in cut = happy
- Texture, taken care of = happy
- Sophisticated = not Indian
- Cylindrical, medical, doctor, pleasing colour
- executive = silverfish colour = calm



Other Dustbins with similar overall profiles

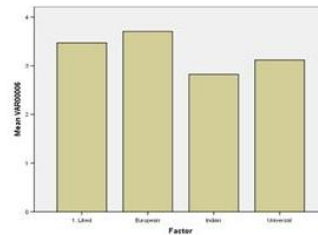
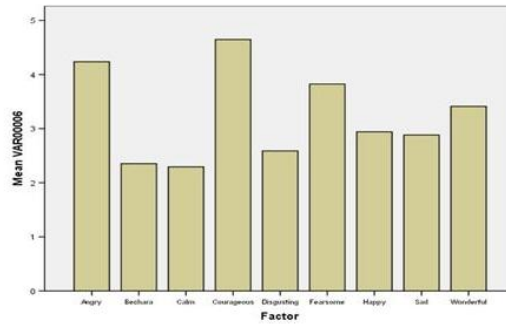


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Some of users explanations to the ratings

- Bright red and black = not happy
- Nuts and bolts = sturdy = courageous
- Black – red colour and bolts = not happy
- Energetic = happy, courageous = wonderful
- Colour = angry
- Colour, rivets = fear
- Iron, robust, bolted pins = courageous
- Black and red, bolts = angry
- Form = not Indian
- Contrast colours = Indian
- Texture, screws = railways
- Colours = post office, public places = India



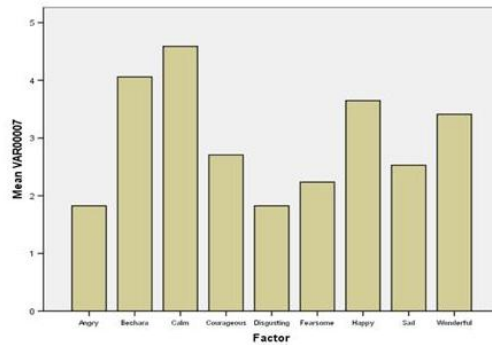
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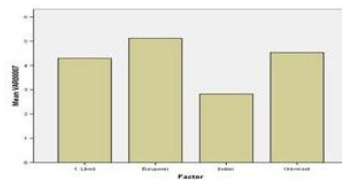


Some of users explanations to the ratings

- Function dominates in elicitation
- Soft edges = happy
- May get locked inside = fear
- Going into dark place = courage
- It is being held tightly = bechara
- White, light colour, soft = calm
- Can fit anywhere = universal
- Suffocated
- Squeezed in = bechara
- Good design = wonderful
- Colour = calm
- Look, kitchen = European
- Sophisticated = European
- Sophisticated = happy
- Packed, tied = bechara
- Sliding = sophisticated = European
- Shape, colour = simple = calm, wonderful
- Taken care of = happy
- Innovation = wonderful
- White, it is held still = calm
- Clean, well made = not Indian
- Once used-removed = bechara
- Clean, doing it's work= happy
- Clean, good guy = calm



Other Dustbins with similar overall profiles



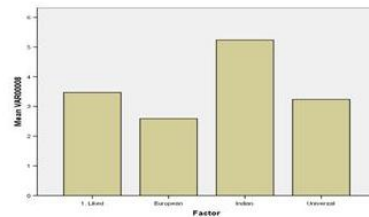
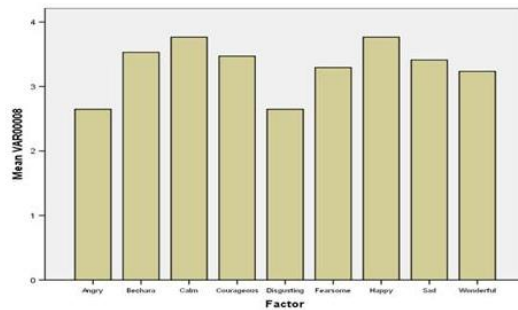
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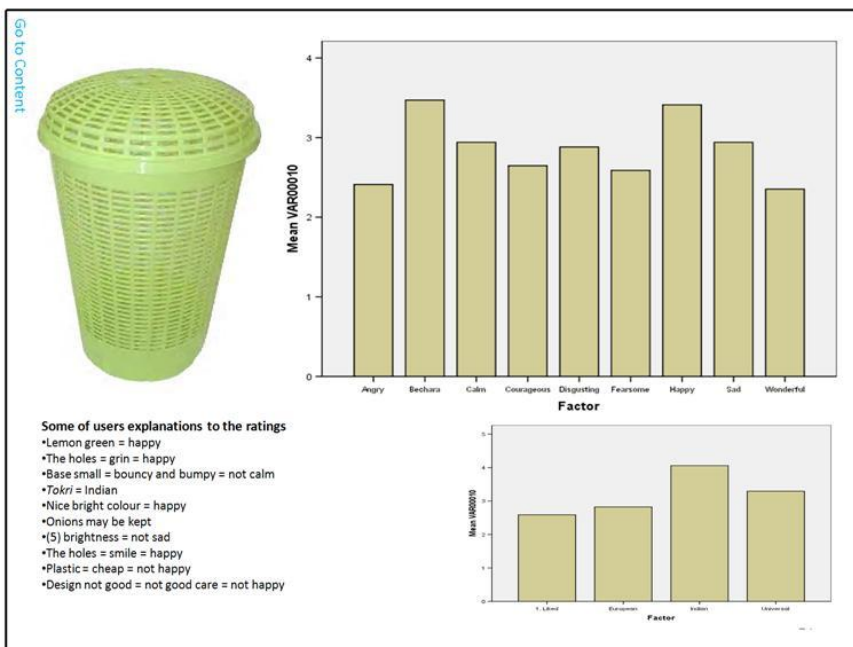
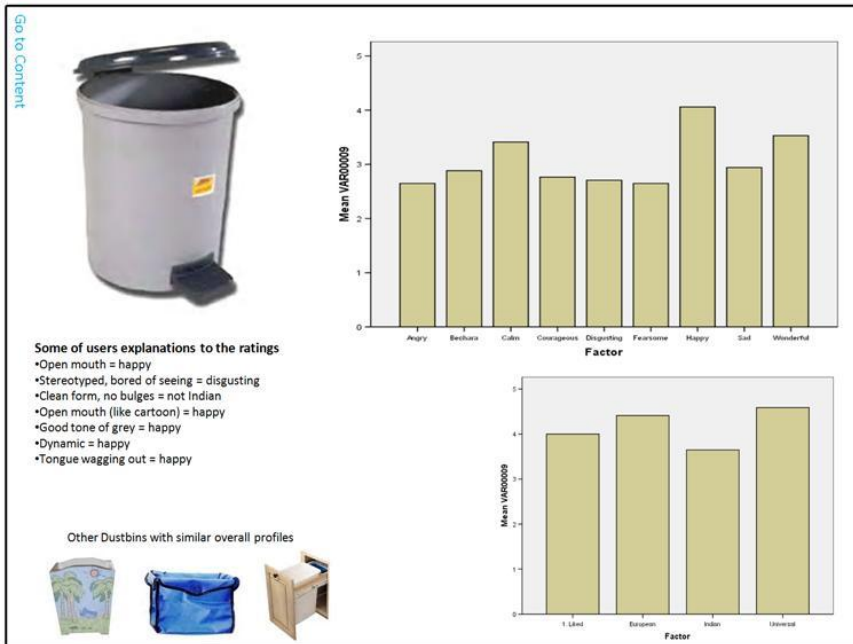


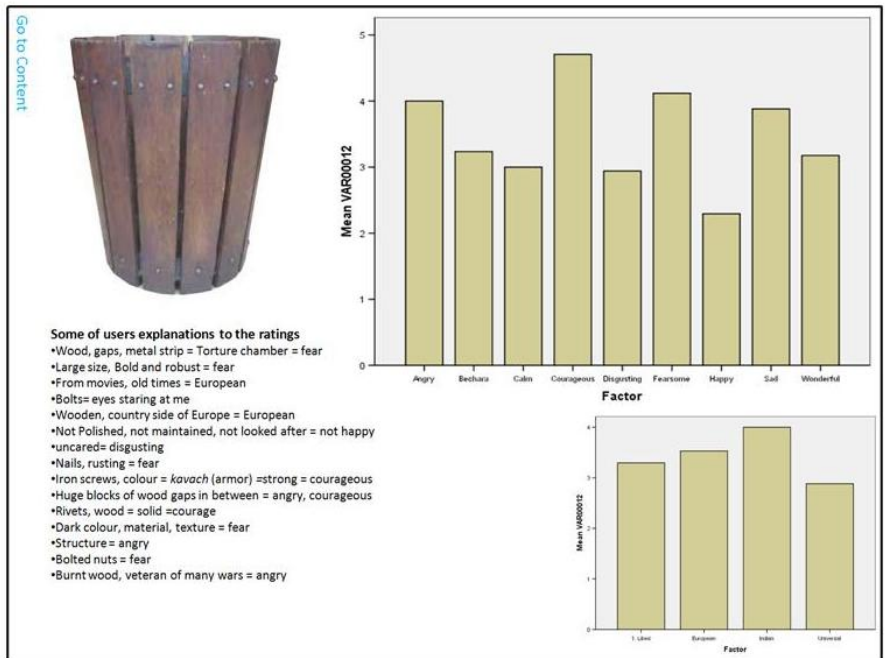
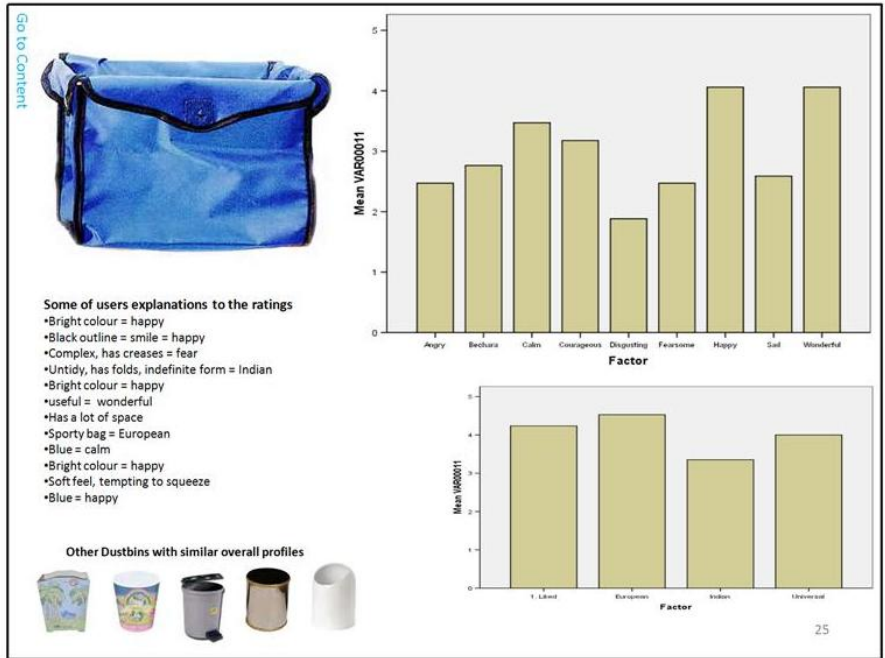
Some of users explanations to the ratings

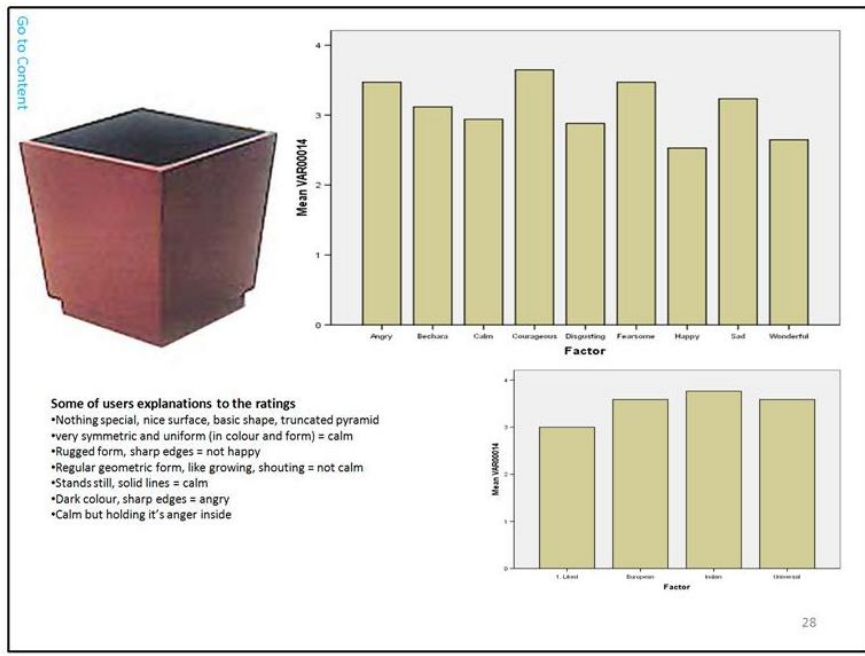
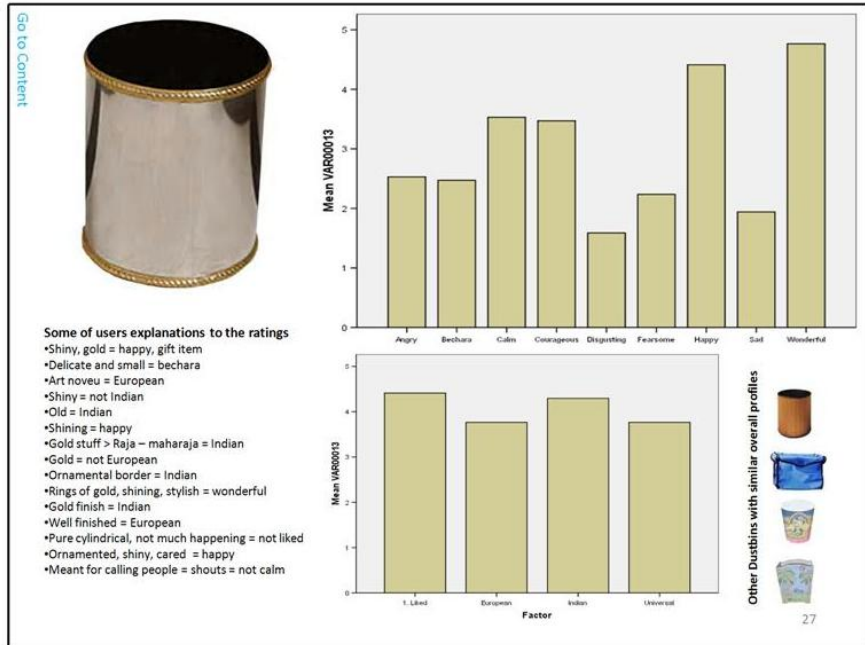
- Belly = laughing = happy
- Texture and dark colour = fear
- Snake pitara = fear
- The shape = disgusting
- Can't make out the utility, may be for leaf in tea gardens
- 9.3 Known Indian Craft
- Dull = sad
- Craft, handicraft = India
- Artistic, not normal kind of = happy
- Big face = fear
- Bamboo weaving = India
- Fat – fat , round and bellied = happy
- Not cared = bechara
- Not taken care of = angry
- Gray colour = not Indian

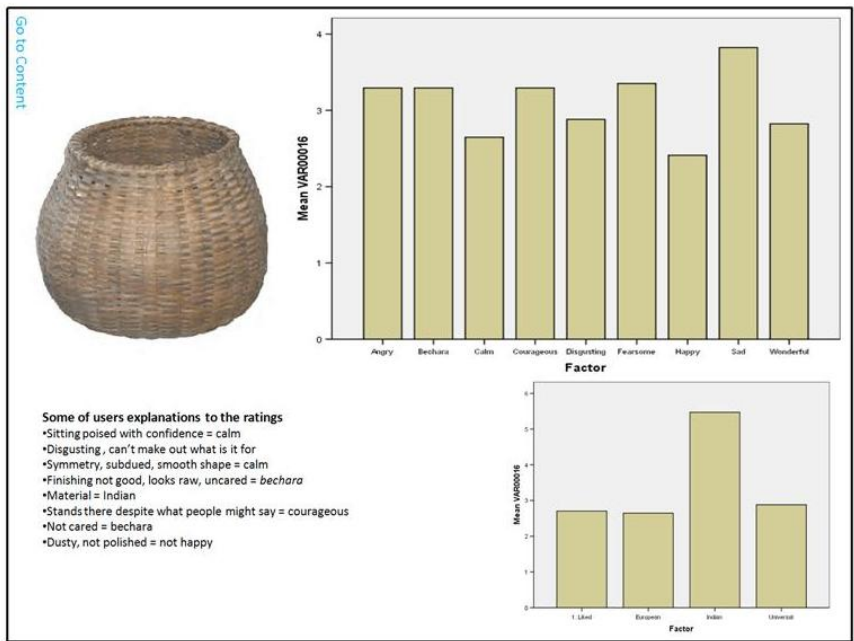
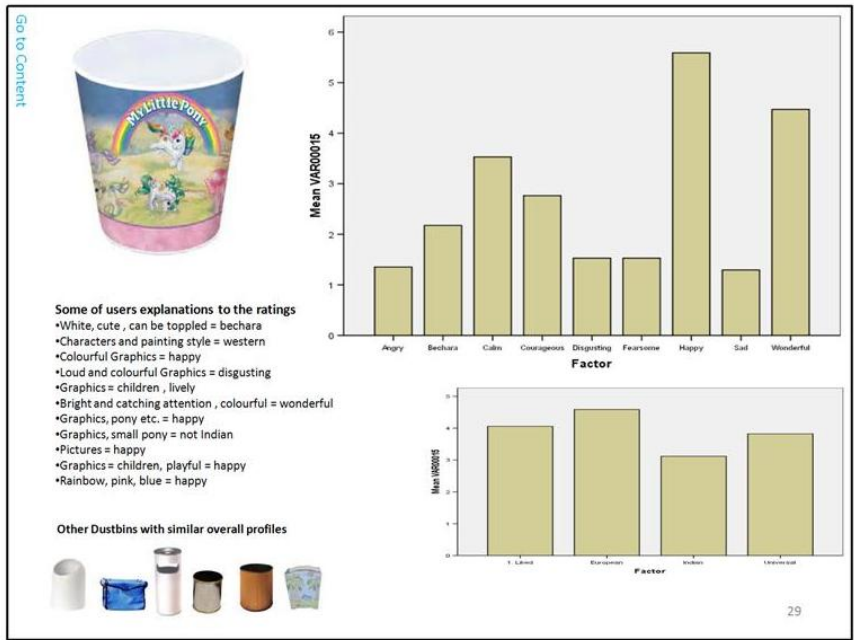


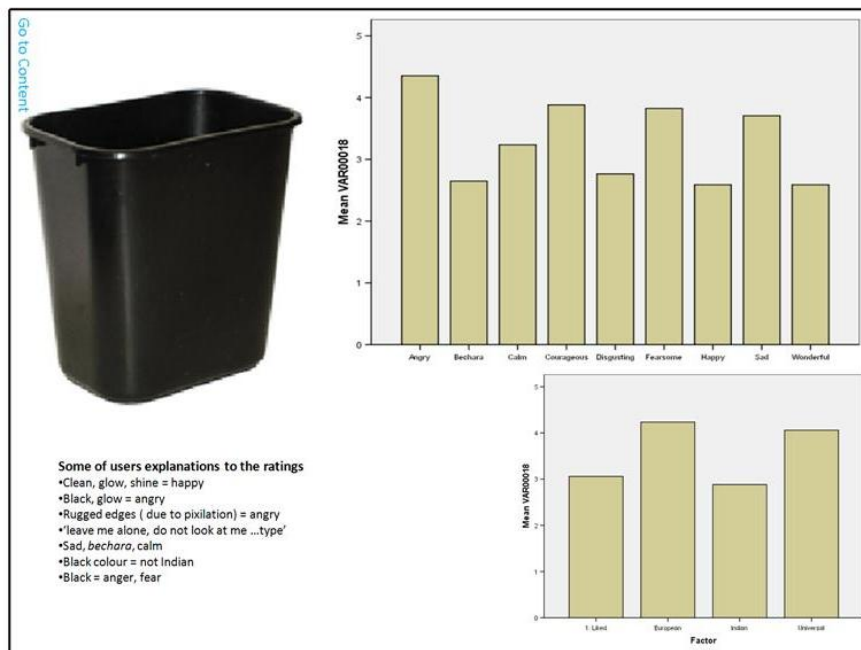
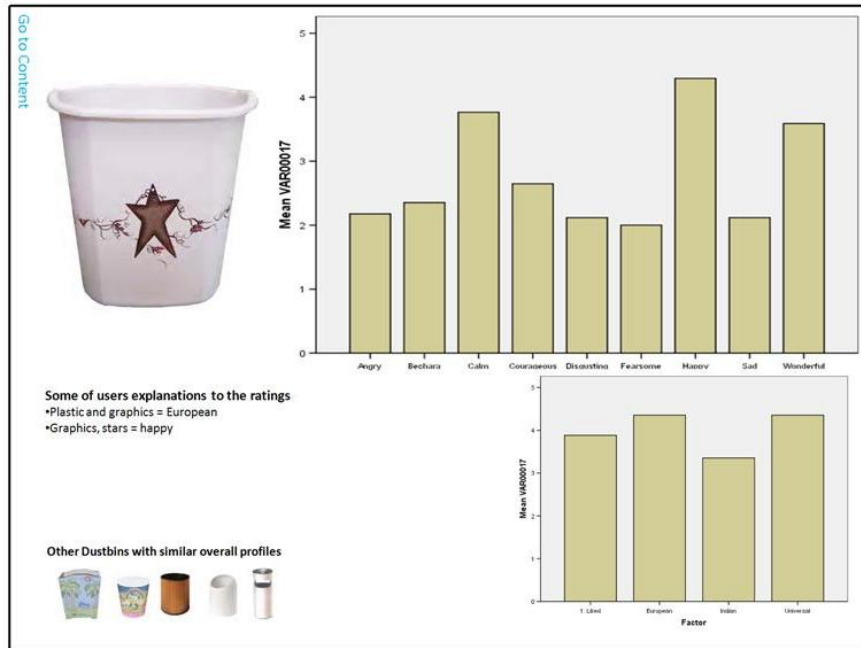
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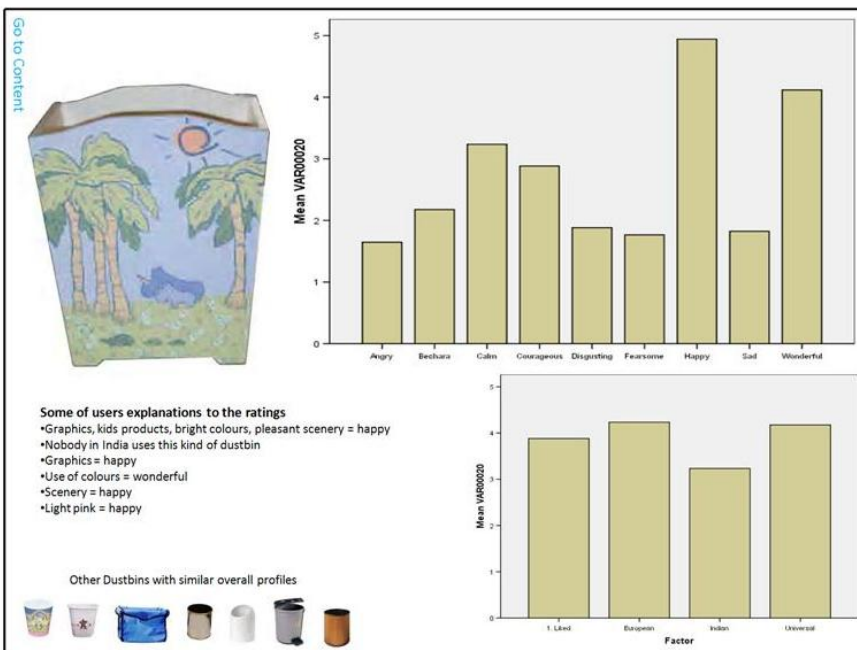
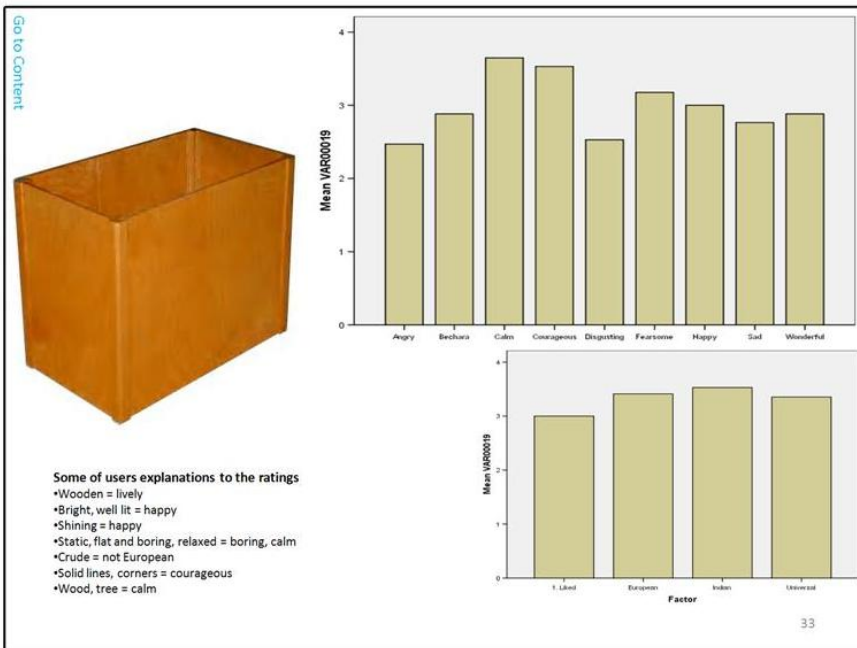


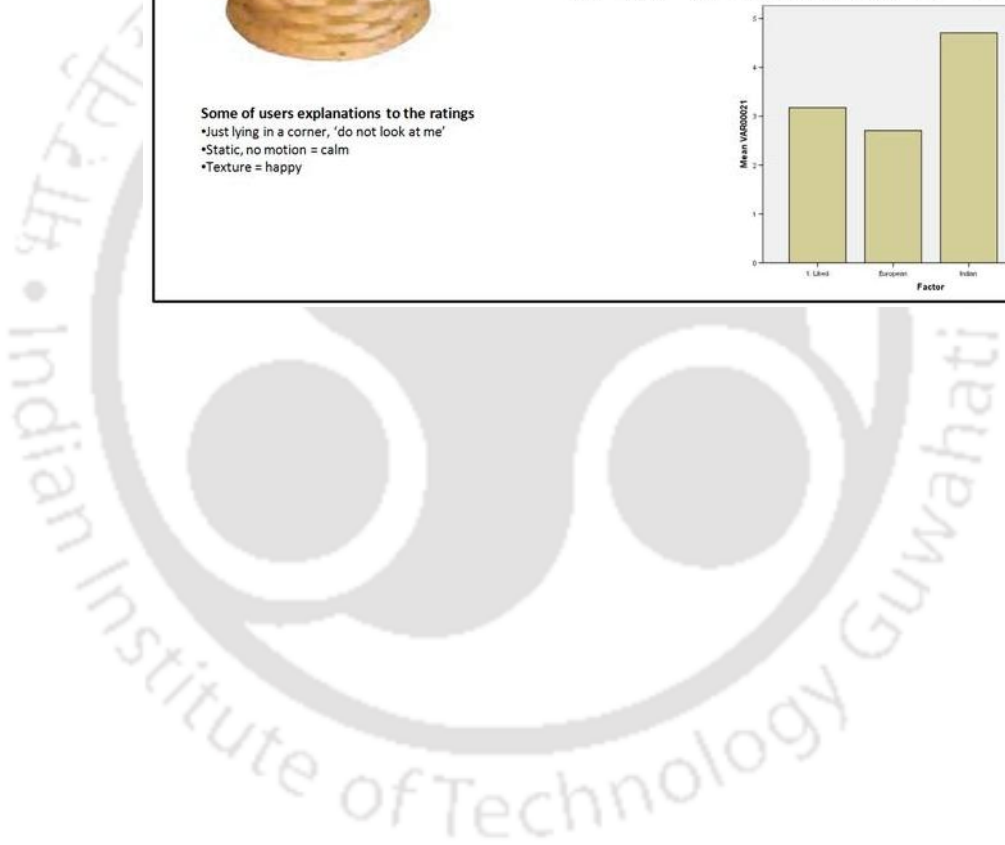
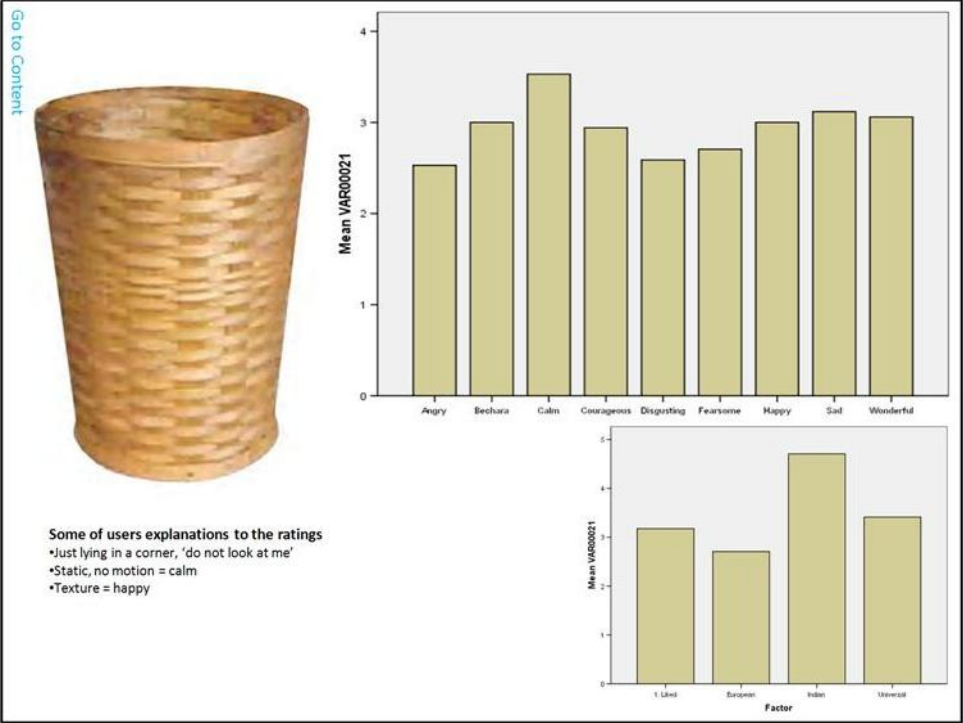
















Appendix F

F.1 Development of Fuzzy Inference tool to aid designers' decision making

Introduction: Need of user data in the design thinking process has been recognised. The format in which the data collected from the users can be given to the designers is not yet a well researched area. In this thesis, two ways of presenting data to designers were explored and the influence of these different ways on the designers design thinking process was observed. This study has been described in detail in section 3.6. Here creator of one of the data presentation methods namely, a Fuzzy Inference system based tool has been described.

Procedure: After the participants had rated the images along the emotional categories, they were asked to verbally report, reasons for the emotions felt in the product images. Participants were asked 'what prompted them to give the particular ratings to the images'. Sometimes participants found it difficult to explain and lacked words while at other times they could give satisfactory explanations for the same in terms of surface features and related memories. The quality of verbalisations and verbosity was found to vary from participant to participant.

Qualitative analysis was done on the verbal data gathered from all participants. First prominent surface features expressed by users were recognised and then their frequency was counted. Upon weighing the features by number of users and then by the emphasis laid on them by users, seven features most influential for the elicited emotions were identified. The seven surface features identified were:

brightness (as opposed to dullness),

smoothness (as opposed to roughness),

shininess (as opposed to mattness),

Rigidity (as opposed to weakness and softness),

Multichromaticity (Oleintitude of hues)

Novelty and

Elegance.

Out of these 7 surface features 1,2,3 and 5 were found to be related to 'happiness'; , 1,2,3 and 6 were found to be related to 'wonderfulness'; 1 and 2 to 'calmness'; 1,3and d to 'anger'; 1 and 3to 'disgust' and 1,2,3 and 4 to 'fear'.

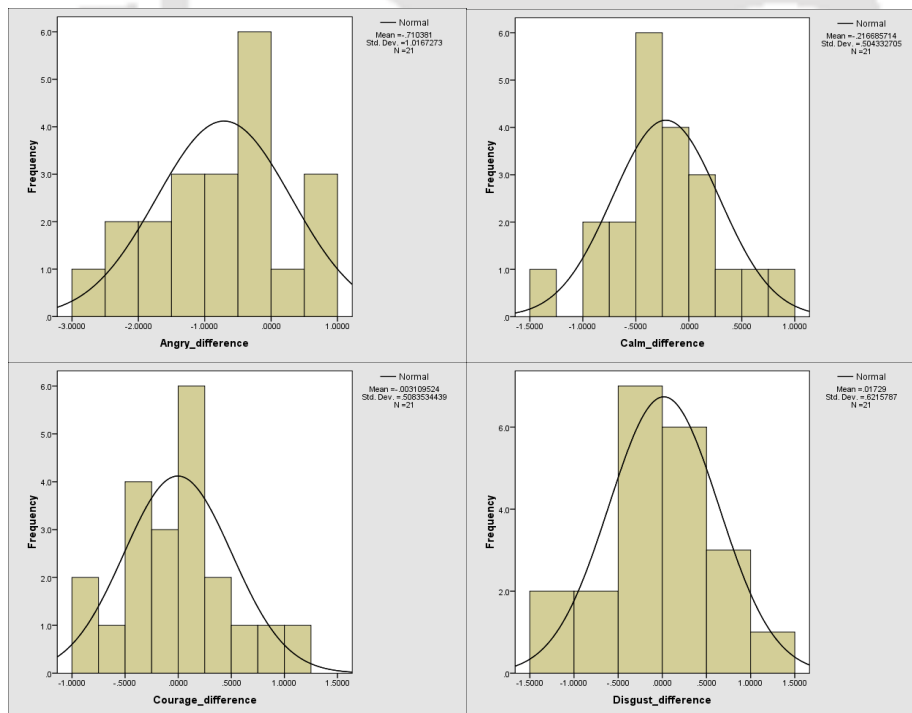
Using the identified surface features and the related evoked emotions, perceptual rules were created to be used in FIS. These rules were of the form 'if surface features 'x' is *low/medium/high* then evoked emotion 'y' is *low/medium/high*'. Several of these rules were created for each emotional category to enable the correct mapping. These rules were further fine tuned by changing relative weights of each rule in the overall result in FIS by hit and trial method. Some of the final mapping surfaces used in FIS have been exhibited in figure 4. In fig 4, z axis denotes evoked emotions and the x and y axis are the input variables. For each emotion, several of these maps exist in the FIS programme, depending on the number of input variables.

Initially the aim was to investigate possibility of mapping surface features of the products to the evoked emotions by using Fuzzy logic method, the designers' ratings for surface features as input was used to the FIS and examined the output by FIS. Mean ratings by designers for the 7 surface features were collected and were fed to the FIS as input values. The output values generated by FIS were compared with the participants' elicited ratings for each emotion and for each image. Difference between mean of participants' responses and the FIS output has been displayed in figure 5. Out of the 21 images that the FIS was applied for, 20 outputs for emotion 'calm' were found to be within -1,+1 interval of the users actual ratings. Out of 21 images, 20 for 'wonder', 20 for 'courage', 18 for 'fear', 17

for 'happy', 18 for 'disgust' and 13 for 'anger' had FIS values within -1,+1 of the users actual responses.

Taking into account, the imprecision and uncertainty associated with emotions, this match between the FIS output and the users response seems to be good enough for approximate prediction of evoked emotion for 5 of the 7 emotions. This result argues for FIS as a suggestive tool to the designers in design decision making process for affective semantics. Even though, the exact numerical prediction is difficult and is lying an interval of the actual data, when images are actually ordered from highest to lowest values for a given emotional category the fit of the order between the predicted and actual is almost always accurate.

All the rule editors, rules, input output maps, membership functions used in creating the FIS system has been listed for reference in following pages.



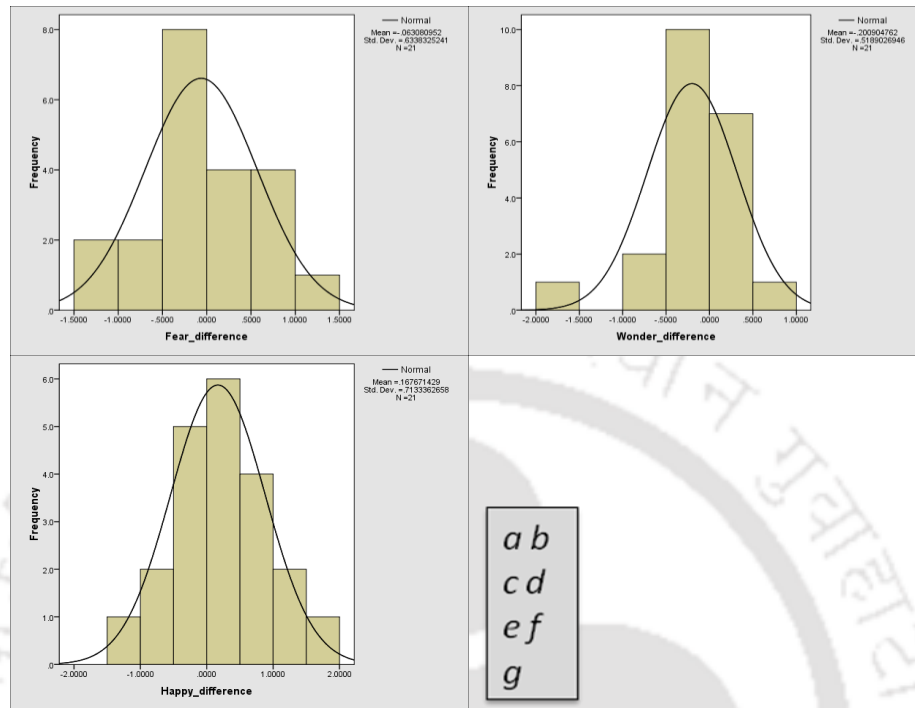
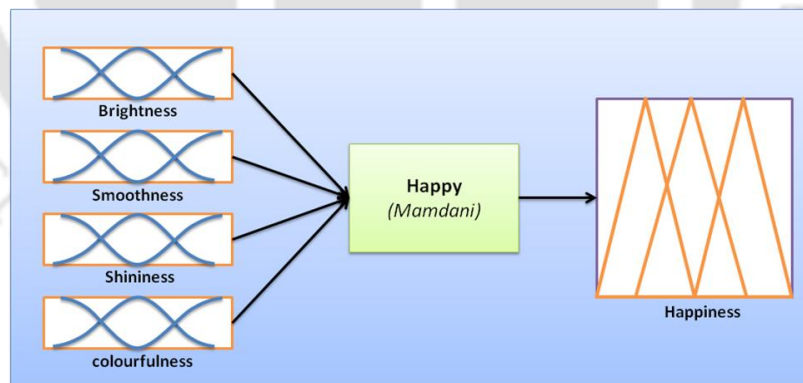
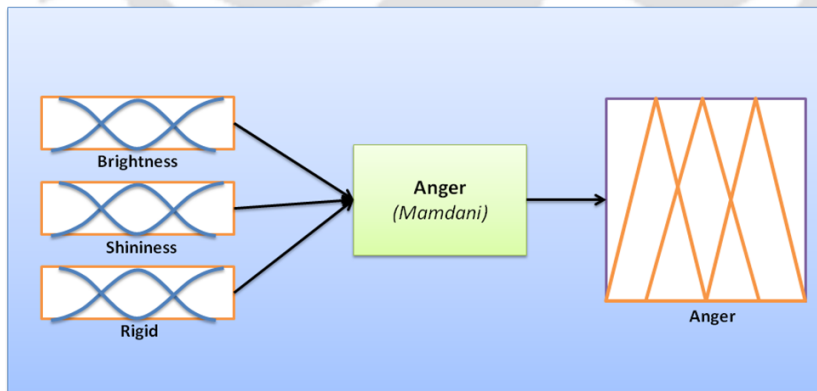
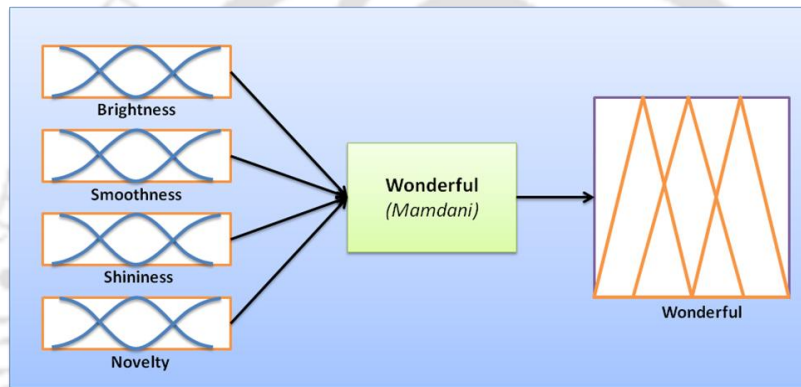
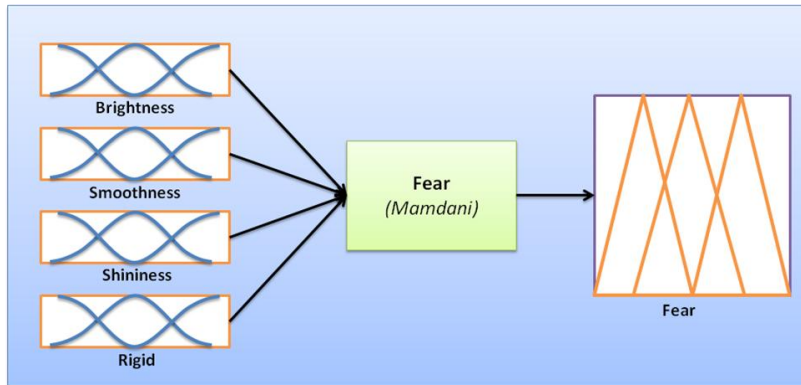
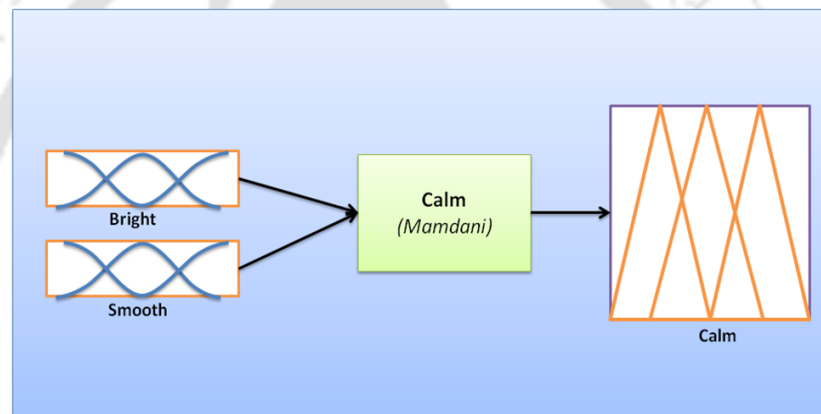
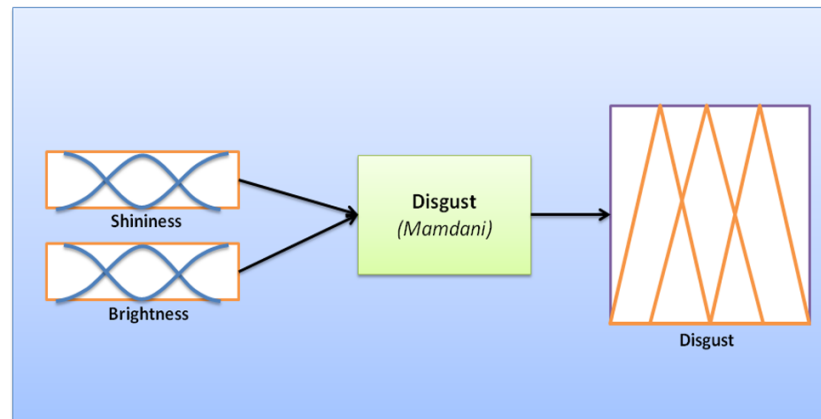


Figure 5 Differences between FIS output and users' responses from first set data
Rule editors for each emotional category







Membership Functions for the input and output variables: Mostly Gaussian bell shaped curves were used as membership function for the input variables. For instance input functions for emotion 'happy'; Brightness, smoothness, shininess and colorfulness were all bell shaped curves. Reason for choice of Gaussian shapes was that the contribution of each input variable like, smoothness was prominent only at the peaks of its value and degraded fast beyond a value.

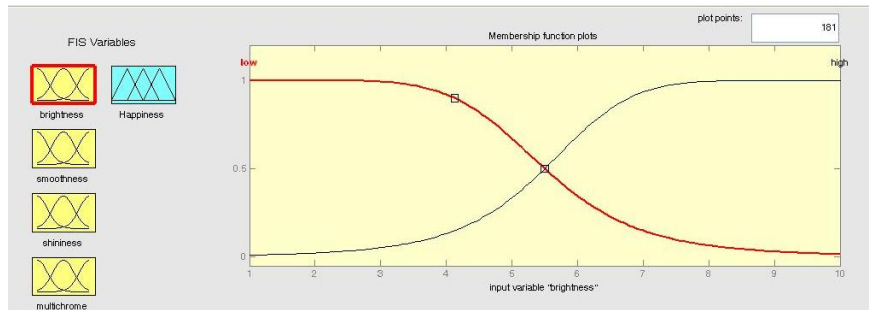
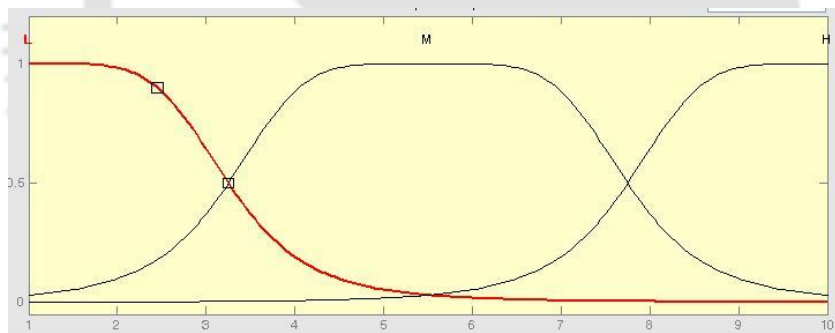


Figure 1: Membership function for input variable brightness in FIS for happyness

Though for some emotions, the membership functions were adjusted to match the desired output. For instance, for emotion ‘disgust’ it was found to be difficult to match the input to output results and hence the membership function was adjusted manually till the results were close to the desired limits.



Number of output functions differed from emoting to emotion. By iteratively fine tuning the rules for each emotion and increasing the levels of complexity in rules desired output results were achieved.

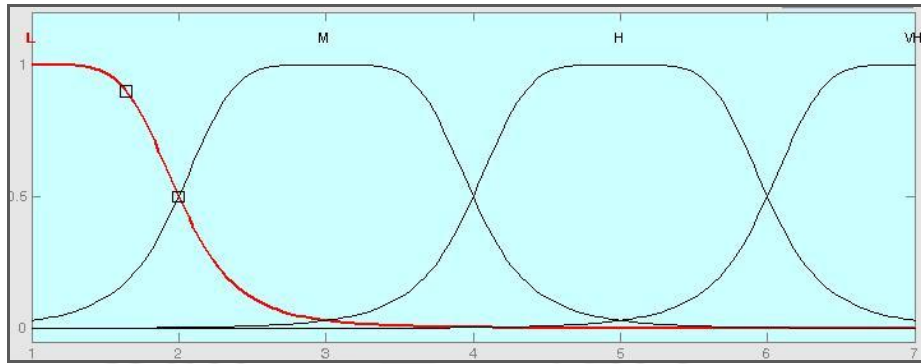


Figure 2: Output variable for Courage

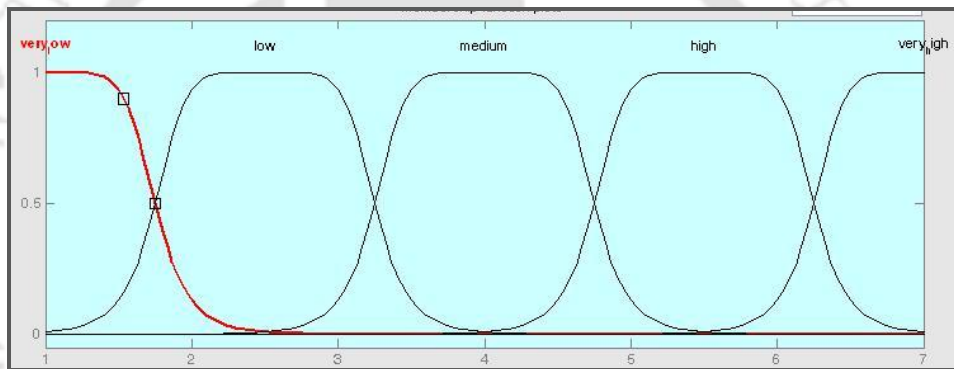


Figure 3: Output Variable for happiness

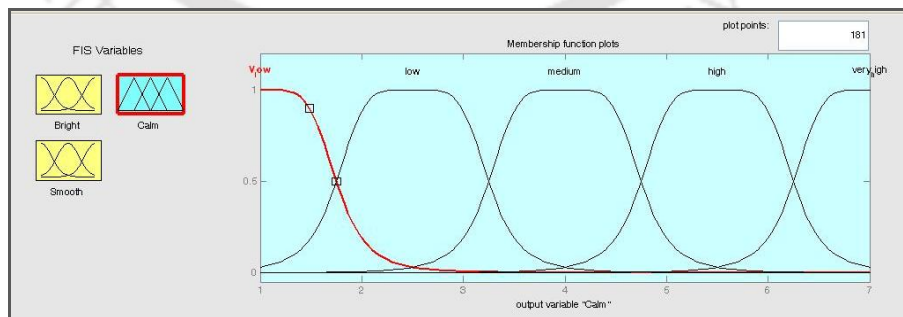


Figure 4: Output Variable for Calm

Fuzzy rules used in Fuzzy Inference system

Fuzzy inference rules for emotion 'Fear'

1. If (brightness is low) and (smoothness is low) and (shininess is low) and (Rigid is high) then (Fear is very high) (1)
2. If (brightness is low) and (smoothness is low) and (shininess is low) and (Rigid is low) then (Fear is high) (1)
3. If (brightness is low) and (smoothness is low) and (shininess is high) and (Rigid is low) then (Fear is high) (1)
4. If (brightness is low) and (smoothness is high) and (shininess is low) and (Rigid is low) then (Fear is high) (1)
5. If (brightness is high) and (smoothness is low) and (shininess is low) and (Rigid is low) then (Fear is high) (1)
6. If (brightness is high) and (smoothness is low) and (shininess is low) and (Rigid is high) then (Fear is medium) (1)
7. If (brightness is low) and (smoothness is high) and (shininess is low) and (Rigid is high) then (Fear is medium) (1)
8. If (brightness is low) and (smoothness is low) and (shininess is high) and (Rigid is high) then (Fear is medium) (1)
9. If (brightness is low) and (smoothness is high) and (shininess is high) and (Rigid is high) then (Fear is medium) (1)
10. If (brightness is high) and (smoothness is high) and (shininess is low) and (Rigid is high) then (Fear is medium) (1)
11. If (brightness is high) and (smoothness is low) and (shininess is high) and (Rigid is high) then (Fear is medium) (1)
12. If (brightness is low) and (smoothness is high) and (shininess is high) and (Rigid is low) then (Fear is low) (1)
13. If (brightness is high) and (smoothness is low) and (shininess is high) and (Rigid is low) then (Fear is low) (1)
14. If (brightness is high) and (smoothness is high) and (shininess is low) and (Rigid is low) then (Fear is low) (1)
15. If (brightness is high) and (smoothness is high) and (shininess is high) and (Rigid is high) then (Fear is low) (1)
16. If (brightness is high) and (smoothness is high) and (shininess is high) and (Rigid is low) then (Fear is very low) (1)

Fuzzy inference rules for emotion 'Wonderful'

1. If (brightness is low) and (shiny is low) and (multi-chrome is low) and (Novelty is low) then (Wonderful is very low) (1)
2. If (brightness is low) and (shiny is low) and (multi-chrome is low) and (Novelty is high) then (Wonderful is medium) (1)

3. If (brightness is low) and (shiny is low) and (multi-chrome is high) and (Novelty is low) then (Wonderful is low) (1)
4. If (brightness is low) and (shiny is high) and (multi-chrome is low) and (Novelty is low) then (Wonderful is low) (1)
5. If (brightness is high) and (shiny is low) and (multi-chrome is low) and (Novelty is low) then (Wonderful is low) (1)
6. If (brightness is high) and (shiny is high) and (multi-chrome is low) and (Novelty is low) then (Wonderful is medium) (1)
7. If (brightness is low) and (shiny is high) and (multi-chrome is high) and (Novelty is low) then (Wonderful is medium) (1)
8. If (brightness is high) and (shiny is low) and (multi-chrome is high) and (Novelty is low) then (Wonderful is medium) (1)
9. If (brightness is high) and (shiny is low) and (multi-chrome is low) and (Novelty is high) then (Wonderful is medium) (1)
10. If (brightness is low) and (shiny is high) and (multi-chrome is low) and (Novelty is high) then (Wonderful is medium) (1)
11. If (brightness is low) and (shiny is low) and (multi-chrome is high) and (Novelty is high) then (Wonderful is medium) (1)
12. If (brightness is high) and (shiny is high) and (multi-chrome is high) and (Novelty is low) then (Wonderful is high) (1)
13. If (brightness is high) and (shiny is high) and (multi-chrome is low) and (Novelty is high) then (Wonderful is high) (1)
14. If (brightness is high) and (shiny is low) and (multi-chrome is high) and (Novelty is high) then (Wonderful is high) (1)
15. If (brightness is low) and (shiny is high) and (multi-chrome is high) and (Novelty is high) then (Wonderful is high) (1)
16. If (brightness is high) and (shiny is high) and (multi-chrome is high) and (Novelty is high) then (Wonderful is very high) (1)

Fuzzy inference rules for emotion 'Anger'

1. If (bright is low) and (shiny is high) and (Rigid is high) then (Anger is high) (1)
2. If (bright is high) and (shiny is high) and (Rigid is high) then (Anger is high) (1)
3. If (bright is low) and (shiny is low) and (Rigid is high) then (Anger is high) (1)
4. If (bright is low) and (shiny is high) and (Rigid is low) then (Anger is medium) (1)
5. If (bright is high) and (shiny is low) and (Rigid is high) then (Anger is medium) (1)
6. If (bright is high) and (shiny is high) and (Rigid is low) then (Anger is medium) (1)
7. If (bright is low) and (shiny is low) and (Rigid is low) then (Anger is low) (1)
8. If (bright is high) and (shiny is low) and (Rigid is low) then (Anger is low) (1)

Fuzzy inference rules for emotion 'Disgust'

1. If (shine is low) and (bright is low) then (Disgust is high) (1)

2. If (shine is low) and (bright is medium) then (Disgust is medium) (1)
3. If (shine is low) and (bright is high) then (Disgust is medium) (1)
4. If (shine is high) and (bright is low) then (Disgust is medium) (1)
5. If (shine is high) and (bright is medium) then (Disgust is low) (1)
6. If (shine is high) and (bright is high) then (Disgust is very low) (1)

Fuzzy inference rules for emotion ‘Courage’

1. If (bright is low) and (smooth is low) and (Rigid is high) then (Courage is high) (1)
2. If (bright is low) and (smooth is low) and (Rigid is low) then (Courage is medium) (1)
3. If (bright is low) and (smooth is high) and (Rigid is high) then (Courage is high) (1)
4. If (bright is high) and (smooth is low) and (Rigid is high) then (Courage is medium) (1)
5. If (bright is low) and (smooth is high) and (Rigid is low) then (Courage is low) (1)
6. If (bright is high) and (smooth is high) and (Rigid is high) then (Courage is medium) (1)
7. If (bright is high) and (smooth is low) and (Rigid is low) then (Courage is low) (1)
8. If (bright is high) and (smooth is high) and (Rigid is low) then (Courage is low) (1)

Fuzzy inference rules for emotion ‘Calm’

1. If (bright is low) and (smooth is high) then (Calm is low) (1)
2. If (bright is low) and (smooth is medium) then (Calm is very low) (1)
3. If (bright is low) and (smooth is low) then (Calm is very low) (1)
4. If (bright is medium) and (smooth is high) then (Calm is high) (1)
5. If (bright is medium) and (smooth is medium) then (Calm is medium) (1)
6. If (bright is medium) and (smooth is low) then (Calm is medium) (1)
7. If (bright is high) and (smooth is high) then (Calm is very high) (1)
8. If (bright is high) and (smooth is medium) then (Calm is very high) (1)
9. If (bright is high) and (smooth is low) then (Calm is high) (1)

Fuzzy inference rules for emotion ‘Happiness’

1. If (brightness is low) and (smoothness is low) and (shininess is low) and (Multi-chrome is low) then (Happiness is very low) (1)
2. If (brightness is low) and (smoothness is low) and (shininess is low) and (Multi-chrome is high) then (Happiness is medium) (1)
3. If (brightness is low) and (smoothness is low) and (shininess is high) and (Multi-chrome is low) then (Happiness is low) (1)
4. If (brightness is low) and (smoothness is high) and (shininess is low) and (Multi-chrome is low) then (Happiness is low) (1)
5. If (brightness is high) and (smoothness is low) and (shininess is low) and (Multi-chrome is low) then (Happiness is low) (1)
6. If (brightness is high) and (smoothness is high) and (shininess is low) and (Multi-chrome is low) then (Happiness is medium) (1)
7. If (brightness is low) and (smoothness is high) and (shininess is high) and (Multi-chrome is low) then (Happiness is medium) (1)

8. If (brightness is high) and (smoothness is low) and (shininess is high) and (Multi-chrome is low) then (Happiness is medium) (1)
9. If (brightness is high) and (smoothness is low) and (shininess is low) and (Multi-chrome is high) then (Happiness is medium) (1)
10. If (brightness is low) and (smoothness is high) and (shininess is low) and (Multi-chrome is high) then (Happiness is medium) (1)
11. If (brightness is low) and (smoothness is low) and (shininess is high) and (Multi-chrome is high) then (Happiness is medium) (1)
12. If (brightness is high) and (smoothness is high) and (shininess is high) and (Multi-chrome is low) then (Happiness is high) (1)
13. If (brightness is high) and (smoothness is high) and (shininess is low) and (Multi-chrome is high) then (Happiness is very high) (1)
14. If (brightness is high) and (smoothness is low) and (shininess is high) and (Multi-chrome is high) then (Happiness is high) (1)
15. If (brightness is low) and (smoothness is high) and (shininess is high) and (Multi-chrome is high) then (Happiness is high) (1)
16. If (brightness is high) and (smoothness is high) and (shininess is high) and (Multi-chrome is high) then (Happiness is very high) (1)

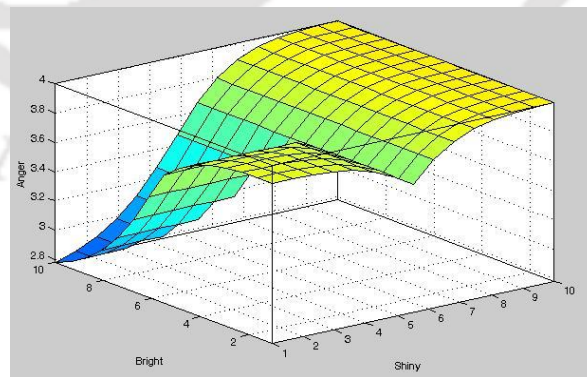
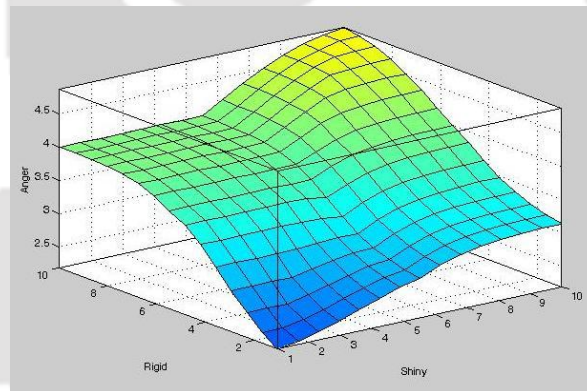
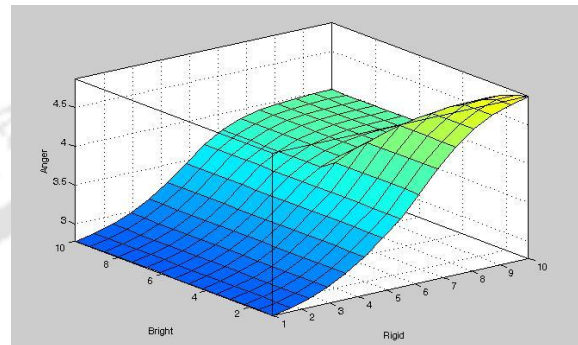
Fuzzy inference rules for emotion 'Happiness' and 'Courage' together

1. If (bright is low) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is very low) and (Courage is high) (1)
2. If (bright is low) and (smooth is low) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
3. If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is low) and (Courage is high) (1)
4. If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is low) and (Courage is high) (1)
5. If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is low) and (Courage is medium) (1)
6. If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
7. If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is medium) (1)
8. If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is medium) and (Courage is medium) (1)
9. If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
10. If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is medium) and (Courage is medium) (1)
11. If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
12. If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is high) and (Courage is medium) (1)

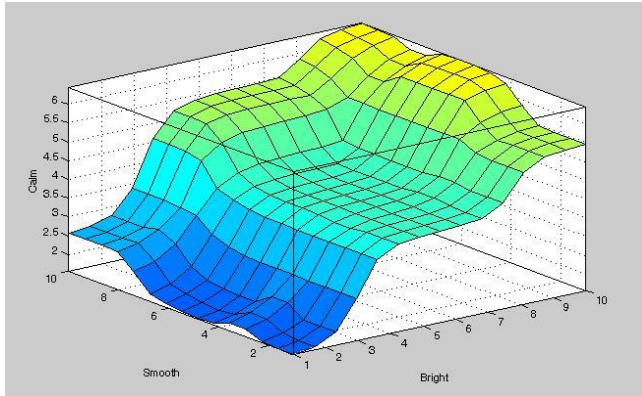
13. If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is very high) and (Courage is medium) (1)
14. If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is high) and (Courage is medium) (1)
15. If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is high) and (Courage is high) (1)
16. If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is very high) and (Courage is medium) (1)
17. If (bright is low) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is very low) and (Courage is medium) (1)
18. If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is medium) (1)
19. If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is medium) (1)
20. If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is low) (1)
21. If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is low) (1)
22. If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is medium) and (Courage is medium) (1)
23. If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is high) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
24. If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
25. If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
26. If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
27. If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
28. If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is high) and (Courage is low) (1)
29. If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is low) then (Happy is very high) and (Courage is low) (1)
30. If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is high) and (Courage is low) (1)
31. If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is high) and (Courage is low) (1)
- 32.** If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is very high) and (Courage is low) (1)

Relationship between elicited emotion and visual characteristics of stimuli as created in Fuzzy Inference System

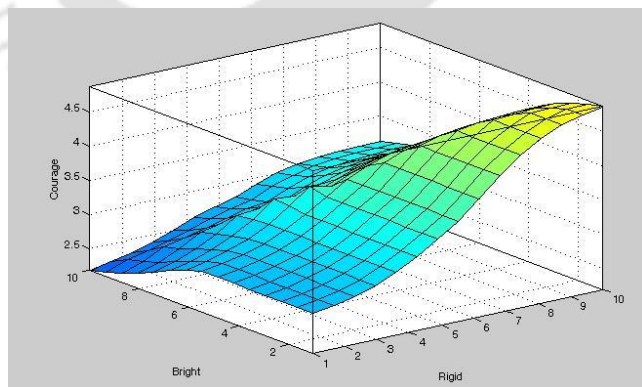
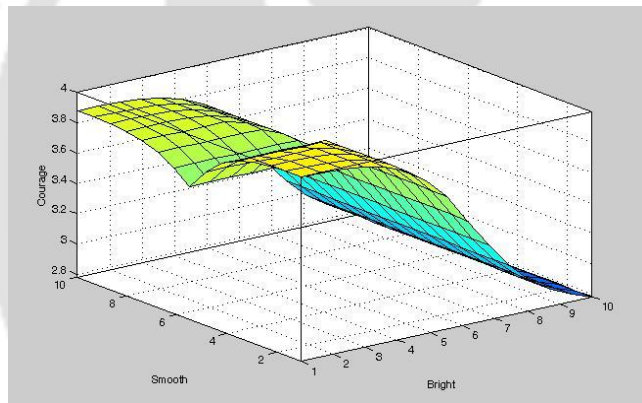
For Emotion 'Anger'



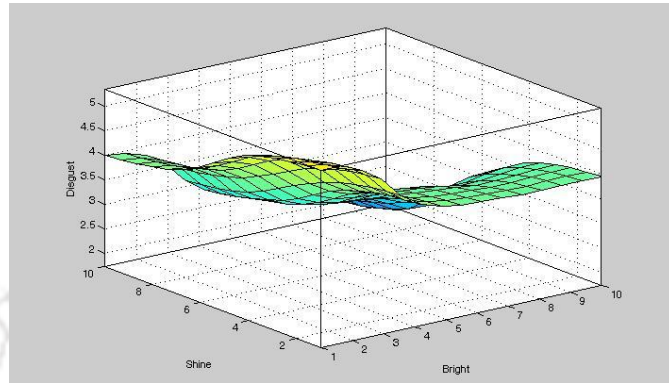
For Calm



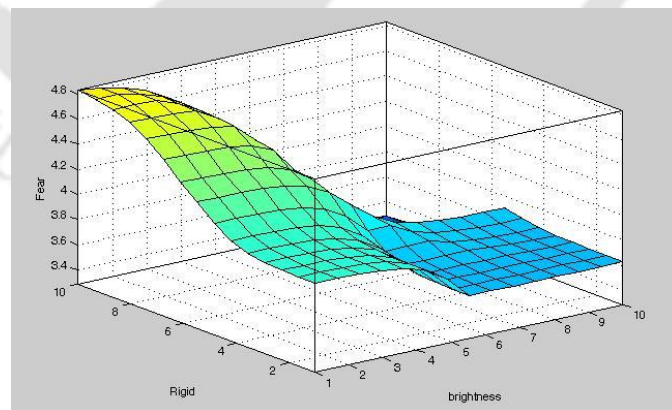
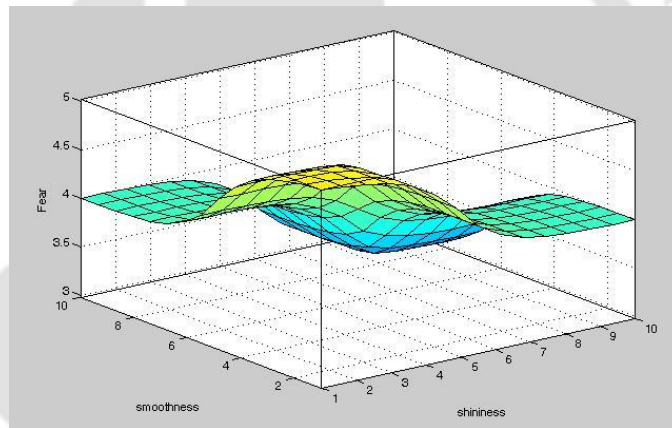
For courage

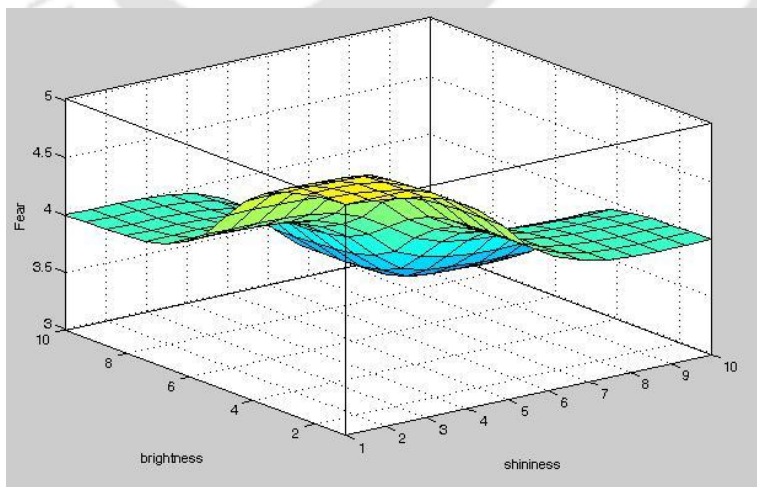
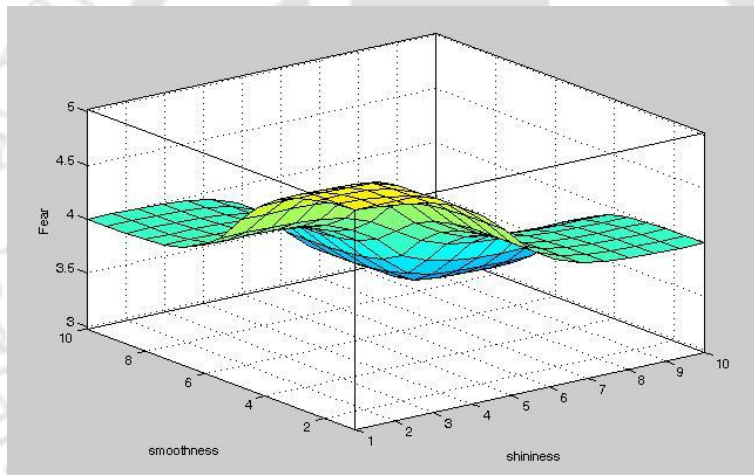
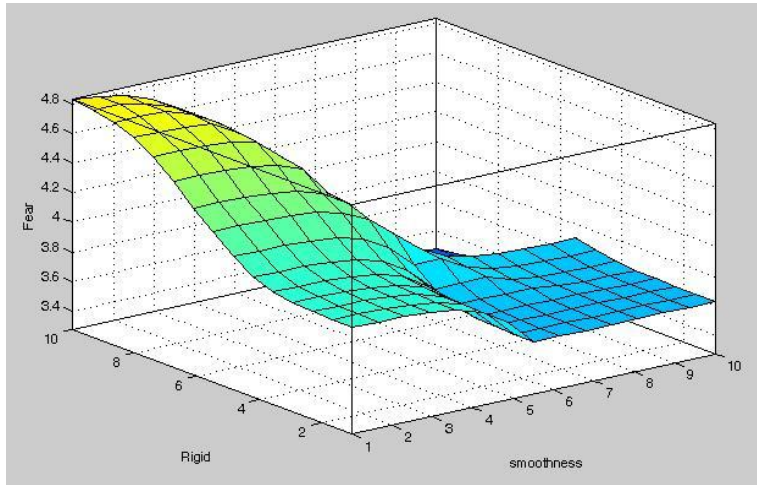


For disgust

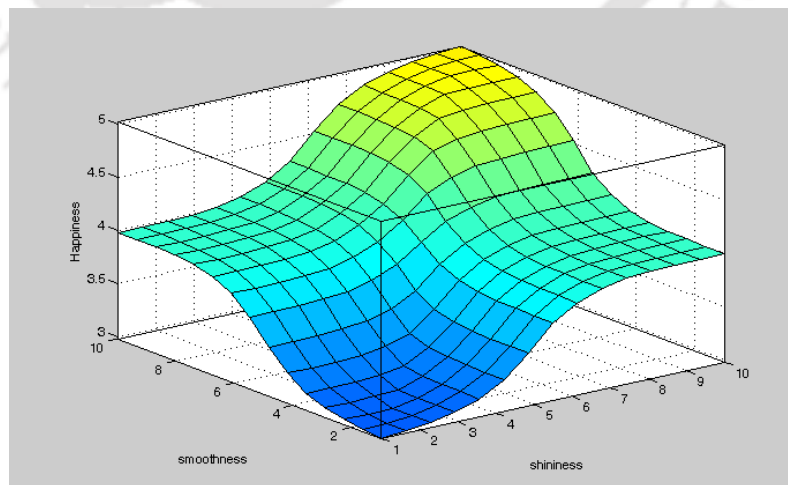
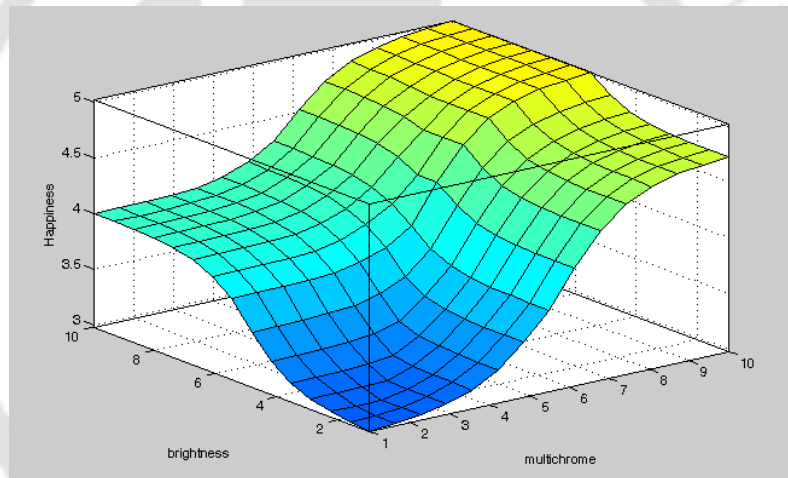
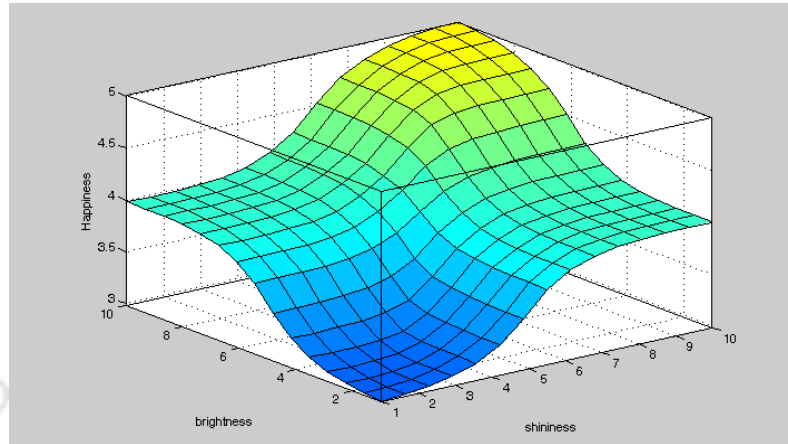


For fear

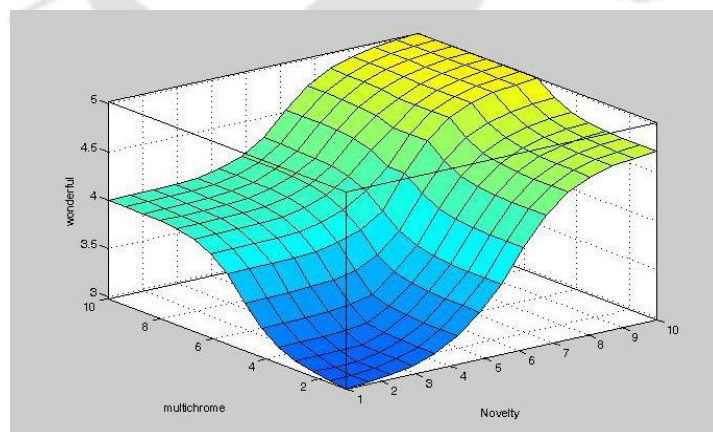
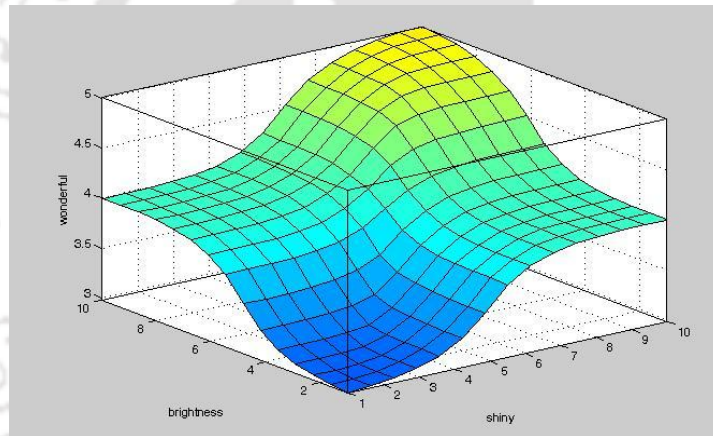
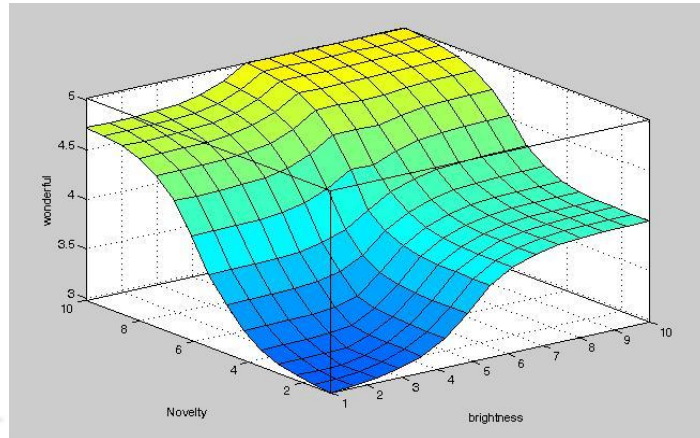




For happy



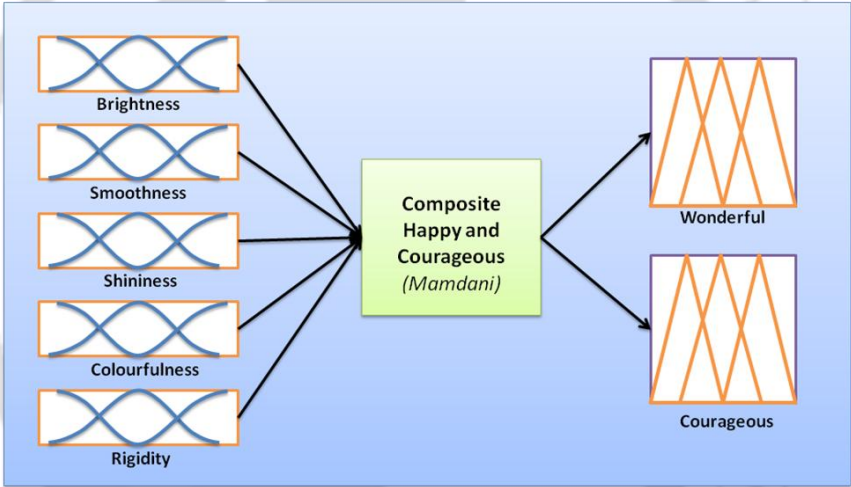
For wonderful



FIS design for two emotions in one system.

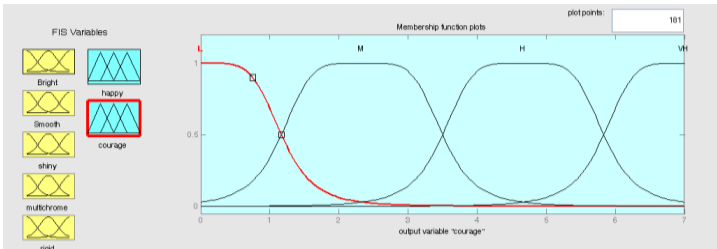
After succeeding with creating FIS that could satisfactorily predict users responses for one emotion, two emotions were tried to be built in one. It was tested for accuracy and was given to designers' as aid in design thinking. The designers' design thinking process under influence of FIS was observed and has been reported in chapter 3. Here the rules, membership functions and surface maps between the variables have been displayed.

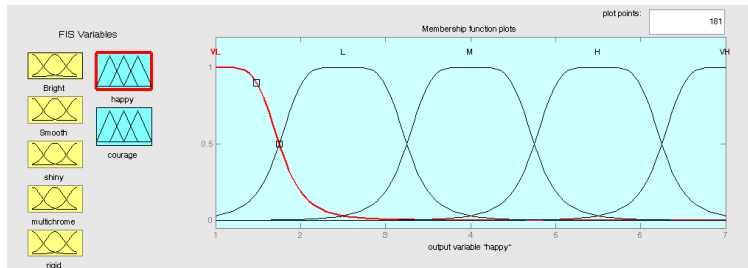
Rule editor for composite



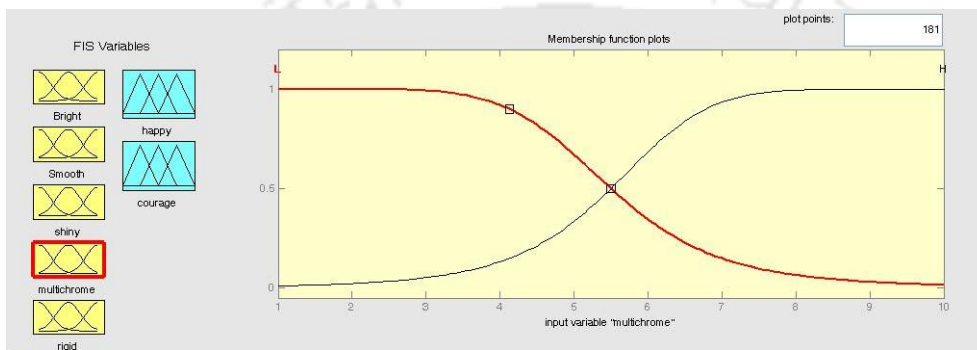
Membership functions for composite

Output Membership functions





Input membership functions



Rules for Mamdani Fuzzy Inference System for the composite

Fuzzy rules for two emotions in one FIS

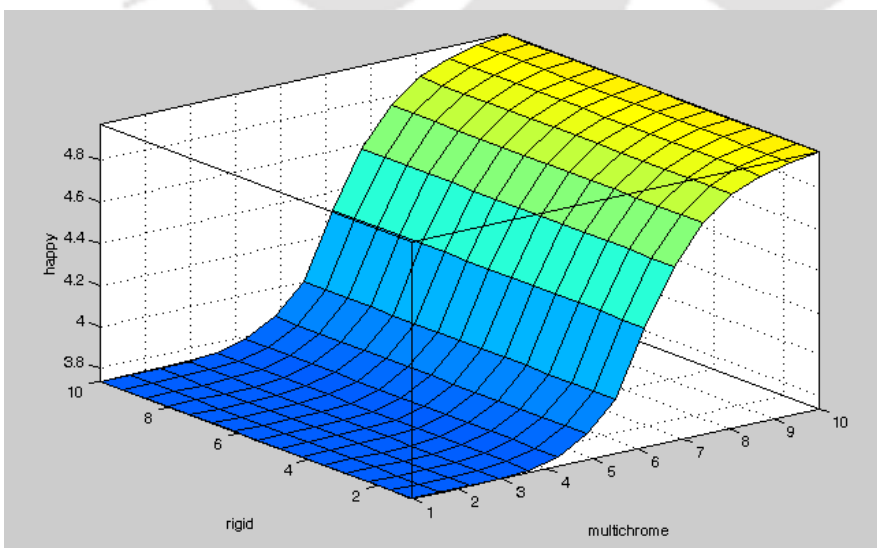
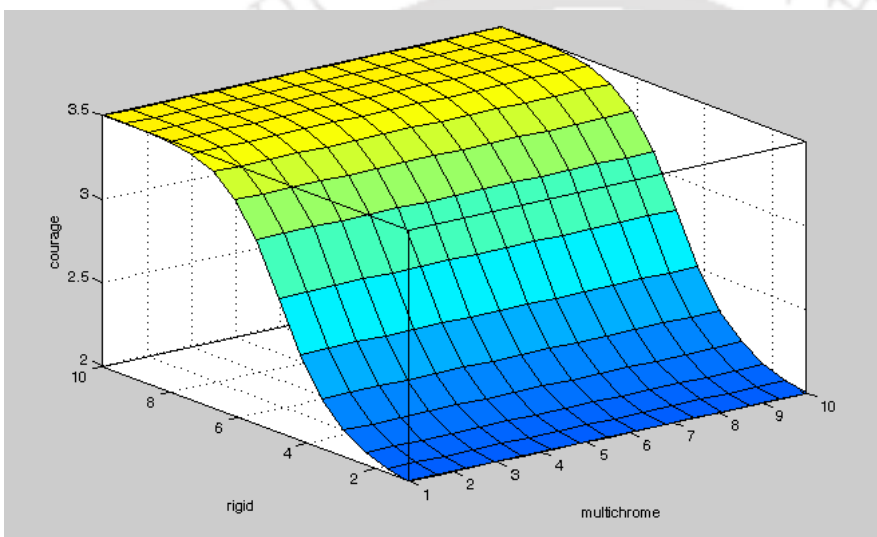
1. If (bright is low) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is very low) and (Courage is high) (1)
2. If (bright is low) and (smooth is low) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
3. If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is low) and (Courage is high) (1)
4. If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is low) and (Courage is high) (1)
5. If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is low) and (Courage is medium) (1)
6. If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
7. If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is medium) (1)
8. If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is high) then (Happy is medium) and (Courage is medium) (1)

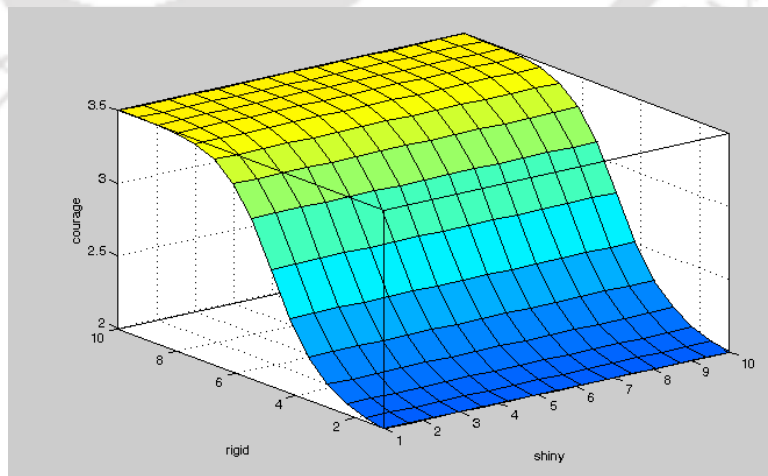
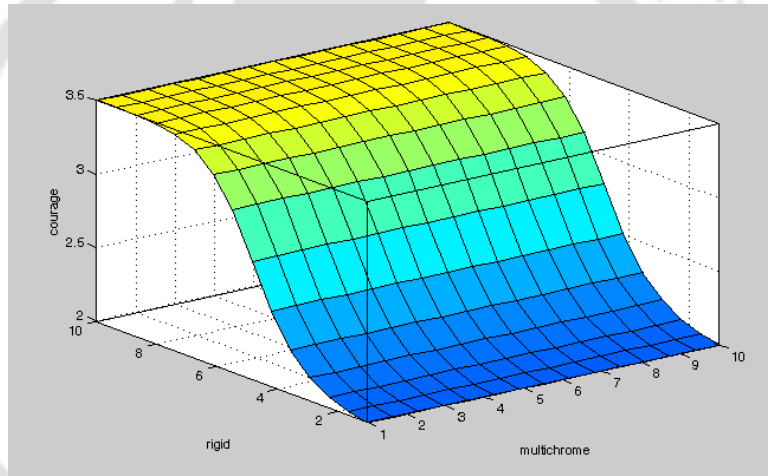
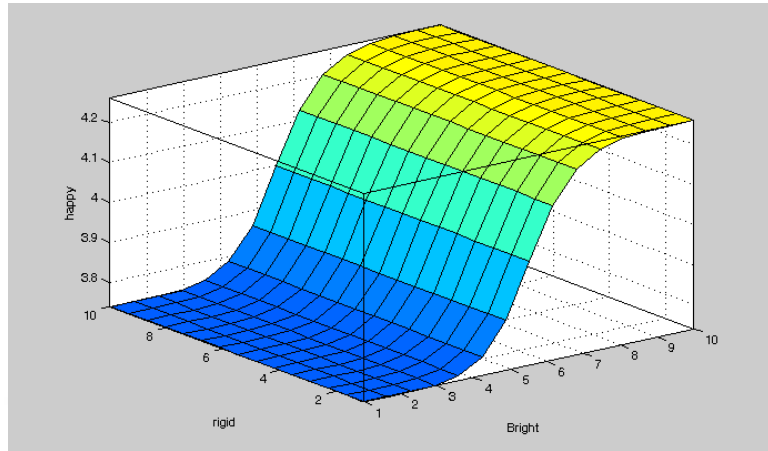
9. If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
- 10.If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is medium) and (Courage is medium) (1)
- 11.If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is medium) and (Courage is high) (1)
- 12.If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is high) then (Happy is high) and (Courage is medium) (1)
- 13.If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is high) then (Happy is very high) and (Courage is medium) (1)
- 14.If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is high) and (Courage is medium) (1)
- 15.If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is high) and (Courage is high) (1)
- 16.If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is high) then (Happy is very high) and (Courage is medium) (1)
- 17.If (bright is low) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is very low) and (Courage is medium) (1)
- 18.If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is medium) (1)
- 19.If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is medium) (1)
- 20.If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is low) (1)
- 21.If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is low) and (Courage is low) (1)
- 22.If (bright is low) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is medium) and (Courage is medium) (1)
- 23.If (bright is high) and (smooth is low) and (shiny is low) and (Multi-chrome is high) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
- 24.If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is low) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
- 25.If (bright is low) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
- 26.If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
- 27.If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is medium) and (Courage is low) (1)
- 28.If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is low) and (rigid is low) then (Happy is high) and (Courage is low) (1)
- 29.If (bright is high) and (smooth is high) and (shiny is low) and (Multi-chrome is high) and (rigid is low) then (Happy is very high) and (Courage is low) (1)
- 30.If (bright is high) and (smooth is low) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is high) and (Courage is low) (1)

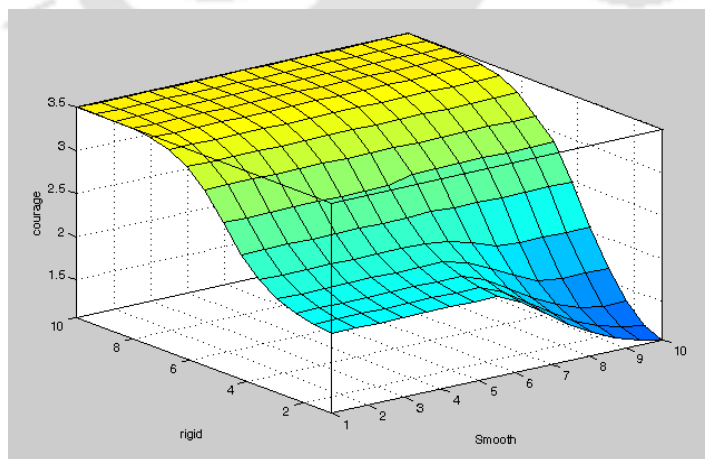
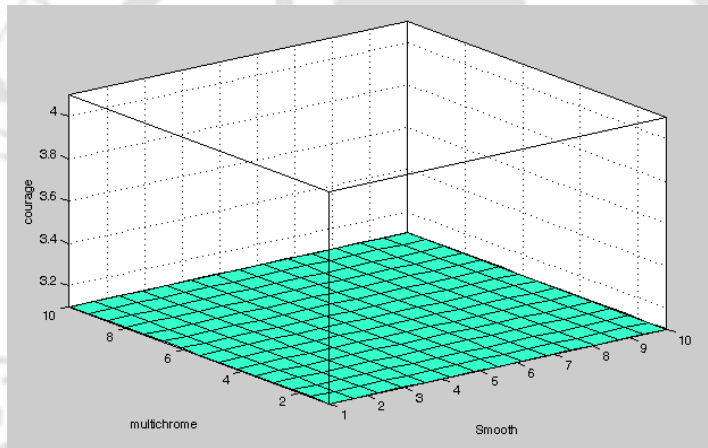
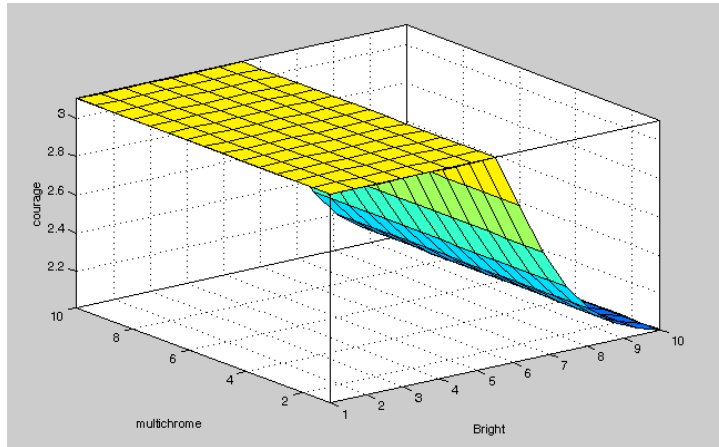
31.If (bright is low) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is high) and (Courage is low) (1)

32.If (bright is high) and (smooth is high) and (shiny is high) and (Multi-chrome is high) and (rigid is low) then (Happy is very high) and (Courage is low) (1)

Relationship between elicited emotions and visual characteristics of stimuli for composite Fuzzy Inference System design







Conclusion

The perceptual rules developed from the affective response data from participants were found to be effective in mapping the identified surface features to the evoked emotion. FIS based on rules derived from the user's data satisfactorily predicted the evoked emotions. The findings were close enough to expected results, to be helpful in designers' design thinking process. FIS as a tool could help the designers in guessing the users affective responses for a designed product.

These findings give hope for a tool, which can aid in designing affective semantics in products for specific user groups. This tool could specifically be helpful when the users and designers come from different cultural backgrounds, making it difficult for the designer to guess the users' affective responses as culture has been found to influence affective responses. A design framework using soft computing has been graphically presented in figure 8.

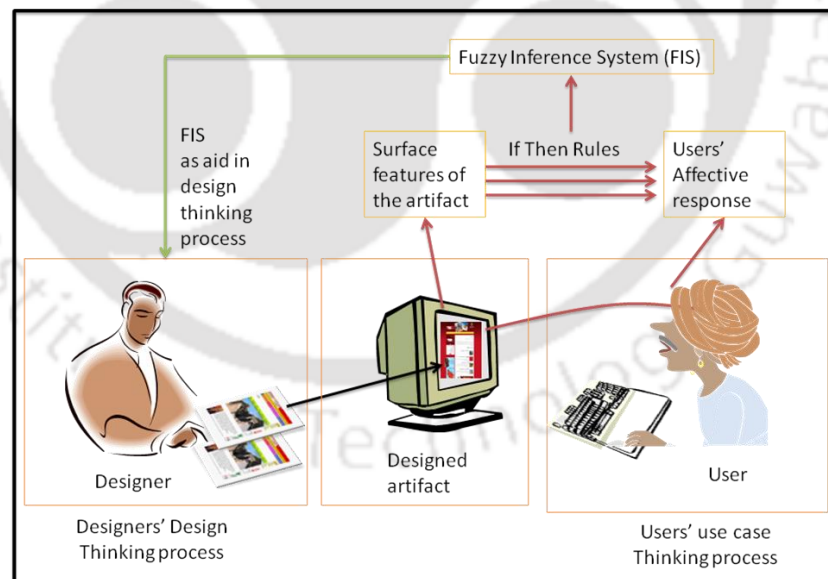


Figure 8 Proposed framework for Using Fuzzy Inference System as an aid in designing for affective semantics





Appendix G

G.1 Study with designers design thinking process

As this thesis aims at identify data gathering techniques that are suitable for experiential design process by supplying information on users to designers to aid in the design thinking process, it becomes imperative to check the data of one of the techniques for its usage by designers. In this section study done with novice designers who have had experience of do 1 to 2 HCI design projects in Industry is being presented.

Aim: To observe the influence of user data on designers' design thinking process in an experiential design task.

Background: Designers design thinking has been recognised as a creative problem solving ability (Newell et al., 1962; Guilford, 1964) and the design problems as ill structured problems (Simon, 1973). Designers' internal representations which are acquired through one's experiences are used to solve design problems (Falzonetal., 1990; Simon, 1995). When the experience of user has not already been experienced by designer it may be a hindrance to designing proper systems meant to provide intended experience to users. Information from users is expected to help ease this gap between users and designers experiences. Hence designers design thinking process has been observed in this study both in absence and in presence of experiential data from users to identify issues related to use of data gathered from users.

Research Design: Studying design students who had experiences of internships on HCI design projects were given an icon design problem. Initially no data was provided to them and their thought process was retrospectively interviewed after the design task was over. Then all of the students were given data collected from users to be used in design thinking process. The differences in approaches on two occasions were observed. Expert's (Professors teaching in department of design

and having experience of more than 20 years in field) opinions were also taken on the designed icons to come to infer about the designers' design thinking approach. After observing some weaknesses in the method of presentation of data, data charts were reformulated and same design tasks were given to a different set of similar design students. After observing positive influences of the user data on design thinking process, a more complex experiential design problem was given to the students. Again their design cognition was observed. Finally a rule based Fuzzy inference system was given to the designers as an aid in their design thinking and after observing overwhelming success of the tool, the study was concluded.

Materials and methods: Design students were given colour pencils and paper which are their usual tools aiding in design thinking. Design students were successively given design tasks in four steps. These four steps would be described separately below. Though the student participants were all from the homogenous group, most of them being batch mates, those who were given the first three tasks were not given the last one. Hence a total of 20 students participated in the entire study, 10 of them doing first three steps and the rest 10 participating in the last step.

Participants: All the participants were from 3rd and 4th year of bachelor of design programme at Indian Institute of Technology, Guwahati. All the students had undergone successfully basic courses in graphics design and all of them had internship experiences in HCI design for couple of months. All participants belonged to age group 22-24 years. Out of 20 students who participated in overall experiment 4 were females, rest were all males.

Procedure (step 1): 10 design students were given a design task to design a dustbin icon for windows environment which should look 70% 'happy'. They





were to use pencils and paper to communicate their concept in about 30 minutes time.



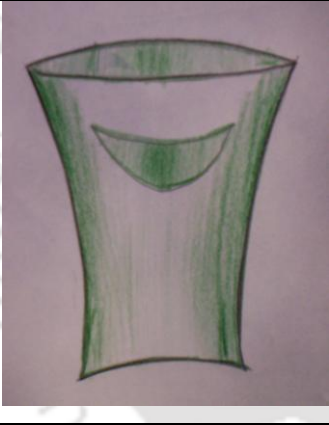

Observations (step 1): 3 out of 10 designers thought of happiness as a function of use and satisfaction related to use that would make the user happy. They could not conceive that the surface features could also evoke feeling of happiness. 5 designers used direct analogy of smiling faces to induce happiness in receiver. Using direct analogy though works for the case of happiness; for a happy face does induce happiness, as was seen in the collected data also, but in design generally direct usages of such cues are not considered good design thinking. When asked to rate their confidence level about how sure they were of their design's ability to evoke happiness in the users. They gave average rating of 3.4 on a scale of 7.


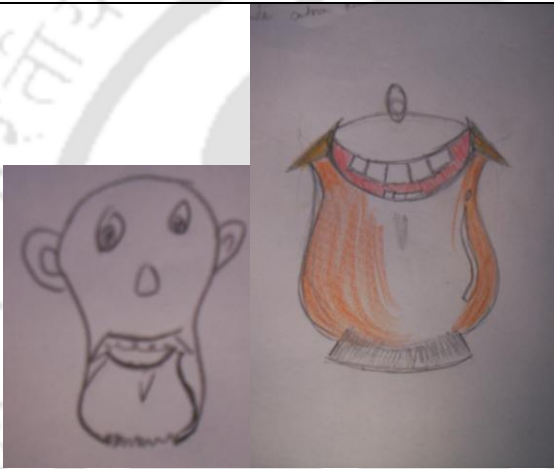
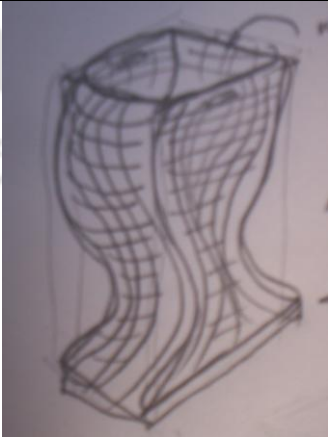
A much narrowed down approach to creating happiness in the bin designs were observed. There were fewer experiments with pencil and paper was observed. Doodlings to aid design thinking were infrequent and were mostly having nervous lines. Strong and bold pencil marks were not seen on the paper. It is a general understanding the art and design academics that strong and bold lines on paper communicate a sense of confidence that the designer has in the design thought moves.

Inferences (step 1): Designers are less confident in their state of knowledge when they design in absence of user data. There tend to use more direct application of analogies from the real world like 'smile' for 'happiness' in order to be surer and creative experimentations are less. A narrowed down approach to design thinking is the result as a deep understanding of the task at hand is absent and more hypothetical thinking is involved by the designer.

Table G. 1: Observations on design cognition in absence of user data

| Designed icon | Observed design cognition |
|---|--|
|  | <p>Sun in the morning is fresh and happy. Having a cup of coffee in the morning is happiness. So use of sky and sun colours on a coffee cup looking dustbin.</p> |
|  | <p>A regular windows bin icon with a smiley on it. The smiley would make the users happy.</p> |
|  | <p>A practical low cost solution would make user happy. "Do not know how to make happy"</p> |
|  | <p>A simple open mouth Bin with Use me tag. Neatness = happiness. Do not know how to create happiness.</p> |

| | | |
|--|---|---|
| |  | <p>New free flowing form, with transparent walls would give look of neatness and thus would make the users happy.</p> |
| |  | <p>Inviting open hands with smiling face would evoke happiness.</p> |
| |  | <p>New shape, with open mouth = happy.</p> |
| |  | <p>Nice smooth curve to evoke 'happiness'. Green colour with smooth lines for neatness = happiness.</p> |

| | |
|---|---|
|  | <p>Direct application of smiley for happiness.</p> |
|  | <p>Direct application of happy face. Designer felt that a happy face looking bin would evoke happiness.</p> |
|  | <p>Happiness through satisfaction of use. The designer was focussed on the practical concern of liquid holding in the bin and hence a flowing looking different bin which would not be smelly would make the users 'happy'.</p> |

Procedure (step 2): The same 10 design students were given the same task to design a dustbin icon for windows environment which should look 70% 'happy'. The second task was given after a gap of 1 hour from the completion of task of step 1. They were to use pencils and paper to communicate their concept in about 30 minutes time.

But this time a 'User data tool' created from the data collected from SD experiments. The affect related data obtained by showing stimuli of dustbins was presented in the format shown in fig G.1 and G.2. The tool was based in PowerPoint and consisted of 21 slides having 21 dustbins images with mean of their affect ratings from first 30 users. It was observed that the designers were having difficulty in comprehending the charts. Information from bar graphs which were juxtaposed with every bin image on the slides was difficult to compare against other images so as to help them develop their own understanding about the features that were probably leading to the bin image being rated higher. As this experiment was running in parallel to the data collection activity using the SD technique hence, for next 29 users, verbal data was also collected along with the ratings on affective scales for the stimuli images.

A new "user data tool" was created with addition of verbal report data obtained from users pertaining to information on 'why' they had rated the images whatever ratings they had given. Further, dustbin images having ratings similar to one being viewed was also presented on the slide of each image (fig. G.3 and G.4). Also additional slides were added to the slide deck showing comparisons between the dustbin images on a single slide. Total of nine such slides, one for each emotional category, depicting hierarchical list of most rated affect category to least rated affect category was added in the beginning of the slide deck (fig G.5 and G.6). Entire slide deck of 'User Data Tool' used for providing user information to

designers has been exhibited in appendix E for convenient viewing. This tool was given to the designers, and designers were asked to design the dustbin icon again.

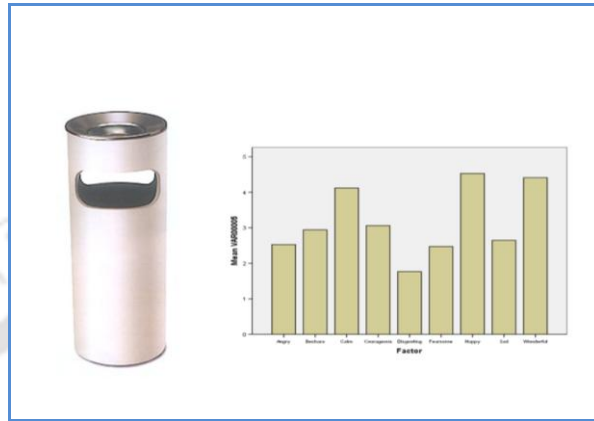


Figure G. 1: A screen from User data tool based on quantitative data alone (image no. 5)

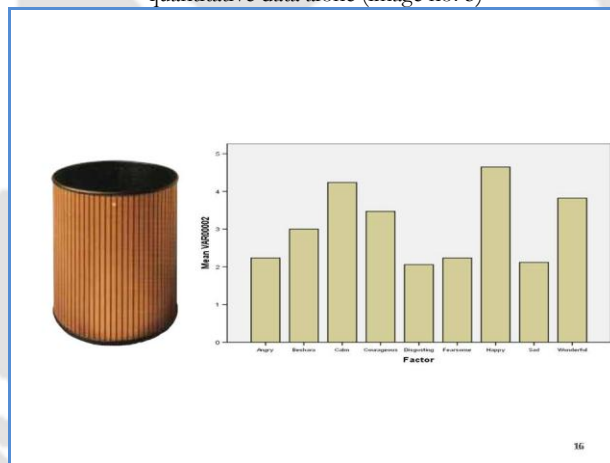


Figure G. 2: A screen from User data tool based on quantitative data alone (image no. 2)

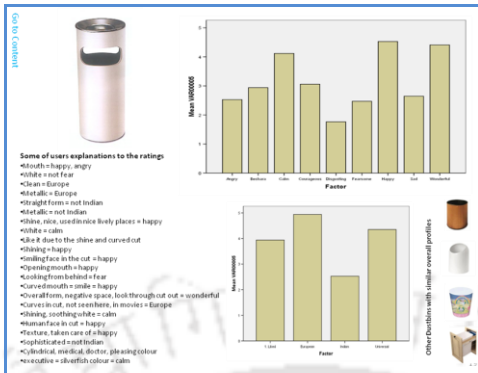


Figure G. 3: A screen from User data tool based on quantitative data and qualitative data (image no. 5)

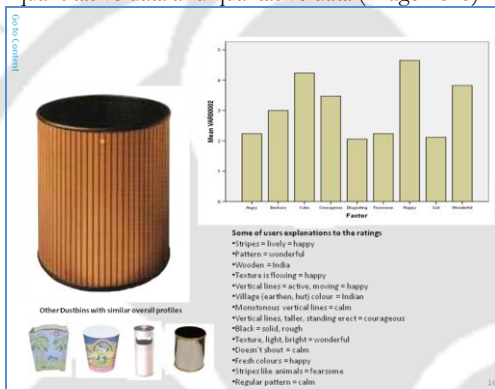


Figure G. 4: A screen from User data tool based on quantitative data and qualitative data (image no. 2)

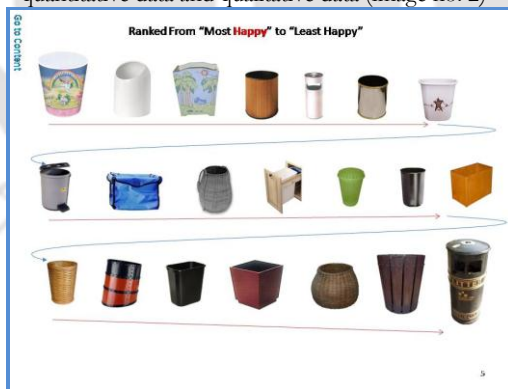


Figure G. 5: One of opening screens from User data tool (images arranged for emotion happy)



Figure G. 6: One of opening screens from User data tool (images arranged for emotion courageous)

Observations (step 2): One of the significant observations was that designers found it easier to use the qualitative data in comparison to quantitative data in their design making process. Designers found it difficult to make sense of quantitative bar created from statistical analysis of data gathered from the users. The strategy that designers had towards quantitative data was to merely get an overview of what the user trends are rather than really using the data in their design thinking process. Quantitative data gave them a sense of how most of the users are thinking but it was not sufficient aid to their design thinking. They were interested in understanding why users are reporting like that? What is it that the users see in the stimuli because of which they have rated them higher or lower along a certain affective scale. Quantitative data helped them select their focus of attention in the entire data. Once the quantitative data told them that a certain image was rated the highest or higher by all the users then they could now focus on those slides which contained the image. At this moment they needed detailed information as to what made the users rate the image higher and it is the meaning rich qualitative at this stage which influenced and guided their design thinking process.


The way designers went about using the user data tool given to them had a significant pattern in it. All the designers first scanned through the slides, making an understanding of what the deck consists of. Then they switched to the first screen which had the content in it with hyperlinks to all other screens. They chose the slide having hierarchical list of happy images and from there on they jumped to the most 'happy' and least 'happy' images subsequently. They would go to the slide of the most 'happy' image, read the users comments, make a note of it and then jump back to some other slide on the happy list. They continuously tried to make sense of what made the users' rate a certain image high on happy. This comparative study of image ratings along with the verbalisations across the list to gather notes on what made them appear 'happy' to the users was observed in all the designers. Designers were taking notes on the paper provided to them, listing the verbal comments observing the image features and summing up their ideas about what features are associated with the 'happy' image. They wrote down words of users that made sense to them in their design thinking process and also started doodling based on the words they could internalize and sort of agree with. From the doodling which consisted of putting down features related to the evoked affect, more confident holistic designs of dustbin icons started emerging. Much more experimentation was observed at this step in comparison to the first step. Also, the designers now reported greater confidence in their designs and gave average of 6 on 7 point scale to the question of 'how confident they were of their design being able to elect the intended emotion?'




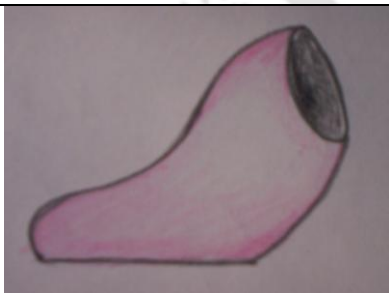
A negative influence of user data tool was also observed. Bias towards the readymade solution in form of the bin design already available in 'user data tool' was also observed. This influence has been illustrated in table x). It was observed that the user data tool was hooking the designers to particular features and solutions already present in tool. And in order to be more confident of their solution they tended to copy features directly from the images on user data tool.


Also there was tendency observed to directly take the words of users as they were instead of cogitating on the deeper reasons about why the users had said so. For instance, users had said a face like feature in dustbin symbolizing happiness in the dustbin image and the designer directly incorporated that feature. But this trend was less significant as only 3 out of the 10 designers showed this tendency to import the direct meaning of the users' reports.

Inferences (step 2): Designers tend to assimilate and use the qualitative data more effectively than quantitative data in their design thinking process. They have problems in comprehending even the visual charts created from statistical data obtained from users. They tend to rely more on meanings in words reported by users to come to their own conclusions. One negative impact of user data tool presented to them was presence of the visual stimuli which biased them towards using the features already present on the slides.

Table G. 2: Observations on design cognition in presence of user data tool

| Icon designed by Designer | Designer's report and analysis |
|---|---|
|  | <p>This was rated high by the experts on design criteria though they were not sure of the emotion elicited by the design.</p> <p>This design also has direct influence of the 3rd image on the slide deck (Appendix A) in terms of the colour used and having a wide and angled opening.</p> |

| | |
|---|---|
|  | <p>This idea has direct influences from image number 5 on user data tool (appendix A).</p> |
|  | <p>This idea was an attempt to imitate 'colourfulness' of the most 'happy' image.</p> |
|  | <p>This designer had also attempted to create 'Indianness' in the dustbin, by giving it a shape of a cane basket, depicted in images 8 and 16. It also has direct influence of image 3.</p> |
|  | <p>This was a novel idea with influences from the image no. 3.</p> |

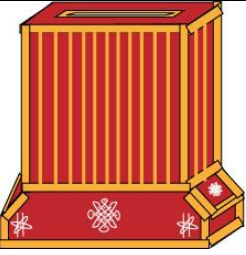



| | |
|---|---|
|  | <p>Usage of face to communicate happiness, idea from image no. 4 and using colours and images, influence of image no. 15.</p> |
|---|---|


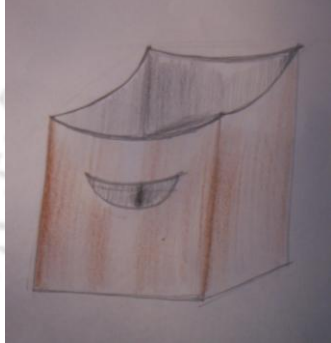
Procedure (step 3): This time same designers were asked to design a happy and courageous dustbin icon using the user data tool. This task was given observing that there are features which would confuse the designers.

Observations (step 3): It was relatively easier to create the emotion 'happy' using the user data tool than combining both happy and courageous in the same icon. Designers were observed to be confused about which features to choose as these emotions were elicited by contrasting features. Again, the designers made notes of the features and verbal reports of users but had hard time figuring out the correct combination. This time also designers were asked to use any software tool of their wish to design the bin icons.

Inferences (step 3): Designing for more than one affective experience at the same time was found to be more difficult using the user data tool. It was hard to find the features that would provide with the optimum balance between the contrasting affective elicitation by the same feature.

Table G. 3: Observations on design cognition in presence of user data but with a complex affective design task

| | |
|---|---|
|  | <p>Box like strong look to communicate courage and fine lines with bright colors intended to communicate happiness.</p> |
|  | <p>Confusion between soft features communicating strength.</p> |
|  | <p>Strong built for courage with bright colors for happiness.</p> |
|  | <p>Attempt to give a rugged feel for courage.</p> |

| | |
|---|--|
|  | <p>Using rivets to communicate the sturdiness associated with courage as communicated by the users verbalisation.</p> |
|  | <p>Attempt to communicate courage by putting strong and sturdy features and a happy face to communicate happiness.</p> |
|  | <p>Strength for courage and colour for happiness.</p> |

Background work (step 3): After having observed some of the weaknesses of the user data tool in terms of the bias created towards design solutions by already available solutions observed in the user data tool and the inability to design for mix of emotions having contrasting features another attempt was made to create a more 'smart' tool which could guide the designers without showing them the images. It was observed from the notes of the designers when they were

interacting with the User data tools that certain features were observed by all the designers to be associated with certain emotions. For instance, happiness evoked by the image was observed to be directly associated with how ‘bright’, ‘smooth’, ‘shiny’ and colourful it was. Similarly other features associated with the 9 emotional categories have been listed in table x. Out of the emotional categories, related features associated with the positive emotions were easier to find. After identifying, the surface features associated with elicited emotions a soft computing technique was used to map these features to the elicited emotions and the tool prepared using soft computing was given to the designers to design.

Table G. 4: Surface features identified as contributing to elicitation of each emotional category

| Emotional categories | Image features associated |
|-----------------------------|--------------------------------------|
| Anger | Bright, shiny and rigid |
| Calmness | Bright and smooth |
| Courage | Bright, smooth and rigid |
| Disgust | Shiny and Bright |
| Fear | Bright, smooth, shiny and rigid |
| Happy | Bright, smooth, shiny and colourful. |
| Pity | <i>Difficult to figure out</i> |
| Sadness | <i>Opposite of happy</i> |
| Wonder | Bright, shiny, colourful and novel. |

Soft computing is mainly characterized by its ability to deal with 'soft' variables which have imprecision and partial truths. One of the soft computing techniques is 'Fuzzy Logic' which operates on fuzzy sets and was introduced by Lotfali Zadeh (1965). Soft computing techniques are the foundation component for the emerging field of conceptual intelligence. The ability to take 'human like' decisions where imprecision and approximations are involved makes the soft computing techniques suitable for prediction of many semantic constructs of designed products like, emotion, aesthetics, culture etc.

Fuzzy logic and Fuzzy Inference System

As opposed to conventional 'hard' computing, which deals with only 'either' and 'or' belongings of a variable, the fuzzy set theory, accepts the partial belonging of the variables to the set. For example, in conventional logic, a product feature could either lead to the product being either 'happy' or 'not happy', whereas in fuzzy logic, the same could contribute to the product being 'somewhat happy'. As shown in figure G. 7, for instance, the contribution of a 'member' feature be either '0' or '1' in conventional logic whereas it can have different partial values in fuzzy logic. Here, member means the factors contributive to the output value.

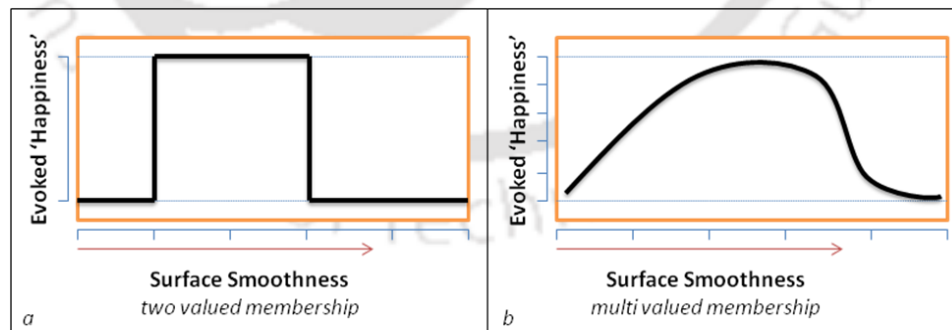


Figure G. 7: Classical set (a) versus Fuzzy set (b)

The partial contributions of each member features are summed up to arrived at a crisp output value. This method of mapping input-output spaces is called ‘Fuzzy Inference System’ or ‘FIS’ in short. FIS is very effective in cases where the linear or piece wise linear functions of conventional mathematics fail to handle the complexity of the input-output relationship. For instance, the conventional logic, at best could give us maps as shown in figure 2(a) where as a much more realistic picture would be given by the FIS (figure 2(b)).

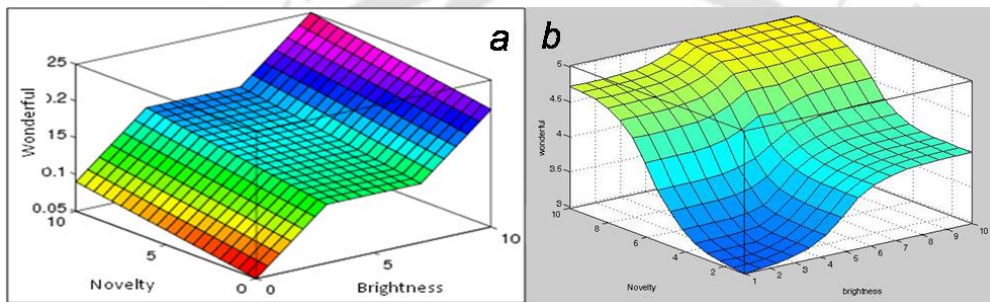


Figure G. 8: (a) piece wise linear function mapping (classical) and fuzzy mapping (b)

The basic structure of fuzzy inference system is a model that maps input characteristics to input membership functions, input membership function to rules, rules to a set of output characteristics, output characteristics to output membership functions, and the output membership function to a single-valued output.

For implementing FIS in this research, relationship between the input and output data was considered and guesses were made about the rules that govern them. A set of rules derived by common sense from user data was fed into the FIS system and was continuously refined till a match between FIS output and emotions elicited by users was matched. For example, as listed below, one of the eight rules used for emotion ‘Courage’ was “If (Brightness is Low) and (Smoothness is Low) and (Rigidity is High) then (Courage is High).” And similarly, one of the nine By successively varying the contribution from each of the surface characteristics to

the emotion felt, the right output was achieved. All the rules have been illustrated in appendix F for reference.

Fuzzy rules for emotion 'Courage' as fed in fuzzy inference system:

If (Bright is Low) and (Smooth is Low) and (Rigid is High) the (Courage is High)

If (Bright is Low) and (Smooth is Low) and (Rigid is Low) the (Courage is Medium)

If (Bright is Low) and (Smooth is high) and (Rigid is High) the (Courage is High)

If (Bright is Low) and (Smooth is Low) and (Rigid is High) the (Courage is Medium)

If (Bright is Low) and (Smooth is high) and (Rigid is Low) the (Courage is Low)

If (Bright is high) and (Smooth is high) and (Rigid is High) the (Courage is Medium)

If (Bright is high) and (Smooth is Low) and (Rigid is Low) the (Courage is Low)

If (Bright is high) and (Smooth is high) and (Rigid is Low) the (Courage is Low)

This was followed by decision on membership functions and it depended on the nature of the input and output variables. Then FIS type was decided. Most popularly used types of FIS are 'Mamdani type' and 'Sugino type'. In this paper 'Mamdani type' inference which is available with Matlab 7 software has been used (Mamdani and Assilian, 1975). FIS were first created for every single emotional category and after success satisfactorily matching the output of emotional ratings given by the FIS, on the basis of ratings of surface features given as input to the FIS, to the emotion reported by the user, a FIS was created two affects built in it. Fig G.7 illustrates rule editor for single emotion elicitation and fig G.8 illustrates rule editor for two emotions elicited. Capability of FIS for giving outputs of felt emotions based on the surface feature inputs was tested with different stimuli. Designers rated surface features of 30 stimuli, both graphic and in 3D form, and some users rated the same stimuli for elicited emotions. The output of FIS upon giving the feature related inputs was compared with the emotional ratings by the users and upon finding significantly high agreements between the two, FIS with two affective output, namely 'happiness' and 'courage',

was given as a tool to designers to aid their design decision making. Figure G.9 exhibits the way the FIS tool looked to the designers.

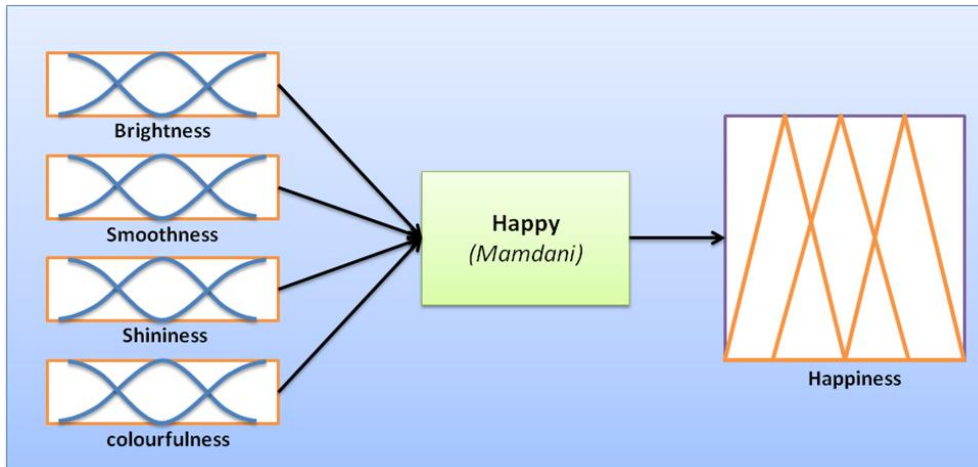


Figure G. 9: Rule editor for emotion 'Happy' in FIS

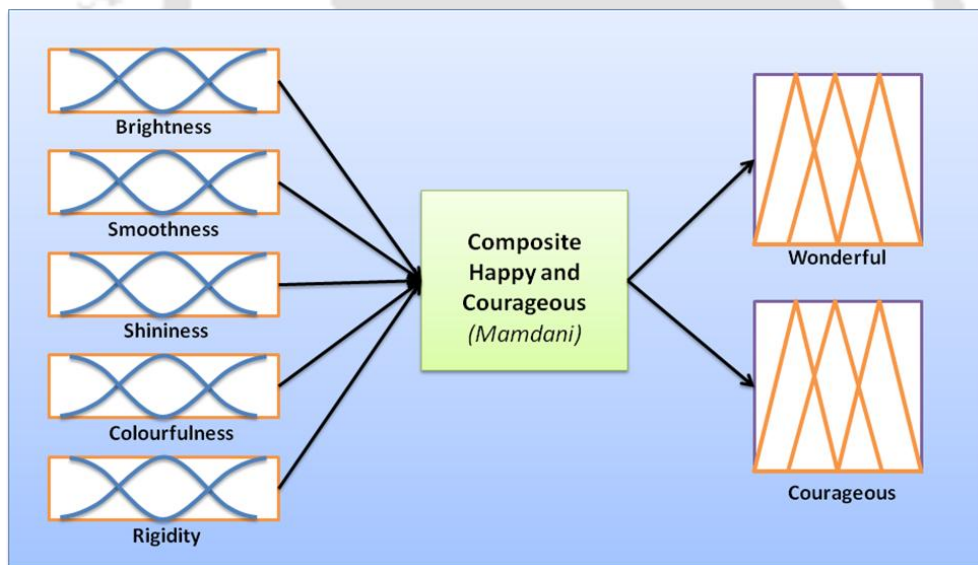


Figure G. 10: Rule editor for 'Happy' and 'Courageous' in FIS

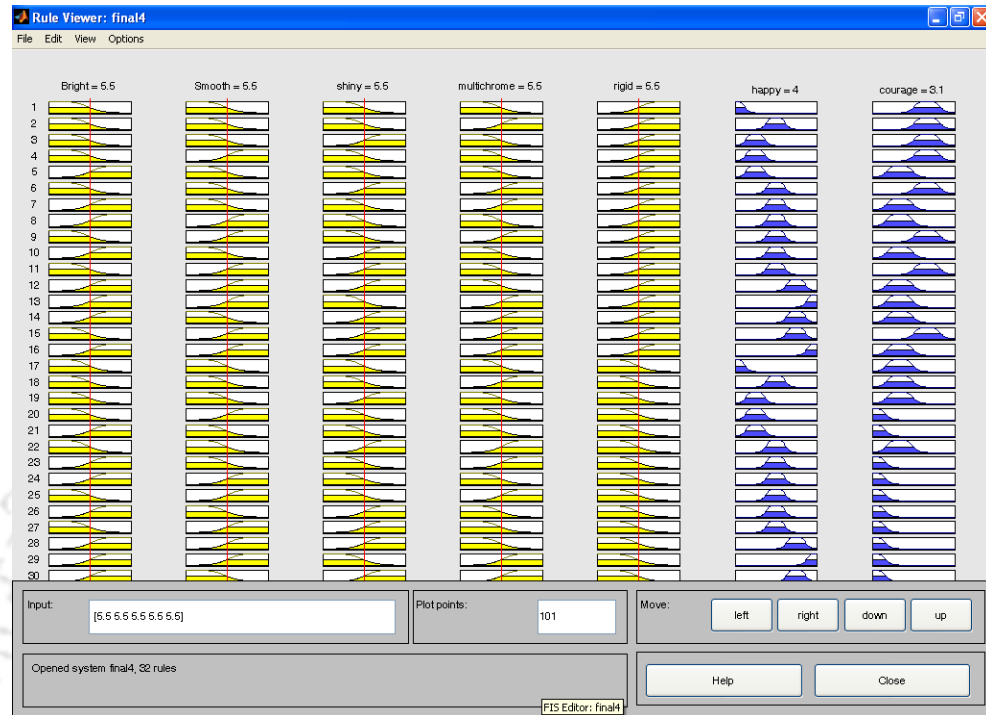


Figure G. 11: The FIS interface used as guide to design decisions

Procedure (step 4): FIS capable of giving outputs of felt emotions based on the surface feature inputs was given to the designers. This time the designers were different from the ones participated in steps 1,2 and 3. These was done in order to remove the bias of having interacted with the ‘user data tool’ and hence correct judgement of the FIS tool as aid in design thinking could not be established. The participants though were from the same homogeneous pool of design students. The designers were asked to design a dustbin icon eliciting happiness 50% and Courage 50%. FIS tool was having sliders that could be adjusted to feed in the input of the ratings for surface features. Changing the value of surface features immediately reflected in the value of elicited emotions on the right side of the screen.

Observations (step 4): Designers took much less time in comparison to the ‘user data tool’ in getting familiarize with the FIS tool. The fuzzy inference tool

helped them come at conclusions quickly as to which surface features are directly related to which of the emotions and which features are inversely related. FIS also helped them identify the features which needed to be more carefully played with as the intensity with which they affected the elicited emotions was different for different features. Also, as the design task was to design for two emotions, some surface features were quickly identified as affecting directly in eliciting one emotion while same feature was found to affect the other emotion inversely. Hence a fine tuning of the feature in the designed icon had to be achieved.




Also this tool was free from creating bias in the mind of the designer towards the stimuli rated higher while being used during the data gathering from users. The FIS tool gave designers an empty page for creativity and the design solutions could take any direction. This was unlike the user data tool experiment where the designers had the tendency to get tied to the visuals present in the tool.

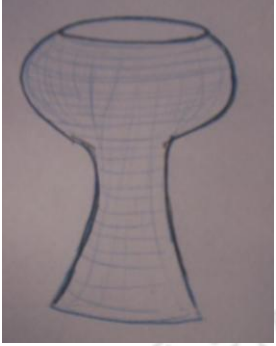

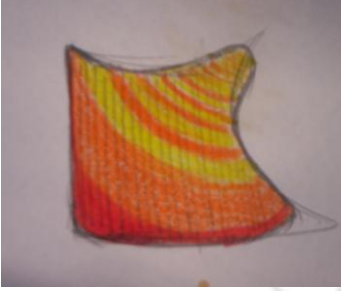
It was also observed in interview with designers that they were not confident about the correctness of the FIS itself, for it had contrasting data from their own assumptions about the elicited affect. But they assumed that the tool would be true and if the tool were true then their design also would be as they had matched the criteria through surface features for the elicited emotions. However the designs created by designers using FIS tool was appreciated more both by the users and experts for creative and novel solutions (Table G.5).



Inferences (step 4): Merely presenting the data as it is to the designers does not aid them in their design thinking. Post processing of the data gathered from users is required to be done. Best mode in which the designers can make use of the data gathered is if rules could be created. In general designers are not confident of their design concepts if they have not used sufficient data to make design

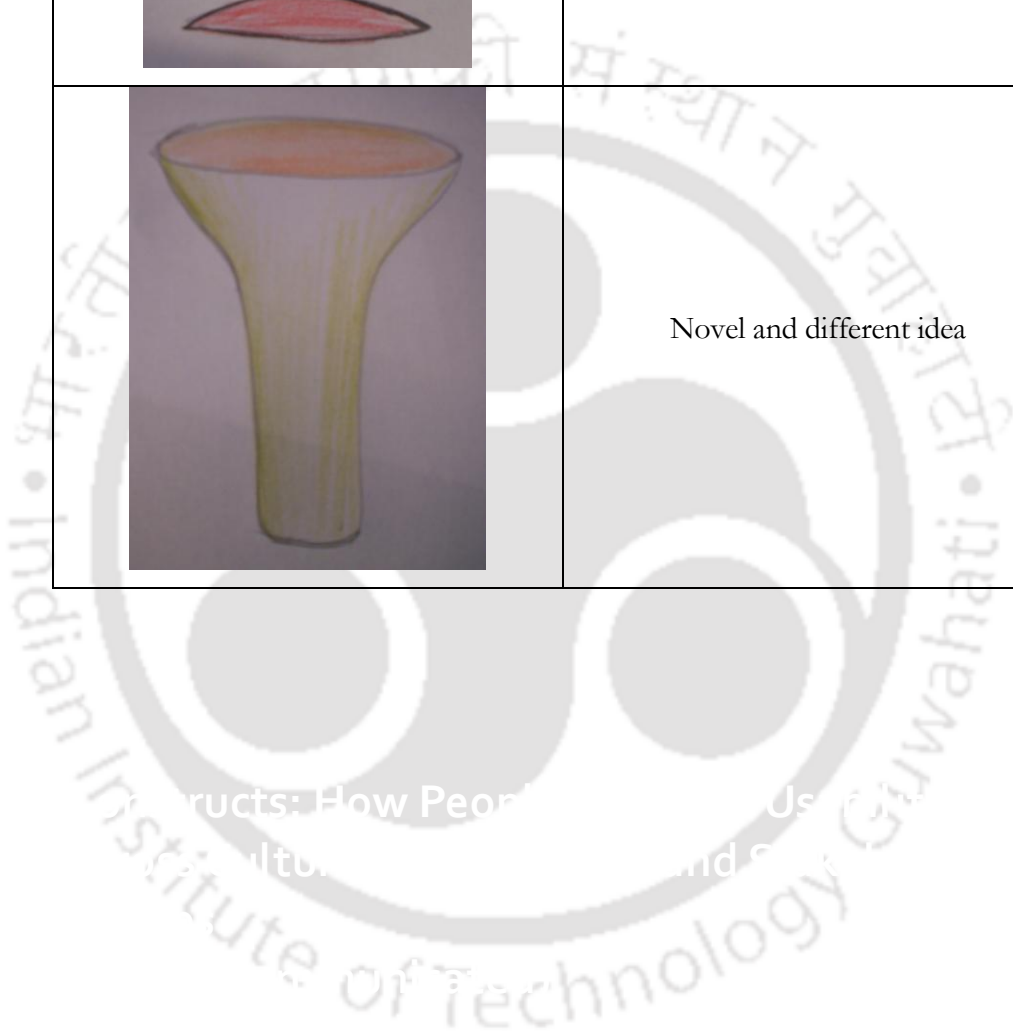
Inferences. If a method of helping the designers internalize the user data could be provided, designers will be able to make more sure design decisions.

Table G. 5: Observations on design cognition in presence of FIS system based tool

| | |
|---|--|
|  | <p>Attempt to use colours to depict happiness. Rated high by experts for novelty and aesthetics.</p> |
|  | <p>Attempt to build sturdiness to mean courage and colours for happiness.</p> |
|  | <p>Building sturdiness' to speak of courage.</p> |

| | |
|---|---|
|  | <p>Novel and different idea</p> |
|  | <p>Novel and different idea. Was rated high by experts.</p> |
|  | <p>Novel and different idea</p> |

| | |
|--|---|
|  | <p>Novel and different idea. Was rated high by experts.</p> |
|  | <p>Novel and different idea</p> |







Appendix H

List of publications associated with output of this thesis work.

Jyoti Kumar, Pradeep Yammiyavar and Janni Nielsen. *Mind Tape technique - a usability evaluation method for tracing cognitive processes in cross cultural settings.* eMinds:International Journal of Human Computer Interaction, Vol. I No. 3 (Dec. 2007). ISSN: 1697-9613 (print) - 1887-3022 (online). www.eminds.uniovi.es

Jyoti Kumar and Pradeep Yammiyavar. *Impact of user's aspirations on choice of interface: towards validating Indian Psychology Perspective.* Proceedings - Indo – Danish HCI Research Symposium 14th –15th May 2006, Department of Design, IIT Guwahati.

Jyoti Kumar, Janni Nielsen and Pradeep Yammiyavar. *Tracing Cognitive processes for Usability evaluation: A cross cultural mind tape stud.* Paper # 1876, Proceedings of Second International Conference on Usability & Internationalization, HCI International Beijing China, July 22-27 2007.

Pradeep Yammiyavar, Torkil Clemmensen and **Jyoti Kumar**. *Influence of Cultural background on Non-Verbal communication in a Usability Testing Situation.* International Journal of Design – International Journal of Design, Special issue on Culture, August 2008. www.IJDesign.org.

Pradeep Yammiyavar, Torkil Clemmensen and **Jyoti Kumar**. *Analyzing non-verbal cues in Usability Evaluation tests;* Proceedings of Second International Conference on Usability & Internationalization, HCI International Beijing, China. July 22-27 2007.

Pradeep Yammiyavar and **Jyoti Kumar**. *Use, User, Usability: Bounded rationality perspectives in cross cultural framework.* Proceedings - Indo – Danish HCI Research Symposium 14th –15th May 2006, Department of Design, IIT Guwahati.

- Torkil Clemmensen, Quinxin Shi, **Jyoti Kumar**, Huiyang Li, Xianghong Sun and Pradeep Yammiyavar. *Cultural Usability Tests – how usability tests are not same all over the world HCI International*, N. Aykin (Ed.): Usability and Internationalization, Part I, HCII 2007, LNCS 4559, pp. 281–290, 2007
- Morten Hertzum, Torkil Clemmensen, Kasper Hornbæk, **Jyoti Kumar**, Quingxin Shi, and Pradeep Yammiyavar. *Usability Constructs: A cross cultural Study of How Users and Developers Experience Their Use of Information Systems*. HCI International '07, Beijing, China
- Morten Hertzum, Torkil Clemmensen, Kasper Hornbæk, **Jyoti Kumar**, Quingxin Shi, and Pradeep Yammiyavar. *Personal Usability Constructs: How People Construe Usability across Cultural Backgrounds and Stakeholder Groups* TOCHI (communicated)
- Torkil Clemmensen, Quinxin Shi, **Jyoti Kumar**, Huiyang Li, Xianghong Sun and Pradeep Yammiyavar. *Cultural usability: think aloud usability tests sessions in diverse cultural settings Advances in Human-Computer Interaction* (communicated)





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