VIRTUAL TELEVISION CHANNELS

CONCEPTUAL MODEL, USER INTERFACE DESIGN AND AFFECTIVE USABILITY EVALUATION

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Abstract

This doctoral dissertation aims to investigate user interface (UI) design, implementation and evaluation for interactive television (ITV) applications.

Computer mediated entertainment (e.g. video-games, digital music, DVD movies, ITV) has emerged as a major economic factor in the media industry, taking-up a large portion of consumer spending and leisure time. Advances in set-top box technology made possible the digital video recorder (DVR) and Internet connectivity, thus making the television interactive. The objective of the present work is to evaluate the established human-computer interaction (HCI) theory against the requirements of ITV applications. Previous HCI research about ITV focused only on the design of the electronic program guide (EPG) and did not consider the enhancement of the TV content. Furthermore, previous research approached ITV from a single perspective (e.g. computer engineering, advertising, communication) and it did not consider the conflicts of interest between the broadcasters and the consumers, between the developers and the producers, and more crucially, it did not consider the ITV user as a TV viewer.

For this purpose, the established TV watching behavior is identified in other scientific disciplines, such as advertising and communication, and it is combined with the Information Technology (IT) usability mentality. The design methodology involves two phases. The objective of the first design phase is to formulate a small set of principal elements that are generic to the design of ITV UIs, such as Virtual Channel conceptual model, UI principles, UI development toolkit, prototyping platform, and affective usability evaluation framework. The objective of the second design phase is to employ the elements identified in the previous stage into the development of an ITV application. The ITV application was evaluated by consumers and addressed three contemporary UI issues: video skipping, animated character, and dynamic advertisement insertion. Overall, the methodology employed a holistic design approach for ITV applications, in which the UI model and the business model were systematically mapped to and validated through an ITV music application.

In brief, it was found that the track-skipping UI seamlessly enhanced consumer entertainment. Moreover, it was found that an animated character is preferred, when compared with the traditional transparent box for the presentation of related information. Consumers evaluated the dynamic advertisement insertion positively, thus, opening-up many opportunities for novel advertising formats. The employment of the proposed HCI elements made the design and the development of the ITV appli-

cation a straightforward process and produced an entertainment experience that was liked by the consumers.

The results entail significant implications for the TV industry. ITV is currently perceived as a set of decorative elements, which do not provide any actual improvement of the existing TV content. On the other hand, video-skipping is a familiar functionality that should be exploited, instead of neglected due to the fear of cannibalizing the fixed advertising of the broadcast schedules. The dynamic advertisement insertion in the TV content stream offers a novel advertising format. Finally, there are opportunities for a new mediating role in the media industry that combines the available broadcast transmission with additional elements (Internet resources, computer generated graphics) for the provision of personalized virtual television channels.

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Abbreviations

CME: Computer mediated entertainment
ITV: Interactive Television
DTV: Digital Television
STB: Set-Top Box
EPG: Electronic Program Guide
VOD: Video on Demand
VCR: A Video Cassette Recorder
DVR: A Digital Video Recorder
HDD: Hard Disk Drive
CE: Consumer Electronics
IT: Information Technology
UI: User Interface
CHI/HCI: Human Computer Interaction
API: Application Programming Interface
VBI: Vertical Blanking Interval

1 COMPUTER MEDIATED TELEVISION

Computer mediated entertainment (CME) is emerging not only as a major economic force, but also as an issue of scientific discourse. In the past, it was military and space exploration that drove scientific innovations that later became consumer products, such as the PC and the Internet. More recently, forms of CME (e.g. interactive television and video games) have been the main drivers of innovation in information technology (Bryant and Love 1996). Consequently, CME innovations are finding many application areas, like scientific visualization, simulation, and education (Rosenbloom 2003). Besides scientific importance, CME has emerged as a major economic factor in the media industry (cinema, video rentals, music, books, radio, television), taking-up a large portion of consumer spending and leisure time. In particular, television, which has traditionally occupied the largest share of consumer leisure time, is now undergoing a process of technological transformation. Interactive Television (ITV) is a development that will gradually replace the traditional TV and introduce interactive media into the consumer's living room. For broadcasters, ITV is an opportunity for a personalized approach to individual viewers (Spangler et al. 2003). Nevertheless, there is evidence that most ITV services have a slow adoption or they have already failed in the marketplace (Carey 1997). Then, *the objective of the present research is to identify the shortcomings of the current approaches to ITV, to propose solutions and to test them with consumers.*

Computer science research had been indifferent to TV, until IT advancements started converging with the TV delivery platform. In the beginning, IT was introduced at the production and at the broadcast studio in the form of digital tools, then at the transmission system with digital satellite broadcasting and lately at consumers' homes with the digital STB. In the past, academic research for the effects of the TV content on audiences was only conducted in a few disciplines, such as advertising and communication. The former discipline is primarily concerned with influencing consumer behavior through advertising messages, while the latter is concerned with the effects of TV content on the psychology of the viewers. Both disciplines agree that TV is the most important entertainment medium, and that it has a wide array of effects on everyday life, such as influence (Shrum 1999) and entertainment (Vorderer

2001). In particular, media entertainment has emerged as the most prevailing method for spending the available leisure time and TV is the most popular entertainment medium (Zillmann 2000). For example, TV watching is an activity performed due to ritualistic or instrumental motives (Rubin 1982), which may be: escapism, information, entertainment, social grease, mood improvement, social activity, and social learning (Lee and Lee 1995). Then, *the core focus of the present research is to examine ITV applications from the consumer's perspective.*

Recent research has tackled ITV from a diversity of perspectives, such as technology, business, regulation, and human-factors. It is argued that after the necessary technology becomes available, and then the most important aspect will be the design of services that are highly desirable by consumers (Carey 1999). There is also a growing number of research works regarding ITV from diverse perspectives such as virtual reality and computer supported cooperative work (Benford et al. 2000; Bowers 2001), regulation (Galperin 2002), strategy and forecasting (Jacobs and Dransfield 1998), adoption (Choi et al. 2003), sociology (Theodoropoulou 2002), retailing (Wade and McKechnie 1999), business modeling (Pramataris et al. 2001), personalized advertising (Lekakos and Giaglis 2002), ITV content and services (Carey 1999; Jaaskelainen 2001) cross media service delivery (Spinellis 2003), digital rights management (Bell and Gemmell 2002), and market trials (Carey 1997; Curry 2000). Therefore, ITV is a prominent domain that is examined from multiple scientific perspectives. In the present work, *ITV is examined from the perspective of the human-computer interaction (HCI) scientific discipline.*

Traditional HCI settings involve a task-oriented approach where the human interacts with an application to perform a particular goal. The present research is based on the realization that the desktop computing paradigm is not appropriate for ITV, because it is adapted to fundamentally different user aspirations and activities. Previous HCI research for ITV is implicitly inspired by an IT mentality. HCI concepts developed for productivity environments are inappropriate for the ITV, since they do not consider the established TV watching behavior, as it is described in previous studies (Gauntlett and Hill 1999; Kaufman and Lane 1994; Kubey and Csikszentmihalyi 1990; Lee and Lee 1995; O'Brien et al. 1999). Therefore, t*he emergence of computer-mediated television requires a fresh view of the current HCI paradigms and a careful examination of how this change of perspective affects their relevance.*

1.1 RESEARCH PROBLEM AND AIM

The major HCI research problem treated in the present work is UI design and evaluation for CME through television in a domestic setting.

Despite the significance of CME, work-oriented task models that have been the main focus of previous HCI research poorly describe the infotainment and leisure activities. Therefore, there is a need to re-examine the principal HCI notions. There are mainly three core elements of the HCI approach to computing research problems that are treated in the present work: 1) conceptual model, 2) UI principles, and 3) usability evaluation. All of them were employed in the design of an ITV music program. Moreover, the ITV prototype was implemented by employing a novel Application Programming Interface (API) that was developed to address the unique challenges of ITV user interface design, in the context of the present thesis.

- Research Problem: *UI design, development and evaluation for ITV*

  There are three research questions that correspond to three of the major HCI notions (conceptual model, UI principles, UI evaluation).

- Question 1: *Which is the user interface conceptual model for ITV that integrates digital broadcast transmission, persistent local storage and Internet resources?*
- Question 2: *Which are the factors that affect the design of UIs for ITV applications?*
- Question 3**:** *Which methods and constructs are appropriate for the affective usability evaluation of an ITV application?*

  There are also three hypotheses that correspond to major issues faced by the HCI practice and the media industry.

- Hypothesis 1: *Consumers' affective usability scores are different between the track-skipping user interface and the traditional linear flow of the TV content.*
- Hypothesis 2: *Consumers' affective usability scores are different between the animated character and the transparent information box for the presentation of information related to the TV content.*
- Hypothesis 3: *Consumers are exposed to more advertisements in an ITV application that employs a video track-skipping user interface with dynamic advertisement insertion than in a linear TV schedule.*

The identification and formulation of the above research issues is performed through an extensive literature review in chapter 2.

1.2 JUSTIFICATION FOR THE RESEARCH

Television is undergoing a process of technological transformation. The impact of IT on TV is important for HCI theory and practice, because it extends the current focus from work settings toward domestic settings and leisure activities. The television industry (broadcasters, advertisers) is also affected by the introduction of digital STBs with DVR functionality and it has to adapt to a changing business environment. In the rest of the section the research problem area is justified according to the potential impact on theory and practice and according to the relevance of the skills of the PhD candidate.

HCI has been a central theme of my research experience. Firstly, I approached HCI from an engineering perspective and developed a UI for Web services (Computer Engineering thesis). Then, I combined HCI and marketing theory, in order to design and evaluate with consumers a UI for ITV advertising services (Msc Marketing and Communication thesis). At the same time I was occupied in EU funded research projects and the experience with the digital media industry offered a first-hand experience of the contemporary practice issues. The present thesis is a combination of the above fields. In brief, HCI is the central theory, CME is the research problem area, and ITV is the specific domain, while the approach includes elements from engineering, marketing and communication research.

CME is emerging as a theme of scientific discourse in the computing disciplines. In the past, mainly researchers from the communication research and the advertising research disciplines have conducted academic research for television. Lately, the introduction of DTV and digital STBs has motivated researchers from the computing disciplines to study issues related to TV. In the rest of the section, workshops, conferences and journals from the computing field that have treated ITV are presented.

Numerous workshops have taken place in major conferences and new series of conferences have been organized to focus on ITV issues. The SIGCHI conference on Human factors in computing systems in 2003 had a focus on the special themes of interactive mass communication and emotion. In addition, there are also a few more specialized conferences and workshops. For example, the EuroITV conference series is offering a multidisciplinary approach to ITV issues. Moreover, the Design and En-

gagability conference has a focus on designing aesthetically pleasing products. In addition, there are two series of conferences that directly address CME: 1) The International Conference on Entertainment Computing and 2) the International Conference on Advances in Computer Entertainment Technology. Finally, the Appliance Design conference in 2004 has a special theme on Home Entertainment and Appliances. Therefore, ITV is a theme that has spurred active discussion in the emerging CME field.

Moreover, the trend toward an academic approach to ITV is being established with special issues of major journals and new journals that emphasize on CME. The rising importance of CME is signified by the introduction of a new quarterly journal by ACM, named 'Computers in Entertainment', which, among others, has an area of interest in ITV. Furthermore, ITV was treated in special issues of two established journals: 1) Computers and Graphics, and 2) User Modeling and User Adapted Interaction. Overall, in addition to videogames, entertainment robots, and mobile multimedia, ITV is a growing theme of research in the area of CME.

Beginning with the decade of 2000, there are various PhD theses about ITV. Previous doctoral theses have treated ITV production issues for management (Jaaskelainen 2001), programming languages and authoring tools (Agamanolis 2001), application development methods (Peng 2002), learning (Butcher 2002), sports video processing (Ekin 2003), interactive advertising (Lee 2003), personalized advertising (Lekakos *Unpublished*) and ethnographic methods for requirements capturing (Eronen *Unpublished*). Nevertheless, there is no PhD research in the area of HCI design for ITV, which is a gap that the present thesis has setout to address.

Finally, attending the ITV conferences and discussing with the participants revealed that there are more than a few researchers who are doing their PhD theses or action research projects in some area of ITV, thus ensuring that the field is in a growth period and that more theses and published papers will appear in the coming years. It is unlikely that ITV will come to constitute an academic discipline by itself, but it will remain a distinct theme of interest for practitioners in a number of fields (i.e. interactive content, usability, internet, etc), while academics will find in ITV an additional (to TV, PC, mobile) medium to develop and apply their theories and methods.

1.3 APPROACH

The research approach involves two design phases. The objective of the first design phase is to identify a set of principal elements that are generic to the design of ITV UIs and that relate to the three research questions (conceptual model, user interface principles, and evaluation methods). In addition, the complementary issues of a programming library and of prototype methods for ITV are addressed. The objective of the second design phase is to employ the elements identified in the previous stage into the development of an ITV application that is evaluated by consumers against three contemporary ITV issues (video skipping, animated character, and dynamic advertisement insertion). The employment of the principal design elements into a working application functions as an evaluation of their applicability in other cases, too. For each one of the above-mentioned issues a different approach is employed, as explained below:

- Conceptual model: The identification of a conceptual model for ITV is a two-step approach that consists of: 1) a thorough investigation of the evolution of the established conceptual model for TV, thus identifying the familiar patterns and 2) a literature review of the most recent academic research for ITV, thus identifying novel ITV patterns.
- UI principles: Following a literature review of diverse scientific perspectives relevant to ITV applications (IT, Advertising, Communication), the most useful findings from each discipline are collected, analyzed and presented in an easy-to-use designer's check-list of trade-offs.
- Prototyping: Initially, scenario writing is employed to instruct the prototype development and inspire the whole design process. Then, the emphasis is placed on the media consumer experience realized through a high-fidelity prototyping platform, mimicking the look and feel of ITV (remote control and TV). TV content (music video clips) and TV-language rules and aesthetics (transparent overlays, related information) are exploited for prototype development.
- Usability evaluation framework: Previous work in the communication and the advertising has addressed methods and techniques for measuring the impact of TV content on viewers. Recent work in HCI has extended the productivity concepts to include the affective dimension of usability. Constructs from the above-mentioned fields are com-

bined and organized in a framework that was build upon the most recent scientific findings for emotional responses and for entertainment experiences.

- Service design: The conceptual model, the respective programming library, the UI principles, and the prototyping platform were employed in the design of an ITV application that addresses contemporary HCI and digital media issues. The testing of the prototype employed the affective usability evaluation framework.

1.4 OUTLINE

Chapter 2 identifies the current issues associated with UI design for ITV. There are two groups of issues: 1) The theoretical issues are represented by three major research questions (conceptual model, UI principles, usability evaluation framework). Those are complemented with the closely related issues of programming library and prototyping platform. The latter do not constitute part of the main issues, but it was necessary to address them, in order to deal with the hypotheses testing. 2) The practical issues are formulated as three hypotheses (consumer-level video skipping, animated characters, dynamic advertising insertion) and they are mapped to the respective features of an ITV music application.

Chapter 3 describes the methods that are employed to approach the research issues. For each issue an appropriate method is identified from the respective literature. In brief, the research questions are approached with methods from human factors design and the hypotheses are approached with methods from usability engineering.

Chapter 4 employs the methods from the previous chapter and presents a set of UI elements for the design of ITV applications. The conceptual model is described by referring to the familiar and the emerging patterns of the user experience. Next, the UI principles are formulated by achieving a balance between the established TV watching behavior and the opportunities offered by IT. Finally, the affective usability evaluation framework is constructed by employing methods from HCI and from consumer research.

Chapter 5 is a case study of an interactive music television prototype that was designed by employing the principal UI design elements that were developed in Chapter 4. The prototype is also developed to address the hypotheses raised in Chapter 2. This chapter represents the intersection and evaluation of all the pieces developed in the previous chapters.

Chapter 6 provides a discussion of the results that were obtained from the design and the development of the prototype and from the usability tests with consumers. The results are discussed in the context of the findings from analogous research and in the context of the established HCI theory. Overall, this chapter describes the contribution to the HCI theory and methods. In addition, it presents the implications of the findings for the media industry (content producers, advertisers, broadcasters).

Finally, Chapter 7 provides directions for future research and Chapter 8 summarizes the findings of the research effort with regard to the research problem and the research issues.

In summary (Figure 1), the structure of the present thesis is fairly typical. The literature review is performed with a different objective in the different stages of the research. For example, besides the typical review of the established HCI theory in chapter 2 and methods in chapter 3, chapter 4 examines other disciplines, beyond HCI, for appropriate ITV UI design principles and evaluation methods. Overall, all the important elements that constitute a PhD thesis (i.e. identification of issues from previous research, methodology, generic system design, case study, discussion of results, implications and further research) have been included in a typical eight chapter document structure.

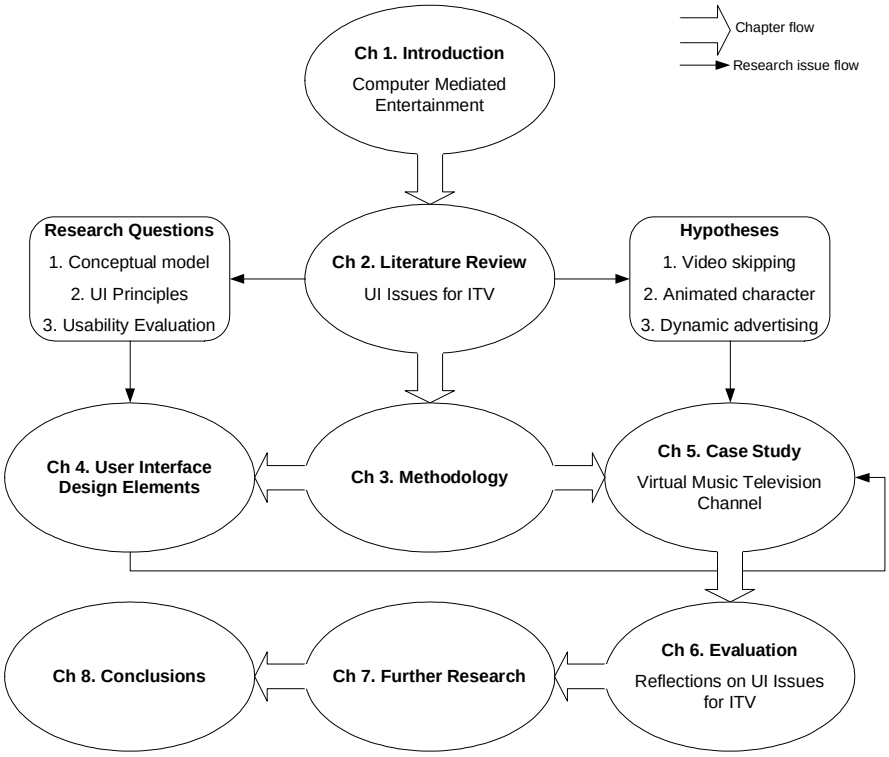

Figure 1 Flow chart of the thesis structure and relationships between the chapters

1.5 DEFINITIONS

Definitions adopted by researchers are often not uniform, so key and controversial terms are defined to establish positions taken in the PhD research. Here, the ambiguity of some terms is not due to a controversy within a scientific discipline, but mainly due to the multidisciplinary approach employed. The parent discipline is Human-Computer Interaction (HCI) and the majority of definitions are in accordance with the respective theory and methods. Nevertheless, HCI is a multidisciplinary field and, furthermore, the present work draws ideas from other fields relevant to the research problem. Therefore, different definitions are used in different contexts, depending on the perspective employed.

The person who interacts with a television system may be called with different names depending on the scientific discipline: *User* (HCI), v*iewer* (mass communication), and c*onsumer* (marketing). Since this thesis is based on HCI theory and methodology, most of the time, the word 'user' is preferred. Nevertheless, in the context of the management and the mass communication discussions the respective definitions are preferred.

A television system that supports interactivity at consumers' homes may be called with different names depending on the technologies used. *Interactive Television (ITV)* is a generic term used for all television systems that offer consumer interactivity beyond channel changing and Teletext. It is also used in the advertising and communication fields to describe TV system that fall beyond the mass TV. The *Digital Television (DTV)* term is used to refer to the digital transmission and reception of the television signal, which contains video and/or data and it is mainly used in technical fields. *Digital Video Recorder (DVR)* refers to the ability to record television content on a Hard Disk Drive (HDD).

Conceptual models, mental models and metaphors are an integral part of every software system, whether the designer has deliberately selected them or not. A *conceptual model* is the general framework that a designer is using to present the required functionality to end-users. A *mental model* is a person's internal representation of a system. For example, people have a mental model of the TV set, what the buttons are, how it works, what will happen if they do certain actions, etc (Wickens et al. 1998, p.460). People's mental model may not be the same with a designer's conceptual model (Norman 1988, p.16) and in addition mental models may also be different among different people or even change over time (Petersen et al. 2002). Finally, a *metaphor* refers to the notions that are taken from a non-computer domain. For exam-

ple, the desktop metaphor is an established and widely accepted metaphor employed in PC software.

Finally, there is an ambiguity in the usage of the terms that describe human emotions. According to Reeves and Nass (1996, p.136) the mediated experiences elicit emotional responses from people, in exactly the same way as the real experiences do. Research concerning emotion responses has used a multitude of terms, such as mood, affect, feeling, and emotion, without much consideration for defining those terms (Luomala and Martti Laaksonen 2000). In the present work, the following definitions will be used. *Mood* is different from affect, but there is a relationship between mood and affect, since the one may have an impact on the other. For example, a negative mood may impose a negative affective state, but, on the other hand, positive feelings may help overcome a negative mood. Both mood and affect have been found to play an important role in consumer psychology and research (Gardner 1985; Luomala and Martti Laaksonen 2000). There is also a subtle but important difference between *affect* and *emotion*: 'Affect is the general term for the judgmental system, whether conscious or subconscious. Emotion is the conscious experience of affect, complete with attribution of its cause and identification of its object (Norman 2004).'

1.6 DELIMATIONS OF SCOPE AND KEY ASSUMPTIONS

The present work elaborates on the design and evaluation of the UI for computer mediated TV. CME includes a wide range of other applications such as video-games, educational titles, DVD movies, etc. In the present research, the focus is on UIs for ITV from the consumer's point of view and in particular on TV programs that have been stored on a HDD and are enhanced with information retrieved from Web resources. In particular, the digital STB stands for an emerging class of TV-centric appliances used for infotainment. A digital STB can be a satellite receiver, a digital video recorder, a video games console, or, a Consumer Electronics (CE) appliance that connects to the TV and hi-fi equipment, coupled with broadcast reception and probably Internet connection, for the provision of advanced audiovisual services, in a relaxed, non-productivity oriented setting. The UI issues of ITV applications are approached by employing theory and methods from HCI, advertising and communication.

HCI is the parent scientific discipline behind this work. HCI has been defined as a multidisciplinary scientific field, which sprung from cognitive psychology and

computer science (Marcus 2002), in order to address interaction of people with computers, mainly in the workplace. As computer technology became more widespread and came to affect many aspects of everyday life, HCI has grown and has imported ideas from additional scientific disciplines, such as mass communication, sociology, management, industrial design and more lately aesthetics and emotion. Even within the field of HCI, there are many critics who argue that HCI has no substance by itself, because it does not have a critical mass of theory and methods of its own (Castel 2002). Other critics attest that the contributions to the HCI literature depend more on importing ideas from other disciplines and less on previous HCI publications (Zhang et al. 2002). In the present work, the HCI approach is applied to a TV system, which has traditionally been of concern to the communication research and marketing research disciplines. Accordingly, theories and methods of the latter two disciplines are employed to complement and extend HCI research computer mediated television.

Interaction of people with computers is also treated by the Management Information Systems (MIS) field, which is one of the scientific disciplines of interest to the Department of Management Science and Technology (DMST) at the Athens University of Economics and Business (AUEB). Since this thesis is submitted in fulfillment of the requirements of the PhD program of the DMST at the AUEB, it is necessary to address the differences between HCI and MIS (Grudin 1993; Zhang and Dillon 2003). In brief, the field of MIS takes a macroscopic view of the effects of computers on people in the working environment, while HCI takes a microscopic view on individuals working on personal computers. In addition, MIS is more concerned with the social implications of computing, while HCI focus on the development and refinement of computing systems (Baecker et al. 1995, p.xi). Nevertheless, there is a lot of overlapping of the two, as it becomes evident in the Computer Supported Cooperative Work (CSCW) from the HCI and in the SIG in HCI from the MIS (Baecker et al. 1995, p.xiii; Zhang et al. 2002). The present work investigates the interaction of people with ITV systems in domestic settings. Therefore, MIS theory and methods are inappropriate, because they concern a different domain (workplace). In contrast, HCI provides the right mentality for approaching the research problem, while it leaves open the possibility of importing ideas from relevant disciplines like advertising and mass communication.

Most doctoral theses in HCI have to address the problem of the multidisciplinary nature of the field, at least for a number of practical reasons, like selecting the appropriate people for the review committee and assessing the contribution of the research against an established body of previous knowledge. It is usually the case

that the candidate is submitting the thesis at a department that is closely related to one of the disciplines that HCI consists of, thus making the primary discipline behind the HCI curtain easier to locate (Johnson 1996). The present work was performed in the context of an MIS department, but as it has been stated above it is more related with HCI. Thus, the problem would have been to locate the primary discipline that drives this work, but it can be argued that there is more than one: 1) a novel application programming interface for ITV was developed and employed in the construction of an ITV prototype —this would have been the objective of a thesis in computer engineering, 2) a laboratory experiment was designed and conducted —this would have been the objective of a thesis in psychology, and 3) a number of issues for digital media management (advertising, content aggregation and navigation) and for human factors (conceptual model, UI principles) were addressed. *On the one hand, none of the parts of the present research work can be considered significant by itself in the light of the respective scientific discipline (i.e. computer science, psychology, advertising research, communication research), but, on the other hand, the sum of the parts makes a significant contribution to the HCI research agenda and to the media industry's practical issues.* Correspondingly, the author's profile is a match for such an undertaking, having a multidisciplinary background firstly in computer engineering and then in marketing and communication.

Besides the above-mentioned definitions of scope, there are also a number of key assumptions.

Firstly, this thesis assumes the broadcast model of interactive multimedia as the most economical way of delivering multimedia information to masses of people. Alternative means for digital media distribution are the pull model (used in the Web) and the P2P model (used in file sharing networks), both of which are beyond the scope of the present investigation. Moreover, it is assumed that there will be no major technological change to the production and transmission part of the broadcast chain, because TV is a pervasive technology that is very difficult to change radically. Finally, it is assumed that consumers will have access to an advanced digital STB with high-capacity HDD storage. The selection and the presentation of the stored TV content (video, related information) were assumed to be performed by a personalization scheme that is not treated here; instead, the focus is on how the consumer will interact with ITV applications. Finally, the interaction between the user and the computer-mediated television is assumed to be done through a basic TV set and a remote control.

This research investigates and integrates a wide spectrum of previous findings about TV, based on the belief that the currently dominant UI for the PC is inappropriate for ITV, since it serves fundamentally different user goals and activities. Therefore, there is a need to re-examine the traditional usability engineering principles and methods before applying them to the case of ITV. Furthermore, it assumes a close integration between the UI and the TV content. Previous HCI research about ITV has focused on the design of the EPG and authoring tools, thus the UI was considered to be distinct from the TV content, just like a document in Word is separated from the tools and menus for editing it. In terms of the type of TV content treated in previous research, TV news and story-telling (soap operas, movies) were dominant. Here, the focus is on a UI that is closely integrated to widely available types TV content (news, music, documentary) that are entertaining but they are not based on story-telling.

1.7 SUMMARY

In summary, *the objective of the present research is to 1) support ITV developers and producers for the design of appropriate UIs for ITV applications, 2) evaluate a video skipping and an animated character UI for ITV and 3) identify new business model opportunities for broadcasters, through innovative forms of advertising.*

This chapter laid the foundations for the report. It introduced the research problem and research questions and hypotheses. Then the research was justified, definitions were presented, the methodology was briefly described and justified, the report was outlined, and the limitations were given. On these foundations, the report can proceed with a detailed description of the research.

2 USABILITY ISSUES

In this chapter, the literature review reveals neglected issues and shortcomings in the approach to the design, the development and the evaluation of UIs for ITV. The research issues for ITV UIs are identified in the context of the established HCI theory and practice. The theoretical issues are mapped to three research questions (conceptual modes, UI principles, affective usability evaluation), while the practical issues are mapped to three hypotheses (consumer-level video skipping, animated characters, advertising).

2.1 INTERACTIVE TELEVISION RESEARCH

ITV is a research subject that has elicited interest from diverse academic disciplines. In the present section, an overview of the previous research for ITV is presented from a general computer science perspective. At the end of this section, a brief overview of the HCI field is provided, in order to create links between the broader ITV research and the HCI discipline.

2.1.1 Research Streams

The most prominent research streams from the past and the present are presented bellow.

Video-on-Demand

Video-on-demand and streaming of TV content to the consumer's home was the central element of the early vision of ITV services, during the 1990s (Little and Venkatesh 1994). Correspondingly, the academic community put effort into server side architectures, broadband delivery and thin network clients (Bryhni et al. 1996; Furht et al. 1995). In terms of the commercial success, a retrospective evaluation of the respective research leads to the conclusion that the video-on-demand direction

was not worthwhile pursuing. Nevertheless, a more careful examination may reveal that there were also numerous benefits from that approach, such as the broadband Internet, and there are may be few important lessons to be learned for the contemporary research by studying previous findings.

Electronic Program Guide

The TiVo EPG (Figure 2, left) is designed to help consumers choose a television program to watch or record, but quickly becomes overwhelming for hundreds of channels. At any given instance the EPG displays only a small fragment of the available broadcast content. The TiVo menu also offers a UI for stored programs (Figure 2, right), but future digital STBs will have terabytes of storage (Draper et al. 1999) and the navigation complexity problem will arise again. The EPG and the file explorer-like UI are not appropriate for long TV listings, since they contain less information per screen than a printed TV magazine. Moreover, both methods for navigating TV content are based on a simple visual mapping of the underlying data structures, without much consideration for the established TV channel selection behavior. Currently, there is no published usability evaluation of the TiVo EPG and the local storage UI.

Figure 2 TiVo EPG (left) and local storage navigation on TiVo (right, misleadingly named as 'Now Showing')

Besides the commercial implementations of an EPG, there is a large body of academic research for the EPG, which appears to be the most popular part of the contemporary ITV research. In brief, previous research for the EPG has addressed issues such as conceptual model (Bonnici 2003), navigation (Barbieri et al. 2001; Eronen and Vuorimaa 2000), web based video retrieval (McDonald et al. 2001), zooming interface (Tinker et al. 2003), natural language interaction (Johansson 2003), participatory design, prototyping, and guidelines (van Barneveld and van Setten 2003), and MHP

implementation (Peng 2002). In above cases, the research approach follows the IT perspective and assumes that the viewers, each time they open the TV, need to select a channel or a program out of the available set of broadcasts. However, long established research in the media psychology discipline has identified that TV viewers settle down with a small number of channels (Ferguson and Perse 1993) and that they adhere to a ritualistic process in watching the same programs everyday or every week (Lee and Lee 1995). Finally, considering the EPG as the most important element of the ITV design entails the implicit assumption that the TV channel and content need not change and thus be benefited by the convergence with the IT and the Internet. Accordingly, the design of a novel navigation framework for ITV applications is formulated as a research question, later in this chapter.

Personalized Television

A series of workshops about personalized television has brought together researchers from the communities of user modeling and adaptive hypermedia to discuss the applicability of previous theories in the field of ITV. Within that paradigm, there are a few discreet sub-streams of research: 1) personalized EPG, 2) personalized TV content, and 3) personalized advertising.

A significant part of the personalized TV research concerns the design of a personalized EPG. Researchers have long realized that the EPG is merely a data-set to link with user preferences and watching behavior, in order to provide input for recommendation engines (Ehrmantraut et al. 1996) or for automatically recording TV content on video servers (Nakamura et al. 2000). Previous research regarding the EPG has treated themes such as recommendation, and personalization (Smyth and Cotter 2000), trust, and accuracy (Buczak et al. 2002), cold start problem (Baudisch and Brueckner 2002), stereotypes (Gena and Ardissono 2001), and architecture (Ardissono 2001). The respective research community argues that the personalization of the EPG is the most important element of ITV design, because the proliferation of the available broadcast channels makes difficult the selection of a TV program to watch (Smyth and Cotter 2000). The emphasis of the Personalized TV research stream on the design of the EPG is evident from the proceeding of the respective series of workshops, in-which half of the papers concern the recommendation engine for a personalized EPG system. Overall, the research about a personalized EPG system has made quite a few assumptions from an IT perspective that may not hold true for the actual TV environment.

Moreover, there is always a need for a visual user interface in order to display program recommendations to the users. The majority of the respective research has neglected the issues of presenting the recommendations or automatically assembling a TV program. In one rare exception to the rule, animated characters have been proposed as a way of increasing trust and reducing user expectation from program recommendations (Diederiks 2003), but in general, beyond presenting a list of choices, the method that should be used for presenting the recommendation results is still an open research issue. Accordingly, the presentation of information related to the TV content is formulated as a hypothesis later in this chapter.

Besides personalized EPG design, there are also a few works about personalized TV news (Maybury 2001; Merialdo et al. 1999). Last but not least, the Personalized TV stream of research has treated the special case of TV advertising content (Lekakos et al. 2001b; Lekakos and Giaglis 2002; Spangler et al. 2003). In the present thesis, dynamic advertising insertion, which could be personalized, is employed everytime the user skips a part of the TV content.

Interactive Content and Applications

Previous research has addressed a wide diversity of content and applications suitable for ITV, although the respective treatments are at an early stage of development. Thus, they are still not mature enough to be considered in individual categories, but their aggregation gives an overview of the emerging types of ITV content that will be available in the near future. In particular, there are research works that consider ITV issues for adaptive instruction applications, such as a T-learning framework (Lytras et al. 2002), a virtual studio (Gupta and Hüttemann 2003), and usability evaluation (Damásio 2003). Moreover, there are treatments for ITV documentaries (Nardon et al. 2002), interactive narrative (Lankoski and Ekman 2003), augmented news (Dimitrova et al. 2003), and communication services (Chuah 2002).

Interactive content and applications for TV hold great promise, but the current generation is still close to the traditional multimedia models. In the present thesis, TV content is combined with computer graphics and additional resources, in order to enhance a music TV channel.

Responsive Television

Responsive Television research addresses the production and creation of story-driven TV content. From that respect, it is probably the most innovative proposition toward ITV content, since story-driven content is the most popular type of TV con-

tent (Pedder 2002). Responsive Television research studies the creation of a dynamic TV program from the perspective of the TV program editor and producer (Agamanolis 2001). Nevertheless, it does not offer any directions for the design of an ITV UI for consumers. In brief, the respective stream of research has approached story-driven TV content and has investigated the dynamic synthesis of scenes for the creation of new content items, such as movies, soap operas and series. Strategies and authoring tools for responsive television programming have been studied by Agamanolis (1997, 2003) and the object-based media group at the MIT Media Lab (Bove et al. 1999). On the other hand, there is evidence that increased consumer interaction is not always appropriate for story-driven media programming (Vorderer et al. 2001). Moreover, in a recent study, none of the subjects wished to be able to buy the clothes that the actors wear, which is one of the suggested applications of the Responsive Television research (Maguire, Unpublished), although the region-linking techniques may have other significant applications. Overall, Responsive Television research focuses on the dynamic synthesis of video at the scene level, with no consideration of an integrated (e.g. local video, Internet resources, real time broadcasts) television experience at the content item level (e.g. music video clip, news story).

2.1.2 How Previous Research has Defined Interactive Television

Interactive television is a generic term and stands for different meanings depending on the background of the author.

From a *computer engineering* viewpoint, ITV systems consist of two IT developments. The first one is digital video recording functionality on HDD, initially introduced commercially by ReplayTV and TiVo. The second technology includes functionality such as Teletext, and Web browsing, such as WebTV, which is the most radical departure from the current TV viewing experience. These two technological definitions (TiVo, WebTV), are usually coupled with modem technology, which closes —although with asymmetrically lower bandwidth— the unidirectional communication between the TV transmitter and receiver.

From a *communication research* perspective, ITV is an extension of the traditional television content to include interactive narrative. For example, Vorderer (2001) makes the implicit assumption that ITV content is always related to an interactive narrative structure by saying: 'Interactive television provide users with the opportunity to influence the narrative they are watching by playing their own role within

that setting.' From this perspective, communication research is closer to the viewpoint of the emerging video-games academic literature.

From an *advertising research* point of view, ITV is a system that allows more precise control and more creative options of the advertisement. Creative improvements include the enhancement of advertising messages with interactivity (Lee 2003). Furthermore, there are new opportunities for media planning and message evaluation (Pramataris et al. 2001). Overall, advertising research is considering ITV as an extension of the potential of TV as a communication vehicle for marketing messages and as an opportunity to approach an emerging demographic of consumers that are familiar with interactive media.

2.1.3 Human Computer Interaction Design

Human computer interaction for ITV is the core focus of the present thesis, although there are also a few implications for the technological and business perspectives. Before commencing the analysis of the UI issues for ITV, a brief overview of HCI for computers is provided, in order to connect the issues and findings of the present work to an established body of scientific knowledge. The Curriculum Development Group of the ACM Special Interest Group on Human-Computer Interaction (SIGCHI), provides the following definition (Baecker et al. 1994, p.1): *'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.'*

The HCI discipline has been mainly developed alongside with the personal computer (PC) and the graphical user interface (GUI). The story behind the popular desktop metaphor offers a useful insight into the nature of HCI design. The first prototype of graphical user interface (GUI) was designed by Engelbart et al. (1968) at the Stanford Research Institute, and demonstrated with the use of a mouse. Xerox's Palo Alto Research Center (PARC) exploited the idea in the 70s by building the Xerox Star (Smith 1982, Johnson 1989), although it did not achieve any commercial success. A decade later Apple Computer and then Microsoft created the first GUI products that were successful. The lesson learned is that in human factors design it takes time and multiple iterations from different design groups, until an acceptable design is reached (Johnson et al. 1989; Norman 1988, p.181).

By making the analogy from the PC to the ITV, the ITV products currently seem to be at the stage of the Xerox Star. In other words, the technological research has

progressed enough to be feasible to create advanced digital STBs, but there is still not enough research about the needs and the behavior of ITV users. By taking the analogy one step further, the first CHI conference coincided with the introduction of Apple's Lisa and it was held in the beginning of the 1980's. Correspondingly, the HCI issues for ITV have been addressed for the first time in a few ITV conferences and workshops that commenced in the early 2000's. Therefore, HCI for ITV is an emerging research area that will have great impact on the usability of future TV systems.

- *Research Problem:* User interface design and usability evaluation for Interactive Television consumers

The term UI is usually associated with the visual display units (VDU) employed for office work, but Grudin (1990) identified five levels of UI development, in terms of the role of the designer in each level: 1) the interface at the *hardware* mainly concerns the engineers at CE companies, although there are consumers (hobbyists and hackers), who override the manufacturer's specifications either for the purpose of augmenting the functionality or for breaking copyright protection locks, 2) the interface at the *programming task* concerns the software (S/W) developers, 3) the interface at the *terminal* concerns a wider variety of disciplines such as S/W developers, psychologists and graphic designers, 4) the interface at the *interaction dialogue* involves domain experts, who model user goals and tasks, in order to provide adaptive interaction to the user and 5) the interface at the *work setting* involves the social disciplines who study a group of people working on shared goals and tasks.

The main body of HCI research has evolved through the years from the lower levels (1 and 2) toward the last ones (3, 4, and 5), although there are always contemporary works that address the lower levels, in order to create novel interaction paradigms, such as haptics. ITV research is not following a similar path of evolution, because most of the parts at all levels may be transferred and adapted from previous research in related disciplines. In that sense, ITV research has an applied nature, when compared with the more basic research performed in the related disciplines. The present work, deals with ITV, but it can be argued that the same five levels apply here, too. Level 1 corresponds to the broadcast system infrastructure (including the consumer digital STB), level 2 corresponds to the STB S/W API and level 3 to the STB UI. Levels 4 and 5 correspond either to a single TV viewer, or to a group of TV viewers. In the context of the thesis, the main focus is on levels 2 and 3.

The HCI discipline has attracted researchers with academic backgrounds as diverse as cognitive psychology, computer science, and graphic design. As a matter of

fact, the methods employed are usually diverse, since they are reflective of the respective background. Nevertheless, at a high-level there is consensus regarding the development process. The designers of the XEROX STAR (Smith et al. 1982) mentioned that the design methodology consisted of three principal processes: 1) conceptual model design, 2) user and task analysis and 3) prototyping, in order to perform user testing during the development phase. The usability engineering lifecycle suggested by Nielsen (1994, p.17) comprises of 1) UI principles, 2) prototype development, 3) development tools and 4) usability testing. Similarly, according to Baecker et al. (1995, p.74), the design process for user-centered computing systems consists of: 1) conceptual design, 2) prototype development, 3) user interface development tools, 4) principles and guidelines and 5) usability evaluation. In general, design is usually defined as a complex and thus highly intuitive and creative process (Caroll 2000, p.19). Nevertheless, he suggests a few of those elements (conceptual model, patterns, prototypes, and user testing) are common in the works of all the designers, independently of the domain (be that architecture, industrial, or graphic design).

Therefore, the following common elements have been selected for an in-depth investigation in the domain of ITV: 1) conceptual model, 2) UI principles, 3) prototyping, 4) development tools, and 5) usability evaluation. Once the above elements have been refined for the domain of ITV, then appropriate ITV applications can be built and validated from user testing.

In summary, there are numerous tools and methods for user-centered design, such as these that are described in the international standards (Maguire 2001). Since CME for TV pertains to a different context and different user goals, it is argued that there is a need to re-examine the traditional techniques before applying them to the home environment (Monk 2000). In addition, the core of HCI research is gradually diversifying its focus, in areas such as: 1) influencing the user through persuasion (Fogg 2002) and 2) video-games and fun (Draper 1999). In this context, the present research work employs a design approach that is in-line with the high-level HCI methodology, but it also considers the literature from the domain of TV (mainly the research in advertising and in communication). In addition, it proposes and tests ITV design solutions for a few prominent notions and issues from HCI theory and practice. In the following sections, the status of the ITV research regarding the major HCI elements is identified and the respective research questions and hypotheses are formulated.

2.2 CONCEPTUAL MODEL

This research is based on the realization that the currently dominant model for the personal computer —i.e. the desktop metaphor— is not appropriate for television, because it is adapted to fundamentally different user and task sets. The need for alternatives to the desktop metaphor has been described before from Aaron Marcus (1993): 'in the coming decades, not only workstations, but playstations, appliances are likely to contain embedded microprocessors. These products will offer users complex data and functions available through networked computer systems communicating with one another.' Then, he suggests the use of metaphors, 'fundamental terms, images and concepts that are easily recognized, understood and remembered,' as a means of effective communication. For example, there are many metaphors employed for using a PC, such as a desktop, a trash-can, a folder, a document, etc. One decade later Aaron Marcus (2002a) reaffirms his persistence on the importance of metaphors by saying that he does not 'foresee future interfaces devoid of metaphors.' Metaphors are the visible part of the conceptual model of a system. Metaphors are used to communicate to the user the conceptual model of a system, in order to aid the user in the formation of the right mental model. The differences and the relationships among the notions of conceptual model, mental model, and metaphor are defined bellow.

The conceptual model is a critical part of the design, because it defines the system image, which in turn will be the basis for the formulation of the user's mental model (Norman 1990, p.190; Wickens 1998, p.462). According to Wickens et al. (1998, p.460) a conceptual model is the blueprint for a software system that provides user interactivity: *'In designing a system, the analyst begins with a general conceptual model of how the software will look and act. A conceptual model is the general conceptual framework through which the functionality is presented.'*

Correspondingly, the users of the system are forming a mental model about its function (Wickens et al. 1998, p.460): 'Mental models are internal psychological representations of a person's conceptualization and understanding of a system. A mental model is a dynamic model of system components, how the system works, how components are related, what the internal processes are, and how they affect the components.'

In summary, UI design for ITV should be based on an appropriate conceptual model, in order to create applications that are consistent and coherent and in order to allow the consumers to form clear and consistent mental models for their function.

2.2.1 Designer's Conceptual Model for Interactive Television

Explicitly strong evidence of the importance of a mental model for ITV is provided by O'Brien et al. (O'Brien et al. 1999), in an ethnographic study of a digital STB trial, in which they point out the need for a 'working model' of the technology being employed by users in home activities. Mental models of products for the domestic environment depend to the previous experience with similar products (Petersen et al. 2002). Therefore, the introduction of new CME products should be based on familiar conceptual models.

Previous research has evaluated more than a few metaphors for ITV. The metaphors were inspired from various fields, like the Web, the cartographic map, the book, the EPG, and human presenters (Burmester and Koller 1996, Koller et al. 1997). In that study, the majority of the metaphors (7 out of 9) were not implemented as an ITV prototype. Instead, the metaphors were static and were explained verbally to the study participants. It can be argued that the respective evaluation methodology does not leave much confidence regarding its validity. It can be also argued that the majority of the metaphors tested in that study correspond to a vision of ITV that has been transferred from unrelated paradigms. Thus, it is necessary to study familiar ITV metaphors that are applied to a working ITV prototype.

There is a large body of previous IT research that has put considerable effort to transfer and adapt established computing paradigms for ITV.

Firstly, the majority of previous research about ITV conceptual models concerns the design of EPG systems. This is a worthwhile effort because the modern digital broadcast systems (cable, satellite) offer numerous channels (at least 500) that cannot be mapped to the few buttons of a remote control. The EPG stream of research has devised alternative models for navigation in the list of broadcast channels, and more recently, the personalization and recommendation paradigms have been adapted to the case of TV channel listings (Ehrmantraut et al. 1996; Smyth and Cotter 2000). Bonnici (2003) proposed a conceptual model for the EPG, but there is no conceptual model for the case of recorded TV content. It can be also argued that the design of ITV content is not the design of the EPG, unless it is assumed that the TV content itself will remain unaffected by the introduction of interactivity. In summary, it is evident that the EPG paradigm has been convenient among researchers with a background in information retrieval and user modeling, but the respective research provides little contribution to conceptual models for ITV.

Secondly, another stream of research, backed by researchers with a Web background, has put effort to adapt Web to TV and has introduced a few commercial products (e.g. WebTV). It can be argued that the pull model of the Web and the characteristics of Web use are not appropriate for TV, although a few underlying properties may be integrated with the ITV content. For example, on-demand information related to a video-clip may be retrieved dynamically from Internet resources, thus employing only the transmission part of the Web technology, instead of the presentation one. A parallel stream of research (Internet TV) is assuming the wide availability of a high-speed Internet connection to consumers' homes. It has proposed to by-pass the broadcast model in favor of the Web model for distribution and consumption and it has introduced a few commercial products (e.g. RealOne).

Overall, previous research about conceptual models for ITV is only limited to the EPG and to the transfer of experience from the Web and the PC. With the advent of digital television (DTV) transmission, Internet-enabled set-top boxes (STBs) and digital video recorders (DVRs), consumers are starting to have the need for a multimedia experience that seamlessly integrates diverse sources of information and entertainment content.

- Question 1: *Which is the conceptual model for interactive television that integrates digital broadcast transmission, persistent local storage and Internet resources?*

The Virtual Channel model is a proposed conceptual model for ITV, which is introduced in detail in Chapter 4. It was developed in accordance with a systematic approach, which is presented in Chapter 3.

2.3 USER INTERFACE PRINCIPLES

User interface principles are needed to move from the semantic level of the conceptual model to the syntactic level of the system function (Wickens et al. 1998, p.462). There are generic and application specific principles that address the multitude of issues associated with UI design, such as screen design, user needs and performance, input device, etc (Nielsen 1994, p.91). For example, it is suggested that a UI should provide visibility of the current status and immediate feedback. UI design principles usually stem from the extensive experience of a few HCI experts. Most principles seem to be common sense, but it is argued that it is impossible for the designer to have all of them in mind, so principles are offered as checklists (Wickens et al. 1998,

p.465). Nevertheless, the HCI discipline was mainly developed alongside the PC and most of the current UI principles reflect the respective context of use. In the next section, UI principles are discussed in context of ITV.

2.3.1 User Interface Principles for Interactive Television

On the one hand, UI principles have been applied widely to the PC productivity applications. On the other hand, there are only a few scientific publications and only some research projects sparsely scattered through the 90s on the topic of UIs for ITV, so there is no critical mass of experience to draw principles from. It can be argued that UI principles from the PC and the Web computing paradigm do not transfer to ITV. For example, the television grammar requires all programs as well as presentation styles to be dynamic and surprising (Meuleman et al. 1998), which contrasts sharply with the traditional UI principle for consistency. Moreover, a comparative evaluation between two consistent versions of a UI for TV and PC revealed that the consumers preferred the PC version of the UI (Nissler and Thoma 1999). The preference of the consumers for the PC version of the UI may be explained as an effect of the inappropriate PC mentality of the UI principles that were employed in the TV UI. This is not to imply that each ITV application should be build on creative intuition only, since there should exist at least an underlying consistent conceptual model, as described in the previous section. In addition, UI design for ITV applications should be performed along an elastic set of ITV UI principles.

Differences between the two environments and suggestions for resolution of issues have been noted by academics and professional UI designers (Brouwer-Janse et al. 1992; Herigstad and Wichansky 1998; Mountford et al. 1992; Teasley et al. 1996). According to these researchers, there are many reasons for identifying new UI principles for ITV. Reasons are digital broadcasts coupled with rich metadata, digital video recording of TV programs and random access playback, dynamic generation of TV content and most crucially a different context of use. Recent research about ITV has extensively addressed the case of the EPG and has proposed a few design guidelines for it (Bonnici 2003; van Barneveld and van Setten 2003). Nevertheless, there is still little research available both for generic and content specific principles for ITV. There are only a few ITV researchers who have addressed ITV UI design issues beyond the EPG. For example, Lamont (2003a) has proposed an 8-step process for designing UIs for ITV content, and makes a few suggestions about the presentation of information that is related to the running TV program. Overall, *previous research for*

ITV has not taken any systematic approach to identify and formulate UI principles that apply to different types of ITV content. Moreover, it has neglected to review and build upon established research in scientific disciplines that have extensively treated the TV issues, in the past.

- Question 2: *Which are the factors that affect the design of user interfaces for interactive television applications?*

  UI principles for ITV are presented in Chapter 4. The principles were identified after a systematic literature review that was performed in TV related research. The identification was done in accordance with the approach presented in Chapter 3.

2.4 PROTOTYPING

The basic rationale for developing prototypes of computer systems before actually implementing the final system is to gain better understanding of the user needs early in the development process (Nielsen 1994, p. 93). The philosophy of prototyping begun from the S/W engineering discipline: 'The question is not whether to build a pilot system and throw it away. You will do that. The only question is whether to plan in advance to build a throwaway, or to promise to deliver the throwaway to the customers. [..] Hence plan to throw one away; you will anyhow' (Brooks 1995, p.116).

Besides the validation of the technical feasibility, the development of a prototype gives to the designers the opportunity to validate the product idea with consumers. There are two types of prototypes: 1) *vertical* that provides full functionality for a small set of the system's features and 2) *horizontal* that provides all of the system's features without the underlying functionality (Nielsen 1994, p.94). There are various techniques for creating prototypes, but the simplest one is scenario writing. Other popular forms of low-fidelity prototypes are the paper prototypes and screen mock-ups. High-fidelity prototypes are usually interactive and provide realistic input and output interfaces (Rudd et al. 1996).

Embedding computers in devices such as STBs and smart-phones raise many difficulties for the creation of high-fidelity prototypes, because the input and output devices do not correspond to the powerful PC keyboard, mouse and monitor. In those cases there is a need to create flexible prototyping platforms, before actually developing the prototype itself (Pering 2002). Correspondingly, the need for a flexible prototyping platform for ITV is described in the next section.

2.4.1 Prototyping for Interactive Television

A common approach in previous research is the employment of PC and Web tools, instead of actual ITV platforms, for the development and the usability testing of ITV applications. This is an approach that is quite expected, since there is a scarcity of ITV authoring and simulation tools. In addition, most of the time ITV platforms come at a high price, because they are targeted to broadcasters and follow different pricing schemes compared to office software and hardware packages. Therefore, the majority of prototype implementations are presented within the PC or Web modalities, as revealed by the screenshots provided in the respective publications. For example, ITV applications are presented inside browser windows —complete with navigation buttons and menus— or inside operating system windows —complete with minimize, maximize, close buttons— and in all these cases the evaluations are taking place using high-quality —compared with TVs— PC monitors. It usually follows that input devices are the desktop mouse and the keyboard for interacting with the ITV applications. There have been few exceptions to the above practice, in which a TV and a remote were employed and the PC running the prototype was concealed (Eronen and Vuorimaa 2000). In conclusion, it is argued that the use of inappropriate equipment is detrimental to the external validity of the user evaluations of ITV prototypes.

Prototyping platforms and tools is not a research question in the present thesis, but it is treated in the context of an ITV prototype. The prototype is developed in Chapter 5, in accordance with the approach described in Chapter 3.

2.5 USER INTERFACE DEVELOPMENT TOOLS

It is argued that the design based on human considerations is not enough because design can rarely be detached from implementation and that the UI development tools implicitly give shape to the final application (Baecker et al. 1995, p.313). They also argue that 'today's computers are not particularly malleable. They lend themselves to particular interface paradigms.'

According to Grudin (1990) there is a level of HCI research that is concerned with UI design for the programmer of interactive systems. Therefore, besides UI design from the perspective of the TV audience, there is a need to design a UI for ITV developers and producers. That level is of secondary importance to the present thesis, which is primarily concerned with conceptual design and evaluation by consum-

ers. Nevertheless, a preliminary investigation is necessary, in order to assess the technical feasibility of the proposed conceptual model.

Previous research has addressed the shortcomings of the conventional PC multimedia authoring environment and suggested authoring tools for the TV editor (Agamanolis 2001). Previous research has also addressed the development techniques for DTV applications at the platform developer level (Peng 2002). Nevertheless, there is no research available for high-level programming libraries that support consumer ITV UI development.

2.5.1 Programming Library for High-Level Interactive Television Development

The developers of ITV applications have implicitly shaped UI design for ITV by employing development tools that are closer to the PC mentality of applications. For example, the OpenTV system offers the option either to develop an ITV application in the C programming language (using a proprietary programming library), or to use a generic visual authoring environment. Furthermore, the authoring tools available for the Multimedia Home Platform (MHP) standard are either accessed directly through the computer programming language Java or indirectly through an authoring environment that is an adaptation of a multimedia authoring environment from the PC (for example the Alticast MHP authoring system is very similar to the Macromedia Director).

Overall, no existing ITV authoring tool offers an explicit conceptual model or a TV-based grammar that the designer should employ to develop an ITV application. Thus, the result is an inconsistent and idiosyncratic UI for each ITV application. In addition, the implicit development strategies employed in an ITV application is usually reflective of an IT developer viewpoint, instead of that of an ITV creator. The creative part of the development process has a subordinate (decorative) role, because the requirements in technical knowledge for using the respective authoring tools demand a strong IT background. In conclusion, the contemporary ITV authoring tools are familiar to IT developers, who do not usually have the appropriate mentality (knowledge and experience) to design for TV audiences. Therefore, *there is a need to have a high-level ITV platform (preferably on-top of commercial platforms, such as MHP, MSTV, OpenTV) that will facilitate the ITV UI development effort.*

In the context of the present work, a high-level programming library was developed in accordance to the properties of the proposed conceptual model for ITV and not as a complete solution to the technical issues of high-level UI development tool-

kits for ITV. Nevertheless, the programming library is described fully in Chapter 4 and it was developed in a systematic way, as described in Chapter 3. The implementation of the programming library is presented in the appendix.

2.6 USABILITY EVALUATION

During the development process a UI should be systematically evaluated, in order to ensure that it is appropriate for the target user population. In general, evaluation methods may be applied during the whole product cycle, from conception, to development, to implementation, up to deployment (Nielsen 1994, p.17). Depending on the product lifecycle stage, the characteristics of the product and the users, there are different usability evaluation methods and techniques to select from and apply to each testing stage. In terms of the nature of the collected data, the usability evaluation techniques may be broadly distinguished to quantitative and qualitative. In addition to the traditional research methods, such as experiment, ethnography, longitudinal, survey, simulation, and in addition to the traditional techniques, such as questionnaire, focus group, interview, the HCI discipline has devised a set of methods and techniques that fit in the stages of the usability engineering lifecycle (Nielsen 1994, p.71). In particular, during the development stage, there is a set of methods called discount usability engineering (Nielsen 1994, p.17), because they provide a quick and informal, yet, very effective approach to UI design and evaluation.

The objectives of a usability evaluation session have been classified in five broad categories: 1) learnability, 2) memorability, 3) efficiency, 4) effectiveness and 5) user satisfaction (Nielsen 1994, p. 26). Each one of the above objectives is deconstructed in more concrete and measurable design goals (Wickens et al. p.478). For example, effectiveness is usually inferred by counting the number of errors or the number of successful task completions, while efficiency is usually inferred by measuring the time required to complete a task. The latter goal, user satisfaction, differs from the rest in that it is largely subjective and it is measured by eliciting the users' opinions about specific issues. Previous research has established that the perceived ease-of-use and utility correlate positively with user acceptance for a new technology (Davis 1989) and that, in most cases, the objective and the subjective usability measures are positively correlated (Nielsen and Levy 1994). Accordingly, most of the research in the domain of software usability has focused in improving the perceived ease-of-use and user performance for S/W products. Nevertheless, more recent research has ad-

dressed the limitations of the above correlations and suggested that the application domain, the user's experience, and the context of use should also be justified (Frokjer et al 2000). In summary, the traditional usability objectives are still valid for the office environment, but the diffusion of computers outside the office for the purpose of entertainment has created the need for alternate conceptions of usability.

The HCI discipline has grown to include alternative perspectives of the usability paradigm that go beyond the notion of task completion and performance measurement. Interest in the emotions elicited by IT products was established by the Affective Computing paradigm, which argues that computers that do not sense and respond to the human affective state will be less usable and less useful (Piccard 2000). There are many distinct directions and efforts within the respective paradigm, such as modeling emotion, sensing emotion, and presenting emotion to the user. In addition to the Affective Computing paradigm, a parallel stream of research has established the Media Equation paradigm (Reeves and Nass 1996). The Media Equation title refers to the finding that people subconsciously respond to computers, TVs and other media just like they would have done if they responded to real people and physical events. Both research paradigms had a significant impact on the traditional perspective of HCI and have elicited a lasting research stream that investigates the emotional design of computer mediated experiences.

In summary, traditional HCI settings involve a task-oriented approach, in which the human interacts with an application to accomplish a particular goal. Accordingly, usability evaluation techniques measure successful task completion, efficiency and error rate parameters that are assumed to correlate positively with user satisfaction. Nevertheless, as discussed in the next section, there is evidence from the non-productivity type of applications and from the emerging type of CME applications that the user satisfaction does not correlate with the traditional usability objectives.

2.6.1 Affective Usability Evaluation for Interactive Television

There is growing evidence that the traditional desktop usability conception does not account for the pleasure of the user experience (Hassenzahl et al. 2001; Tractinsky et al. 2000). Most notable among the recent findings for ITV applications is the realization that users' subjective satisfaction is at odds with performance metrics. For example, a usability test of three video skipping interfaces (two commercial and one novel) revealed that user satisfaction was higher for the interface that required more time, more clicks and had the highest error rate. In other words, the most usable in-

terface was not the most preferred interface. Users reasoned their choice on the basis of how fun and relaxing the interface was (Drucker et al. 2002). Since traditional HCI settings involve a task-oriented approach, computer-mediated leisure applications require a fresh view of the current paradigms. Therefore, in the context of CME for ITV, there is a need to consider an alternate conception of user goals. Several conceptions of affective usability have been proposed: Enjoyment, fun, trust, engagement, motivation (Draper 1999), hedonic quality of a user experience (Hassenzahl et al. 2000) and consumer emotions (Desmet 2003) are the most relevant.

In addition to the shortcoming in the conception of the notion of usability, there are also issues in what concerns the evaluation methods. Previous usability evaluation studies regarding the EPG (Eronen and Vuorimaa 2000, Lamont 2003b) have applied discount usability engineering techniques. Indeed, EPG usability is very similar to the usability of productivity software, because it involves more information processing than enjoyment of TV content. EPG navigation and information processing can be modeled after the traditional HCI tasks and goals, but for most other types of ITV content there is a need for an affective usability evaluation instrument. Moreover, the discount usability engineering methods employed in the above studies are suitable for the development stage of an ITV UI, especially for increasing the designers' understanding of the specific issues, but they should be also augmented with quantitative evaluation instruments before the introduction to the market and longitudinal studies after the deployment to consumers.

Besides discount usability engineering, a few research works have applied complementary qualitative research methods. Maguire (2002) identified that DTV services require an alternative approach and provided a set of issues, each one corresponding to one of the three proposed research methods: 1) user trials, 2) focus groups, and 3) interviews. Other researchers have taken an ethnographic approach for the issues related to domestic entertainment technologies such as ITV and the home-theater (O'Brien et al. 1999; Petersen et al. 2002). Overall, *previous research about the usability evaluation of UIs for ITV was based only on traditional usability engineering concepts and methods, thus neglecting the highly relevant research for the affective dimension of usability.* So far, affective usability studies have been only applied to the Desktop and the Web models of computing.

- Question 3: *Which constructs and instruments are appropriate for the affective usability evaluation for an interactive television application?*

The approach to identify constructs and instruments is described in the next chapter, while an affective usability evaluation framework for ITV is presented in Chapter 4. In Chapter 5, the framework is applied to the usability evaluation of music ITV application.

2.7 APPLICATION DESIGN FOR INTERACTIVE TELEVISION

This section moves a step away from the theoretical HCI issues for ITV and identifies ITV application design issues.

In the present work, the focus in on a few important UI issues, such as video-skipping and animated characters that were raised in the previous research for ITV. These issues have been also treated extensively in traditional HCI settings (PC, Web). In addition, dynamic advertisement insertion is an emerging issue that may become an integral part of ITV services. Finally, music TV content has been widely neglected from previous ITV research, despite being a popular TV program, so it was selected as the case study for ITV application design in the present research.

2.7.1 Navigation for Digital Video Libraries

Searching for content in very large video libraries is a continuous theme of research in HCI that followed historically textual data search in databases and that complements the scientific literature for information retrieval. The increasing storage capacity and the efficiency of the video compression algorithms motivated interest in digital video libraries. In the early 1990's digital video libraries were mature enough to hold thousands of hours of video content. Then, a UI was needed to browse and search for video content. The majority of the research in the multimedia and HCI disciplines concerns mainly the design of UI for content authors, producers and scientists, in order to search more efficiently into large digital video libraries (Wactlar et al. 1999). Academic research about consumer-level UIs for digital video libraries has been limited so far, but the introduction of cheap digital storage in domestic settings for entertainment activities raises many new issues.

The first consumer device that offered TV video recording was the Video Cassette Recorder (VCR), but searching for stored video cannot be considered an HCI issue, because the videotape has only a few hours of storage and the tapes are stored physically on the shelves, thus making video retrieval an easier task. Nevertheless, the usability of the VCR received many criticisms (Norman 1988, p.81). Consumers

consider that using the VCR to record TV content is a difficult task, when compared with other domestic CE devices (Freeman and Lessiter 2003). Thus, UI design for the DVR is very important from a historical perspective, too. Since the DVR offers a superset of the VCR functionality, it presents a chance, for the first time after 20 years, to change what is regarded as one of the most difficult to use CE devices.

The difficulty to use the VCR for recording TV is due to the lack of a common code of communication between the broadcast signal, the recording medium (VCR) and the TV (Norman 1988, p.177). Manufacturers of CE devices have collaborated with broadcast engineers and have devised a few enhancements that allow a basic protocol of communication to exist, yet, consumer intervention is always necessary, in order to change the tape and to program the VCR. For example, Petersen et al. (2002) report that there was an improvement of VCR usability due to the integration of the VCR with the TV set and the addition of broadcast flags in the Teletext pages. In conclusion, the usability of the DVR is expected to improve, since it integrates the DTV EPG and additional information from the Internet, but there are currently few usability evaluations for DVR devices.

Affective Usability for Consumer-Level Video Skipping

There are very few research works that concern the consumer UI for digital video libraries, although video navigation for digitally stored video has been an active research area from the beginning of the 1990's. The latter research was performed from the perspective of the TV author and producer. It is usually assumed that the users of digital video libraries are in front of a desktop computer that may display tens of thumbnails and video sources at the same time, by employing an advanced GUI (Merialdo et al. 1999). Those assumptions break down in the living room, in which the user is far away from a low resolution TV and has remote control. A traditional comparative usability evaluation test revealed that consumers preferred a UI that was perceived as fun and relaxing to use, although it had the worst performance in terms of efficiency and effectiveness (Drucker et al. 2002). Therefore, a consumer-level UI for video skipping should be evaluated with affective usability methods. Furthermore, there is no previous research that studies digital video navigation that is in close relationship with a specific type of TV content.

- Hypothesis 1: *Consumers' affective usability scores are different between the track-skipping user interface and the traditional linear flow of the TV content.*

The usability evaluation methodology is discussed in Chapter 3. Affective usability is a multidimensional construct that is described in Chapter 4. In Chapter 5, an interactive music television prototype offers the option to skip a music video clip and it is compared, in terms of affective usability scores, with the traditional linear music television channel. The results of the usability evaluation test are presented in Chapter 6.

2.7.2 Animated Characters

Animated characters research begun in the HCI discipline as an alternative to the desktop metaphor and as a visual UI for agent-based systems (Laurel 1990; Maes 1994). Since then, animated characters research has initiated research activity in many different disciplines, such as Computer Graphics (Muller et al. 2001), while it maintains a strong following in the HCI (Rickenberg and Reeves 2000) and in the Intelligent User Interface (IUI) domain (Diederiks 2003).

The first commercial implementation of an animated character for desktop systems was made by Microsoft, as an alternative UI metaphor for the Windows operating system under the name Bob. It was a failure in the marketplace, despite the fact that it was based on the widely acclaimed research from Reeves and Nass (1996). Nevertheless, Microsoft Research was committed to the notion of the UI agent and developed the Microsoft Office Assistant, which offers adaptive help in the Office suite of productivity applications. Furthermore, Microsoft released an API for the animated character system (MS Agent), allowing third-party developers to create and control animated characters, without having any requirement for licensing fees. Since then, there is a wide community of researchers and practitioners, who develop animated characters.

Animated characters used in desktop computing have been widely researched, but the respective commercial implementations (most notably the infamous Microsoft Office Clip) are reported to be annoying to end users (Catrambone et al. 2002; Schaumburg 2001). An explanation might be that the attention grabbing and interrupting nature of animated characters is inappropriate for productivity computing. On the other hand, television content has traditionally been about stories and character development (Lee and Lee 1995). Therefore, animated characters might be viable in a domestic environment for leisure activities, like television watching. In fact, there is evidence that animated characters are suitable in the entertainment domain, because users liked more and were more engaged with the UI version of an interac-

tive game that displayed a face to depict the opponent player (Koda and Pattie Maes 1996). Next, the focus shifts on the previous research concerning animated characters for ITV.

Animated Characters for Interactive Television

In the beginning, researchers at the Fraunhofer Institute (Burmester and Koller 1996) proposed alternative UI metaphors for ITV applications. In a usability evaluation (Koller et al. 1997), they found that the use of human characters as virtual guides raised the least amount of negative opinions, while at the same time it raised the majority of suggestions for improvements, in relation to other UI metaphors borrowed from the Web and PC computing paradigms. The former might be the result of the TV viewers being familiar with the idea of having human presenters for television shows. Regarding the latter, subjects' might wish more natural and conversational interaction.

Immediately after Fraunhofer, it was Philips Research (Kohar and Ginn 1997; Meuleman et al. 1998; Diederiks 2003) that continued to investigate the use of animated characters for ITV applications. The respective usability tests, which were performed using animated characters designed by Philips Inc., have reported positive user evaluations for a number of issues, such as trust, expectations, and preference. Nevertheless, animated characters were solely used for presenting TV program recommendations from the personalization engine. From this perspective, animated characters have been only tested as a UI for a personalized EPG application. Yet, there is no comparative affective usability evaluation between animated characters and traditional information presentation for TV. Furthermore, there is no previous research regarding the use of animated characters as an integral part of TV content.

- Hypothesis 2: *Consumers' affective usability scores are different between the animated character and the transparent information box for the presentation of information related to the TV content.*

The usability evaluation methodology is discussed in Chapter 3. Affective usability is a multidimensional construct that is described in Chapter 4. In Chapter 5, an animated character and a transparent information box are employed in an ITV music application, in order to convey information related to the video clips. The results of the usability evaluation test are presented in Chapter 6.

2.7.3 Advertising

TV viewers had become accustomed to the burden of irrelevant advertising (Dawson 1996), but lately, technological innovation —with DVR devices such as TiVo and ReplayTV— has allowed them to record television programs and fast-forward through the advertising break. On the one hand, the wide spread use of TiVo-like devices may mean the end of the advertising supported TV. On the other hand, the exploitation of the HDD storage for recording and playing dynamically the advertisements (ads) is a new opportunity for the advertising industry. Skipping ad breaks became possible, for the first time, with the VCR. Since advertising is the main source of revenue for TV broadcasters, previous research has addressed the issues of skipping advertising messages with a VCR and found that repeated watching of zipped commercials had a positive effect on the recall and the recognition constructs, when compared to viewing the same advertising message just once (Martin et al. 2002). Therefore, skipping of video should be studied for DVRs, too, in order to assess the impact of the new technology on advertising and consider new advertising opportunities.

An analog VCR is not as disturbing to TV advertising as it is its successor, the DVR. HCI research about video skipping has explicitly addressed the importance of the business model that supports TV content, but it did not provide any solution (Drucker et al. 2002). Contemporary DVRs offer a 30 second skip button, but content and network providers are reluctant to adopt a STB technology that neglects their main revenue source (i.e. advertising) and are interested in alternative forms of TV advertising. For example, TiVo is offering a special area (named 'TiVo Showcase'), whereby advertisers may store their ad and users watch them on-demand. Alternatively, short ads (5 to 10 seconds) or video clip-like ads might be a choice when users choose to skip recorded content, although a subscription service may still be ad-free. Previous research has addressed the personalization of the scheduled advertising break (Lekakos and Giaglis 2002), but still, there is no research about dynamic advertising insertion as a remedy to video skipping.

Dynamic Advertisement Insertion

Dynamic advertising insertion has been delivered to consumers by the XTV service from BSkyB in the UK. The XTV service was developed by NDS as a remedy to the introduction of external DVR devices. Both BSkyB and NDS belong to Rupert Murdoch's News Corporation and collaborated to protect the interests of the mother company in the content industry. Letting the option to the subscribers of the BSkyB

service to buy a stand-alone DVR would have allowed consumers to skip advertising that supports part of the cost of the TV content. News Corporation has been proactive to this threat and is offering the DVR service as an integral part of the BSkyB Plus service, in order to apply in the video skipping functionality its own rules. Thus, each time a consumer skips a part of the stored TV content the XTV service may have been configured to display a single advertisement that may be targeted to each STB according to previous TV consumption behavior and demographics. Since XTV is a commercial product there is no information regarding its design and its usability during the development. Furthermore, it would be also useful to have a study about the reaction of consumers to the dynamic advertising insertion after the introduction of the BSkyB Sky+ service. Thus, dynamic adverting insertion has been selected as an important feature of ITV that merits in-depth academic research.

The major research question concerning the dynamic insertion of an advertising message when the user of a DVR chooses to skip a video segment is whether that form of advertising is acceptable by consumers. Asking consumers directly if they would be willing to watch more ads in exchange for video skipping of TV content, would not produce valid responses, because most consumers are negative to the current number of ads on public TV (Dawson 1996). Then, a possible way to quantify consumers' opinion regarding that matter would be to count the advertisements watched during a session that allows video-skipping and compare them to the traditional linear watching session.

- Hypothesis 3: *Consumers are exposed to more advertisements in an ITV application that employs a video track-skipping user interface with dynamic advertisement insertion than in a linear TV schedule.*

In chapter 5, a dynamic advertising system is employed in an ITV prototype, in order to insert an ad every time the video skipping functionality is used. The results of the experiments with consumers and the implications for the advertising industry are reported in Chapter 6. The dynamic advertisement insertion opens-up many issues for further research, which is suggested in Chapter 7.

2.7.4 Music Television

The overview of the available ITV literature revealed that the majority of consumer-level applications are the Electronic Program Guide (EPG) and the content recommendation systems. Smyth and Cotter (2000) argue that EPG design is an important factor that may influence the selection of TV programs to watch, given a large chan-

nel repertoire and local storage of programs. On the other hand, Carey (1999) maintains that the enhancement of each type of television content and the introduction of new formats can actually drive ITV adoption by consumers. In accordance with the latter, the present research elaborates on interactive music TV, which is a commercially successful, popular and worldwide available format of TV content.

Music video clips as a form of television programming have some unique characteristics. Firstly, it is the only type of TV advertising (together with infomercials) that is sought after by the audience (Jenkins 2002). Music television belongs to the thematic type of TV programming —along with news, documentaries, movies, cartoon, sports— that are broadcasted 24 hours a day. The importance of music TV channels is signified by the MTV brand. Most countries receive either local or international versions of MTV. At the same time, there are also local music TV channels (e.g. MCM in France, VIVA and ONYX in Germany, MAD in Greece). Music TV channels occupy a significant share (5.4%) of television watching time (Pedder 2002) and that share is considerably larger as far as the younger demographic groups are concerned (Knobloch and Mundorf 2003). Moreover, adolescents and young adults are already familiar with interactive content and may be more receptive to interactive services, which are coupled with their favorite entertainment content. Finally, music video clips have a younger target group and a larger life-span —compared with news items— that make easier an experimental set-up and evaluation by readily available university students.

Music TV channels are considered to be innovative, because they have a young and dynamic audience, so they can play the role of the Trojan horse for novel ITV applications. MTV was the first TV channel to offer information related to video-clips a while ago, and since then, there have been many followers, even in different program types. MTV has been also showing which music video comes next. Music information usually contains trivia about the artist, or biographical information and discography. Music TV channels had originally adopted the informational video overlays, because they make viewers spend more time in front of the TV set, instead of using it like a radio. An interactive music TV channel is part of the XTV service developed by NDS and it is offered by the BSkyB Plus service. The respective service is named Music Jukebox and offers storage, interactive play of music videos and buying of music CDs. Since it is a commercial product, there is no further information regarding its design, or any reports about the usability issues during the development. It was not available for in-depth analysis, but a longitudinal study of its use in the homes of BSkyB subscribers would be useful for the design of future interac-

tive music video services. In summary, music TV plays an important role in the ITV field, and deserves further academic research.

Interactive Music Television Issues

Previous research in media psychology has thoroughly investigated the effects of music and music videos on audiences. Watching music videos is considered as a super set of listening to music, with an additional effect mainly on the arousal levels of viewers. The addition of visuals to music was found to have an impact on arousal levels of viewers (Zillmann and Mundorf 1987). The communication research literature asserts that the combination of music with video has created the opportunity for music to carry additional levels of meaning. On a first level, listening to music is an activity that has become pervasive in modern societies. Besides the aesthetic pleasure that human beings experience during the music listening activity, communication research has also documented many more additional effects (e.g. therapeutic). On a second level listening to music may: 1) reveal personality traits, depending on the preferences of songs and genres, 2) be used as a signal and discussion placeholder for social communication, 3) be used to perform mood management through the selective exposure to songs with certain specific energy levels, and 4) have an effect on the emotions (Knobloch and Mundorf 2003). The above elements may now be affected by the introduction of interactivity in Music TV. Therefore, *there is a need to investigate whether an animated character has an effect to the emotional responses to music TV.*

Despite the concerns of the music industry, consumers are creating and maintaining large data bases of digitally encoded music. Digital libraries for music have been a theme of previous research. Cunningham et al. (2003) identified that previous information retrieval strategies implied an efficiency paradigm. They performed an ethnographic study, in order to discover the fundamental music retrieval strategies employed by consumers in their everyday lives. In addition, previous research in media psychology has investigated consumer behavior for music listening. In particular consumers may use a digital music library, in order to moderate their moods (Knobloch and Zillmann 2002). It is likely that digital libraries will extend to include music video clips, as well. Therefore, *there is a need to investigate consumer opinions regarding the navigation in an ITV music application.*

Advertising supports most music TV channels, so it makes sense to devise new models of advertising in correspondence to the above mentioned novel music TV features. Choosing advertising as a case study may seem controversial. On one hand television advertising is irritating to a lot of people. On the other hand, Bell and

Gemmel (2002) proposed that advertising may be a remedy to the Digital Rights Management (DRM) issues that arise when manipulating copyrighted media content in the home: 'Publishers will insist on DRM to protect their content and ensure their revenues. As DRM matures, cache stuffing will allow for some interesting opportunities such as insertion of advertisements that can please both viewers and distributors.' Therefore, the dynamic insertion of advertising, during the play-out of copyrighted media content in the home, is a form of substitution for the license fees that have to been paid to media owners. In the present work, *dynamic advertisement insertion is considered as a trade-off for music video skipping.*

The interactive music TV research issues were selected in a way that they correspond to the generic service design issues for ITV, which were formulated as hypotheses, in the previous section. Overall, the music ITV application was developed in order to employ and to validate the concepts developed to address the research questions and in order to assess the hypotheses. The development process is described in Chapter 5. Nevertheless, as a side effect of the case study, the usability evaluation provides insights that are useful for the commercial development of ITV music services, which are presented in Chapter 6. Further research for interactive music TV is discussed in Chapter 7.

2.8 SUMMARY

There are numerous issues associated with UI design for ITV. Previous research has treated them to some extent, but there are still open issues for further research. Besides the main streams of ITV research, which were presented in the beginning of the chapter, Table 1 provides an extended index to the contemporary ITV research themes. Those selected for an in-depth investigation are highlighted in Table 1, in the context of contemporary ITV research.

Issue	**Previous treatment**
EPG	Conceptual model (Bonnici 2003), personalized (Smyth and Cotter 2000), recommendation (Ehrmantraut et al. 1996), navigation (Eronen and Vuorimaa 2000, Barbieri et al. 2001), trust, usability (Buczak et al. 2002), cold start problem (Baudisch and Brueckner 2002), web based video retrieval (McDonald et al. 2001), stereotypes (Gena and Ardissono 2001), architecture (Ardissono 2001), zooming interface (Tinker et al. 2003), natural language interaction (Johansson 2003), participatory design, prototyping, and guidelines (van

	Barneveld and van Setten 2003), MHP implementation (Peng 2002)
News	Personalcasting (Maybury 2001), automatic construction (Merialdo et al. 1999), content augmentation (Dimitrova et al. 2003), mixing with computer generated elements (Marrin et al. 2001)
Learning	(Lytras et al. 2002), virtual studio (Gupta and Hüttemann 2003), usability evaluation (Damásio 2003)
Storytelling	Programming language, authoring tool (Agamanolis 2001), multi-user game (Lankoski and Ekman 2003), interactive video production (Nardon et al. 2002), readers and skimmers (Cappelletti et al. 2003)
Communication	Virtual communities (Célia Quico 2003), messenger (Chuah 2002), Virtual reality game (Benford et al. 2001)
Design approach	8-step process (Lamont 2003b), participatory (Eronen 2002), scenarios and storyboarding (Black et al. 1994)
Conceptual model	EPG (Bonnici 2003), metaphors (Burmester and Koller 1996), *Conceptual model for Integrated broadcast, local storage and Internet resources?*
Principles	Strategic questions for content design (Jaaskelainen 2001), heuristics for ITV content (Ali & Lamont 2000), *ITV UI generic principles?*
Evaluation methodology	Discount usability engineering (Eronen and Vuorimaa 2000, Lamont 2003a, Lamont 2003b), interviews (Burmester and Koller 1996, Koller et al. 1997), *Affective ITV evaluation methods and instruments?*
Accessibility	Visually impaired user needs (Gill and Perera 2003), elderly (Maguire, Unpublished; Masthoff and Deemter 2003)
Remote control	Haptic (O'Modhrain and Oakley 2003), speech enhanced (Ibrahim et al. 2001), minimal remote (Angiolillo 1995)
Usability management	Iterative design (Lamont 2003a)
Requirements collection	Attitude based segmentation (Freeman and Lessiter 2003), Semiotic approach (French and Springett 2003), qualitative research (Eronen 2003), gender and age differences (Bjoerner 2003), uses and gratifications (Livaditi et al. 2003)
Ethnographic study	Digital STB trial (O'Brien et al. 1999), home theater (Petersen et al. 2002)
Policy	Regulation (Galperin 2002), strategy and forecasting (Jacobs and Dransfield 1998)
Video navigation	Effectiveness and efficiency of video skipping (Drucker et al. 2002), key frame navigation (Barbieri et al. 2001), *Affective usability for video-skipping?*
Animated characters	Trust and expectations from recommendation (Diederiks 2003), *Affective usability and Integration with TV content?*
Advertising	Personalized break insertion in broadcast (Lekakos et al. 2001a), interactive advertising (Lee 2003), business model (Pramataris et al. 2000), D*ynamic advertisement insertion?*

Table 1 Research issues for interactive television

Table 1 depicts that despite the academic approach to ITV being very recent, there is a broad range of themes. It also becomes evident that previous research has treated extensively EPG issues, but there are many opportunities for research in other themes. It can be argued that previous research has been very fond of the EPG because it has a tabular structure that feels familiar to IT researchers —at least when compared with TV audience issues that pertain to the realm of advertising and communication research. Moreover, previous UIs for ITV make the implicit assumption that television viewers are always actively engaged and they are usually done according to the manufacturer's idiosyncrasy or by applying rules from the desktop experience. Leaving aside television content quality questions, the present work focuses on the issues that have been pervasive in previous research in the HCI discipline. Namely, these are animated characters, video navigation, UI principles and evaluation, and conceptual models. Moreover, advertising is considered, since it is a very important element for the future of the ITV industry.

In the next chapter, the methodology for each one of the research issues is described.

3 DESIGN METHODOLOGY

In the previous chapter, the HCI literature review revealed that the UI design, development and evaluation approach, previously employed for the PC and the Web, is inappropriate for ITV applications (research questions 1, 2 and 3). A systematic investigation of the scientific literature concerning consumers' behavior in domestic settings as related to watching TV will result in pervasive findings about the usability requirements of ITV applications. The TV watching behavior has been formed through the many years of people's exposure to the mediated experiences offered by TV content. It is unlikely that consumers will drop their daily domestic routines, in order to adapt to any new technology. Thus, it is more prudent to identify the established TV watching behavior and shape ITV applications around it, instead of assuming that consumers will be willing to adopt the PC and Web paradigms, even if they are adapted in the ITV context. After the introduction and wide adoption of basic ITV applications there will be increased understanding of the consumer behavior with ITV applications, and thus ample opportunity for novelty.

This chapter describes the methods that were employed in order to approach the research issues that were identified in the previous chapter. For each one of the issues the respective literature of methodology was reviewed, in order to identify the most appropriate methods. It is argued that the high-level user-centered design methods from traditional HCI for the PC are still valid in the ITV environment, but there is also a novel agenda of methodological concerns that are specific to the home use challenge (Monk 2000). In general, the research questions were approached with methods from HCI design. The hypotheses were approached with methods from HCI usability evaluation and laboratory experiments.

3.1 OVERVIEW

The present research work involves two design phases (Figure 3). The objective of the first design phase is to identify a set of principal elements that are generic to the design of ITV UIs and that relate to the three research questions (conceptual model,

user interface principles, and evaluation framework). The first design phase is described in Chapter 4. The objective of the second design phase is to employ the elements identified in the previous stage into the development of an ITV application that is evaluated by consumers, in order to address the three hypotheses (video skipping, animated character, and dynamic advertisement insertion). The employment of the generic design elements into a working prototype functions as an evaluation of their applicability in other ITV applications, too. The second design phase is described in Chapter 5.

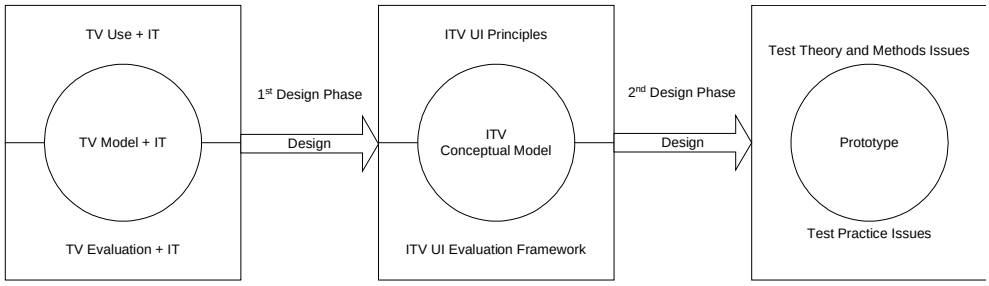

Figure 3 Overall scheme of the design methodology employed

The first design phase is concerned with the research questions (conceptual model, UI principles, and affective usability framework). The methodology employed to approach those research issues complies with the design paradigm developed and established in the HCI discipline. Design is considered as a problem solving process that has six main characteristics and difficult properties. The most relevant for the problem at hand are the following: 1) trade-offs among many interdependent problems, 2) reliance on a diversity of knowledge and skills (Caroll 2000, p.22). In the present research, a multidisciplinary approach is applied in order to formulate a set of principal ITV UI elements, in which each one of them is identified as a trade-off between the TV and the IT perspective.

The second design phase involves the consumers in the development process. The UI elements from the previous design phase are applied in an ITV prototype, in order to validate them. Furthermore, the prototype is used to test the hypotheses.

There are many reasons for following a structured and explicit design approach for the development of a UI for ITV. Firstly, the principal elements employed in the design are common for every type of ITV application, such as news, documentaries. That is, the employment of a conceptual model, the selection of an implementation platform, the justification of the UI principles, and the specification of affective usability goals are a major part of the design of every ITV application. In addition, the designer of an ITV application is faced with two options: 1) deliberately employ an ex-

plicit design approach or 2) be guided by intuition and employ an idiosyncratic design approach for each one of the above elements. By selecting the former, the ITV application will be directly addressing those issues that previous research has identified as significant. Moreover, it will be easy to trace back the design to the principal building blocks for the purpose of changing or enhancing it. By selecting the latter, the designer will employ intuition for each one of the important issues. The result will depend on the designer talent and experience: a talented and experienced designer will unconsciously produce a flawless ITV experience, but the un-talented and the in-experienced one will produce an idiosyncratic result. Nevertheless, explicit design methods cannot guarantee a successful result, but they can be tested, improved incrementally and contribute to previous knowledge.

3.2 CONCEPTUAL MODEL

In the previous chapter, it was argued that a conceptual model for ITV should move away from the mentality of the PC and the Web and the notion of information retrieval and active search. There are also many HCI experts suggesting that the desktop metaphor is not appropriate for information appliances and computer mediated applications beyond the office and the productivity paradigm (Marcus 2002a). *The aim of the conceptual model for ITV is to seamlessly integrate the digital broadcast transmissions, persistent local storage and Internet resources, in order to augment the TV as a medium of entertainment and passive discovery.*

There is agreement that the design of a conceptual model is an intuitive and iterative (trial and error) process, but, there are also some generic guidelines. Wickens et al. (1997, p.462) argue that 'there really are no specific guidelines for how to design an effective software system at the conceptual stage.' Nevertheless, Norman (1990, p.13) argues that every artifact to be used by people should provide 'a good conceptual model that allows the users to predict the effects of their actions.' In particular, according to Norman (1990, p.189) 'a good conceptual model' requires that 1) the principles of operation are observable, 2) all actions are consistent with that model, and 3) there is feedback of the current state of the system in a way consistent with that model. He adds that the designer should develop a model that 1) is appropriate for the end-user, 2) captures the important parts of the operation of the device and 3) is understandable by the user. The above points constitute a checklist of generic re-

quirements that may be used for the evaluation of a conceptual model, but they do not guide the process of developing one.

There is a considerable body of previous research that analyzes and develops metaphors for computing systems, although this is done from the perspective of the end-user (mental model) and not that of the designer (conceptual model). Nevertheless, in some cases, it is feasible to trace back from the user's mental model to the designer's conceptual model, since the user's mental model is a reflection (through the system image) of the designer's conceptual model. In particular, a user's mental model is realized through the system image and through the use of metaphors (Norman 1990, p.16, p.189). The most persistent and systematic approach to UI metaphors is provided by Marcus (1993, 1998, 2002a), although the respective guidelines and methodology are directed mainly toward the visual design of a system and not toward the design of its functional part. Initially, he 1) identified that there may be multiple metaphors for a single software product, 2) mentioned the cultural differences and 3) suggested that the metaphors may be retrieved from the physical context of the computer application (Marcus 1993). Then, he identifies that there are some parts of a system that are generic among a domain of activity and some others that may be unique for each specific application. Furthermore, he suggests a process for developing metaphors: 1) identify items among data and functions that should be targets, 2) identify sources of metaphorical reference, 3) generate many possible metaphors, 4) identify and evaluate matches and mismatches, 5) revise metaphors to strengthen effective matches and reduce harmful mismatches (Marcus 1998). Overall, it is recommended that *a metaphor should be 1) familiar to the user and 2) related to the domain of ITV.*

In summary, in order to identify a conceptual model for ITV, it would be reasonable to make 1) a thorough investigation of the evolution of the established conceptual model for TV (*thus identifying the familiar patterns*) and 2) a literature review of the most recent academic research for ITV (*thus identifying the emerging interactive patterns*), in order to reveal repeating patterns. Then, the underlying patterns of the ITV experience may be combined to formulate a generic conceptual model for future ITV applications.

In the next sections, the analysis continues by making an analogy with the Windows Icons Menus Pointing (WIMP) model, in order to establish a semantic bridge between the current discussion and the familiar context of desktop PC interaction. Then, the requirements of a formal definition of a conceptual model are presented.

3.2.1 Analogy with the WIMP Conceptual Model

The WIMP model is a generic conceptual model that should not be confused with application-level conceptual models. The notion of the conceptual model is used invariably in the HCI literature to describe either a specific application or the generic framework inhabited by applications. For example, the spreadsheet application model (e.g. Microsoft Excel) inhabits within the WIMP model. In particular, a spreadsheet application employs windows, menus, icons, and pointer, and adds the notions of tables and a set of tools. Therefore, there are two layers of conceptual models (Figure 4) for the desktop PC applications.

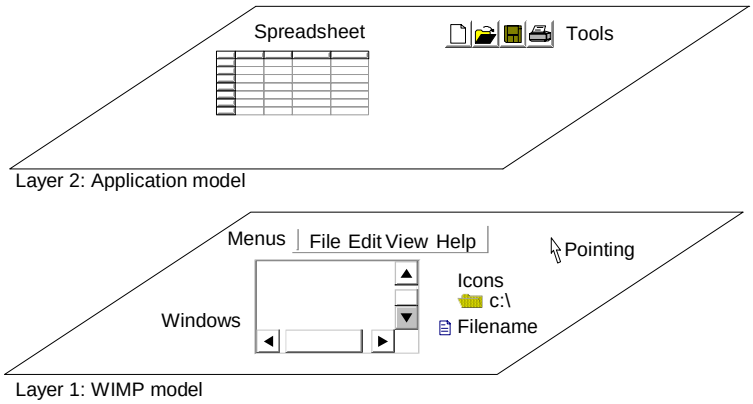

Figure 4 Two layers of conceptual models for desktop PC applications

Similarly, there are two levels of conceptual models for ITV (Figure 5). The generic level defines a few principal elements that are available to all ITV applications. Then, each ITV application employs a conceptual model that is appropriate for a given content-type. For example, a music TV application may consist of music video-clips and music ancillary data objects and these objects may be skipped by the user.

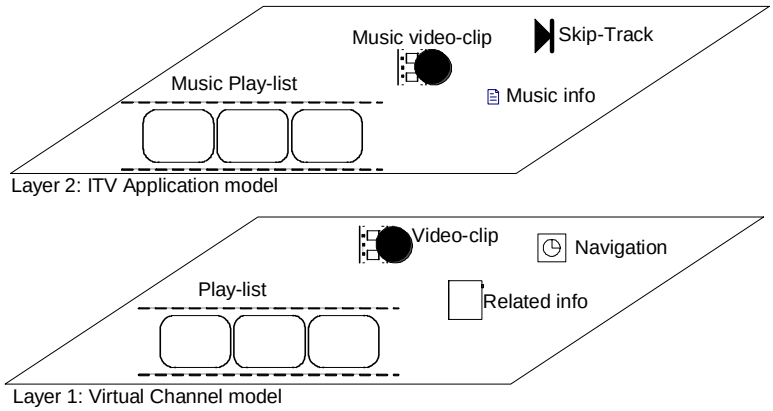

Figure 5 Two layers of conceptual models for ITV applications

3.2.2 Requirements for Formal Definition

There are also a few requirements regarding the way a conceptual model is defined. A formal definition should: 1) be a super-set of the established model (descriptive), 2) allow comparing the proposed model with other models (comparative), 3) facilitate the creation of application-level conceptual models (generative), and 4) offer a smooth path towards the implementation architecture and the UI specification (Beaudouin-Lafon 2000).

The quest for formalism in the description of a designer's conceptual model for ITV UI should avoid a few fallacies. Johnson and Henderson (2002) argue that a UI conceptual model is not: 1) the UI specification, 2) the implementation architecture, 3) the use cases and 4) the user's mental model. On the other hand, they also argue that a conceptual model should explicitly specify and describe: 1) the metaphors and the analogies employed in the design, 2) the concepts that the system exposes to users, including their attributes and the operations that can be performed on them, 3) the relationships between these concepts and 4) the mappings between the concepts and the task-domain. Furthermore, a conceptual model should only include the objects and actions that are visible by the users. The above requirements are given for application-level conceptual models.

In the context of the above characteristics, a generic conceptual model for ITV applications should be even simpler and more abstract, just like the WIMP model for desktop computing. For example, there are no mappings to the task-domain, since a generic conceptual model for ITV applications should be agnostic to the details of the possible content and interactivity employed by each ITV application. An exhaustive treatment of the most appropriate modeling grammar is beyond the scope of the present thesis. Therefore, the established objects/actions analysis was selected to represent formally the conceptual model (Johnson and Henderson 2002).

The Virtual Channel conceptual model is developed and defined in line with the above requirements in the next chapter.

3.3 USER INTERFACE PRINCIPLES

User interface design principles developed for the PC and the Web do not fit directly to the design of ITV, as it became evident in the previous chapter (research question 2). The objective is to provide a flexible check-list of design factors that affect the usability of ITV applications, in order to assist the UI design process. In many senses

(technological, content, audience) ITV is a concept that spans the wide continuum between the traditional TV and the desktop PC-Web experience. Therefore, neither the IT, nor the mass TV design principles are immediately applicable to ITV. As a rule of thumb, depending on the balance between passive and interactive, a CME application may be more like a TV or more like a PC respectively (Vorderer 2000). Overall, the ITV experience may be considered as the gamut of different combinations of the traditional TV and of the interactive PC-Web principles.

In the past, the field of HCI has been benefited by a multidisciplinary approach to design problems (Ballay 1994, Marcus 2002). Successful user interfaces, apart from proven methodologies and multiple design iterations, demand a diverse array of design specialties. For the case of ITV, a literature review has revealed the following important fields that may provide insights for ITV UI design principles: 1) study of media consumption at the home and 2) interactive content production. Researchers from the respective fields have addressed the design of interactive and multimedia services at the home, but there is currently no aggregate effort towards the direction of UI principles for ITV. Following a literature review of diverse scientific perspectives, the most useful findings from each discipline are collected, analyzed and presented in an easy-to-use designer's check-list of trade-offs that should be addressed in the UI development of an ITV application.

3.4 PROTOTYPING TECHNIQUES

The objective of this section is to address the issue of prototype development for ITV. It is currently impossible to fully materialize the future ITV viewing environment, because a number of key technologies are not available and the exact shape of devices and content to become available is not completely predictable. In the light of these shortcomings, the research effort has to reside on interactive prototypes. It is suggested that low-fidelity prototypes should be used early in the design process, in order to communicate ideas between the design and development teams, and that high-fidelity prototypes should be used later on for testing with users (Wickens et al. 1997, p.477). Here, the emphasis is placed on the media consumer experience realized through high-fidelity prototypes (Rudd et al. 1996), mimicking the look and feel of the target platform. In this way, it is possible to make exploratory research, test the usefulness of a number of central functionalities and assess their impact on the current TV consumption patterns.

Previous experience with ITV technologies and applications has revealed that whatever is presented on the TV screen is assessed in comparison with the current television experience. Computer-like menus, pages and navigation look irrelevant on a TV screen, even when used by experienced computer users (Lekakos et al. 2001a). Before a high-fidelity prototype is implemented and presented to users, there is a clear need for television-values based creative development. One possible resolution strategy would be the utilization of broadcasted content and TV-language rules and aesthetics. In summary, the objective is to create a flexible prototyping platform for ITV, such as the one created for testing smart-phones (Pering 2002). The main characteristic of a flexible prototyping platform is that it looks and feels like the final product from the consumer perspective. At the same time, it is based on off-the-shelf components (PC H/W and S/W), so it can be updated easily.

In addition to interactive prototypes, scenario writing is employed to instruct the prototype development and inspire the whole design process. A scenario is the most basic and simple type of a prototype and it may also be discussed with experts or be evaluated by the end-users (Nielsen 1994, p.95). Scenario writing is an established prototyping tool, especially during the early stages of the product development process. Scenario writing has several advantages, such as providing a common vision for the product to diverse development disciplines and communicating the product to the consumers. The process and the benefits of scenario development have been studied in-depth by HCI researchers and it has been proposed as a principal element of the design process (Caroll 2000). In particular, scenarios provide understanding of consumer needs, envisioning of new activities and focusing the design work on the users' activities, instead of describing a list of product requirements, which was the norm so far in S/W development (Caroll 2000, p. 46). Overall, scenarios are an integral part of the envisioning part of the design process. In the present work, scenarios are used to describe the current TV experience and to visualize the future ITV experience.

3.5 PROGRAMMING LIBRARY

The literature review, in Chapter 2, revealed that the IT researchers were eager to shape the future of ITV, but they approached the new medium using the traditional development techniques for the PC and the Web and they put their efforts on the issues that are most familiar to them (e.g. information retrieval and personalization for

the EPG). The objective of this section is to present a methodology for ITV authoring tools that facilitate the high-level production process of TV producers. At the same time, those tools should support and guide IT developers into designing appropriate ITV applications, by providing an explicit and consistent conceptual model. According to Baecker et al. (1995, p.313), a UI development tool should: 1) minimize the effort it takes to translate the semantics of the interface design into the semantics of the toolkit offerings and 2) minimize the distinctions between the design, prototyping and implementation phases. The above were the main objectives in the development of a high-level programming library for ITV. Yet, there are a few sub-goals, which are described next.

The majority of the development tools and techniques for an S/W UI assume that the final software product will be some variation of the Windows, Icons, Mice and Pointing (WIMP) paradigm. Beyond the WIMP paradigm, previous research has identified four types of non-WIMP user interfaces: 1) Virtual reality for special input and output device, such as gloves and VR helmets, 2) embedded, whereas the computer is invisible in an appliance, 3) notebook for mobile use with pen and handwriting recognition, and 4) hypermedia for hyperlinked multimedia (Green and Jacob 1991). Here, the UI for ITV is a combination of the embedded and hypermedia styles. Furthermore, they identify various research issues: 1) input transduction, which refers to the different input devices, 2) time management, which becomes of primary concern, instead of the predominant spatial organization of the WIMP style, 3) UI description languages, and 4) implementation support that is suitable for the underlying implementation platform. Here, the second and the forth issues are addressed in the development of a high-level programming library for ITV applications. Finally, in terms of the implementation approach and the programming language, the object oriented paradigm is the most appropriate to address the complexity, the user-centered and the high-level mentality required for the development of ITV applications.

The implementation of a programming library for high-level development of ITV applications is based on the underlying properties and the features of the Virtual Channel model. Since the there are common patterns at the conceptual model level, it is appropriate to identify the respective patterns at the S/W level, too, in order to formally implement them in a programming library for ITV applications. In this way, the development effort will avoid replicating the same basic building blocks all over again. Furthermore, there will be a direct mapping between the UII design and the semantics of the UI development toolkit. Finally, enclosing repeating functionality

into re-usable packages has been a successful way to improve the S/W development process in terms of both cost and quality.

In the following sub-sections, DTV platforms and the current computer graphics experience for TV are described, in order to select an implementation platform and in order to define the requirements for the programming library.

3.5.1 Digital Television Platforms

In the marketplace there are a few alternative product offerings that support ITV applications. The most popular is the OpenTV system, which is a proprietary end-to-end system for ITV application authoring, delivery and consumption. The OpenTV system reflects the immaturity of the ITV industry, since it poses the requirement that all the business players comply with a single closed system. For example, producers should develop an ITV application using the OpenTV authoring tools, then the broadcaster should offer support for transmitting the OpenTV application, and finally, the consumers should be equipped with a digital STB that is compatible with the OpenTV system. The OpenTV system was established in the emerging ITV marketplace because it was supported by a successful, vertically integrated business entity (News Corporation).

Researchers and engineers with an IT background will find more flexibility and familiarity with MSTV or MHP that are reviewed next.

MHP is the most widely accepted standard for DTV applications. Apart from Microsoft, all other technology providers are either opting for MHP application development or are developing their own MHP-compliant implementations. Nevertheless, early commercial implementations of MHP lack major features (like DVR, which has been available by TiVo for a long time), are having very slow response times and are not very stable. Moreover, MHP authoring environments are very few, and are always too expensive, without realistic options for academic or research pricing. The above problems are natural for a new technology, but MHP is also facing regulatory problems in the European Union (EU) marketplace. Despite heavy support by many companies and groups, MHP's reliance on Java has not allowed it to be pushed by the EU's regulatory body as the continent's standard for interactive television applications. Overall, MHP is superior because it has been built from the ground-up as an extension of the widely established Digital Video Broadcasting (DVB) standard and is also supported by the respective research community and by all the manufacturers of broadcasting equipment.

Microsoft TV (MSTV) technology was selected for the implementation of the high-level programming library for ITV for a number of reasons. Most importantly, the core components of MSTV are available in the Windows XP operating system and can be run on affordable personal computers (PCs). In addition to the pervasive availability of a television API, MSTV technology can be utilized within a familiar and mature Integrated Development Environment (IDE). Microsoft Visual Studio offers a multitude of tools for designing, developing, testing and deploying an application. In contrast to MSTV, other proprietary implementations (like Liberate, Mediahighway, OpenTV) require the respective authoring environments that consist of idiosyncratic and expensive IDE and STB technologies. Against the use of MSTV is the fact that Microsoft has a very limited installed base of STBs compared to competitive implementations.

3.5.2 Requirements for Dynamic Computer Graphics

Computer graphics play an instrumental role in delivering the traditional TV experience (Barton et al. 1985, Shoup et al. 1980). For example, computer graphics and animation have been used widely in the post-production of television content (Figure 6) for inserting the channel logo, animated intros/endings, and displaying various kinds of information (sport statistics, quiz show status, stock market ticker, news ticker, etc). Computer graphics are merged with audiovisual content and are converted to video at the production studio or at the broadcast station. The final video is transmitted and displayed from TVs in its fixed form, without any opportunity for local dynamic update of the embedded computer graphics. The fixed TV channel continues to serve adequately the least common denominator, but, in order to facilitate diverse consumer preferences, there is a need to personalize the TV experience for each consumer separately.

Until now, the TV viewers' interactive experience has been stuck to the Teletext, which is actually an information tool and is usually unrelated to the running television content. Recent advances in STB technology have introduced real time video capturing and rich multimedia at consumers' homes. A DVR stores television content, while the user controls the television flow with an on-screen user interface. In addition to dynamically embedded graphics for advanced UIs, television content can now be enriched with rich computer generated content, like animated characters and Internet information sources. Therefore, the programming library should support high-level access to the computer graphics functionality that has become common in

TV production. Yet, the programming library should support interactive computer graphics at each STB, instead of authoring in the production and broadcast studio. Then, it should be more straightforward to develop ITV authoring tools and applications.

Figure 6 Computer generated graphics are fixed for each traditional television channel: Music information from MTV (top left), Channel Mosaic from Disney (top right), financial information from Bloomberg (bottom left), additional information from Eurosport (bottom right)

3.6 AFFECTIVE USABILITY FRAMEWORK

The literature review in the previous chapter revealed that the usability evaluation for ITV UIs is at an early stage of development and most of the previous works are applying directly the approach from the productivity-computing paradigm. The emergence of CME applications, such as ITV, does not entail a complete abandonment of the established paradigm. For example, an ITV news application, used in the morning before leaving the home for work, should be very efficient in terms of fast information retrieval. The same application, used in the evening after returning home from a long day at work, should be more automated and encourage relaxed

use*. Therefore, in most cases, there is a need for evaluating the affective dimension of usability. Nevertheless, the majority of the previous studies that contained an evaluation of an ITV UI have been relatively uninspired, in terms of the constructs employed. An affective usability evaluation framework for ITV should be based on the concepts that have been derived from scientific disciplines that have extensively treated TV, in the past. The approach employed to identify affective usability constructs for ITV from previous research is described in the rest of the section.

The explicit distinction between the hedonic and the utilitarian experience is anything but novel for the academic literature. Previous works in consumer research has addressed the differences between information processing and experiential consumption (Holbroock and Hirschman 1982), while others proposed a scale to measure the hedonic quality of the consumer experience in retail stores (Babin et al. 1994). Moreover, consumer research has acknowledged the importance of the affective dimension in the consumption activities and proposed a framework of determinants for the subjective leisure experience (Unger and Kernan 1983). In addition, consumer researchers investigated the theme of playful consumption, thus implying an interactive consumer and they established the importance of emotional responses to the consumer buying decision process (Holbroock et al. 1984). Besides the consumer research field, the most relevant research for the emotional responses to TV has been performed in the fields of communication and advertising research, which are reviewed in the following sections, in order to retrieve appropriate constructs and instruments.

The main task of the methodology for a usability evaluation framework is to identify constructs and instruments that address the affective dimension of an ITV UI. Previous work in the communication and the advertising research domains has addressed techniques for measuring emotional responses to TV content. Previous work in the HCI domain has addressed methods for measuring the usability of a UI, although, in most studies, the mentality has been in favor of productivity goals, instead of leisure ones. Recent work in HCI has extended the traditional concepts to include the affective dimension of usability. The instruments employed to measure an ITV UI refer to the third research question. Next, the approach employed to develop an affective usability framework for ITV is presented. The presentation begins

* Credit for this example goes to Steve Draper, during my PhD proposal presentation and the discussions held at the SIGCHI '03 Doctoral Consortium

with a background discussion of the TV entertainment experience, in order to set the scene for the development of the affective usability framework for ITV.

3.6.1 Conceptualizing the Interactive Television Entertainment Experience

Entertainment is a multidimensional construct that cannon measured as such, but it consists of several parameters that can be measured (Vorderer 2001a). From a media psychology perspective, according to Vorderer (2000), entertainment can be conceptualized as mood management. It is argued that people spent most of their leisure time trying to moderate their moods. Daniel Goleman (1995, p.57), the author of the influencial book Emotional Intelligence, said that 'managing our emotions is something of a full-time job: much of what we do —especially in our free time— is an attempt to manage mood. Everything from reading a novel or watching television to the activities and the companions we choose can be a way to make ourselves feel better. The art of soothing ourselves is a fundamental life skill.' A mediated experience elicits an emotional response from the viewer of TV that is partly valence (pleasure) and partly arousal (Reeves and Nass 1996, p.136). Then, the measurement of the ITV entertainment may reside on the same constructs used to assess viewers emotional responses to TV content (Figure 7).

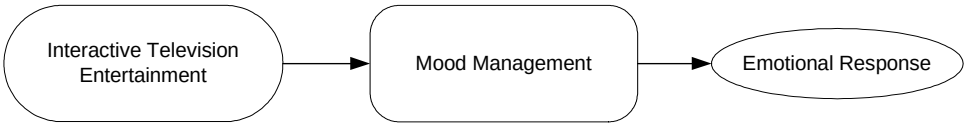

Figure 7 Entertainment for ITV is measured through the emotional response of the user

Still, there is also a need to consider the interactive part of ITV, for which there is no extensive research in communication studies (Vorderer 2000). For that purpose, concepts for measuring emotional responses to a UI are retrieved for the recent HCI literature about affective usability. Overall, measuring the ITV entertainment experience is broken down to two parts: 1) measuring emotional responses to TV content and 2) measuring emotional responses to a UI (Figure 8).

Breaking the ITV entertainment experience in parts may seem artificial, because both the UI elements and the TV content are meant to provide an integrated experience that should be more than the sum of the parts. The decomposition of the ITV entertainment experience in two parts (Figure 8) is not meant to measure independently the parts, but to assess whether the addition of alternative UI elements has any effect on the constructs that have been important in previous research for TV. In other words, the decomposition of ITV in the UI and the TV component is merely an

operational arrangement, which is used in the present thesis to structure the presentation of the related research. Therefore, the decomposition does not correspond to a need for employing different techniques for measuring the UI and the TV parts of ITV. Instead, it is argued that the UI should become an integral part of the future ITV experience.

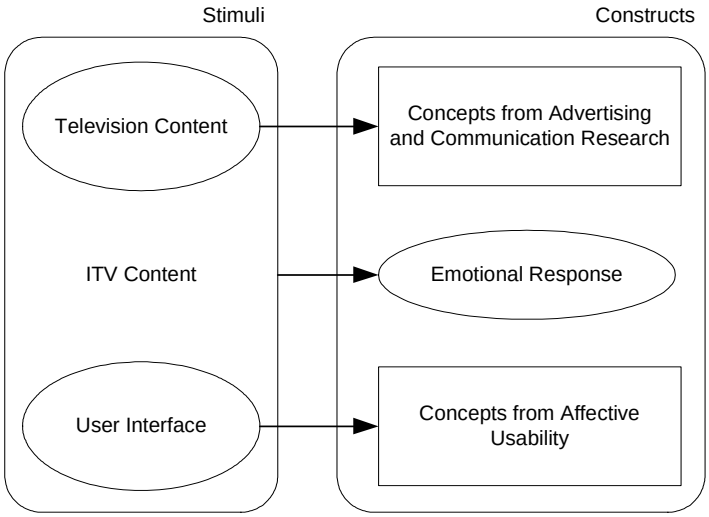

Figure 8 Emotional response to the ITV entertainment experience may be elicited either due to the UI or due to the TV content

3.6.2 Measuring Emotional Responses to Interactive Entertainment

Since there is a theoretical ambiguity of the concept of emotion there are a few alternative theories about emotion (Ortony et al. 1990). Correspondingly, previous research has developed more than a few instruments for measuring emotion that range from physiological measures to iconographic scales (Desmet 2003). Early research modeled emotion as a cognitive process, whereas the emotions may become evident through physiology (facial recognition, EEG, etc), language, self-reports, and behavior (Ortony et al. 1990, p.14). Here, the feasible data collection methods to identify emotions are through self-reports and behavior monitoring in computer log files.

One decade later, advancements in emotion theory have resulted in increased understanding of the brain structure, in concern with the emotional response to external stimuli.

According to Ortony et al. (2004) there are three distinct levels of brain mechanism: 1) the visceral level, which is the pre-wired part of the brain and acts automatically to external stimuli, 2) the behavioral level, which contains the brain processes

that control everyday behavior and 3) the reflective level, which is the contemplative part of the brain. For example, a person may react instinctively to a dangerous situation while driving a car. This is evidence of the existence of the visceral (automatic reaction) and the behavioral (driving a car) levels. Another example is when someone gives a talk, or over the course of an informal discussion, it may happen that an interesting idea emerges in the talk almost subconsciously. Then the speaker might say: 'This is a good idea! Let me jot it down!' As if it was someone else who had the idea. This is evidence of the existence of the behavioral (language) and the reflective (thinking rationally about what was said) levels*.

Recent research suggests that each of the three levels plays a different role in the emotional functioning of people and each level requires a different design strategy (Norman 2004).

Each level of the emotional brain may be associated to a different class of constructs and the respective instruments, which can be employed in order to evaluate the differences between alternative design strategies. For example, an ITV application may create the sense of pleasure and enjoyment at the visceral level. Then, the user may continue using the ITV application for a long time and become emotionally absorbed in the experience, which is a behavior that happens while actually using the application. Finally the user may decide that she like the specific ITV application, which leads to the formation of an attitude.

In summary, there are three distinct levels that process and convey emotion, and each one may become evident through the respective data collection methods (Figure 9). The physiological measurement techniques are suitable for evaluating emotions at the visceral level and the behavioral measures for the behavioral part. The self-reporting methods are used to measure each one of the three parts of the emotional brain, although there are many situations in which the individual may disguise the actual emotion felt.

The emotional response at the visceral level may be inferred by a physiological measure (e.g. EEG, skin conductance, heart rate, and facial expressions), language and behavior, but the most feasible method for the present work is the self-report. The emotional response at the behavioral level may be detected by the analysis of the interactivity logs, and self-reports that convey the attention, involvement and engagement of the user. Finally, the attitudes are the most straightforward to measure

* These examples were presented by Don Norman, during his closing keynote address at SIGCHI '03 conference

through questionnaires. In the next chapter, each construct is related to a level of emotional response and it is presented together with the respective data collection instrument.

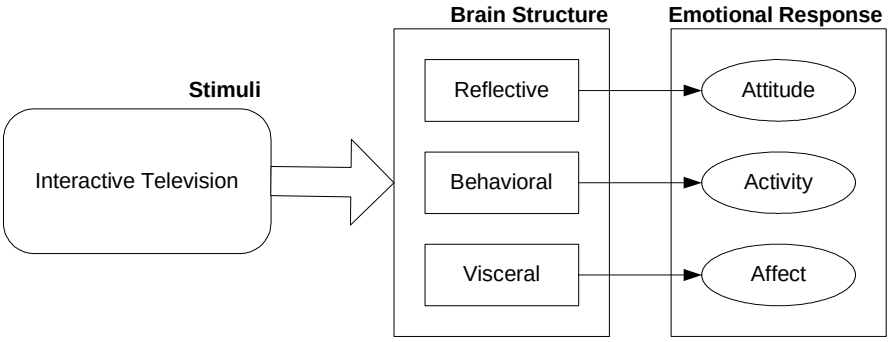

Figure 9 The ITV entertainment experience creates a multitude of emotional responses each one reflective of the three levels of cognitive processing

In summary, the entertainment experience from ITV is elicited by the TV content and by the UI. Previous research in advertising and communication has addressed the TV content, while previous research in HCI has addressed the UI. The primary focus of the present research is to measure the UI for ITV, but it is still not completely clear whether the UI is an integral part of the ITV experience, or it can be considered separately. Therefore, both the UI and the TV constructs should be assessed. The rationale for retrieving instruments from previous work about traditional TV is the need to test whether the UI elements have an effect on the established concepts from the respective theories. Moreover, the affective usability framework for ITV is in accordance with the most recent research for the emotional brain. It is beyond the scope of the present thesis to investigate thoroughly and draw final conclusions for the possible new usability evaluation techniques for ITV. Since that theme has been widely neglected from previous ITV research, the approach taken here is to identify and apply the viable constructs and instruments from related research about TV and UI evaluation. The proposed affective usability framework for ITV is presented in the next chapter.

The above-mentioned usability metrics are employed in usability evaluation sessions with consumers. Therefore, there is need to consider the specific evaluation methods that will be used, which is described in the next section.

3.6.3 Evaluation Methods and Techniques

Previous studies about TV content and audiences employed a multitude of research methods, because there is no single research method that is appropriate for all research problems. For example, an ethnographic study may provide in-depth insights about the different uses of TV in everyday domestic life. Then, a survey may reveal relationships between the uses and the type of the family or the viewers' profile, and to give quantitative results. In some cases, a longitudinal study may be used to study the evolution of a variable along short or long periods of time (from a few hours through a few years). Besides ethnographic studies, surveys, and longitudinal studies, the majority of research about TV has been conducted in the laboratory with experimental methods. Media psychology research employs large samples of people, in order to study the effect of features that exist in commercial products and content. On the other hand HCI research is focuses on the study of system development, because it is usually too late to improve a product after it has been released. TV-related research in HCI employed performance measurement, which was insufficient to predict the user satisfaction with the system (Drucker et al. 2002). Therefore, there is a need to consider both quantitative and qualitative usability evaluation methods and techniques.

In the present research, the most appropriate evaluation method was determined by the early development stage of the ITV system and the need for an alternative approach, instead of performance measurement. Since the ITV system is actually in prototype form and there are no analogous systems in the marketplace (Nielsen 1994, p.223) the most feasible method is a modified version of usability testing (Nielsen 1994, p.165) coupled with observation, interviews, questionnaires and logging of actual use (Nielsen 1994, p.207, p.209, p.217). The usability testing method was adapted for the ITV according to the selective exposure paradigm (Knobloch and Zillmann 2002) from communication research.

The majority of the usability evaluation studies that are performed in research and practice are qualitative, because they are easier and less expensive to perform and they provide with enough results to inform the development part of the usability engineering lifecycle (Nielsen 1994, p. 17). Here, the qualitative usability evaluation methods are used to complement the quantitative instruments. The quantitative methods provide explicit results for formulated hypotheses and concrete user interface issues, while the qualitative methods are used to reveal UI issues that have not been identified by the designers. As a matter of fact, the qualitative research methods

come first, in order to identify issues worthwhile of further in-depth investigation with the quantitative methods. The combination of quantitative and qualitative data for gaining a more complete picture of users has been also proposed by previous research both in information systems (Gable 1994) and in ITV (Eronen 2001). In the present work, a set of concrete UI issues has been identified from the literature review in the previous chapter and the respective set of hypotheses has been formulated, still, qualitative research methods are employed in order to identify further issues and gain more understanding about the research problem in general.

It is necessary to justify the use of a small set of methods, because the time and resources to complete a thesis are restricted. The specific method to be used depends on many factors, such as stage of design, number of expected users, and novelty of project (Nielsen 1994, p.224). Although UI design for ITV has been treated before, as described in the literature review, it poses a number of novel issues. Therefore, the focus will be on a small number of users by employing qualitative research techniques. In addition, a set of quantitative techniques will be used in order to provide initial input for further research for ITV UI evaluation methods. According to Grudin (1990), there are different evaluation methods for the different levels of the user interface focus. The interface at: 1) the programmer level is tested informally, 2) the terminal level is tested with laboratory experiment and 3) the dialogue level is tested with log analysis and observation methods. All three levels are addressed and evaluated with the employment of the respective methods and of the appropriate techniques (Table 2).

Usability Evaluation Method	**Issues**	**Used**
Experiment	Provides only quantitative results and it demands precision control	No
Usability test (informal experiment)	Provides both qualitative and quantitative results, and demands moderate design and control. *It was enhanced with selective exposure*	Yes
Survey/Ethnography	Effective identification of UI issues for deployed systems	No
Longitudinal study	The most suitable method for studying a pervasive medium, but it is difficult, time consuming and expensive to manage in the context of a doctoral thesis	No

Table 2 Usability evaluation methods that were justified for the present work

Qualitative usability evaluation may be performed either during the testing session or after its end. For the former case, the observation technique was employed (Nielsen 1994, p.207). After the end of each session, interviews were conducted with each user. In the beginning, the interviews were unstructured, but gradually, the interviews became more focused to repeating issues, mentioned during the interviews or observed during the testing session (Nielsen 1994, p.209). Once qualitative information has been gathered, it must be documented and organized in some form. In the appendix, the data collected with the qualitative research methods is presented in a matrix with lists of findings for each one the UI issues (Wickens et al. 1998, p. 61), while a detailed description can be found in the appendix. In summary, the qualitative usability techniques for the ITV prototype consisted of 1) observation during the testing session, 2) interview after the end of each session.

Quantitative usability evaluation may also be performed either during the testing session or after its end. For the former case, logging actual was employed (Nielsen 1994, p.217). After the end of each session, the users answered questionnaires that measured their emotional responses to the ITV entertainment experience. Since the experiment was designed to manipulate only the UI as an independent variable, then the differences in emotional responses may be attributed to the differences between the UIs.

The questionnaires were based on previous research from disciplines related to TV. Communication and advertising have employed and adapted research methods from psychology. But, according to Reeves and Nass (1996, p.116) the traditional psychology research is deconstructing every phenomenon to its parts, in order to study each one in isolation. That approach is helpful to identify the causality of each effect, like characters, story, elements of the setting etc, but it results in an unnatural media experience. Thus, they argue that media research should avoid that approach, because it does not have any external validity. Accordingly, the experimental set-up is designed to provide a realistic ITV experience to the user, as it was described in the prototyping section. In summary, the data collection techniques are depicted in the next table (Table 3).

Usability Evaluation Technique	**Issues**	**Used**
Thinking aloud	It reveals the cognitive process in real-time, but it is unnatural for TV users and it may influence emotional responses and involvement	No
Performance (e.g. errors, task comple-	Inappropriate for ITV	No

tion time)		
Logging actual use	Provides only quantitative results and it demands precise control	Yes
Questionnaire	Provides quantitative results, but it is not directly connected to lower level cognitive processes (affect, behavior), besides the attitudes	Yes
Observation	Unobtrusive but it does not reveal why the user performed a specific action	Yes
Interview	Provides depth into user motivations, but it is retrospective	Yes
Focus group	Reveals group dynamics, but needs skillful moderation	No

Table 3 Usability evaluation techniques that were justified for the present work

The usability evaluation methods and techniques are employed in the evaluation of an ITV prototype in Chapter 5.

3.7 APPLICATION DESIGN

The objective of the present section is to describe the approach employed for the design and evaluation of an ITV application. The literature review in chapter 2 revealed that besides the ad hoc employment of traditional usability engineering, there is no scientific research about ITV usability design methods.

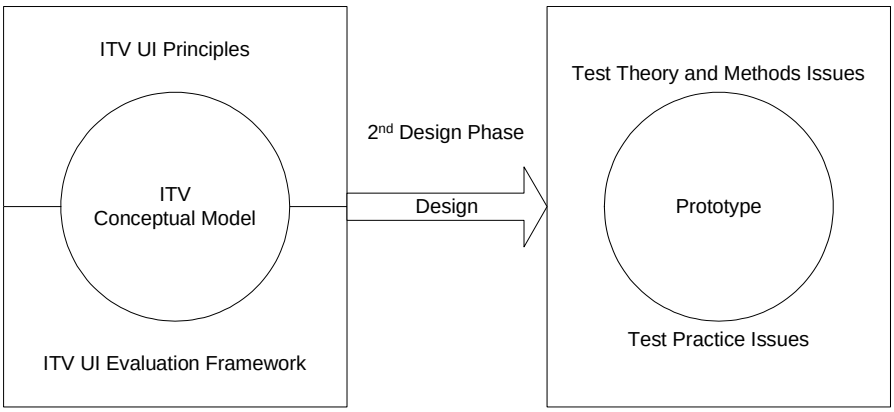

Figure 10 Methodology for the design of an ITV application

Performing hypothesis testing for an interactive application that does not yet exists, but which was the product of the present research, may seem to have little practical value, since the respective system may never materialize in the marketplace. Still, the hypotheses were carefully formulated, so that they address open issues from

previous research. Furthermore, the hypotheses were mapped to specific and pragmatic issues that are of concern for music TV channels. In summary, the prototype was constructed with two distinct objectives: In order to 1) evaluate the principal ITV UI elements developed in the first design phase and 2) test a set of hypotheses that are important for the research problem and assess the evaluation framework, which was developed in the first design phase.

3.8 SUMMARY

The usability evaluation may be considered as a part of the design process (Baecker et al. 1995, p. 73), since there are several methods like participatory design and expert evaluation that have blurred the borderline between design and evaluation. Moreover, most of the evaluation activity in the field of HCI happens during the UI development process, instead of after the deployment of a system. This is standard practice, because it is very difficult to change the UI of a finished S/W product, so changes have to be postponed until the next version, unless early usability evaluation finds the flaws during the development process.

The ITV UI is designed by employing the user-centered method that consists of the: 1) conceptual model, 2) user interface principles, 3) prototyping, and 4) evaluation with consumers. The conceptual model is identified by analyzing the established models, identifying repeating patterns, and assessing the impact of new technology on the previous two. UI principles are identified by studying previous research about TV audiences and IT developments for TV. Prototyping is performed on the basis of scenarios and according to the high-fidelity paradigm, since TV audiences are accustomed to high-quality audio-visual experiences. The prototype is constructed on a generic programming library for ITV UI development. Finally, the prototypes are evaluated by consumers, as described bellow.

The ITV UI is evaluated by employing usability engineering, consumer and advertising research methods and instruments. Usability engineering contributes user observation and log file analysis techniques, while advertising research contributes various instruments that measure different aspects of the emotional response of the consumers. In both cases, the usability test method is used to conduct evaluations with consumers interacting with an ITV prototype. It should be noted that the usability engineering lifecycle is iterative, so the aforementioned microscopic level could be

repeated indefinitely —depending on the resources and on the business goals for a given ITV product.

The first design phase is addressed in Chapter 4, and it develops a set of principal UI patterns for ITV applications. Then, in Chapter 5, the second design phase employs and validates the findings of the former, in an ITV prototype. Finally, the ITV prototype is used for assessing the hypotheses.

4 USER INTERFACE DESIGN ELEMENTS

This chapter addresses the research questions (conceptual model, UI principles, and affective usability framework) that were raised in chapter 2. Firstly, the Virtual Channel model is described by referring to the familiar and the emerging patterns of the ITV user experience. Next, the UI principles are formulated by achieving a balance between the established TV watching behavior and the opportunities offered by IT. Finally, the affective usability evaluation framework is constructed by employing methods both from HCI and consumer research. In addition to the research questions, there is coverage for the programming library and the prototyping platform.

4.1 OVERVIEW

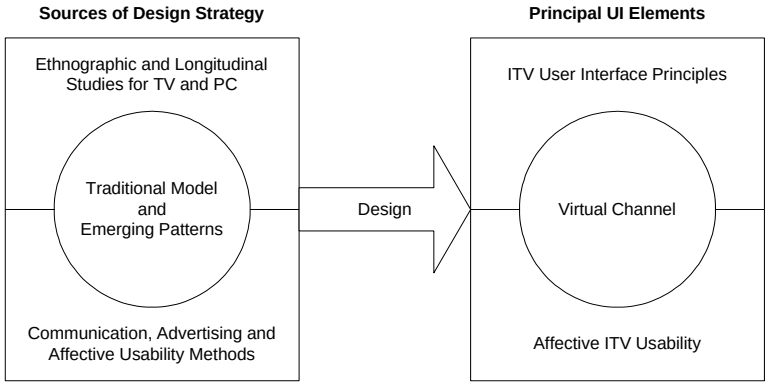

Figure 11 Design method from the sources of strategy to the identification and formulation of the principal UI elements for the design of ITV applications

In order to address the research questions, the literature review extends beyond HCI to include communication research, advertising research and broadcast engineering. These disciplines have been studying television content, television audiences and television technology for a long time. Here, the objective is not to locate open research issues in the respective disciplines, but to locate possible design strategies that are related to the three research questions: 1) conceptual model 2) UI principles and 3) affective usability evaluation for ITV. In the following sections, findings from these disciplines are retrieved from the respective literature and they are combined with

the traditional IT oriented HCI literature in order to devise principles and methods suitable for ITV UI design (Figure 11).

4.2 VIRTUAL CHANNEL MODEL

The conceptual model was formulated after a thorough investigation of the evolution of the established conceptual model for TV (for the identification of familiar patterns) and a literature review of the most recent academic research for ITV (for the identification of emerging ITV patterns).

4.2.1 Familiarity with the Traditional Television Channel

The ubiquity of broadcast transmissions has established a universal method for access to media programming. The television channel is a familiar concept for providing easy access to audiovisual content across all user groups. Different TV channels provide competing assortments or themed TV content. As a matter of fact, the log analysis of the use of a digital video library system revealed that the most popular method for accessing stored TV content in a digital video library was mainly by channel, and then by theme (McDonald et al. 2001). Previous research has proposed the notion of the channel repertoire, which is the number of available television channels that viewers choose to watch, typically fewer than a dozen, and can be distinguished to two types: 1) Mindful channel repertoire (MCR) is the number of channels that viewers freely recall watching, and 2) total channel repertoire (TCR) is the number of channels that viewers remember watching if aided recall is used (Ferguson and Perse 1993). Therefore, the TV channel is a familiar concept and viewers are loyal to a small set of channels.

It is usually assumed that the introduction of new technology results to increased interactivity and choice, but there is evidence that this opportunity does not always materialize for the case of the TV channel repertoire. Ferguson (1992) found that the impact of the VCR and the remote control on the channel repertoire did not substantially increase the number of channels that viewers watch. Moreover, the channel repertoire did not change significantly even in cable homes where there are 7 times as many channels available as can be viewed on public TV broadcasts. Those results indicate that having more channels or more opportunities to navigate between available channels does not mean the viewer will automatically watch them. Therefore, new technologies should be used to enhance the existing channels, instead

of increasing even more the number of available channels or instead of putting more effort into devising novel navigation schemes (such as the EPG) between the available channels.

The notion of the TV channel is strongly coupled with the notion of push. Despite the fact that the push mentality of the television broadcast system has remained seemingly unchanged for the past few decades, a careful examination of the history of the TV reveals a constant stream of innovation and evolution toward the personalization of the TV experience along two distinct dimensions: 1) Spatial personalization that refers to the dynamic insertion of information overlays and to the spatial arrangement of the video content and 2) temporal personalization that refers to the TV experience being detached from the real-time broadcast schedule.

Spatial Personalization

The first technology to alter the notion of the one-size-fits-all character of the television broadcast is closed captioning (Figure 12, top left). Closed captioning was conceived as a service for people with hearing disabilities. It provides text captions for popular television programs like news and movies. Closed captioning was implemented by exploiting an invisible part of the television signal, known as the Vertical Blanking Interval (VBI). Closed captioning is using only the line 21 of the VBI to transmit text captions. The presentation of closed captioning is optional for the viewers at each TV set that supports the decoding of line 21 of the VBI. Thus, the technology needed to support this functionality is only an extension of the available infrastructure. At the broadcast station a terminal is used to type the text captions and a multiplexer to insert the text captions into the line 21 of the TV signal. The TV set should have a de-multiplexer to read the line 21 of the VBI and a video mixer to embed the audiovisual signal with the text captions.

Consumer interactivity with television went beyond channel changing with the introduction of Teletext (Figure 12, top right). Most TV sets support decoding and presentation of Teletext pages either over a solid background or overlaid to the respective TV channel. Teletext has been very popular with consumers and it has become a medium by itself, alongside the medium of television. Lately, the Teletext usability has been improved considerably by employing caching of the VBI information. For example, there are consumer level TV sets that allow the storage of one thousand Teletext pages, thus offering immediate browsing and access to whichever page, without considerable delay. Teletext usability has been further improved for DTV. The latest versions of DTV Teletext have been separated from the constraints of

the VBI. DTV Teletext is an application that runs on each STB and allows alternative navigation paradigms, beyond the number of the Teletext page and the four colored buttons.

The introduction of digital broadcast transmission allowed television producers to insert numerous meta-data, executable code and additional information inside the TV signal. DTV systems offer an electronic program guide (EPG) and short information about each TV program (Figure 12, bottom left). A natural extension of the functionality of related information would then be to offer on-demand information about sport game statistics, information about music video clips, etc. Advanced DTV systems (e.g. OpenTV) support download and local execution of interactive applications. One successful type of application is the interactive quiz game that can be played at each household separately, alongside with the live studio contestants (Figure 12, bottom right). It becomes evident that contemporary TV systems are either taking away the control of the related information from the TV director or they are making the consumer an active participant in the TV experience.

Figure 12 The evolution of the spatial personalization of TV content: From closed captioning (top left), to Teletext (top right), to DTV now plays information (bottom left), to interactive quiz games (bottom right)

Overall, consumers have become familiar with the idea that information and interactivity related to TV content is not anymore fixed to the broadcast video and may be displayed on the TV screen at their own convenience, thus enabling the spatial personalization of the previously fixed TV experience.

Temporal Personalization

The first technology to alter the notion of the synchronized TV transmission and TV watching was the VCR. It was introduced in the early 1970's by JVC (VHS format) and Sony (Betamax format) and was marketed as a time-shifting device that allowed consumers to record their favourite TV content and to watch it at their own convenience. The rest of the history of the VCR is still a case study for the media industry. The broadcasters and the content owners were negative to the VCR, because consumers would be able to create libraries of copyrighted content. It is now acknowledged that the VCR has actually increased revenues for the copyright holders, through movie buying and rental. In brief, the history of the VCR gave two lessons: 1) consumers want on-demand access to TV content in the home and 2) consumers need a simpler to use video recorder.

In the early 1990's, numerous ITV trials by the media and the telecommunication industry put their efforts on delivering VOD. Consumers were interested in having VOD, because the functionality was similar to that of a movie rental and to that of a VCR, all at the same time, but the cost was prohibitive for the service providers. The introduction of the DVR in the late 1990's resolved the issue of usable video recording in the home. Recording TV content is straightforward and undemanding, because the DVR has adequate intelligence to find the necessary space on the HDD and to index automatically the recordings by checking the broadcast metadata on the Internet. In addition to usable recording functionality, the DVR offers automatic recording and recommendation of new TV content.

Overall, consumers have become familiar with the idea that TV content is not anymore tied to a broadcast schedule and that it can be manipulated along the dimension of time, thus enabling the temporal personalization of the TV experience (Figure 13).

In conclusion, the above examples have as a common denominator an evolving separation between the broadcast signal and the way the users experience television. Previously, the television channel was experienced in the same way as it had been transmitted. Contemporary enhancements of the broadcast transmission system, platforms' convergence and the introduction of the video recording devices allowed

the total manipulation of the TV channel along two dimensions: 1) temporal and 2) spatial personalization.

Figure 13 The evolution of the temporal personalization of TV content: From the tedious recording procedure of the analog VCR (left) to the instant pause of live TV with TiVo (right)

In the next section, the spatial and temporal dimensions are identified in the previous scientific research for ITV applications, alongside with the emerging patterns of ITV usage.

4.2.2 Patterns Relevant to Interactive Television

Besides the above product developments, spatial and temporal personalization for TV continues to be an ongoing research effort, as it is described below. It is demonstrated that these properties have been hovering for a long time in ITV related research. Thus, the objective of this section is to identify a common underlying conceptual model as an integrating framework of previous dispersed work and to provide a common vision for the ITV experience. Accordingly, the presentation of the previous works is organized in three sections: a) spatial personalization, 2) temporal personalization and 3) integrated spatiotemporal systems.

Spatial Personalization

The spatial personalization property refers to the enhancement of the original broadcast TV content with additional sources of information that may be textual, audiovisual, or computer generated. Sodergard et al. (1999) proposed the integration of TV and newspapers for the creation of personal channels. They implemented a UI for access to TV content and news through the Web, but the UI for the TV is based on pages that are static, like the Teletext. Enhancing the TV content with additional information from the Internet has been the theme of previous research (Dimitrova et al. 2003; Livingston et al. 2003). In addition, it was proposed that computer generated

TV content may be produced at each digital STB, since computer graphics have reached the TV video in terms of quality, after the introduction of the latest generation of video-game consoles (Dempski 2002) and that 3D graphics may be mixed with TV content in real-time (Marrin et al. 2001; Rafey et al. 2001), thus, further enhancing the opportunities for the spatial personalization of the TV content. Nevertheless, none of the previous works made an explicit identification of the underlying property of the spatial personalization for ITV applications.

Temporal Personalization

The temporal personalization property poses the requirement that the source video material should be segmented and indexed for a number of video-clips. Content retrieval from distinct video-clips was studied before (Dimitrova et al. 2001) and it was found that users see more value in segmenting non-narrative programs (e.g. news) than narrative programs (e.g. movies). Drucker et al. (2002) proposed a UI that detects scene changes in raw video content that was stored without any indexing. Their SmartSkip UI depicts the transition points with thumbnails, along a timeline that can be zoomed upon. The SmartSkip UI is an effective way to navigate in raw video material (which is good for home video and analog TV), but it neglects that there are many indexing and meta-data schemes for the commercial DTV content. Dynamic video synthesis for narrative content was considered in previous research (Agamanolis 2001), but it is beyond the scope of the present research work. In summary, once digitally stored on a HDD and indexed with related data, the TV content is set free from the constraints imposed by the medium of broadcast, and can therefore be manipulated in countless different ways. Nevertheless, none of the previous works made an explicit identification of the underlying property of the temporal personalization for ITV applications.

Spatiotemporal Systems

The vision of an integrated multimedia experience was first described in early works for interactive digital video (Fox 1989). That research concerned optical media, but it addressed the major elements of a spatiotemporal ITV system, such as real-time video and interactive elements, both generated from a PC. One decade later, researchers from Sony proposed the dynamic synthesis of material and offered an overview of the architecture and the implementation (Gonno et al. 2000; Gonno et al. 2001). An integrated temporal and spatial personalization scheme was suggested for the first time for TV news content (Merialdo et al. 1999). Despite not being presented

in generic terms and having as its sole focus the TV news content, they offered a solution for personalizing TV news content by employing video-clips that have been captured from TV broadcasts and news captions retrieved from the Internet. Similarly, Marin et al. (2001) treated the case of TV news without generalizing to the concepts of spatial and temporal dimensions of the ITV content. Nevertheless, they identified the need to integrate the elements offered by WebTV (spatial personalization) and TiVo (temporal personalization) into a coherent service and they proposed an architecture that complements the TV video with real-time mixing of 3D graphics. An additional shortcoming of those works was that they do not consider a UI for ITV consumers, and instead, they rely on a desktop UI for the presentation and selection of the personalized news content. As a matter of fact, they do not consider the consumer and they do not perform any kind of usability evaluation for the proposed system. Finally, there are a few EU-funded research projects (e.g. NexTV, ICE-CREAM) that have developed a spatiotemporal vision for ITV. Nevertheless, none of the above works provides an explicit identification of the underlying properties or any generic conceptual model for ITV applications.

In summary, previous research has addressed all of the properties and features of an emerging model, and there are a few more additional and complementary directions (Responsive Television and Steerable Media). Still, in all cases, previous works have addressed specific types of TV content for either of the two main properties, thus lacking any generality of the solution beyond the respective TV content type. Furthermore, there has not been any systematic treatment of the user interface issues that arise from the extension of the TV toward dynamic spatial and temporal personalization. In contrast, the present work develops a generic model for ITV applications, which is described in the next section.

4.2.3 Outline

The notion of the Virtual Channel refers to the television channel not being a static audiovisual experience that is shared by all TV viewers in the same way, but a dynamic synthesis of discrete video, graphics, and data controlled at the consumer's digital STB. The traditional television experience consists of video and overlaid graphics-text and it is created at the media source (the TV broadcast station or the TV production studio), thus it is fixed for all TV viewers. The Virtual Channel model (Figure 14) shifts the decision-making about TV programming from the media source to the STB. The television experience is now created and controlled at the STB from a

combination of locally stored material, real time broadcast transmissions, and Internet resources. Therefore, the Virtual Channel model augments the familiar access method to broadcast programming (i.e. the simple notion of a channel), to an integrated model for accessing multimedia content from diverse sources.

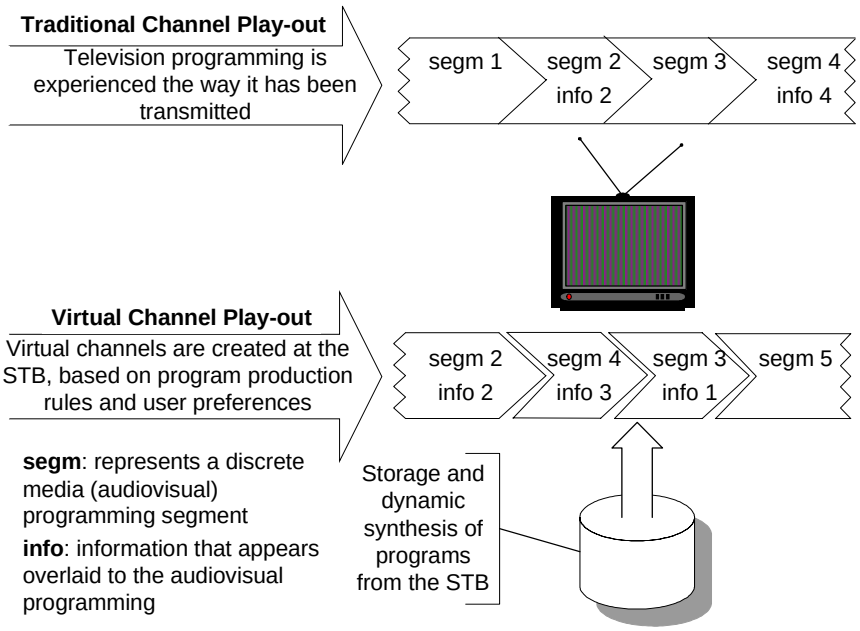

Figure 14 A generic model of a system employing the virtual channel metaphor, in contrast with the traditional broadcasting scheme

Every ITV application can be described along two dimensions:

- Temporal personalization via dynamic video synthesis: The local storage can be used to produce dynamic flows of television channels. ITV applications should support continuous video flow by default, unless consumers actively select to stop the video.
- Spatial personalization via dynamic video overlay: Traditional television content remains at the core of ITV services and can be optionally enhanced with time-driven interactive elements (user interfaces) and with additional personalized information that appear inside unobtrusive semi-transparent dialogs.

It is worthwhile noting that the temporal personalization property relates to the research issue of navigating television content from the STB's local storage (consumer-level video skipping). Similarly, the spatial personalization property relates to the research issue for the presentation style of related information (animated character).

The organization of media content into a small number of spatiotemporally personalized virtual channels simplifies the choice from a vast array of available broadcasts, stored programs and Internet resources. The presentation of media programming from virtual channels gives the potential for more control to the user, who can actively shape the televised content. The Virtual Channel model suggests only a minimal shift from the current patterns of media use, while it focuses further research on the design of a content specific UI and personalization schemes for managing a virtual channel.

In the next section, the Virtual Channel model is defined formally.

4.2.4 Semantics

The Virtual Channel model was broadly defined as a personalized TV channel, which can be dynamically adapted along the temporal and the spatial dimension. In this section, it is analyzed into specific objects and actions. The objects and actions analysis employs a template* for the description of the Virtual Channel model. The dimensions of the template are presented in the table bellow. Each element is then defined by answering the respective questions.

Element name	A name that is descriptive of the properties and actions that are exposed by the element
Description	What does the element do? What is its rationale and intent?
Properties	Which properties are needed to distinguish between different instances of the element?
Actions	Which actions are possible on the element?
Appearance	How does the element look and feels to the user?
Limitations	Are there any limitations?
Related elements	Which elements are related to this element? What type of relationship they have?
Example Use	Give a few example uses of the element

Table 4 Template used for describing the semantics of the Virtual Channel model

The Virtual Channel model consists of the following objects (Figure 15).

* The template is based on the popular 'Gang of Four' template for software patterns (Gamma 1995). There are a few changes to the template, because, in the present discussion, the patterns refer to a conceptual model for user interface design and not to software code.

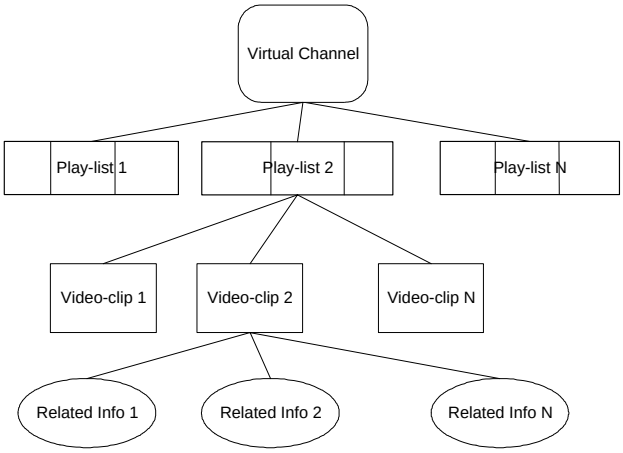

Figure 15 Object hierarchy in a virtual channel

The *video-clip* is a distinct audiovisual item, such as a news story, or a music video. A video-clip is usually displayed in full-screen or it occupies the largest share of the screen. There may be exceptions, such as the channel mosaic, in which a few video-clips share the TV screen, in equal parts. A video-clip may also play a secondary role, as described in the ancillary data concept. The video-clip together with the ancillary data concept resembles the MPEG21 Digital Item definition. Yet, that is a model that corresponds to a technical implementation, while the Virtual Channel is a conceptual model that does not have any specific implementation requirements (i.e. it defines how designers should think about UIs for ITV applications).

Element name	Video-clip
Description	The video-clip is the core element of the established TV experience. TV programs are produced at the studio by assembling together video-clips. ITV applications manipulate dynamically a collection of video-clips A video-clip is a distinct audiovisual atom. Distinct atom means that the video-clip makes sense to the user and it can be watched by itself
Properties	A video-clip has a name A video-clip may have any number of additional metadata that describe its content, author, purpose, etc
Actions	Play, stop Display: name, ancillary data, additional properties
Appearance	A video-clip is usually displayed in full-screen, or it occupies the largest share of the screen, but there may be exceptions, such as the channel mosaic, in which, a few video-clips share the TV screen A video-clip may also play a secondary role to another

	video-clip, as described in the ancillary data element
Limitations	There are some types of ITV applications that do not require any video-clip, such as the EPG. Yet the EPG is becoming obsolete in a virtual channel environment The current definition of the video-clip does not cover the case of dynamically editing a new distinct audio-visual item
Related elements	Video-clips are linked to ancillary data Video-clips are organized into play-lists
Example Use	A news story, or a music video

The *play-list* is a queue of video-clips. Since the video-clips are stored on a HDD, the queue can be updated dynamically, at any time. The video-clips may be physically stored in a file-system structure, but the play-list arranges them as a continuous flow of audiovisual content. The play-list may be controlled either by the broadcaster, or by the consumer (or some combination of both).

Element name	Play-list
Description	The play-list is a vector of video-clips A traditional TV program can be defined as a linear fixed flow of video-clips ITV applications are programs that manipulate the queue of the video-clips dynamically, based on the properties of the video-clips, the profiles of the users, and broadcaster rules
Properties	A vector of video-clip identifiers Type (TV content, advertising break)
Actions	Skip to next/previous video-clip Alter the video-clip queue. There are many ways to alter the queue. The most straightforward is to display the video clips names and let the user change the flow. Play-list navigation is based on the attributes of the video clips
Appearance	The video-clips may be physically stored in a file-system structure, but the play-list arranges them as a continuous flow of audiovisual content. The play-list may be controlled either by the broadcaster or by the consumer.
Limitations	
Related elements	Play-lists belong to virtual channels Play-lists consist of video-clips
Example Use	A play-list of music video clips creates a music TV program, such as the Top20 on MTV

	Music TV navigation may include actions such as stop, play, next, previous, repeat, just like a normal CD player Further navigation options may be available for music videos, such as selection of genre, artist, mood, tempo, decade, etc.

A virtual channel is a computer program that manipulates a collection of one or more play-lists. A virtual channel may be created and controlled by the broadcaster or by the consumer. For example, a music TV broadcaster may create an interactive complement to the existing channel, or a consumer may arrange a virtual music channel by selecting the favorite music video clips from local storage. Moreover, a virtual channel may be part of a broadcast channel, or be a totally independent entity. For example, a broadcaster may choose to create personalized advertising breaks that are inserted in the place of the static advertising breaks in the broadcast TV channel. An independent virtual channel is created by arranging the available content (video-clips and ancillary data) in play-lists and by retrieving additional content from the broadcasts and the Internet.

Element name	Virtual channel
Description	A virtual channel is an interactive, personalized, and locally generated audio and video stream that merges broadcast content, locally stored time-shifted material, interactive features, and material transmitted using out-of-band mechanisms. A virtual channel may be created and controlled by the broadcaster or by the consumer A virtual channel may be combined with a broadcast channel or be a totally independent entity A virtual channel is created by arranging the available content (video-clips and ancillary data) in play-lists, and by providing a navigation scheme
Properties	A collection of one or more play-lists
Actions	Switch to another virtual channel Define/edit/delete a virtual channel
Appearance	The virtual channel appearance is the combined appearance of the play-list and the navigation
Limitations	Does not regard story-driven content
Related elements	Play-list Navigation
Example Use	A music TV broadcaster may create an interactive complement to the existing channel, or a consumer may

	arrange a virtual music channel by selecting the favorite music video clips that are stored in a HDD A broadcaster may choose to create personalized advertising breaks that are inserted in the place of the static advertising breaks in the broadcast TV channel

Multiple items of ancillary data are linked to each video-clip and they can take many forms, such as video-clip, image, text, application. Ancillary data appears overlaid or at the edges of a video-clip that is a part of the running play-list. Ancillary data is synchronized (temporally and spatially) with the video-clip it is linked to. A simple form of ancillary data is the text captions that are related to the running video-clip (e.g. closed captioning, information about music video, news ticker, stock ticker). The definition of ancillary data may be extended to include items that are loosely related to the running video-clip. For example, a quiz game may offer to the viewer the opportunity to play alongside the studio participants.

Element name	Ancillary data
Description	Multiple items of ancillary data are linked to each video-clip and they can take many forms, such as video-clip, image, text Ancillary data may provide depth or breadth of information about a video clip
Properties	Ancillary data is synchronized (temporally and/or spatially) with the video-clip it is linked to
Actions	Show, hide Navigation for ancillary data depends on the category and the specific attributes of an item (video clip, text, image, application)
Appearance	Ancillary data appears overlaid or at the edges of a video-clip that is a part of the running play-list The simplest form of ancillary data is a list of the names of the video-clips in the play-list Another form of ancillary data is the text captions that are related to the running video-clip
Limitations	
Related elements	Ancillary data is linked to a video-clip
Example Use	Closed captioning, information about music video, news ticker, stock ticker

Finally, the concept of navigation applies to play-lists and to ancillary data. There are a few generic navigation actions, but, in general, the navigation is based on the properties of the respective items. In particular, play-list navigation is based on

the properties of the video clips. For example, music video navigation may include generic actions such as stop, play, next, previous, repeat, just like a normal CD player. Further navigation options may be available for music videos, such as genre, artist, mood, tempo, decade, etc. Navigation for ancillary data may depend on the category and the specific attributes of an item. For music TV example, text information about a music video clip can be browsed sequentially, or organized in categories, such as biography, discography, trivia, etc.

Employing a template to describe the model's semantics validated the comparative power of the Virtual Channel model. The fixed TV channel can be described using the same set of elements (objects/actions), thus validating the descriptive power of the proposed model. Moreover, in the next chapter, the UI design for a music ITV application is discussed as a refinement of the generic set of conceptual model elements, thus validating the generative power of the proposed model.

4.2.5 Reference Architecture Elements Requirements

The semantic details of the conceptual model should be mapped to an implementation architecture that considers the technical features of the ITV domain. Therefore, Virtual Channel programming library for ITV should support the following features:

- Broadcast: The real-time broadband reception of the TV signal remains at the core of the future ITV as an efficient means of transferring popular objects. An ITV application "listens" to the broadcast channel and retrieves new objects (An ITV application may be also self-updated through the broadcast channel)
- Local storage: An ITV application fetches objects from the broadcast channel or the Internet and stores them locally.
- Internet resources: Data broadcasting may be used to provide real-time updates of popular objects, but the Internet is more flexible for providing personalized objects to a diverse audience.
- Continuous video flow: A TV screen that stays still is beyond the previous experience of consumers and will feel unfamiliar. ITV applications should support continuous video flow by default, unless consumers actively select to stop the video.
- Video overlays: Traditional television content remains at the core of ITV services and can be optionally enhanced with interactive elements (user interfaces) and with additional personalized information that appear inside unobtrusive semi-transparent windows or at the edges of the screen.

- Advertising breaks: The cost of TV production is very high and it has been traditionally supported by advertising, at least at some part, which is the case even for subscription schemes. ITV could also enhance the traditional advertising models with personalization and new advertising schemes (e.g. dynamic advertisement insertion, interactive advertisements).
- Time-driven Vs user-driven UI: The appearance of an ITV element on screen can be triggered by the user, but for the most part it is the producers' rules that define when the consumer may interact with additional content.

Each one of the above features refines the definition of the Virtual Channel model one step further towards the required implementation architecture. Besides the broadcast and the Internet resources properties, the rest of them were implemented in a programming library, which is described later, in this chapter.

The Virtual Channel model is appealing because it complements previous research and because it augments the traditional TV broadcast scheme. In the next section, practical considerations for implementing the Virtual Channel model are discussed.

4.2.6 Practical Considerations

The Virtual Channel model is backward compatible with the established broadcast transmission and the emerging DVR functionality. It poses the feasible requirement that consumers have a DVR and that broadcasters provide meta-data for their TV content. In this section, the technological requirements are outlined and the technological developments that make the Virtual Channel model feasible are identified.

For consumers, there are two alternative choices in order to benefit from application that are based on the Virtual Channel model. The first choice is that the household is equipped with an advanced digital STB. The H/W specification of the respective STB is identical to that of a multimedia PC, with the addition of a broadcast receiver, a real-time video encoder and a HDD of large capacity. In terms of OS S/W, either Windows or Unix is suitable, although both should be adapted for displaying to a TV and getting user input from a remote control.

The existence of a full-featured DVR is not a perquisite for implementing the Virtual Channel model in domestic settings. An alternative choice is a TV with a LAN connection or a network computer (thin client) that stream the ITV experience from a home PC located elsewhere in the household. In that case, the PC should be equipped with a broadcast receiver card, in addition to the Internet and LAN connec-

tion, HDD and the Virtual Channel software. It is an open technical question how much functionality will reside within the PC (server) and the thin client.

In practice, a DVR that is used for the recording of TV content (such as TiVo) may be immediately enhanced with virtual channels (Whittingham 2000, p.22). In conclusion, the Virtual Channel model can be introduced to consumers by exploiting the current generation of IT and CE products.

For broadcasters and content providers, the implementation of the Virtual Channel model sets a few requirements in some parts of the broadcast chain and it demands the introduction of new building blocks that have been solely part of the IT industry. The requirements that are posed by the Virtual Channel model affect mainly the TV production workflow, in order to support the dynamic synthesis of interactive entertainment at the consumer STB. For example, a music channel that decides to offer a virtual channel to consumers needs only to provide meta-data for the music video-clips within its broadcast schedule. Then, an ITV service would employ a personalization scheme to choose the video-clips to record and would offer a navigation scheme to the consumer for the spatiotemporal personalization of the ITV content. Moreover, it would offer the related information and optional ecommerce functionality, through the integration with an Internet entity. The above requirement may be implemented with existing technology, such as the analog broadcast or the DVB and the Internet. The MPEG and XML technology may also be used, in order to provide structured meta-data for the TV content, as discussed next, but this is not a prerequisite.

The Virtual Channel model can be implemented even over traditional non-digital broadcast systems. A pre-condition is the existence of a digital STB at the consumer's home and a digital production workflow at the broadcast station. Moreover, both the transmitter and the receiver ends should provide support for the VBI, which can be used for annotating and structuring the invariably linear broadcast. A television news show will be assembled at the broadcast studio and transmitted as normally, with the addition of meta-data into the VBI that describe and structure the linear audiovisual analog broadcast. Then, the digital STB will use the VBI information to store and organize the video segments. The annotation and recording equipment should have very high precision (at least 1/25 sec), otherwise a video segment may contain portions from the next or the previous one. VBI metadata can be also used to retrieve information from Internet resources (Livingston et al. 2003). Alternatively, the Internet may be used for posting the meta-data information about the analog broadcasts, which is a practice that has been successfully followed by TiVo for the

EPG and the automatic recording features. Since most countries have a plan to switch from analog to digital broadcasts sometime within the current decade, such a system would be only useful for the transition period.

The characteristics and the additions in the evolution of the MPEG (Moving Picture Experts Group) standard are reflective of the movement toward structuring and describing audiovisual content, and linking it to related information and delivery platforms and devices. The MPEG standard begun by offering coding, in order to compress the audiovisual content for more cost effective storage and transmission without noticeable loss in quality. Later on, the MPEG standard evolved to offer descriptors for the audiovisual content, in order to improve indexing, search and retrieval and in order to link the audiovisual content with related content. In particular, the MPEG1 offered audiovisual coding for efficient digital storage. Next, the MPEG2 offered audiovisual coding and meta-data for high-fidelity transmission and storage (Broadcast, DVD). Since the MPEG4 standard, the focus has shifted from the coding to the description of the audiovisual content, in terms of the objects (natural or synthetic) contained. The MPEG7 offers rich meta-data and an XML schema for describing audiovisual content. Finally, the MPEG21 defines a framework for the consumption of multimedia content across diverse platforms. The MPEG 21 also offers content identification, copyright information and digital rights management (DRM), which has become a prominent issue due to the increased digitization and sharing of content on the Internet.

With the introduction of Synchronized Multimedia Integration Language (SMIL, pronounced smile), multimedia creators have an accessible tool-set for building time-based, streaming multimedia presentations that combine audio, video, images, and text. The SMIL standard defines an XML-based language that allows control over the what, where, and when of media elements in a multimedia presentation with a markup language similar to HTML. SMIL is very efficient for delivering streaming presentations over Internet, because the images and text are combined on-the-fly with transition effects at the client side. In the case of video clips, which constitute the main part of the Virtual Channel model, the bandwidth gain is not considerable. Assuming that video clips are pre-recorder in a home media gateway, then SMIL is a practical choice for implementing the Virtual Channel model for a variety of terminal devices in the home (TV, PC, mobile).

In summary, the commercial implementation of the Virtual Channel model has several S/W and H/W requirements on both ends of the broadcast chain. It can be argued that in terms of the technical requirements, the Virtual Channel model can be

immediately implemented and deployed as a consumer product. The building blocks for the implementation of the Virtual Channel model are all readily available. Therefore, the Virtual Channel model is far from being simply a theoretical proposal for ITV application development. Correspondingly, an effort for implementing the respective API has been made in the context of the present work.

4.3 PRINCIPLES AND TRADE-OFFS

The literature review in chapter 2 revealed that besides the employment of traditional UI design principles and a few guidelines for the EPG, there is almost no scientific research about generic UI principles for ITV applications. In addition, there is a need to consider the domestic television watching experience. Differences in audience behavior factors, content production, and distribution channel, affect the design of UIs for ITV. The objective of the present section is to formulate a few generic design factors that affect UI design for ITV applications (research question 2). The design factors are formulated after a systematic and critical review of previous research in: 1) ITV, 2) traditional TV and 3) IT for the PC and the Web.

4.3.1 Study of Media Consumption in the Home

The role of ethnographic research in the home, regarding the use of the STB class of devices, is instrumental. Early studies of digital media use in the home indicate that there is an important technology-driven shift in the household's media consumption patterns every decade or so. In the 80's there was the PC (Vitalari et al. 1985) and in the 90's there was the Internet (Kraut et al. 1998). The trend towards DTV transmission, local storage and manipulation of TV content is expected to have an impact on the domestic media consumption patterns, too. Ethnographers have already studied the case of the digital STB (O'Brien et al. 1999). In addition to ethnographic research, useful insights can be gained from studying previous research, regarding the use of traditional television. Advertising researchers have identified a number of fundamental uses and gratifications that people seek from television watching (Kaufman and Lane 1994; Lee and Lee 1995). Finally, there are two in-depth longitudinal studies of TV consumption that offer numerous insights regarding the complexity of behaviors related to TV watching (Gauntlett and Hill 1999; Kubey and Csikszentmihalyi 1990). The above works were studied in order to identify the established patterns of TV watching and they were contradicted with the corresponding IT patterns of PC

and Web usage. The results were formulated in factors that affect the UI design for ITV applications.

It is usually assumed that TV viewers are always concentrated on the TV content and that ITV will bring a multitude of channels and choices, but there is ample evidence that TV usage takes many forms, as far as the levels of attention of the viewer are concerned. Jenkins (2001) opposes to the popular view that ITV will support only the needs of the channel surfers by making an analogy: 'With the rise of printing, intensive reading was theoretically displaced by extensive reading: readers read more books and spent less time on each. But intensive reading never totally vanished.' Recent research for an ITV documentary has confirmed experimentally the existence of readers and skimmers, as two distinct groups of TV viewers (Cappelletti et al. 2003). In addition, Lee and Lee (1995) found that there is a wide gamut of attention levels to the television set —from background noise to full concentration. For example, a viewer may sit down and watch a TV program attentively, or leave the TV open as a radio and only watch when something interesting comes-up (Clancey 1994). These findings contrast 'to the image of the highly interactive viewer intently engaged with the television set that is often summoned up in talking about new possibilities.' (Lee and Lee 1995) Therefore, UI designers should consider the multiple levels of attention to the ITV application.

The most remarkable difference between the PC and the TV is the number of people involved in each of the two activities. PC usage is always performed by a single person, while TV watching is considered as a social activity (Gauntlett and Hill 1999, p.35) and it might provide a better experience when watched with family members (Kubey and Csikszentmihalyi 1990; p.111). Recent research for an ITV adaptive instructional program confirmed that people tend to choose the TV content that would fit the preferences of a certain group of viewers (Masthof 2002). Group adaptation has been also studied for the case of movie genres and it was found that for a given group of people the suggested TV content was better liked when the system considers the profiles of the respective group (Goren-Bar and Glinansky 2002). Therefore, ITV designers should balance between the need of single and group ITV usage.

The study of TV consumption in the home reveals that TV viewing is usually a planned activity, which is a finding that sharply contrasts with the focus on the EPG as a method to select a program to watch each time a user opens the TV. In particular, a longitudinal study found that two-thirds of the time the TV will be on for an already-familiar program (Gauntlett and Hill 1999, p.32). Ritualized TV viewing was

also confirmed by a survey, in which 63% of the respondents had watched the program before and knew it was going to be on (Lee and Lee 1995). Moreover, communication researchers found that viewers recall fewer than a dozen of TV channels (Ferguson and Perse 1993). Nevertheless, there is always a fraction of the viewers that impulsively select a program to watch, especially among the younger demographic (Gauntlett and Hill 1999, p.35, p.37). In summary, the UI of an ITV application should consider multiple levels of planning (from channel surfing to appointment viewing) regarding the TV channel and content selected from viewers.

Design Factor	Description
Low Vs High Attention to Television	There are multiple levels of attention to television
Group Vs Individual Watching	ITV UIs should handle either group or solitary use and it should provide means of adapting to different situations if both are desirable
Planned Vs Impulse Program Selection	Viewers are usually loyal to a small number of programs, but now they are faced with an increased number of channels and ways of viewing their favorite programs

Table 5 Audience behavior factors that affect the design of ITV

Table 5 summarizes the most important and relevant to the case of the ITV UI design factors that consider the user from a media consumption point of view. Human centered design of ITV applications should address and explicitly offer a resolution strategy for those factors that are relevant to the problem at hand.

4.3.2 Interactive Content Creation

The introduction and wide adoption of the Web has been promoted and attributed to the interactive nature of the new medium. It often goes without much thought, that if something is interactive then it is also better and it will be preferable. Interactivity with the user might be considered as the principal element of ITV, but there is evidence that interactivity may be disruptive to the entertainment experience. Vorderer et al. (2001) found that there are some categories of users who do not like to have the option to change the flow of a TV story; they just prefer to watch passively. However, the passive uses and emotional needs covered by the broadcasted media are either desirable, or, in some cases, they have an implicit interactive nature that takes place outside the medium itself (Lee and Lee 1995). An example of the latter is the social interaction that takes place in groups of TV viewers, or the virtual-competition

with the televised players of quiz programs. Nevertheless, there are other cases such as video games, in which the addition of interactive elements enhances the entertainment experience, especially for young people (Malone 1982). Therefore, explicit interactivity with the user should be justified and in most cases of ITV content it should not be enforced to the user. In other words, the ITV experience should be a continuous flow without the need for user intervention, unless the user desires to affect the flow.

Recent evidence with ITV applications has also revealed that whatever is presented on the TV screen is assessed in comparison with the established television aesthetics. Computer-like menus, pages and complex navigation look irrelevant on a TV screen, even when used by experienced computer users (Lekakos et al. 2001a). It has been also found that ITV producers prefer a TV-values information design and story-driven content (Jaaskelainen 2001, p.5). An additional difficulty in the domain of ITV UI design is the interface's inability to stay attractive over time. The established television grammar requires all programs as well as presentation styles to be dynamic and surprising (Meuleman et al. 1998), which is in sharp contrast with traditional usability principle of consistency (Nielsen 1994, p.132). It is suggested that the most useful insights about the creation of interactive content and interactive experiences may be contributed by video-game design (Malone 1982). In summary, the interactive elements borrowed from the PC and the Web, such as menus, buttons, icons, links, should be re-examined for the case of ITV. It is unlikely that UI standardization would be of any help for the case of ITV. Rather, creativity and emotional impact should guide the visual design of an ITV UI.

Nevertheless, TV content is not only about emotional gratification. The TV offers a wide variety of content that spans from pure entertainment to pure information. For example, a music channel offers entertainment content for teenagers and young adults, while a financial news channel offers information content for the investors. It is not always clear which type of content a TV channel offers, but there is usually a focus on either of the two dimensions. Furthermore, from a media psychology perspective the entertainment experience is largely subjective, so the value of a piece of ITV content cannot be determined in-advance (Vorderer 2000). In many cases, it is suggested to employ informational elements in order to augment entertainment content (Livaditi et al. 2003). For example, a music video channel could insert information related to the video clips, such as trivia, discography, which is a practice that was successful for the commercial music video channel MTV. In summary, it is sug-

gested that depending on the nature of the ITV content and the profile of the user the UI should support a combination of entertainment and information elements.

The insertion of computer generated graphics inside the TV content is an established practice that is usually performed in the broadcast studio. Computer graphics may be also generated and merged with TV content dynamically at each digital STB, since computer graphics cards have reached the TV video in terms of quality, after the introduction of the latest generation of video-game consoles (Dempski 2002). Furthermore, the latest video coding schemes, such as MPEG4 and later, allow for rich description of the content, thus enabling the melding of real-time three-dimensional graphics with the video (Marrin et al. 2001). Previous studies found that consumers like the idea of virtual presenters (Burmester and Koller 1996; Meuleman et al. 1998). Therefore, a UI for ITV should extend beyond the notion of simply manipulating the audiovisual or text content. The design of a UI for ITV should aim at becoming a seamless part of the content.

The broadcast model of computing encompasses a radical shift in the mentality of application development process and tools. Milenkovic (1997) highlights the differences with the client-server mentality, describes the concept of the carousel and explains why the characteristics of the networking infrastructure are an important factor in the type of feasibly deployed applications. For example, an application and its file-system may be downloaded from the carousel and then its data input may be retrieved from a real-time cyclical broadcast stream (object and data carousel respectively). Therefore, strong knowledge of the broadcasting model of computing is an important asset for the design of the ITV applications. Engineers should also justify the use of persistent local storage, which currently makes inroads into a multitude of CE products. Digital local storage technology (Whitingham 2001) takes viewer control one big step further —from simple channel selection with the remote— by offering the opportunity for non-linear local programming and content selection.

Design Factor	**Description**
Entertainment Vs Information	Viewers use television for a wide variety of goals from pure entertainment to pure information
Interactive Vs Passive	Interactivity can be feasibly deployed on DTV, although current television patterns of use are passive
Computer generated content Vs fixed content	Computer generated content may replace static video elements (channel logo, ticker, info, sport statistics, etc), or human presenters
Computer Vs Television Visual Design	Television viewers are accustomed to stories and characters in contrast to computer users who prefer objects and actions

Real Time Vs Time Shift	Both types of programming, stored and broadcast, should be available, without sacrificing easy access to either type of content. Each type should complement instead of competing with the other

Table 6 Interactive content creation factors that affect the design of the STB

Table 6 summarizes the factors that affect the design of ITV applications from the perspective of interactive content creation. The media content industry has devised these factors through many years of experience, but the computer industry is used to a different approach. Media content developers should cooperate with interaction designers, in order to evolve unique content for ITV.

4.4 PROTOTYPING PLATFORM

The objective of this section is to offer a generic set of techniques that may aid the creation of high-fidelity ITV prototypes. There are four principal elements that should be considered in the development of ITV prototypes: 1) Output device, 2) Input device, 3) H/W and S/W platform, and 4) content. The output device should be a normal TV set, although future ITV prototypes may need to consider a wider variety of digital screens, such as LCD screens, HDTV sets, plasma screens and video projectors, as well. The input device should be a normal remote control, although future ITV prototypes may need to consider alternative input mechanisms, such as voice and haptic interfaces. The H/W and S/W platform is selected on the basis of the platform requirements for the final system and the familiarity of developers with certain prototype development tools. Finally, it is fundamental to employ high-quality TV content and to develop UIs that resemble the established TV grammar. Next, the prototyping system developed to address the needs of the present research is described in detail.

The central element of the experimental set-up may be a portable computer, running Microsoft Windows XP Professional. The use of a portable computer is not a prerequisite, but it allows installing the ITV prototype to alternative locations, such as laboratory, consumers' homes. The use of a Wintel PC offers reduced cost and access to the MSTV API —ensuring easy migration to the MSTV STBs later-on. The display software should be configured at the extended desktop setting and the ITV application should be set to display at the TV (second monitor). Thus, the PC's screen is available to monitor the running ITV application. Then, the laptop's TV-out and

audio-out is connected to the audio-visual input of a TV screen. The ITV application is designed to run in full-screen and in window-less mode. After running the ITV application, the portable's lid is closed and placed away from the TV. The portable's lid could be kept open or the laptop's VGA-out could be connected to a PC monitor (for example, in a usability observation room), in order to observe in real time the user's activity. Furthermore, using a video splitter, the video signal may be also sent to another big screen TV or video projector in the usability lab observation room and super-imposed with the video feed of the user, so that it resembles a full usability evaluation set-up.

Application developers working on PCs should consider how to hide away the underlying desktop and GUI environment. For example, in Visual Basic, for achieving a seamless TV experience it is important to set the form border style (FormBorderStyle) to 'none', so that there is no visible window around the video. In the context of DirectX and Microsoft TV technologies, it is also important to run the Video Control at full-screen mode (MSVidCtlLib.DisplaySizeList.dslFullScreen), so that there is no visible portion of the Windows desktop. Video resizing may be detrimental to the quality, so it is suggested that the video source resolution is similar to the screen resolution used for testing. For example, given a consumer TV, setting the screen resolution at 640x480 and displaying similarly sized MPEG video files produces a result that is identical to broadcast television quality, at least in the eyes of the consumers. The full-screen mode is not necessary during the development process, during which it is suggested that the video runs next to the development environment, in order to evaluate the output.

For supporting relaxed control with a normal TV remote control, the laptop's serial port is connected to an infrared sensor that receives the signals from the remote control. The Evation's Irman infra-red sensor is strong enough to collect the signals, so it could also be put at the side of the TV. The sensor's software driver and the supportive applications are used to map the remote control's buttons to specific keyboard buttons. Then, application developers are programming the actions of an ITV application's UI by assigning them to the PC keyboard buttons. The mapping of the remote control buttons to the keyboard buttons acts as an abstraction layer between the ITV application and the different infrared remote controls that can be used to control it. The whole set-up is unobtrusive and seamless to the television viewer (Figure 16). It also allows the experimenter to take the experiment 'on the road' and perform evaluations at consumers' homes.

Figure 16 A low-budget set-up for interactive television usability evaluation consists of a portable computer, an infrared receiver, a normal remote control and an audiovisual cable to connect to the TV

4.4.1 Scenarios

The following scenario is a story that encapsulates the current mentality used for the design of ITV applications.

> *Michelle had a stressful day at work and immediately after returning home she switches on the TV and tunes into her favorite channel only to find out that it is currently showing a football game. It is still an hour left before her favorite weekly series begins so she decides to bring up the electronic program guide and find something more suitable for her preferences. She presses the menu button and then selects EPG, which brings up a list of a few channels alongside with a list of their respective schedules. She takes a minute reading the list and then presses the page down button to bring up the second part of the channel list. Since she installed a satellite receiver she has approximately a hundred channels in her language and a few hundred more in languages she speaks. She goes on like this, searching for an interesting program to watch for the next 10 minutes. She decides to switch-off the television when she realizes that she now feels more stressed because she had been using the EPG instead of watching television and relaxing.*

The next scenario is a vision for a future ITV experience that is based on the Virtual Channel model.

> *It is a late weekday afternoon, after returning home from work, Tom enters the kitchen and switches on the television set. He tunes into the news channel*

only to find out that he has just missed out the headlines of today's news stories. Before he starts preparing tonight's dinner he presses the menu button on the remote, which brings-up a list of today's news headlines. He uses the cursor and the ok button to select a few interesting news items —which are added to his favorite news-sections that have been automatically selected by the system. He presses the play button and the television switches from live broadcast to display a continuous flow of the dynamic synthesis of recorded news programming that has been stored on the STB HDD during the course of the day. Half an hour later the user enjoys his dinner while watching the television news, when the television alerts him that a news story he watched a few minutes ago has been updated. He presses the ok button, which inserts the updated news story to his virtual television news channel. As soon as the current news story has ended the updated one is displayed. By this time the television is showing the financial news of the day and the user, who has just finished his dinner, picks up the remote control and presses the info button which immediately brings up a running ticker of his financial portfolio's stock quotes at the bottom of the screen.

4.5 VIRTUAL CHANNEL CONTROL LIBRARY

In order to support high-level development for ITV applications and local generation of dynamic computer graphics, the Virtual Channel Control Library (VCCLib) was built on top of the Microsoft Windows and TV (MSTV) platforms. The .NET edition of Visual Studio was employed to develop the programming library and the ITV prototype using the Visual Basic language for both, although the use of the C# language would not have made any difference at all, since the .NET framework assumes a Common Language Runtime (CLR) for all builds. The VCCLib is a programming library that can be employed by developers who wish to program ITV applications at a high-level (Figure 17). Alternatively, developers should implement their own code for each ITV application they work on. The latter approach would be a waste of resources and it would probably undermine S/W quality, since there are some well-defined patterns of UI development for ITV.

The VCCLib was implemented as an ActiveX control (a popular type of reusable software component used in Microsoft Windows) that can be used for rapid prototyping of ITV applications. Both broadcasters and developers can use the library of the Virtual Channel properties, methods and events to design prototypes of ITV ap-

plications. Ideally, a standard Virtual Channel API should be agreed upon by a wide range of people working in the respective industry, like DTV platform operators, DTV application developers, TV producers, content creators, etc.

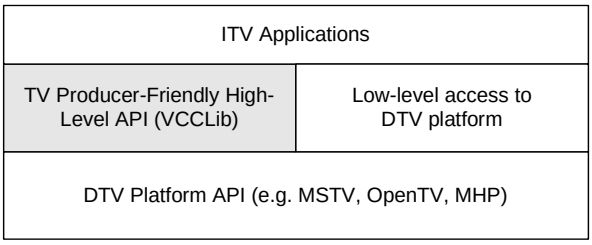

Figure 17 Using a high-level API to make ITV development more friendly to TV producers

Previous failures of ITV systems have been attributed to immature technology, high costs and mainly to IT-driven features coupled with user UI inspired by the personal computer practice (Carey 1997). The VCC Library (VCCLib) is a higher-level ITV API that takes interactive computer graphics further away from the specifics of the underlying implementation and closer to the traditional TV production values. In this sub-section, the most important methods, properties, events of the VCCLib are described briefly. The objective is to present its features, alongside with the principles of the Virtual Channel model, so that it is well understood for applying in ITV application development and for realizing in other contexts, with alternative implementation tools and low-level DTV platforms.

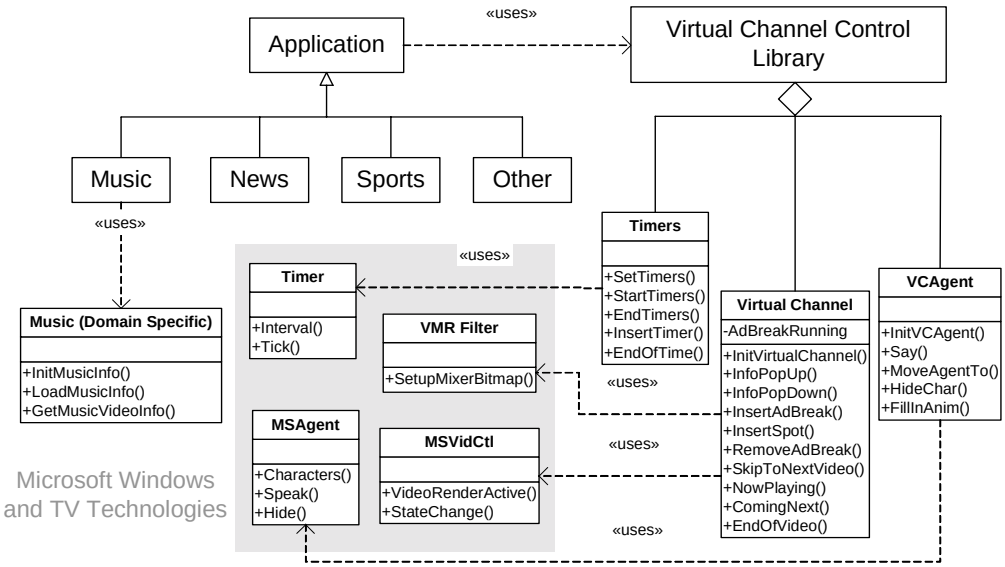

Figure 18 Class diagram for the Virtual Channel API with references to a MSTV implementation

The implementation of a programming library that facilitates UI development for ITV in accordance with the Virtual Channel model was a complementary task of the present research and it is presented here in brief, in order to provide the foundation upon which the interactive music TV prototype was build. The implementation details can be found in the appendix.

4.5.1 Virtual Channel Control

The VCC description is based on the groupings inherent in object-oriented programming (events, methods, properties). Firstly, there is an internal data structure that is used for storing videos and advertisements is presented. The file paths to video clips and to the ads are stored in a Visual Basic Dictionary object that is very similar to a hash table; a unique identifier provides immediate access to the respective data (a video file ID gives the video file path). A Dictionary object was also used for the virtual channel queue and facilitates easy serial access to the play-list of the video clips (play-list index number gives the video file ID). Moreover, the virtual channel play-list can be easily altered by inserting new video clips or by changing the order of the existing video clips.

The VCC defines four events that are useful for most types of ITV applications: 1) As soon as a playing video reaches the end, the EndOfVideoFile event is raised. An application can handle this event to clear global application variables or run application specific subroutines. It should be noted that in accordance to the continuous video flow principle of the Virtual Channel model, the VCC implementation automatically plays the next video in a playlist, immediately after raising the EndOfVideoFile event. 2) The StartOfVideoFile event is raised when a new video begins to play and it can be handled to initialize the timers and update the time left to the next advertising break. 3) The AdBreakTime event is raised when the time threshold between two advertising breaks is reached and can be used to insert a scheduled advertising break in the video playlist queue. 4) The EndOfAdBreak event is raised when a scheduled advertising break ends. The VCC will automatically continue playing the next video in the play-list queue, but the event can be handled to remove advertising break specific variables or user interface components.

The VCC defines a few public methods for controlling the play-list of video files, and displaying video overlays. Firstly, the VCC is initialized using the InitVirtualChannel method that takes as parameters the paths of the videos, the advertisements (ads), the videos' play-list and the ads play-list, thus supporting local storage. After

the successful initialization, the VCC can be started using the PlayVirtualChannel method. During the Virtual Channel play-out, the hosting applications call the InsertAdBreak or InsertSpot methods to insert a scheduled advertising break or a spot respectively. After the end of the advertising break, applications call the RemoveAdBreak method, in order to restore the Virtual Channel to the video play-list. Non-linear video play-out is currently supported by the SkipToNextVideo method, which can be used to offer relaxed control to the consumer in the form of the familiar 'next track' button found on music CD players. The VCC exposes the InfoPopUp method that takes a text-string as a parameter and displays a video overlay of the text superimposed on a transparent rectangle at the bottom of the video. InfoPopUp is complemented by the InfoPopDown method that clears the video from any previous video overlay.

4.5.2 Timers and VCAgent Controls

The VCCLib offers the Timers Control for controlling the time aspect of ITV applications. The Timers Control is based on the Timer Control and enables the definition and handling of time driven events. Hosting applications initialize the Timers Control with a list of event identifiers and the respective time points, which are defined as the time distance from the start of a video. For each time threshold defined in the events queue of the Timers Control the EndOfTime event is raised. ITV applications handle the EndOfTime event to control the display of a time-driven user interface. Hosting applications also benefit from a reserved event that is raised after an application has displayed a video overlay, in order to clear the screen automatically, in case the consumer has left, thus supporting relaxed control.

The Animated Character Control is a simple wrapper-class around the Microsoft Agent Control. The rationale for defining this class is to provide a level of abstraction between the specific implementation of the animated character (MS Agent) and the programming interface to the ITV application, which is build on top of the VCC API. For example, a future implementation may use an alternative implementation of the animated character or include a sub-system for supporting emotion (Bates 1994), either synchronized with the video content, or the user preferences or based on additional meta-data provided by the hosting application. In the current implementation, the animated character is only used to display information about the running video (VCAgent.Say) or perform simple animations (VCAgent.FillInAnim).

4.5.3 Programming with the Virtual Channel Library

Before the play-out begins, the initialization of the virtual channel requires a number of parameters that are defined inside a few configuration files. The main configuration file defines the paths to the video clips, to the advertisement videos and to the meta-data folders. It also defines the paths to the scheduled advertising breaks and to the video clips play-lists. The advertising configuration path, in addition to the individual scheduled advertising break configuration files, contains a file that defines which advertisement to show, when the user skips a video clip. For example, for an interactive music television application the video clips path contains music videos, but it could be also used for storing news videos or other types of television content, since the configuration files refer to the video clips using numeric identifiers. The VCC also uses the same numeric identifiers internally to control the flow of the virtual channel. In summary, the configuration files can be imagined as the schedule for a television broadcast that is not strictly linear and which can be controlled at the STB according to the rules that are defined by the hosting application of the VCC.

Programming for the Virtual Channel model is similar to Windows object-oriented programming, in which user actions raise events that are handled by the application, in order to perform a set of commands and to keep a visual dialog with the user. At the same time, it is different from traditional object-oriented programming because the events are usually raised by pre-configured timers set by the television producer and also because the virtual channel is a flowing experience without any need for user intervention to keep the human-computer dialog alive. In other words, programming for the virtual channel can be described as a combination that spans the entire continuum between the broadcast and IT mentality for application development. Programming for the Virtual Channel model is a matter of editing a few configuration files, initializing a set of objects, and responding to events, most of which are internally generated. Next, the architecture, the code and the development environment are demonstrated for a simple ITV application, which resembles a fixed TV channel.

It is possible to employ the VCC in an application only by editing the configuration files and initializing the VCC (Figure 19).

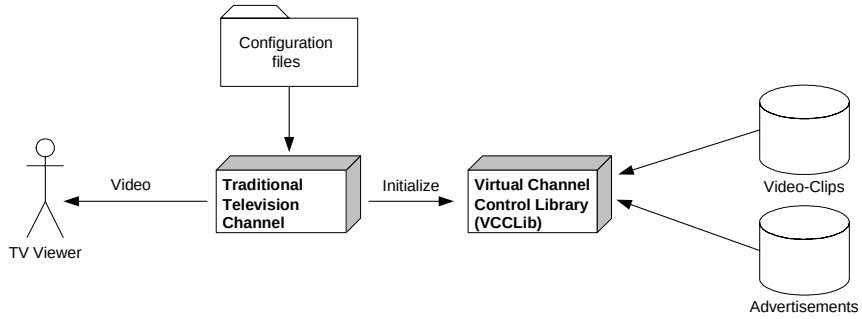

Figure 19 The architecture required for a traditional TV channel. The linear TV channel is just a subset of the functionality offered by the VCCLib

The initialization of the virtual channel is just a matter of a few lines of code, as displayed below (Code 1), which results in a traditional linear TV channel.

```
Sub InitITV()
  LoadConfig(strConfigFilePath)
  VC.InitVirtualChannel(strVideoFilesPath, strAdFilesPath, _
  strVideoPlayListPath, strAdPlayListPath)
  VC.ResetAdBreakTimer(lngAdBreakInterval)
  VC.PlayVirtualChannel()
End Sub
```

Code 1 The code required to create a traditional linear TV channel is just a sub-category of an ITV application, by employing the Virtual Channel programming library

Nevertheless, Virtual Channel programming is more beneficial when handling user events and employing the interactive graphics features, which is described in-detail in the next chapter for an ITV music application.

The development environment is an important part for every programming effort. The main elements of the Virtual Channel development environment consist of: 1) code, 2) output, and 3) debug info. Depicted above, a virtual channel that features an animated character is running next to the Microsoft's Visual Studio Visual Basic development environment (Figure 20). At the bottom ('immediate window') there is a list of the events that have been raised, while just above it ('code window') displays the code —of roughly 10 lines— that is needed to implement an application that skips forward a music video in the virtual channel queue and to display a message with the agent, after having shown an advertisement.

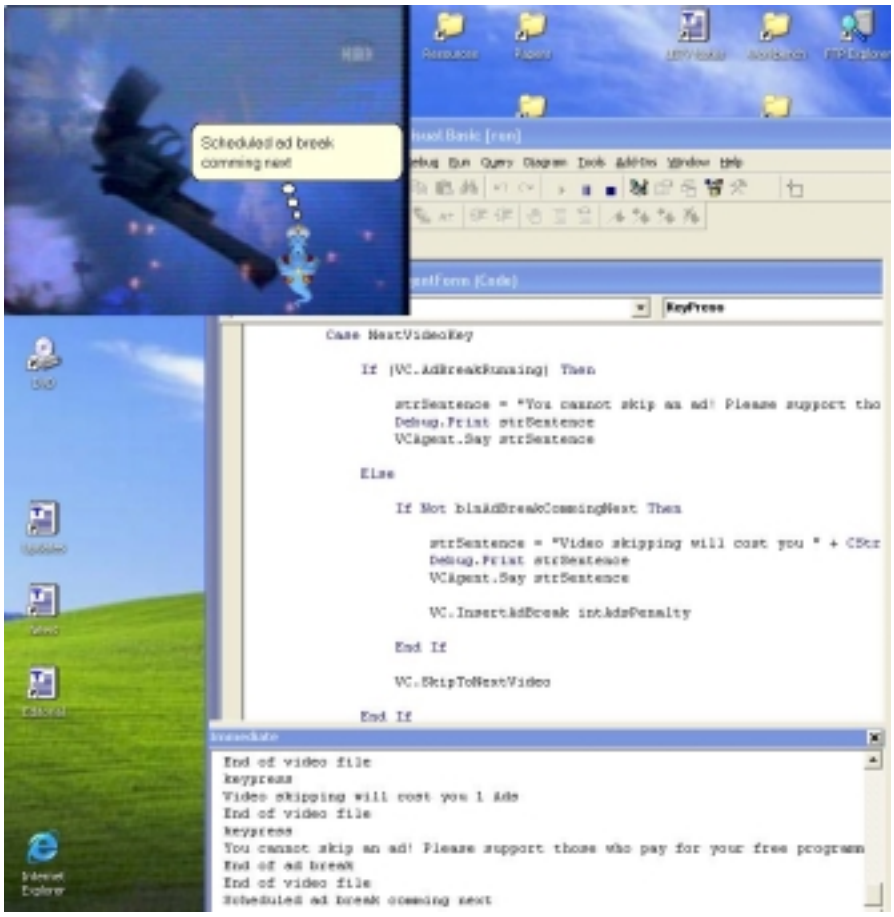

Figure 20 Microsoft Visual Studio for Visual Basic development environment showing code, debug output and an interactive television application for music video clips

4.6 AFFECTIVE USABILITY FRAMEWORK

This section provides a critical overview of the constructs and the instruments that have been used to measure emotional responses to TV or to a UI. The objective is to develop a usability framework that is appropriate for the purpose of measuring the affective dimension of an ITV UI. For the experimental type of research, the most important element is the data collection instrument, which is used to measure a concept that is known from theory to have some significance.

4.6.1 Emotional Responses to TV Content

The measurement instruments were retrieved from the advertising research, consumer research and communication research literature. A review of the advertising

research, consumer research and communication research literature revealed more than a few concepts, together with their respective measurement instruments, that may apply to the case of ITV, too. The most relevant have been selected and are presented bellow: 1) Affect and activation, 2) involvement, and 3) program liking.

Affect and Activation

Emotional response is considered to be a desired outcome of the TV watching activity for many viewers (Lee and Lee 1995), but there is no general agreement about the dimensions of affect. At a high level, most of the theories agree that there are three distinct dimensions of affect: 1) Pleasure, 2) Arousal and 3) Dominance (Russell and Mehrabian 1977), called the PAD model of affect. These dimensions can be used to describe fully the affective state of a person, although they do not give any information about the specific affect being felt. The affect construct corresponds to the visceral part of the brain that is the source of the instictive responses to external stimuli. One popular and easy to administer iconographic instrument for the PAD model is the Self Assessment Manequin (Lang and Bradley 1994), which was selected to measure the affect elicited by two alternative UI designs for ITV. In the past, the Self Assessment Manequin (SAM) has been widely used in consumer research, advertising research and in communication research to capture consumer affect for a variety of stimuli such as mediated experiences, products, service encounters.

In addition to the PAD model, and in accordance with previous analogous studies (Knobloch and Zillmann 2002) the Thayer's (1989) Activation Deactivation Adjective Checklist (AD ACK) is employed, which is a more elaborate model of a person's arousal. Together, *the PAD and AD ACK were used to measure the difference in the elicited affect between the animated character and the traditional overlay box, for presenting information related to TV content.*

Involvement

Involvement with TV content has been of concern for both the marketing research and the communication research literature, although neither of the two has used the same instruments and there is also a diversity of opinions within each discipline about what is and how to measure consumer/viewer involvement with TV content (programs or advertisements). According to Park and Young (1986), 'most researchers agree that the level of involvement can be understood by the degree of the personal relevance or importance.' There is also agreement that involvement may be distinguished to affective and cognitive (Park and Young 1986, Perse 1990). A previous

study in communication research found that involvement correlates with channel changing behaviour (Perse 1998), while a previous study in advertising research suggests that program involvement leads to better recall of embedded commercials (Yansong 1998).

Besides advertising research and communication research, the concept of involvement may also be very important in educational settings that are delivered through ITV. The Involvement construct corresponds to the behavioral part of the brain structure presented previously, because the degree of the personal relevance TV content has on a specific viewer is formed during watching it. Zaichkowsky (1985) has developed a widely used scale that measures the involvement with products or advertisements, called the Personal Involvement Inventory (PII). Communication research has devised alternative scales for measuring involvement with the TV content, but those scales are usually developed in an ad-hoc fashion to measure specific types of TV content, like news (Perse 1990), and they do not have the generality of the PII. Therefore, *the PII was used to evaluate whether the addition of an animated character UI for TV affects the user involvement with the ITV experience.*

Program Liking

Previous research has made a distinction between the feeling states and the program liking (Murry et al. 1992). This distinction is in consistence with the contemporary conceptualization of the brain structure, in the visceral, behavioral, reflective parts, which was presented in the methodology chapter. The Program Liking (PL) construct corresponds to the reflective part of the brain, because an attitude toward an experience is build after watching a specific TV content and deliberately thinking about it. Murry et al. (1992) assert that 'In contrast to feeling states, program liking is a summary evaluation of the experience of viewing a television program.' For example, viewers may enjoy a movie that elicits negative feelings, because they know that it is not actually true. The introduction of interactive elements to TV may have an effect on the formation of the program-liking attitude. Therefore, *there is a need to assess whether the addition of the animated character affects the program liking as a whole, despite the TV content being the same, between two alternative UI designs*.

In summary (Figure 21), the affective state is measured with the SAM instrument (Lang and Bradley 1994), the involvement is measured using the PII (Zaichkowsky 1985), the dimensions of arousal are measured with the AD ACK (Thayer 1978), and the program liking is measured in accordance with previous studies (Murry et al. 1992; Murry and Dacin 1996).

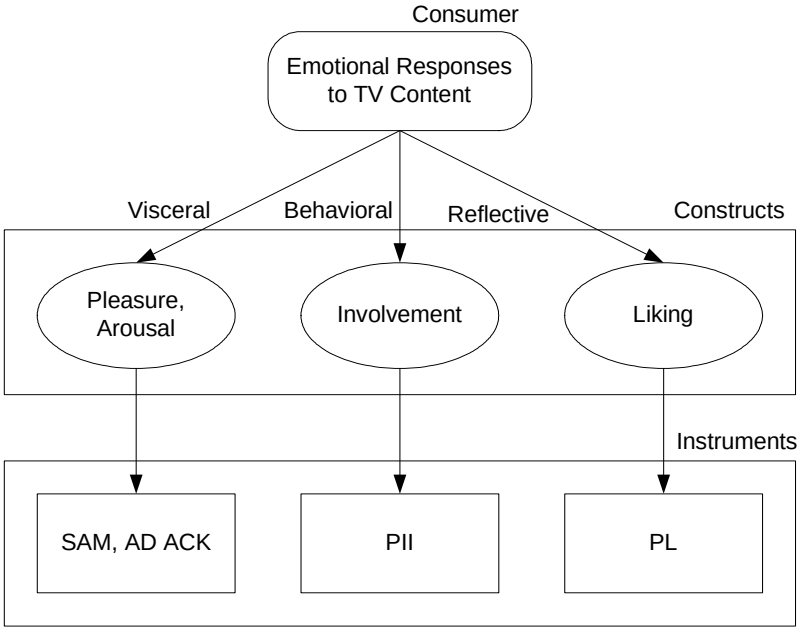

Figure 21 The three constructs and the respective measuring instruments, which measure the emotional responses to TV content. Note how the triad of constructs corresponds to the visceral, behavioral, reflective levels of the emotional brain

Overall, the instruments employed in the present research have been used to measure the respective constructs and have been validated in numerous studies, and published in journals, in the context of advertising, consumer and communication research, thus setting aside the need to run extensive statistical tests for assessing their characteristics, in terms of validity and reliability.

4.6.2 Emotional Responses to User Interfaces

The affective dimension of usability has been neglected from the mainstream of research in the HCI field, during the period 1980-2000, although, ocasionaly, there were a few works that raised the issue of designing an enjoyable and interesting UI (Carroll and Thomas 1988; Malone 1982; Strommen and Alexander 1999). Only recently, more attention has been paid to the enjoyability of the interaction with computers and products and the first workshops and conferences took place. This research area is only at its beginning and there are only a few instruments for measuring the enjoyability of interacting with a UI. A review of the recent HCI research literature revealed a few concepts, together with their respective measurement instruments, that may apply to the case of ITV, too. The most relevant have been selected and are presented bellow: 1) affect, 2) engagement, and 3) hedonic quality.

Affect

None of the usability evaluation studies described in Chapter 2 focused on the feelings elicited during the interaction with the UI. An interactive non-verbal questionnaire that is very similar to SAM was developed by Desmet (2003), but it was not available for other researchers (Desmet, personal communication). Therefore, the emotional response at the visceral level is measured with the instruments from advertising and communication research, which were discussed in the previous section.

Engagement

In the previous section, the involvement construct was reflective of the personal relevance and attention that a user pays to a mediated experience, but it does not reveal the quantity of personal resources that the user is actually devoting to the TV content. For example, a user may spend a few minutes attentively watching a TV content or a few hours of sparse use of an ITV application. For that purpose, the engagement construct is used to capture how much interest is created by a mediated experience. The engagement construct corresponds to the behavioral level of the emotional brain structure. Malone (1982) was the first to measure the time spent using each one of the UI manipulations, in order to get insight about the interest of the players in the different versions of a video game.

The time spent using a learning application has been proposed by the respective research community as a measure of the engagement construct during the instructional process (Chapman 2003; Miller et al. 2003). Correspondingly, if users spend more time with a specific ITV UI then it can be argued that the respective UI had an effect on the engagement with the ITV experience. Analyzing log-files is usually employed during longitudinal field studies, but it can be also employed as a supplementary usability evaluation method during the development process (Nielsen 1994, p. 217).

Therefore, the time spent with each UI was recorded in the log files, in order to compare which UI was more interesting.

Hedonic Quality

After the users have interacted with a system for a certain period of time their affective state and their performance is being evaluated, by the reflective level of the brain. As a consequence, an opinion will be formed regarding the appeal of the system. Indeed, studies in the emerging field of affective usability have validated that users may form different opinions about the ergonomic and hedonic quality of a

software product (Hassenzahl et al. 2000). Hedonic quality corresponds to the reflective part of the brain structure and it is an attitude that is formed after having at least one experience with a software product. Previous research for a TV UI has treated users' attitudes in a limited fashion. Sometimes a single question, such as 'How much fun was the user interface' is included in the evaluation (Drucker et al. 2002), but no systematic treatment of this dimension is performed. The hedonic quality construct corresponds to the reflective part of the brain structure, since it assumes a rational judgement for a given UI. A questionnaire developed by Hoonhout had been used before to measure enjoyability (Bartneck 2003), but it was not available for outsiders of Philips Research (Bartneck, Hoonhout, personal communication). Hassenzahl's et al (2001) instrument was used to measure hedonic quallity, because it is a validated, freely available, short and easy-to-understand verbal scale.

A seven point semantic differential scale was used with reversed polarity of every other pair: (outstanding-second rate, standard-exclusive, impressive-nondescript, ordinary-unique, innovative-conservative, dull-exciting, interesting-boring). The scores were summed and then scaled from 0 to 10.

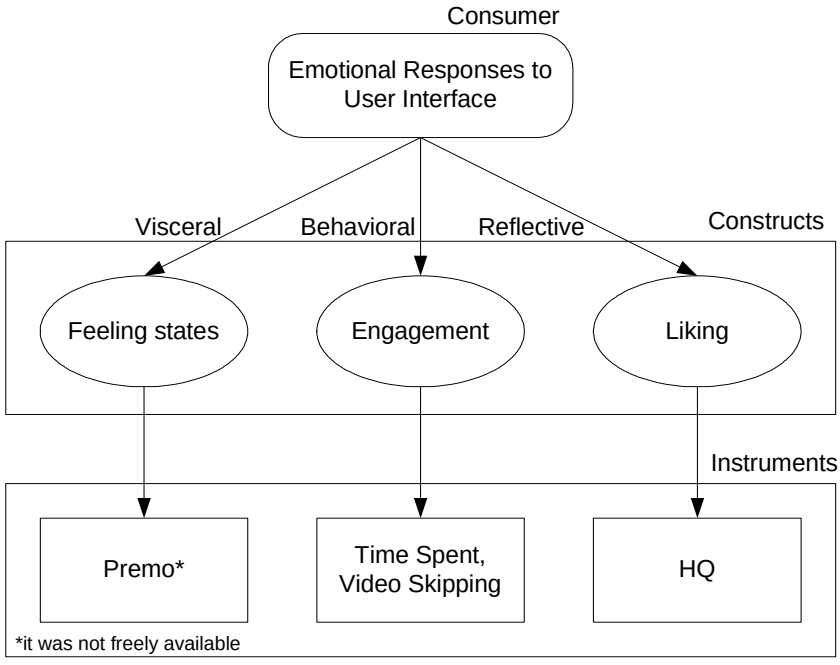

Figure 22 The three constructs and the respective measuring instruments, which measure the emotional responses to a UI. Note how the triad of constructs corresponds to the visceral, behavioral, reflective parts of the emotional brain

In summary (Figure 22), 1) the visceral level of the emotional responses to a TV UI could not be measured because there was no respective affective usability instru-

ment available, 2) the behavior level was measured using the time spent (Malone 1982) and the video skipping action during each testing session, and 3) the attitude level was assessed with the HQ scale (Hassenzahl's et al 2001).

4.7 SUMMARY

The central subjects of the present chapter were the broadcast mentality for delivering broadband information to masses of people and the examination of future scenarios for the ITV entertainment experience. By exploiting the ubiquity and familiarity of the broadcasting mentality, the Virtual Channel model was proposed for access to ITV content. The Virtual Channel extends the consumers' mental model of TV channel changing. In addition to changing between TV channels, in order to find interesting content, consumers should become aware that they could also change content within the same TV channel.

The high-level mentality of the conceptual model demands the respective high-level programming library, which will be used to implement ITV application that conform to the Virtual Channel model. The conceptual model and the programming library can be used to structure and implement an ITV UI.

Moving a little away from traditional HCI theory and methods was a necessary diversion for the research problem at hand. The definition of a set of UI principles aids the design of ITV applications, which may have characteristics from two different mentalities; the IT and the TV one. Finally, an affective usability evaluation framework was defined, in order to measure the ITV UI with the most appropriate tools.

In the next chapter, an example of developing a simple interactive television application for music video clips that features dynamic ad breaks is described in detail. The UI elements are applied directly to the design of a UI for an ITV application and the results lead to a discussion of the implications for HCI research, which are presented in chapter 6. The contributing disciplines (communication, advertising) are not treated extensively, but they are addressed separately in chapter 7, in discussions concerning further research.

5 VIRTUAL MUSIC TELEVISION CHANNEL

This chapter presents a case study of an interactive music television prototype, which was designed in accordance to the methodology for service design described in Chapter 3 and by employing the UI design elements that were developed in Chapter 4. The prototype is also developed to address the hypotheses raised in Chapter 2. This chapter represents the intersection and evaluation of all the issues discussed in the previous chapters.

5.1 OVERVIEW

The main objective of the present case study is to evaluate the UI elements that were introduced in the previous chapter. Since it is not feasible to evaluate a designer's conceptual model by asking the consumers directly about it, the Virtual Channel model and its properties are validated through the design and the usability evaluation of an interactive music television prototype. The same rationale holds true for the UI design principles and the usability evaluation framework. In addition, experiments with consumers were performed by employing the evaluation methods described in chapter 4, in order to shed light on the practical issues of ITV UI design that were identified in chapter 2.

The design of the interactive music TV channel was based on explicit design moves, rather than designer's intuition. In particular: 1) the application was designed according to an explicit conceptual model and it was implemented with the respective programming library, 2) the UI was based on the design factors that affect ITV applications and 3) the features of the ITV prototype were based on market analysis and correspond to the hypotheses to be tested. Nevertheless, the above design moves (from the conceptual model and the design factors to the ITV prototype) cannot be considered deterministic —each designer may have produced a different result from the same source materials and methods. That is, having an explicit design rationale cannot assure the excellence of the end-result, but it provides a consistent path

among issues-solution-evaluation, which can be traced back for iterative improvement.

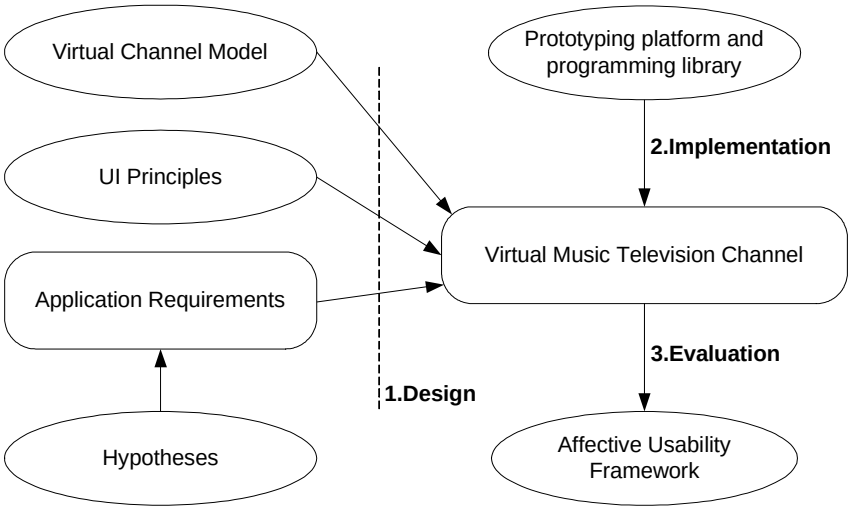

Figure 23 The design and development approach for a music ITV prototype

The virtual music channel is a limited implementation of the following scenario:

It is a late Friday evening and Tom is strolling between the living room and the kitchen preparing drinks for himself and Michelle, who has just switched-on the TV and tuned to the music television channel broadcast. Since it is the time that most people prepare to go outside, the music channel plays upbeat dance music. Instead, that night, they have decided to stay inside and have a dinner in the quiet and comfortable atmosphere of their home, so she presses the mode button that switches from broadcast to the stored music channel and the TV immediately commences playing upbeat pop music, which is their favorite type of upbeat music when they prepare to go out for drinks. At that time, it does not feel like the right music for their mood, so she presses the menu button which displays a list of music genres —rock, pop, dance, ethnic, regional etc— and chooses the regional-Italian option, which she thinks is a perfect match for the Italian dinner they have ordered from a popular delivery chain. She presses the play button and a popular Italian video clip displays. At the same time the STB automatic recorder tunes into broadcasts and stores whichever song is Italian or similar to this type music genre —e.g. other regional music, romantic music, etc. By that time, their dinner has arrived and before they begin eating, she presses the play-list button, which displays information about the upcoming list of songs, alongside with a few relevant attributes like mood. She uses the cursor keys to set the mood indicator to romantic, while, in real time, the list of the upcoming

songs is refreshed to depict the new settings. Now, the next video clip will reflect the changes made.

In the next sections, the presentation of the case study follows the now established sequence of the previous chapters (i.e. conceptual model, principles, prototyping, implementation, evaluation).

5.2 APPLYING THE VIRTUAL CHANNEL MODEL

The Virtual Channel model was employed as the conceptual framework for designing the interactive music television channel. It is assumed that each music video clip is found stored and indexed in the HDD. Music video clip related meta-data and information are stored on the HDD. Then, the virtual music television channel is created for each STB from the available music clips and the respective information items (Figure 24). Since the channel is created separately for each STB, its flow can be changed dynamically according to user preferences or broadcaster rules.

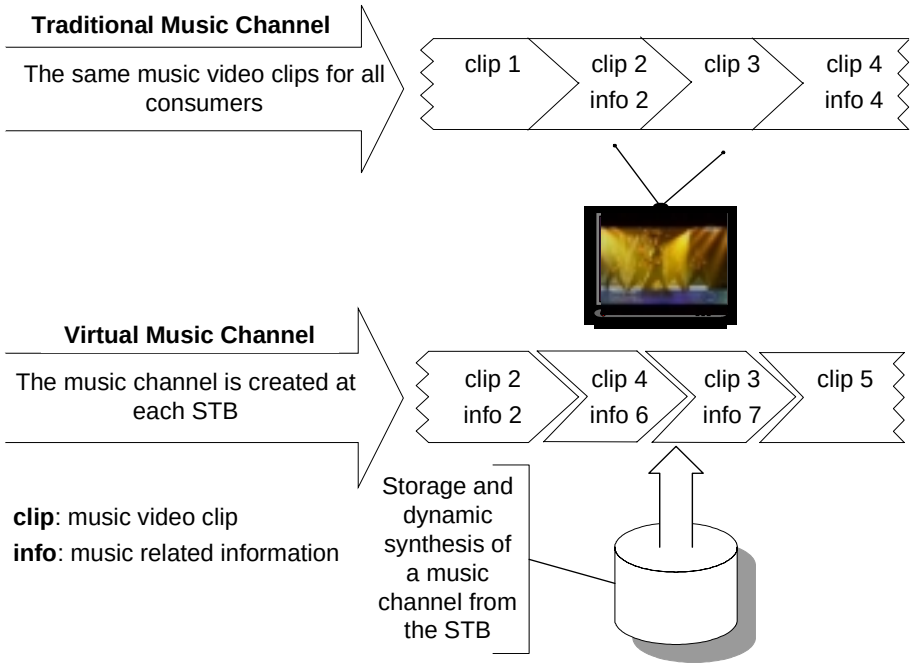

Figure 24 An interactive music television channel that is based on the Virtual Channel model

5.3 RESOLUTION OF DESIGN FACTORS

The Virtual Channel model provides the semantic details, but it does not address the multitude of factors that affect the design of ITV applications. Table 7 presents the design factors that are relevant to a virtual music TV channel and describes the resolution strategy that was selected for each one of them. It would have been possible to design the ITV application without referring back to the UI design principles. It is argued that the employment of an explicit list of design factors would result in less effort for the designer and in a more consistent experience for the consumer, because these factors have been systematically identified after an review of the TV production and consumption literature.

Design Factor	**Resolution Strategy**
Broadcast Vs Local storage	Only the local storage is used to retrieve and play music video clips. Video clip storage and play-list creation are left as open research questions.
Low Vs High Attention to Television	The user may either just tune into the music channel and leave it playing as radio or watch attentively the related information, and choose to browse the stored video clips.
Planned Vs Impulse Program Selection	The viewer may bring up the play list of the upcoming video clips in order to decide when to return back to watch a favorite one, or the viewer may skip through the play-list.
Interactive Vs Passive content	At the beginning of each video clip the system automatically displays the name of the currently playing song and that of the upcoming one. The user may also bring up this information on-demand at whichever point of time. There is a continuous flow of video clips, but the user may also choose to skip a video clip on-demand.
Entertainment Vs Information	The entertaining nature of music television watching is enhanced with additional information about each video clip and an animated character as a human presenter.
Computer generated content Vs fixed video	Static video is used only for the video clips. The rest of the interactive elements are computer generated (animated character, overlay box).
Computer Vs Television Visual Design	TV grammar was used to design the virtual music channel. The video clips were captured from TV broadcasts and combined with information from the Web.

Table 7 Design factors and the respective resolution strategy for a virtual music television channel

It is difficult to draw any final conclusion regarding the validity of the proposed UI principles for the music ITV application, because there is no deterministic way of applying generic UI principles to a given problem. In other words, the intuition and the experience of each UI designer may translate the same UI principles into different solutions, depending on other factors, such as business requirements. In the present research, the UI principles were addressed so that a realistic prototype becomes available for usability testing with consumers. For example, animated characters, and track-skipping were designed, in order to address the hypotheses. In any case, it is necessary to have a set of UI principles that are adapted for ITV, because they serve as a starting point and they define a concrete set of questions to be addressed for each design problem.

5.4 PROTOTYPE DESCRIPTION

This section presents the features of the music ITV application. The prototype was designed by employing the prototyping platform for ITV applications, which was presented in Chapter 3.

Track-skipping was designed to insert an ad, before the next video clip begins (Figure 25). Unless the track-skip button is pressed, there is a continuous flow of music video clips that is interrupted only by the scheduled ad breaks, just like a normal music video television channel.

Figure 25 A virtual music television channel that features video-clip skipping with dynamic advertisement insertion

The video overlays feature of the VCC was used to superimpose information over the music video. MTV displays which music video comes next, a feature that was made interactive by allowing the user to ask for 'what is playing now and what comes next' on-demand. The dynamic insertion of related information to the music video relates to the hypothesis of the presentation style. Two alternative presentation styles were designed: (a) The traditional MTV information box and (b) an animated character with a balloon dialog box (Figure 26).

For supporting consumer interactivity, locally stored music video clips and related information about artists and songs are exploited, in order to build an easy to use interactive music television application. The features of the prototype were determined by the hypotheses, as explained in the beginning of this chapter. After the UI for the ITV application has been defined it is now a straightforward process to implement a prototype, which is described next.

Figure 26 The animated character (on the left, using the Microsoft Genie) and the traditional transparent box (on the right) for displaying dynamic video overlays

5.5 IMPLEMENTATION

The music ITV prototype was implemented by employing the VCCLib. The presentation begins with a description of the ITV application architecture. Next a few code fragments are presented, in order to portray the high-level way that was used to implement the functionality of the music ITV application.

The architecture of the music ITV prototype was organized around a central component that implements the required features. The implementation of the music ITV features was performed in high-level manner by employing the methods and handling the events of the VCCLib. In addition, the central application component had the responsibility to handle the user events. A set of configuration files were used to define the file paths and the values for a few environmental variables that are needed to start-up the music ITV application. For the purpose of hosting the VCC in the music ITV application a few of the respective code fragments are provided next.

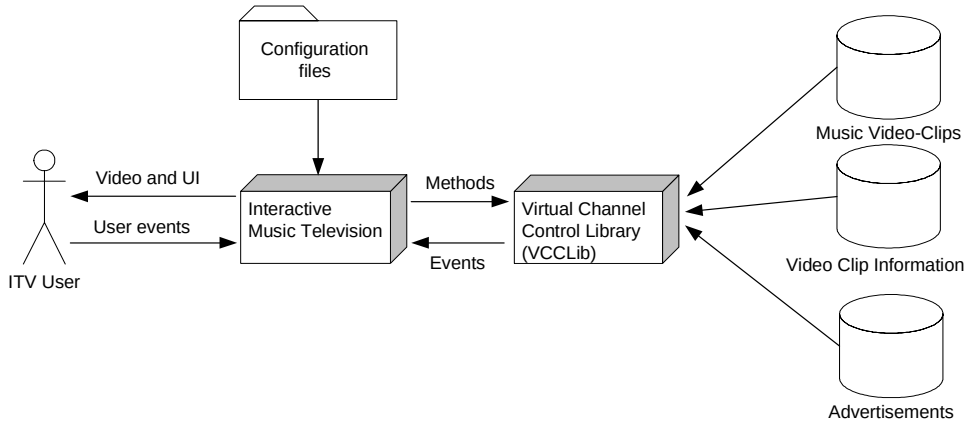

Figure 27 Architecture for an ITV application that employs the Virtual Channel API

The application begins with the initialization of the components that will be using during its lifetime (Code 2). The first step in the initialization phase is to load and read the configuration files, in order to inform the VCC and the domain specific objects for the paths of the video files and the related information. Then, it starts a log file, in order to store user input and video file identifiers, which can be used for analysis. In the case of the animated character, the VCAgent should be initialized, too. Next, the virtual channel was initialized. After that, the domain specific class for the music information was initialized. Finally, the virtual channel may start playing.

```
Sub Init
LoadConfig(strConfigFilePath)
LoadAdSpots(strAdSpotsPath)
VCLog.StartLog("log.txt")
VCAgent.STBAgent()
VCAgent.InitVCAgent()
VC.InitVirtualChannel(strVideoFilesPath, strAdFilesPath, strVideoPlayList-
Path, strAdPlayListPath)
VCMusicInfo.InitMusicInfo(strMusicMetaDataPath, strVideoPlayListPath)
VC.ResetAdBreakTimer(lngAdBreakInterval)
blnAdBreakComingNext = False
VC.intDisplaySize = dslFullScreen
VC.PlayVirtualChannel()
End Sub
```

Code 2 Initialization procedure for an application that employs the virtual channel and the animated character

The application supports two types of user choice: 1) information about the currently playing video clip and 2) skipping to the next video clip (Code 3). Depicted in the code fragment below is the code —of roughly 6 lines— that is needed to implement the event handler for the next video key-press, which skips forward a music video in the virtual channel queue and decides whether to insert an ad or to ignore the video-skip command, in case an advertising break is already running. User interactivity was also supported by displaying on-demand which video-clip is currently playing and which one is coming next. The user may ask for this information, in or-

der to learn more about a new music video clip, or to decide whether to skip to the next one.

```
Sub ITV_KeyPress
Select Case KeyPressed
Case NextVideoKey
If Not VC.AdBreakRunning Then
If Not VC.AdBreakComingNext Then
VC.InsertSpot(dctAdSpots.Item(VC.ComingNextVideoID()))
End If
VC.SkipToNextVideo()
End If
Case AskInfoKey
VC.InfoPopUp ("Now playing: " + VC.NowPlaying + ". _
Coming next: " + VC.ComingNext)
End Select
End Sub
```

Code 3 KeyPress event handler is used to receive the commands from the remote control

It is argued that the UI for ITV content should be mainly time driven, meaning that interactive elements should subtly appear and disappear without much user intervention. For that purpose, there is a need for extensive event handling inside the application, instead of handling user input. For example, for the current simple interactive music television application, the majority of event handling concerns internally generated events. When a music video clip starts the StartOfVideoFile event is handled to retrieve the respective music information, to set the timers and to display the typical introductory information with song title, artist and album. Respectively, the EndOfVideoFile event is handled to clear up the timers and the screen (Code 4).

```
Sub VC_StartOfVideoFile
VCMusicInfo.GetMusicVideoInfo (VC.NowPlayingVideoID, objMusicInfo)
VCTimers.SetTimers(objMusicInfo.Timers)
VC.InfoPopUp ("Now playing: " + VC.NowPlaying)
End Sub

Sub VC_EndOfVideoFile
VCTimers.ClearTimers()
VC.InfoPopDown()
End Sub
```

Code 4 StartOfVideoFile and EndOfVideoFile event handler used to initialize and reset related variables of a music video clip for play-out

In addition to dynamic ad inserts, the VCC features an integrated system for scheduled ad breaks. At the initialization time the programmer may set the ad break timers for scheduled ad breaks every 15 minutes, 30 minutes or any duration that is fit for the application at hand. The music ITV application was configured to handle the scheduled advertising break events for inserting a set of ads every 15 minutes approximately, which is the standard for music television channels. It should be noted that calling the InsertAdBreak method does not result to immediately starting

an advertising break, but to setting the virtual channel queue to play the advertising break after the end of the currently playing video clip. When the last ad begins, the VCC raises the EndOfAdBreak event, which is handled to restore the VCC to the music video clip queue (Code 5).

```
Sub VC_AdBreakTime()
VC.ResetAdBreakTimer(lngAdBreakInterval)
VC.InsertAdBreak(strAdBreakPath)
End Sub

Sub VC_EndOfAdBreak()
VC.RemoveAdBreak()
End Sub
```

Code 5 The AdBreakTime event handler is used to insert a scheduled advertising break

Finally, the video overlays functionality was used to display music information by handling the EndOfTime event raised by the Timers control (Code 6). Using the MS Agent for displaying information is as simple as changing the VC.InfoPopUp statements to the VCAgent.Say method. An alternative solution for flexible testing of different visuals UIs would have been to define an application method that would call either of the two UI methods, depending on a flag that was set at initialization time.

```
Sub VCTimers_EndOfTime (ByVal intTimerID)
VC.InfoPopUp(objMusicInfo.Infos(intTimerID))
End Sub
```

Code 6 The EndOfTime event handler is used to display a scheduled information related to the running video clip

In conclusion, the Virtual Channel programming library made possible the implementation of an ITV prototype in a high-level way. The code statements used to implement the ITV prototype are way-beyond the details of the underlying DTV platform. At the same time, the code statements are very close to the TV production grammar that is currently employed during the TV production process. In the next section, the ITV prototype is employed in a usability evaluation with consumers, in order to address the UI hypotheses for ITV service design.

5.6 EXPERIMENTAL DESIGN

The objective of this study was to evaluate user preferences for an ITV application that offers track-skipping for music video clip television and an animated character for presenting information. The experiment was designed to address the main issues identified for ITV service design: (a) consumer-level video skipping, (b) animated

characters for the presentation of related information, and (c) consumer preferences regarding the dynamic ad insertion, when they choose to skip a music video clip. The above issues have been formulated in the respective hypotheses.

- Hypothesis 1: Consumers' affective usability scores are different for the track-skipping user interface compared to the traditional lineal flow of the TV content.
- Hypothesis 2: Consumers' affective usability scores are different between the animated character and the transparent information box for the presentation of information related to the TV content.
- Hypothesis 3: Consumers are exposed to more advertisements in an ITV application that employs a video track-skipping user interface with dynamic advertisement insertion than in a linear TV schedule.

5.6.1 Method

The within groups experimental design was used in order to reduce the effort of recruiting new users and to have the same variance for the two groups. Thus, each participant received two experimental treatments of the user interface for interactive music video television: 1) The animated character and 2) the transparent box, while both of them offered video track skipping with dynamic ad insertion. The track-skipping and the traditional linear UI were not tested independently, in order to reduce the number of the experiments. After the end of each session, participants evaluated separately the hedonic quality of their experience for: (a) traditional music television (all of the participants of the study were frequent viewers of music television, and therefore, they may be considered to be able to recall the respective experience and to evaluate it), (b) music video television with track skipping, (c) information presentation with the transparent box and (d) information presentation with the animated character.

Hypotheses	**Independent**	**Dependent**
Video Skipping	YES / NO	Affective Usability
Related Information	Animated Character / Box	Affective Usability
Dynamic Advertisement	YES / NO	No of ads

Table 8 Dependent and independent variables for each one of the hypotheses

Moreover, they filled-in self-reports regarding their affective state for each of the two prototypes: (a) SAM, and (b) AD ACK. The involvement was measured with the PII and the engagement was inferred from the time spent using each UI. Finally, they

reported how much they liked each of the two prototypes, using the PL scale. Users were assigned at random to each one of the two UI manipulations. Subjects were called back to use the second UI at least two weeks after they had used the first one.

5.6.2 Participants

Tests were run with 21 users (recruited with convenience sampling from the post-graduate and under-graduate departments of the Athens University of Economics and Business). Using five or more users for usability testing has been established as a good trade-off between the cost of a study and the amount of usability issues found (Nielsen and Landauer 1993). More than five users were recruited for each user interface, since a few testing sessions had to be wasted before discovering issues worthwhile of in-depth investigation. The upper threshold for the number of the participants was set by the time available to complete the study and by the exploratory nature of the research. The total number of users who completed the first part of the study was 31, but some of them did not turn up for the second part of the study or they were excluded because they were negative to TV in general —the latter said that they participated to the first part of the study out of curiosity. Ages were between 22 and 35 (13 men and 8 women) for the final set of 21 people that completed the experiment.

5.6.3 Procedure

The study was performed in a relaxed setting, using a TV set and a remote control. Multiple usability engineering methods were employed: (a) user observation during the testing session, (b) a record of user actions was kept in log files, (c) users completed questionnaires and (d) each user was interviewed after the end of the testing session. In the beginning, the interviews were unstructured. Gradually, the interviews became more focused to repeating issues, mentioned during the interviews or observed during the testing session.

During the testing sessions, users were free to choose the music video clip they preferred to watch, as they would do if they were at home. In order to ensure selective-exposure the users were allowed a maximum of 1/3 of watching time, out of the total session duration (Knobloch and Zillmann 2002), that is a maximum of approximately 20 minutes out of the 1h program duration. Users could press the power-off button on the remote to end the testing session and they were told to watch as much as they liked, between 10 and 20 minutes.

In sharp contrast with the traditional usability evaluation paradigm, users were not given any task to perform or any goal to complete, besides the suggestion to watch music TV.

5.6.4 Materials

The testing session contained 16 music video-clips and an advertising break with three ads every 4 songs (approximately every 15 minutes), just like the average commercial music TV channel (MAD TV executive, personal communication).

5.6.5 Justification

The justification of the research methods was discussed in Chapter 3. Here, the justification focuses on the details of the experimental procedure. There are four research design parameters that need to be addressed, in order to establish the quality of the experimental design: 1) Construct validity, 2) internal validity, 3) external validity, and 4) reliability.

Construct validity refers to the establishment of the correct operational measures for the concepts being studied. Both the concepts studied and the respective instruments (i.e. the affective usability framework) were retrieved from previous research. Thus, the concepts and instruments employed in the present study have been extensively used and validated in previous research.

The internal validity is assured by: 1) randomizing the video clip play-list, 2) assigning participants in random order to the alternative UIs. Thus, the differences in the results may be attributed to the differences in the UI and not to other factors of the ITV experience.

The external validity is assured by employing a high-definition ITV prototype in a relaxed setting. A high-definition ITV prototype consists of a TV and a remote control for consumer interaction, while the PC is hidden away. A relaxed setting consists of a quiet environment and a comfortable place to watch TV. Thus, the results can be generalized to the real environment, with some limitations discussed in the next chapter.

Finally, the reliability cannot be assessed, since there was no probability sample and the sampling framework was restricted to university students. Therefore, it is unlikely that the study can be replicated with the same quantitative results, but the usability test is in accordance with the standard usability engineering practice (i.e. informal experiments). Moreover, the usability experiments during the product de-

velopment aim to inform the design process and not to draw final conclusions for an experience that does not exist yet in the real environment.

5.7 USABILITY TEST RESULTS

A few of the results may be conclusive for the research issues, but in most cases the results from the alternative data collection methods should be compared and combined, in order to draw any final conclusion. The usability evaluation results have been organized into four categories depending on the type of the data collected: 1) attitude, 2) affect, and 3) behavior and 4) qualitative. For some of the hypotheses multiple evaluation methods and instruments were employed that gave diverse types of results, which are provided in-detail in the appendix. In the following sections, the results are aggregated and presented in association with each one of the hypotheses, in order to draw final conclusions. In the next chapter, these conclusion are compared with similar studies in previous research.

5.7.1 Consumer-Level Video Skipping

The preference for video skipping was measured and confirmed by the hedonic quality instrument and by the personal interviews.

Participants reported that video-clip track-skipping was an easy and familiar way to navigate a music TV channel. They also reported that they used the skipping feature mainly to avoid video-clips that they did not like. In addition, they reported that they used the information button, in order to find out which is the next video-clip, before deciding whether to skip the current one.

Since the video skipping feature was implemented as an unobtrusive enhancement of the traditional linear music TV channel, it was expected that viewers would like it more. As a matter of fact, users gave significantly higher hedonic quality scores for the video skipping UI.

The familiarity with the track-skipping UI might be due to the transfer of the mental model from the popular music CD player that employs a similar track-skip button for navigating between songs. Users' suggestions for a repeat button provide further evidence that there is a transfer of experience from other music listening devices. In summary, consumer-level video skipping is a highly desired functionality and it should be implemented in accordance with the characteristics of each ITV application.

5.7.2 Animated Character

The findings for the presence of an animated character in comparison with the use of a traditional transparent overlay box, for the presentation of information related to TV content, were mixed.

Consumers had neutral attitudes toward the overlay box for the presentation of related information, which is an effect of the familiarity they have developed with the respective presentation style. The hedonic quality score was supportive of the inclusion of an animated character, but the program liking score, the emotional responses at the behavioral level (involvement, engagement) were not significantly different between the two UI manipulations. Consumer feelings were also unaffected by the addition of the animated character.

Nevertheless, the participants were very emotional when interviewed about their opinion regarding that feature. Most of the participants were very positive, while a few were very negative. It can be argued that the animated character has a carry-over effect from the desktop applications to the ITV applications. Those users, who are already negatively predisposed to it, will continue to be so, at the expense of their satisfaction with the whole ITV experience.

Overall, most of the users considered the character funny and less obtrusive compared with human presenters, who interrupt the video clip to present related information. Yet, it is not clear if those opinions will have a lasting effect after long periods of use. Therefore, the animated character may be employed as a surprise effect in TV programs, but there is also a need for adapting it to individual user preferences, in order to avoid user boredom from repetition.

5.7.3 Dynamic Advertisement Insertion

The findings regarding the dynamic advertisement insertion were very positive, despite the fact that advertising is one of the most controversial features of commercial TV.

During the interviews and the observation sessions, it was found that all the consumers were positive to the dynamic advertising insertion. Log file analysis revealed that consumers actually watched the double number of advertising messages compared with a normal broadcast session. Overall, the consumers justified the trade-off between skipping to the next video clip and watching a short advertisement positively.

Yet, it is not clear which is the cause of the above result, since the system employed two innovative features that affect the number of advertising messages displayed. The dynamic advertisement insertion every time the user skipped a video clip increases the number of messages shown. At the same time, leaving aside for a moment the dynamic advertisement insertion, the video clip skipping action brings the user closer to the next scheduled advertising break, thus increasing the number of advertising messages displayed, during a specified time-span.

Therefore, in order to draw cause and effect conclusions about the number of advertisements watched, a further study is needed that will compare between having dynamic advertisement insertion and not having, for the same video-clip skipping UI.

5.7.4 Interactive Music Television

The users who stayed most attentive to the TV during the testing session were those who traced continuously the informative boxes. These users asked for more control on the flow of information. Especially, they asked for the option to select the type of information to attend to (for example: biographical, discography, trivia, concerts) and the option to browse through the available information at their own pace. Both comments confirm the validity of the arguments for using Internet resources for providing diverse types of continuously updated information and for applying local generation of dynamic computer graphics that suite each user. Furthermore, users reported that even after selecting their favorite type of information to watch, or after having a short burst of information browsing, they would still prefer returning to the auto-pace style of information presentation, thus reconfirming the need for relaxed control and time driven user interfaces.

5.8 SUMMARY

This chapter presented the evaluation of the research work for each issue that was initially identified in the second chapter. For that purpose, an ITV prototype was: 1) designed, 2) implemented, and 3) evaluated from consumers. The design was based on the Virtual Channel model and the UI principles. The implementation was based on the Virtual Channel programming library and the prototyping platform. Finally, the evaluation employed the affective usability framework.

The above results are discussed in the context of the relevant HCI and ITV research in the next chapter. In addition, the music ITV application design took into consideration the business model issues (i.e. dynamic advertising insertion) that broadcasters have to confront in the age of digital broadcast, Internet connectivity and digital local storage. The implication for the broadcast and the advertising industry are analyzed in the end of the next chapter.

6 REFLECTIONS ON THEORY

The present chapter provides a discussion of the results from the design of the ITV prototype and from the usability tests with consumers and it compares these results with analogous research. Overall, this chapter describes the contribution to the HCI theory and methods. In addition, it presents the implications of the present research for the media industry (content production, advertising, broadcasters).

6.1 DESIGN METHODOLOGY

Previous research made implicit assumptions for a number of important issues that concern the design of ITV applications. In most cases those assumptions entailed a transfer of methods from the domains of the PC and the Web. Nevertheless, the introduction of interactivity and the convergence of the IT with the TV do not necessarily correspond to a transfer of the respective paradigms. Instead, *the literature review of the scientific disciplines that have treated TV, such as the advertising and the communication research, revealed a wealth of knowledge that could be useful in extending traditional HCI paradigms into the domain of ITV application design.* On the other hand, the same assortment of high-level UI methods and tools, such as conceptual model, principles and evaluation, may be feasibly employed in the design of ITV applications.

6.2 CONCEPTUAL MODEL

The notion of the virtual channel was first conceived by Nicholas Negroponte (1996, p.48-50), who said that: 'TV benefits most from thinking of it in terms of bits. Once in the machine, there is no need to view them in the order they were sent,' implying that some kind of logic —either user choice or from TV producer rules— could be applied on the TV content. Then he goes on to forecast with accuracy the ability to time-shift programs: 'All of a sudden TV becomes a random access medium, more

like a book or newspaper, browsable and changeable, no longer dependent on the time or day, or time required for delivery.' This early vision has become a reality with products such as TiVo, but neither Negroponte nor TiVo offered a formal theoretical conceptual model that will aid the design of ITV applications. The name virtual channel was first referred to by Whitingham (2000, p.21), as an element of the functionality of the Home Media Server paradigm. That business report neglects any further definition, description and evaluation of the implications that are entailed by the introduction of the virtual channel. The idea and the name of the Virtual Channel model have been presented before, but none of the previous works systematically identified, defined, and tested it.

There are a few research works that addressed an integrated spatiotemporal scheme (Marin et al. 2001; Merialdo et al. 1999). Both treated the case of TV news without generalizing to the underlying concepts of spatial and temporal dimensions of the ITV content. Nevertheless, Marin et al. (2001) identified the need to integrate the elements offered in the functionality of commercial products, such as the WebTV and the TiVo, into a coherent service and they proposed an architecture that adds to the TV video real-time mixing with 3D graphics. A shortcoming of those works was that they do not consider a UI for ITV consumers, and instead, they rely on a desktop UI for the presentation and selection of the personalized news content. As a matter of fact, they do not consider the consumer and do not perform any kind of usability evaluation for the proposed system. There are also a few EU-funded research projects (e.g. iMEDIA, NexTV, ICE-CREAM) that have developed a vision for ITV that is compatible to the Virtual Channel model, but there are no publications that describe such a concept.

Overall, *previous works do not offer a systematic approach that would constitute a contribution to the HCI theory*, because the conceptual model: 1) is not explicitly identified and presented, 2) is closely integrated with a specific type of TV, thus making difficult to identify its generic properties, in order to apply it elsewhere, and 3) there is no usability evaluation with consumers. Nevertheless, those works are further evidence that the suggested solution to create the television experience at each consumer STB from a dynamic synthesis of a wide array of digital data is a valid proposition and it is under scrutiny from many researchers.

A few alternative metaphors for ITV were evaluated in a study with consumers and it was found that the most appropriate metaphors were those of the people and the EPG (Burmester and Koller 1996, Koller et al. 1997). Both of those metaphors are familiar to the TV viewers because they are based on the respective familiar concepts

of human presenters and the printed TV guide. The rest of the metaphors received negative reactions because they were borrowed from unrelated conceptual domains (Web, CDROM, City Map). Therefore, the relevance to the domain of application is of essential importance for the adoption of a mental model. Correspondingly, it can be argued that *the Virtual Channel entails a relevant mental model for consumers, since it is an incremental extension of the established TV channel mental model and, at the same time, provides augmented affordances for interactivity (i.e. changing content within the channel, computer generated content, additional information, etc).* Nevertheless, further research is needed with additional types of TV content, in order to draw final conclusions about the validity of the Virtual Channel model.

A limitation of the Virtual Channel model, as presented in the music video study, is that it addresses only the problem of the organization and the presentation of stored content within a single thematic television channel, while it does not address the case of organizing a network television channel during the total airtime per day or how to navigate between different thematic virtual channels. The proliferation of thematic television channels (music, news, sports, documentary) gives many opportunities for applying the Virtual Channel model, given that the content in this type of channels is alike. For the case of the network channel that broadcasts diverse types of programming, the Virtual Channel model has to be extended with additional interaction paradigms. For example, the network channels may offer multiple virtual channels, one for each thematic category on their broadcast schedule.

The Virtual Channel may not be appropriate for story-driven TV content and dynamic synthesis of scenes for the creation of new content items, like movies, soaps and series. Strategies and tools for interactive storytelling have been studied by Agamanolis (1997, 2001, 2003) and the object-based media group at the MIT Media Lab (Bove et al. 2000). In comparison, Responsive Television research is focusing on the dynamic synthesis of video at the scene level, while the Virtual Channel research defines a framework for the dynamic synthesis of an integrated (local video, Internet resources, real time broadcasts) television experience at the content item (e.g. music video clip, news story) level.

Previous research with a DTV navigator suggests that the formation of a mental model for each ITV service should not be forced to users, because users prefer to navigate 'in the moment', like they are doing for Web sites (Eronen and Vuorimaa 2000). The DTV prototype used for that study runs under the assumption that ITV applications are merely add-ons and have no close relationship with the traditional TV content. Instead, *the Virtual Channel model suggests that interactive services become an*

integral part of TV content, in order to form ITV applications (or ITV content). Therefore, despite the results of that study being valid, it is argued that the prototype used for that usability evaluation is inspired from the now defunct vision of ITV, being a reproduction of the Internet on TV.

The Virtual Channel model provides the designers with a conceptual framework upon which the UI for the ITV application is built. By making an analogy with the desktop model, an application designer needs not to think about the organization of the generic application elements, like menu bar, title bar, toolbars, multiple windows, etc, but only for the application specific elements. In the same way, the ITV application designer has to think only about the basic features of the ITV application, such as timing of the events, navigation options through the video-clips, presentation options for the related information, etc.

The Virtual Channel model implies that ITV application design should conform to a push model of information delivery and should reduce the direct manipulation of content from the consumer. It is widely accepted that the pull and direct manipulation properties have been central to the successful development of the Web and the Desktop models of computing. In particular, the pull property of the Web is the cornerstone of a medium that has excelled mainly in information retrieval and transactions (Berners-Lee 1994). Respectively, the direct manipulation property of the desktop empowers the users to use the PC efficiently as an information processing and productivity tool (Shneiderman 1997). Neither information retrieval and transactions, nor information processing and productivity belong to the domain of activities that shape the TV experience. *The Virtual Channel model exploits IT developments, in order to enhance the core elements of the TV experience; that is enjoyment, relaxation, passive and information exploration.* Nevertheless, there are some cases, like retrieving the morning news before leaving for work, or checking a personal portfolio of investments while watching the financial news, in which the traditional paradigms of information processing have a priority over the affective usability paradigm.

6.2.1 Virtual Television Channels

In this section, the Virtual Channel model is presented within a broader framework of computer science research for ITV.

Building a virtual channel is a three-step process. Digital media delivery (Figure 28, step 1) and digital media filtering (Figure 28, step 2) have been treated extensively in the video technology and in the personalization literature respectively. The former

concerns technologies for video compression, encryption, metadata and indexing with additional resources from diverse network architectures (e.g. P2P, Home-network, Web Services). The latter concerns systems for content recommendation.

Dynamic content selection for TV presentation (Figure 28, step 3) is a new concept both for television viewers —who are accustomed to receive passively programming— and to broadcasters —who have built their business models around pushing content to the masses. Multimedia content presentation has been treated to some extent by the CD-ROM industry and lately by rich media Web sites on the Internet, but in both cases the content is targeted to PC users and not TV viewers. Information visualization research is also inappropriate for interactive television when considering the different characteristics of users (groups of television viewers), equipment (set-top box and television), goals (relaxation, enjoyment, escaping from reality) and transmission (broadcasting).

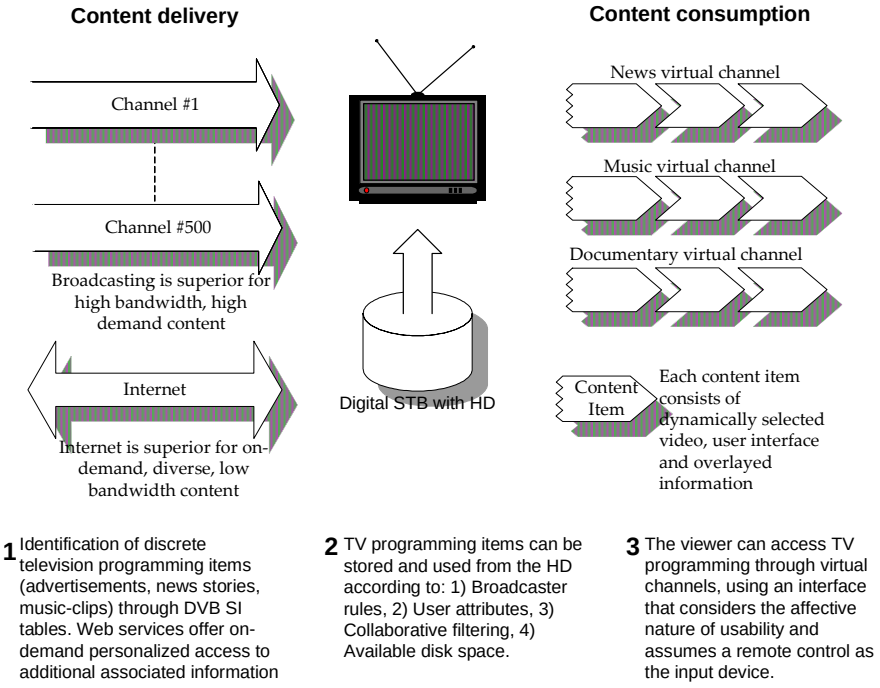

Figure 28 The creation of virtual channels in three steps. The virtual channel model simplifies the choice from multiple program sources, while considering the viewer as an important factor in the televised programming. The focus of the present work is on step 3

Therefore, the virtual channel model builds upon previous technical work done within the broadcasting industry, in order to bring the benefit of digitization to the end users. It also complements the literature about personalized content selection

and presentation, by offering a model for enhancing the TV experience in: 1) a technically feasible way, and 2) an appropriate for the TV paradigm way.

6.3 USER INTERFACE PRINCIPLES

The design of a UI for an ITV application is very different from the one for a PC application. The major difference between the PC and the ITV is that the UI for ITV is content specific, while the UI for the PC is application specific. For example, in a word processor most of the UI principles are common with those of other productivity applications, while the UI for a music ITV application is very different from the UI for a news ITV application. Certainly, there are a few UI principles in a PC application that are content specific and there may be a few UI principles in an ITV application that are generic, but this is the exception rather than the rule. The EPG is one type of ITV UI that is independent of the TV content, although recent research has suggested a closer integration of the EPG with the TV content (Bonnici 2003). From that perspective, UI design for ITV is very similar to UI design for the Web, whereas each Web site has different content, structure and navigation. The UI principles formulated in the present work consider the ITV user as a TV viewer and exploit IT opportunities for the benefit of ITV content. Thus, the ITV UI principles were presented as trade-offs, in order to be elastic in the selection of the most appropriate UI design.

6.4 PROTOTYPING

A common thread in previous research was the use of PC and Web technology, instead of actual ITV platforms, for the usability evaluation of ITV applications. Additionally, the majority of these experimental set-ups are presented within the PC or Web modalities, as revealed by the screenshots provided in the respective publications. For example, previous research about ITV metaphors resided on static representation of the respective metaphors that the users evaluated based on their intuition and the verbal description of the experimenters (Koller et al. 1997), an approach that can hardly be considered valid —at least for the UI items that were static. The use of a disguised PC with a TV and a remote control were used successfully in the qualitative usability evaluation of an EPG (Eronen and Vuorimaa 2000). In the present research, the ITV prototype was a high-definition one. The mapping from the

Virtual Channel model properties, to the virtual music channel prototype features is not deterministic, but it can be argued that the evaluation of the interactive prototype provided consumer feedback that has external validity for the research issues.

6.5 PROGRAMMING LIBRARY

This research is based on the realization that despite the technical progress of the current ITV APIs, in terms of mentality, they are still closer to the IT developer than the TV producer. Since compelling ITV applications are most likely to be developed by TV producers it makes sense to develop ITV production tools that make IT friendlier to them.

On the technical side, it was demonstrated that the availability of a high-level UI programming library can reduce significantly the effort for the creation of an ITV application, thus allowing more time for testing alternative ideas and also more time for testing with consumers. The underlying events that are raised by the Virtual Channel Control (VCC) exhibit the essence of the established broadcasting mentality, that is 'start of video', 'end of video', 'end of ad break', 'scheduled ad break coming next', 'end of timer', etc. In the ITV prototype application, the music content was used in order to validate a programming library that is based on the properties of the Virtual Channel model.

The Virtual Channel may be employed in APIs and visual authoring tools, in order to enforce a consistent development model for ITV applications, just like the Web and the Desktop have defined a common ground within which developers are building their applications. The above argument should not be confused and regarded as a point against creativity in the design of ITV content. Instead, the present thesis is in favor of: 1) designers' creativity, 2) extending the notion of what a UI for ITV is (for example a sad, or fearful UI may be appropriate for ITV, as explained in the next section), and 3) enhancing the traditional TV with new design elements made available by IT developments.

In Chapter 2, the BSkyB Sky+ service, which is based on the commercial product XTV by NDS, was discussed, because it features dynamic advertisement insertion and it also features an interactive music TV application. Since it is a commercial product, there is no information available about the usability evaluation during the development for both of these features. In Chapter 5, the implementation of a music ITV application was described in detail, alongside with the architecture and the re-

spective programming code. In this manner, the application implementation can be repeated in related research or product development.

6.6 AFFECTIVE USABILITY EVALUATION

The findings from the affective usability evaluation of the ITV prototype entail significant implications for the respective methodology. Multiple usability evaluation methods were employed and multiple data collection instruments were used, in order to compare the methods and mainly in order to combine the results. The traditional usability evaluation methods were augmented with theory and methods from TV-related disciplines. In general, it was found that alternative data collection instruments provide different insights into the research and thus more complete results, although there are cases in which a particular instrument is more suitable than others. The results addressed the hypotheses, but they did also lead to important insights about usability evaluation methodology for ITV, which is discussed next.

Previous research about ITV systems was mainly concerned with the technical issues and neglected the employment of usability evaluation methods. Some works applied mainly qualitative methods and performance testing, without any consideration of the ITV environment. In the present research, the qualitative research methods were the most useful for improving the understanding of the research problem and for gaining insights into consumer desires, in order to develop future ITV applications. Moreover, it was found that the log files provided information about behavioral issues and, in addition, log files revealed new issues that require further research.

An adaptation of the performance evaluation method proved useful for the evaluation of the ITV prototype. In particular, Maguire (2002) raised the question: 'Should tasks be fixed or should users be allowed to use the service as freely as they wish?' In accordance with the selective expose theory the users were allowed to use the service for a certain amount of time, without any other goal or task to complete. Moreover, it is suggested that the traditional usability engineering methodology may be applied unchanged for those ITV applications that demand intense information processing from the consumer, as well as for those ITV application that do not have entertainment purposes.

Despite the multitude of usability evaluation methods that were used in the course of the present study, all of them were employed during the limited duration

span of an experiment, instead of spanning through everyday living in consumers' homes. Previous findings regarding the usability of everyday technology demonstrate that the consumers' perceptions and especially the mental models they form about new domestic technologies are very elastic and prone to change in the passage of time (Petersen et al. 2002). Therefore, a longitudinal study would have provided additional information about the research issues.

In previous research, the instruments employed to measure the usability features were either borrowed directly and without any consideration from IT (e.g. Nissler and Thoma 1999) or they were novel attitude questionnaires developed for the specific study, without providing any analysis or evaluation of the respective construct validity (e.g. Cappelletti et al. 2003, Drucker et al. 2002, Koller et al. 1997, Nissler and Thoma 1999). In the present research, *the affective usability framework for ITV employed a combination of previous evaluation instruments employed in TV research. Furthermore, the instruments were structured inside an evaluation framework that addresses the multiple levels of emotional responses to design.* Overall, it is suggested that the usability evaluation instruments for ITV should be based affective usability paradigm, and that they should be developed by adapting previous concepts from TV research.

A few of the measuring instruments did not reveal significant differences between the UI manipulations. For example, it was found that the attitude measuring instruments provided significant results, while the adjective checklists for the lower levels of emotional response did not give any significant difference for the alternative UI manipulations. The latter may be due to the independent variable not being one that has any effect on the dependent one, still, the participants of the study reported that they could not relate to the adjective checklists. Another explanation might be that the sample employed in the study was very small to reveal the differences between the UIs. It should be noted that these instruments were developed in disciplines that study established phenomena —and not system that are under development— and that employ large sample sizes (e.g. 300 subjects). The latter practice is incompatible with the basic HCI design philosophy, in which small samples are used iteratively.

In summary, it is argued that the effects of ITV applications cannot be conclusively assessed, unless there is a longer-term deployment and a longitudinal study of their use, using an appropriate data collection instrument. Nevertheless, appropriate adaptations of the traditional usability evaluation methods and the employment of affective usability framework, fit adequately in the early development process of ITV

applications and provide valuable feedback for the UI design and the application features.

6.7 APPLICATION DESIGN

In this section, the results about the features of the ITV application are compared with findings from analogous studies.

6.7.1 Video-Clip Skipping

The active selection of media for consumption is a popular theme of research in the discipline of communication research, and is based the theory of selective exposure to communication (Zillmann and Bryant 1985). According to this theory, media consumers actively select to be exposed to media that will enhance their moods. In a previous study of music consumption, it was found that respondents in bad mood selected more cheerful music and did so more actively than respondents in good mood (Knobloch and Zillmann 2002). In the present study, participants reported that they used the skipping feature mainly to avoid video-clips that they did not like. One explanation for this difference is that the interactive music TV prototype did not have any extensive controls for navigating video-clips, besides skipping to the next one. Moreover, the participants were not manipulated for mood and the data about music selection were primarily based on retrospective methods that could not reveal the more minute differences that actually motivated skipping a video clip.

Instant video skipping was also a desired functionality in a previous study. Drucker et al. (2002) found that consumers preferred the video skipping UI that exhibited the worst performance metrics, but it was considered to be more relaxing and fun than the alternatives. They concluded that CE devices should be designed with an affective set of usability goals. The results of the present study are confirmatory. The preference for video skipping was measured by the hedonic quality instrument and by the personal interviews. Consumers became immediately familiar with the use of the video clip skipping functionality and used it deliberately during the testing sessions. The familiarity and preference of video clip skipping can be explained as a transfer of experience from the CD audio device.

Therefore, it can be argued that the temporal personalization property of the Virtual Channel model can be used to seamlessly enhance the entertainment value of the consumers' television experience with an ITV application. Consumers suggested

that interactivity with the virtual music TV channel should include more options, such as repeat and pause. In addition, the dynamic synthesis of video clips at the STB allows for much greater flexibility in the selection of the next video clip, way beyond simple track skipping, or free video browsing.

6.7.2 Animated Character

The animated character was regarded as the most innovative and controversial feature in the results of the study. The positive user evaluations prove the validity of the animated character research for ITV and they are in line with related research in the home infotainment domain (Diederiks 2003, Bartneck 2003). The hedonic quality score was supportive of the animated character, but the program liking score was not affected.

There are a few findings that contradict those from previous studies. For example, Koda and Maes (1996) found that both liking and engagement with activity were increased with the addition of an animated character. The difference with the present study may be attributed to 1) the evaluation method and 2) to the integration of the animated character with the activity. The respective study did not use any validated instrument for measuring liking and engagement and it employed only 10 users. On the positive side of that experimental design was that the integration of the faces was more tightly integrated with the interactive game (poker).

The arousal levels were unaffected by the addition of the animated character, while the addition of visuals to music has been found to have an impact on the arousal levels of viewers (Zillmann and Mundorf 1987). The arousal measures did not gauge a difference, either because the animated character is not a significant addition to the visual content of a music video clip, or because the size of the sample was not big enough to reveal such a difference.

The animated characters research in HCI has been part of a movement to give emotional characteristics to computers (Picard 2000, Reeves and Nass 1996). Despite the extensive research effort, the practical contribution to consumer products has not been significant, so far. Here, it was found that the contemporary implementations of animated characters need to be refined before applied to ITV applications. It was also found that the simple integration of the animated character with the presentation of information related to the running video-clip was not enough to provide significant differences in feelings and behavior, although the attitudes were more positive, compared with the traditional information box.

In summary, it can be argued that the spatial personalization property of the Virtual Channel model can be exploited to affect the consumers' attitude about TV content, by using an appropriate visualization for the presentation of related information.

The combined results may lead to the realization that the visual UI for ITV may not have a significant impact on the liking of the ITV experience and despite the fact that the interactive elements are positively perceived, they may be superficial to the core TV content. Still, there are many opportunities for further research, especially for closer integration of the animated character with the TV content, which is discussed as further research in the next chapter.

6.7.3 Dynamic Advertisement Insertion

The dynamic advertisement insertion might be considered a controversial feature, but it was a necessary addition, because advertising revenues support the majority of the broadcast TV expenses.

The insertion of an advertisement, when the user chooses to skip a video-clip, was conceived as a way for slowing down the flow of the virtual music channel, assuming that the HDD has a finite storage capacity and its capacity might be shared with other TV content, as well. It was also conceived as a remedy against the skipping of commercial breaks that has become possible with the introduction of DVR devices.

Before commencing the usability evaluation and the experiment with the consumers, it was not clear whether consumers would welcome an additional format of advertising —the virtual music TV channel already had scheduled advertising breaks. There is no previous research about a similar form of advertising, so it was very difficult to predict consumers' attitude and to compare with similar studies. However, it was found that *the ability to perform video-skipping is a trade-off that balances the nuisance of the additional advertisement message.* Indeed, all the consumers were positive to the dynamic advertising insertion and the behavior results from the log files revealed that they actually watched the double number of advertising messages compared with a normal broadcast session. It might be argued that the experimental setting and the novelty of the system may not have external validity for the everyday viewing situation in the household, but still, the results are encouraging for an otherwise controversial feature of ITV.

In conclusion, the trade-off between skipping to the next video clip and watching a short advertisement was justified positively by the consumers, opening up opportunities for new advertising formats, which are discussed in-detail in the next chapter.

6.7.4 Interactive Music Television

The most interesting suggestions for future improvements concerned the augmentation of the music video skip feature. Users familiar with the PC MP3 players asked for more options when skipping a music video, such as repeating the same song, playing a song from the same artist or playing the same music genre. Moreover, a longer list of the upcoming music videos would be welcome and it would also allow organizing their time better, since they could leave the TV open and plan to return back when their favorite song is on. Using the television as a time management tool to structure activities and organize time was also document before at an ethnographic study of a STB trial (O'Brien et al. 1999). Therefore, providing on-demand information about the upcoming video clips would facilitate the use of TV as a time management tool, while the ability to alter dynamically the upcoming play-list would support interactive behavior.

6.8 IMPLICATIONS FOR THE TELEVISION INDUSTRY

The results regarding the ITV application design issues, alongside with the Virtual Channel proposal, have significant implications for the media industry.

6.8.1 Content Production

Having attended a few international ITV conferences and having participated in numerous meetings with European TV executives there are two anecdotes that keep coming up every time there is a discussion about ITV content and consumer behavior.

The most important anecdote about ITV reflects an apparent pessimism on behalf of the media industry executives regarding the viability of ITV. The saying goes like 'There is no killer application for ITV. The killer application of ITV is TV!' meaning that interactivity is a nice-to-have —but not must-have— enhancement to the traditional passive TV content. There is also academic research that confirms the

above opinion that consumers just want more TV from ITV (Theodoropoulou 2002). The importance of the traditional TV content was also supported in the present study by the program liking results and the results at the visceral and behavioral levels. The addition of the animated character did not have any effect neither on program liking nor on affective states, although consumers, who were already familiar with the music information box from MTV, did evaluated it as having higher hedonic quality. Therefore, it seems that the anecdotal about the ITV killer application is quite right, but the higher hedonic quality scores opens up new issues for TV executives. *ITV is currently perceived as a decorative element, which does not provide any actual improvement of the existing TV content.* Therefore, there are still issues left for further investigation about how program liking and attitudes are affected by the addition of interactive content, especially when the interactive elements are more closely integrated with the TV content or consumer preferences —e.g. having an animated character respond emotionally to the content of the video clip. Finally, it can be argued that there exists a killer application for ITV and that is video skipping.

Another important anecdote about ITV concerns the production and adoption of interactive content and goes like 'Consumers do not buy a digital STB because there is not enough compelling content and producers do no create interactive content, because there are not enough consumers with a digital STB! It is a chicken and egg problem!' Instead of trying to produce interactive content for ITV or to push consumers to adopt a digital STB, it is argued that TV producers should develop applications for digital STBs that exploit the wealth of digital broadcasts, local storage and Internet resources toward enhancing their traditional linear TV programs. Consumers have already started adopting advanced digital STBs, such as DVR, DVD-R with HDD and video-game consoles with HDD. *TV producers should think of their programming in terms of discrete modules —audiovisual, executable code, data— and in terms of their dynamic synthesis personalized for the television user in the form of virtual channels.* For those consumers without a digital STB the same resources should be available through alternative communication channels (e.g. Web). For example, the prototype for the virtual music channel was actually based on content that is on broadcast from a traditional music channel (MAD TV), while the additional information was retrieved from the broadcaster's web site (http://www.madtv.gr). Then, the broadcaster (or additional mediator, as discussed in a following section) needs only to develop a digital STB application and to insert the respective metadata and related information either in the VBI or provide them through the Internet connection. Those consumers

without a digital STB will continue to receive the traditional linear channel, thus providing backward compatibility for the most pervasive medium.

6.8.2 Advertising

The most important contribution to the advertising practice is the concept of the dynamic advertisement insertion when the user chooses to skip a video clip. Previous research identified the need for developing novel advertising schemes for supporting digital media in domestic settings (Bell and Gemmell 2002), but failed to give any concrete guidance. In practice, the commercial DVRs offer a 30 second skip button, but content and network providers are reluctant to adopt a STB technology that neglects their main revenue source (advertising). TiVo is offering a special space (named 'TiVo Showcase'), whereby advertisers may store their ad and users watch them on-demand. Alternatively, short ads (5 to 10 seconds) might be a choice when users choose to skip recorded content, although a subscription service may still be ad-free. In this way, *the dynamic advertisement insertion in the TV content stream offers a solution to the DRM issues that arise as a barrier to the widespread use of digital STB devices that allow recording and on-demand playback of copyrighted material.* The characteristic that makes the dynamic advertising insertion such a powerful means for supporting DRM is the certainty that the viewer will watch it, since it has been implicitly triggered by the viewer, in order to get to the next video clip. As a consequence, for each advertisement there may be accurate statistics regarding the number of STBs in which it has been displayed (reach) and the frequency that has been viewed by consumers. Providing the advertisers with detailed numbers for reach and frequency for each advertising message is part of the Holy Grail for the advertising industry (the other part is measuring the advertisement effectiveness).

Television advertising, like most of the other broadcast content, had been a fixed part of the program. The Virtual Channel model has released the TV channel from the linearity of the fixed broadcast schedule. The same properties that apply to TV content, apply to advertising too. *An advertising video clip need not be part of an advertising break and need not be presented at the same time for all consumers.* For most countries, there is a regulatory framework for TV advertising that dictates how often and how many advertisements may be shown during a broadcast schedule. The extension of the TV experience beyond the fixed broadcast schedule is likely to create new regulations for the delivery of advertising messages. For example, if a virtual channel is left to play by itself, it should conform to the existing legislation that applies to TV ad-

vertising. But, if the consumer chooses to manipulate the flow of the virtual channel, then, the virtual channel should be either supported by a subscription fee or by a novel advertising scheme, which leads to an additional implication for the advertising practice, described below.

After the advertising video-clip is released from the ties of the ad break and the broadcast schedule, creative advertisers will have the opportunity to experiment with new formats. The traditional advertising video-clip may be augmented with additional on-demand information and may diversify its duration beyond the typical thirty seconds. For example, video-clip skipping by the consumer may insert a short advertising teaser that links to a short-movie advertisement and/or to an interactive product demonstration. Thus, *a short advertising teaser may lead to a longer advertising clip that may also offer interactive content and ultimately create a line of contact to the advertiser.* Until now, the advertising break duration and format was dictated by the economics and the technology of the broadcast medium respectively. Air-time duration determined the pricing, while the passive video format only allowed the inclusion of a link to the advertiser's Web site for further interactive information. Both barriers have now fallen and TV advertising may employ interactive and alternative duration formats.

6.8.3 Broadcasters

The Virtual Channel model has implications for the operators of TV channels. Firstly, the broadcasters may offer a virtual channel, in addition to their linear one. Moreover, the offering of virtual channels from the digital STB may be operated by new mediators, who specialize in the aggregation and in the personalization of content. Finally, the dynamic generation of TV channels from each STB raises the question: 'Who controls a virtual channel, the broadcaster or the user?' Each of these propositions is analyzed in detail below.

Existing broadcasters that operate one or more TV channels will find in the Virtual Channel model the opportunity to diversify their static and linear TV schedule. TV channels need not invest on expensive new equipment, because virtual channels are created and controlled at the consumer's household, by receiving and storing on the HDD the currently available broadcast. Most broadcasters that operate a TV channel also operate the respective Web site, which provides additional information and transactions. *TV channels may develop an interactive and personalized TV experience, by integrating the available audiovisual broadcast with the interactive Web site.* For exam-

ple, a music TV channel like MTV may offer a virtual channel called iMTV that provides an interactive music TV experience like the one described in the virtual music channel case study. It may also use the traditional MTV channel to promote the iMTV brand. For example, during the broadcast of the popular 'top20' it may display an overlay suggesting to viewers to switch to a personalized virtual channel playing the 'myTop20'. Switching from the linear to the virtual channel would be a preferable outcome instead of switching to a different channel, in case the viewer does not like the currently playing video-clip. After all, the main objective of the broadcasters is to keep the viewers tuned into their channels and since the one-size-fits-all does not correspond to modern viewers needs, then allowing the viewer to 'change channels', but still, remain within the same 'mother brand', seems like a sweet-spot for broadcasters.

In the past, the DTV systems created the opportunity for a new player in the media industry. TV channel aggregators provide to TV viewers a coherent collection of TV content and services that are targeted to various groups of preferences, like music, sports, movies, news. In the same way, the virtual channel model creates many opportunities for existing and new business roles. *The virtual channel aggregator is a new mediating role in the media industry that combines the available broadcast transmission with additional elements (Internet, computer generated graphics) for the provision of personalized virtual channels.* For example, there are multiple music TV channels available on a digital satellite system and each of them may be targeted, in terms of the type of music video clips aired. Assuming that each of the music TV channels would agree on a scheme to offer their video clips for aggregation on consumer's digital STB and assuming that the video-clips would be offered without any overlay (the channel logo and the overlay information may be added at each digital STB, according to the spatial personalization property of the Virtual Channel model), then there is no barrier to create whatever type of virtual music channel for each household. By reversing the promotion scheme used internally for a music TV channel to promote its interactive spin-off, the aggregated virtual channels may promote their ancestors by displaying overlays suggesting to viewers that 'more music like this may be enjoyed on that channel.' The creation of a virtual music TV channel from content available on potentially competitive music TV channels may seem contradictory, but the role of the TV channel aggregator has always been to re-package the available content and to market it to new audiences, which are not reached by the fixed channel offerings.

Finally, the most controversial implication of the Virtual Channel model is the entity which will actually control the dynamic generation of virtual television channels at each STB. The definition of the Virtual Channel model does not entail any requirement regarding the control issue. On the one hand, the Virtual Channel model implementation may be offered as a shareware or an open-source S/W for PCs and thus, the functionality will be in the control of the consumer. For example, the consumer will able to browse music video content stored on the HDD freely, without any advertisement insertion. Nevertheless, availability and indexing of the content will be restricted to the extent that the TV content can be automatically segmented and indexed with free resources from the Internet. On the other hand, a broadcaster may offer the Virtual Channel model as part of a subscription service. In this case, the broadcaster may assume the complete control of what is stored on the HDD and how it is played from the STB. Nevertheless, it would be beneficial for the broadcaster to allow increased control to the consumer, but it is argued that the transfer of control will be reflected to a higher price on the subscription fee. For example, consumers may be allowed to skip advertising breaks, but they will have to pay a higher fee for that privilege. Besides the two extreme possibilities of control, there is a wide spectrum of control schemes that reside in the continuum between the consumer and the broadcaster sides.

6.9 SUMMARY

This chapter presented the results of the design and the evaluation of the music ITV prototype under the light of previous related findings. The research issues were discussed in the context of the HCI theory and methods, in order to identify the contribution of the present research work (Table 9).

Research issue	**Contribution**
Conceptual model	Virtual Channel model, Spatial and Temporal personalization of ITV content, coherent model for application design and use
User interface principles	Balance between IT and TV values
Prototyping	High-fidelity platform for ITV
Programming library	High-level library for ITV producers
Usability evaluation	Usability as ITV entertainment, affective usability framework for ITV, selective exposure
Video skipping	Affective usability evaluation

Animated character	Affective usability evaluation
Dynamic advertisement insertion	Usability evaluation

Table 9 Contribution to theory

Moreover, the implications of the findings for the media industry were discussed, in order to identify the implications for practice (Table 10).

Business	**Impact**
Producer	ITV is currently perceived as a high-level decorative element, TV producers should think of their programming in terms of discrete modules—audiovisual, executable code, data—and in terms of their dynamic synthesis personalized for the television user in the form of virtual channels
Advertiser	The dynamic advertisement insertion offers a potential solution to the DRM issues, an advertisement need not be part of an advertising break and need not be presented at the same time for all consumers, novel advertising formats (teaser, short movie, interactive content)
Broadcaster	Spin-off interactive brands by exploiting available content, introduce new mediators (virtual channel aggregators), balance the control of the virtual channel between consumer and broadcaster

Table 10 Implications for the media industry

In the next chapter, the experience is translated into further research for the parent and the related disciplines.

7 FURTHER RESEARCH

This chapter provides directions for future research. The present work provided answers for many important issues, but the research problem as a whole is far from being totally resolved. Most of the results and the experience gained during the course of the research have opened-up a new set of issues, in HCI and in many related to the research problem disciplines. The rest of this chapter is structured as follows. Further research directions are provided for each one of the HCI issues that were treated in the present work. Finally, further research for the related disciplines is proposed.

7.1 HUMAN COMPUTER INTERACTION

The Virtual Channel model opens new research questions for the UI designer and the user of ITV applications.

Apart from the music video clip content, the proliferation of other thematic channels (news, documentaries) gives many opportunities for applying the Virtual Channel model, given that the content in this type of channels is alike. For the case of general-purpose channels that broadcast diverse types of content, the Virtual Channel API has to be applied on a per-segment basis or extended with additional interaction paradigms. Further research should employ the Virtual Channel model for diverse types of TV content.

The introduction of the Virtual Channel may influence consumers to reform their current mental model about TV. Since the Virtual Channel model is based on the ubiquitous notion of the channel, consumers do not have to throw away any previous experience. Instead, consumers should merely have to adapt their mental models to include the notion that a TV channel is an elastic entity that may be manipulated to fit their preferences. Further usability research should evaluate and track down the mental models that are formed after interacting for a long time with ITV applications that are based on the Virtual Channel model.

In summary, the Virtual Channel model may be refined and enhanced, as it is being applied and tested with other types of TV content. In other words, the domain and the characteristics of the TV content employed may affect the implementations of the Virtual Channel model. By making an analogy with the desktop computing paradigm, it is evident that there are multiple commercial implementations of the same basic UI principles for interacting with PCs —Windows, Mac and Unix variants to name the most popular— each one developed in different contexts (office work, creative work, scientific work respectively for the three desktop variants). In this fashion, the Virtual Channel may be implemented to support diverse commercial policy objectives. Further research may also complement it with other use paradigms, in order to support easy access to ITV applications or to offer interactive storytelling.

The ITV UI principles were presented as a list of trade-offs, although traditional UI principles are sometimes more specific and concern particular parts of the interaction, such as dialog box, menu, icon etc. Moreover, there are guidelines, which are quantitative reformulations of principles. For example, the generic principle 'respond fast to user commands' may be transformed to 'respond in 1sec to user commands' as a guideline for a specific system. Accordingly, the ITV UI principle for 'multiple levels of attention' may be transformed to a more specific principle, such as 'remove a dialog box, if the user does not interact with the TV system' or transformed to a guideline such as 'remove a dialog box, if the user does not interact with the TV system for 5 seconds.' Therefore, further research should refine the proposed set of UI principles into longer lists of more specific principles and guidelines for particular types of ITV applications.

Prototyping platforms for ITV should be enhanced with additional features that provide more options for usability evaluation. The availability of STB-like PCs will allow the development of ITV prototypes that would be conveniently installed in domestic settings. Moreover, adding a TV tuner would extend the functionality to include synchronization between broadcast and local storage and would allow performing more realistic TV experiments in consumers' homes, over longer periods of time. Then, researchers would able to answer research questions such as: 'which option do specific consumers prefer for some type of TV content under certain circumstances: 1) The fixed broadcast channel, 2) a virtual channel with multiple navigation features, or 3) a personalized virtual channel controlled by the broadcaster.' Thus, further research would be able to test alternative UI strategies and content personalization.

Further research for programming libraries for ITV should consider additional operating systems, such as Unix, and other DTV platforms, such as the Multimedia Home Platform (MHP). Furthermore, UI development for ITV applications will be benefited from a standard implementation of the Virtual Channel model and the respective set of principles. Finally, the Virtual Channel model should find its way inside visual authoring environments and digital STBs.

Further research should treat the affective usability evaluation for validity, alternative conceptualizations of entertainment, and methods, as discussed bellow.

The validation of the proposed evaluation framework is well beyond the scope of the present research, which favors an holistic approach to UI design for ITV, instead of an in-depth assessment of the affective usability evaluation methodology. Therefore, further research should validate formally the methodology for evaluating a UI for ITV, in all stages from development to deployment. The affective usability framework was developed by conceptualizing the entertainment experience as mood management. Since entertainment is a multidimensional construct (Vorderer 2001b), further research should consider other important dimensions that were not treated in the present research, such as play (Vorderer 2001b), or flow Csikszentmihalyi (1991).

The present research was performed in the laboratory, which is not a realistic environment for TV watching and which does not provide information regarding the evolution of consumer attitudes. Petersen et al. (2002) found that consumers' reactions changed after using a home-theater set for a log period of time. It is very likely, that the installation of virtual television channels in a domestic setting for a long time will provide with further insights regarding the major issues of UI design for ITV. In terms of methodology and scale, the most impressive longitudinal study for TV was conducted by Kubey and Csikszentmihalyi (1990) by employing a method of their own, called the Experience Sampling Method (ESM). In bold contrast to the previous approaches to TV content and audiences, they regarded the TV experience as an integral part of everyday life. Accordingly, they justified the use of an instrument that measures a wide spectrum of emotions, activities, and attitudes, during the course of a day and that regards TV watching as a part of those activities. Further research should employ longitudinal methods and the appropriate instruments.

Since digital video libraries have emerged in domestic settings and they are presented in an ITV environment, instead of a PC, it is suggested that HCI research should re-examine the respective navigation paradigms. Moreover, consumer-level video skipping is only going to become more complex if the domestic digital video libraries are combined with remote ones, through fast Internet connections. In the

present study, the most interesting findings for future improvements concerned the augmentation of the music track-skip feature. The familiarity with CD players and the PC-based MP3 music players may be exploited to offer more options when skipping a music video, like repeat the same song, play a song from the same artist or play a new song within same music genre. Likewise, other types of TV content may require video skipping styles that depend on the specific content. Therefore, further research should consider content specific navigation schemes.

Research issue	**Further research**
Virtual Channel model	Apply to diverse types of TV content (news, documentary, sports), assess the mental model of consumers
Principles	Lower-level principles and specific guidelines
Prototyping platform	Employ PCs that look and feel like STBs, add TV tuner and synchronization with broadcast TV
Programming library	Implement the VCCLib in alternative O/S (Linux), DTV platform (MHP)
Evaluation methodology	Entertainment as persuasion or play, longitudinal study
Consumer-level video skipping	Different navigation schemes for each type of TV content

Table 11 Further research for HCI

In summary, there is a need for further research for each one of the issues identified in Chapter 2. Further research may provide either more depth (e.g. principles for designing sad UIs) or more breadth (longitudinal study) for those important issues (Table 11).

7.2 RELATED DISCIPLINES

Besides HCI, which is the parent discipline behind the present research work, there are many other issues that require further research from the respective scientific communities.

7.2.1 Computer Graphics

In addition to static images, a digital STB may offer real-time video mixing of multiple video streams, using the alpha-blending capabilities of graphics hardware de-

vices. For example, an ITV application may blend multiple videos to create a matrix of the current broadcasts or of the available local files. This is usually called 'mosaic' and it is a popular effect for providing an overview of the running TV programs, found on many satellite and cable services. Currently, the mosaic is assembled at the broadcasting station from a pre-selected collection of channels and it is transmitted as a fixed video. A locally generated mosaic has the additional benefit that the specific assortment of videos displayed could be controlled by the user or by an adaptive UI system. (e.g. select the most frequently viewed TV channels, thematic virtual channels). Moreover, a simpler effect would be the insertion of only a single video stream at one corner of the screen, which is known as 'picture-in-picture' (PiP). Local generation of the PiP effect would allow controlling the size and the position of the superimposed TV channel window. Further on, a high-level ITV programming library should also offer support for the full spectrum of animation and transition effects that are used in TV production.

7.2.2 Music Television

Music video clips have a number of unique characteristics that facilitate further ITV technical development. Music content can be easily classified and filtered by employing open Internet databases and Web Services, classification schemes and adaptation models that have been developed for the popular MP3 music format (Pachet 2003). Additional metadata that describe the emotional content may also be used and combined with research about emotion in animated characters (Bates 1994). In the present work, music information (e.g. trivia, biography, discography) was stored in flat text files. One step further would be to use XML to structure and describe the metadata. Then it would be possible to retrieve this information through Internet resources and Web Services.

Providing on-demand information about the upcoming video clips would support the relaxed control of TV as a time management tool. For example, the user could bring up a play-list of 10 upcoming music videos and alter it dynamically along a number of parameters like genre, artist or automatically create a play-lists that is based on a smooth transition of songs between two particular songs (Pachet 2003). The user could also decide whether to skip directly to a music video by pressing the corresponding button on the numeric keypad.

7.2.3 Advertising Research

The positive user evaluation for the application's features entails a need for further research in advertising.

The video-skipping feature has the benefit of revealing whether the viewer is actually paying any attention to television programming. From this respect, the video skipping feature stands as the first instance that the TV advertising research will have an objective behavioral metric, which is directly linked to the viewer's attention to the TV. In addition, further advertising research should include the video skipping parameter into the set of independent variables for the study of the phenomena that concern TV advertising evaluation from consumers.

The insertion of novel interactive elements and computer generated content, such as the animated character, which elicit emotional responses from consumers may have significant effects on the evaluation of advertising messages. It is established that the mood induced by a TV program have several effects on important advertising message variables, such as recall, recognition, attitudes toward the ad and the brand (Goldberg and Gorn 1987; Murry et al. 1992). Since the addition of an animated character was found to have an impact on the emotional responses to the ITV content then it can be inferred that there is an effect on the advertising message variables, too. Therefore, advertising research should study how the addition of an emotional UI may affect consumer responses to advertising messages.

The dynamic advertisement insertion is a novel TV advertising scheme that may require the re-examination of the established theory for advertisement evaluation. It is likely that the dynamic advertisement insertion holds many of the same properties that have been already found for the first advertisement in a pod. Nevertheless, an accidental finding of the usability test was that some users could not remember having seen an advertisement, if it was very short. Further advertising research should study the effect of single short advertisement insertion and the possibility of extending them with short movies or interactive content.

7.2.4 User Modeling

The user modeling (UM) research community is very interested in personalized TV. There are numerous themes of the respective research that are being adapted for ITV, like viewer profiles, cold-start problem, personalized content and UI, etc, which were discussed briefly in the second chapter.

One prominent issue is the need of either implicit or explicit user input, which is used to inform the recommendation engine. Explicit input is not favorable by the users, but it provides straightforward data for the adaptation scheme. Implicit input does not have any requirement on the part of the users, but, past user interactions with a system do not always have a causal relationship to future interactions and, most importantly, they do no address the cold-start problem. The track-skipping feature coupled with detailed meta-data about each video-clip is an implicit input for the STB software that may inform a UM scheme about the preferences of the users, in order to adapt dynamically the flow of content, at least during a single TV watching session. Therefore, track-skipping may become a critical element of the consumer user model, in addition to being a powerful feature for direct content selection.

In terms of the spatial personalization there are many opportunities to offer video-clip related information. For example, a music TV channel may offer personalization of the overlaid information, by providing trivial and lyrics —retrieved from Internet resources. Most of the times, the broadcasters operate web sites with information about their TV schedules and information related to TV content. Besides first-party sources for information related to TV content, popular TV programs tend to be discussed and to become the source of inspiration for many web sites and on-line discussion forums. Under a moderation scheme, Web site content may be routed to the Virtual Channel STB, in order to augment the TV experience with live discussion and related information from alternative sources. Therefore, further research is need for the spatial personalization and integration with Internet resources.

Video-clip personalization can be also benefited from temporal personalization of the virtual channel for each STB. For example, a music TV channel, apart from the normally broadcasted 'Top 20' video-clips, may offer a personalized 'top 20' for each week. The personalized 'top 20' video-clip experience can be constructed by numerous methods such as: 1) Explicit choice from a list, 2) local mining of similar MP3 music, 3) vendor mining of past music purchases and 4) explicit friends' suggestions or collaborative filtering. Therefore, further research is needed for the temporal personalization for music and other types of TV content.

7.2.5 Communication Research

The communication discipline has contributed a lot to the theory and the approach employed in the present research. In turn, it appears that the research issues have implications for further research in that discipline, too. To begin with, media psy-

chology researchers assessed the entertainment value of a movie based on the parasocial interaction of viewers with the protagonists (Vorderer 2001a). The animated character introduced in the music ITV application may also have an impact on the parasocial interaction. Then, there is a need to assess whether the introduction of virtual channels has an impact on the concept of channel repertoire (Ferguson 1992). It is also likely that there are many additional issues for further research, although the concepts described here should have to be established with consumers and broadcasters, before their impact is assessed from the perspective of communication and media psychology.

7.2.6 Intelligent User Interfaces

The animated characters research belongs to the broader HCI field, but it has been a principal research theme especially in the sub-field of Intelligent User Interfaces (IUI). Previous research has studied the use of animated characters as a visual UI for mediating the recommendation results (Diederiks 2003). In the present research, the animated character was linked with the TV content by presenting related information. Further research should consider and investigate a tighter integration of animated characters with the TV content. That would require further research in developing an emotional connection between the character and the background content. In terms of content production and technology, one possible source of inspiration would be the field of video game studies. In brief, further research for animated characters in IUI should aim to blur the line between the experiences of TV and video-games.

Besides HCI there are many research issues that merit further research from the respective disciplines (Table 12).

Research issue	**Further research**
Computer graphics	Local generation of popular TV effects such as PiP, Mosaic
Music TV	Integration with MP3 DBs, filtering techniques and Internet resources
Advertising research	Video skipping as objective metric of consumer presence in front of TV, dynamic advertisement insertion as new advertising format, impact of interactive elements (animated character, UI)
User modeling	Video skipping as implicit input for liking an item, spatial personalization from Internet resources, temporal personalization of the TV content

Communication research	Parasocial interaction with animated character, channel repertoire in the presence of virtual channels
Intelligent User Interfaces	Integration of UI and computer generated content with TV content

Table 12 Further research for related disciplines

7.3 SUMMARY

The Virtual Channel model has proved to be an invaluable tool for thinking about personalized media programming. The Virtual Channel model originates from the broadcasting mentality for media distribution, which has been established through the years as the most widely recognized and familiar method for universal media access. It points towards a future of personalized access to an increasing number of media choices. Finally, it is a model that shows a clear path toward the design of future ITV applications that in addition to informational overlays also feature local storage and networking —either within the home or with the Internet. In the next chapter, the research work is summarized into a few important conclusions.

8 CONCLUSION

The main proposition put forward in the present thesis is that neither the vision of five hundred channels, nor the vision of a single personalized channel is suitable for giving consumer access to the digital STB. Instead, it is proposed that a small number of dynamic virtual channels may offer enough choices to cater for serendipity in media experiences, while simplifying the access to vast and diversified sources of television content. Moreover, the Virtual Channel model presumes only a minimal shift from the current patterns of television use, while it focuses further research on the design of UIs that are content specific and that are adaptive to the viewing situation.

8.1 RESEARCH PROBLEM AND ISSUES

The Virtual Channel is a model that was developed bearing in mind the experience of working with the broadcast and advertising industry and taking into consideration the communication scientific literature. It is argued that the Virtual Channel model represents a feasible and effective synergy between two radically different mentalities; that of broadcast and that of IT. The Virtual Channel model was defined as an incremental extension, along the path of the evolution of the traditional channel, and based on two underlying patterns: 1) spatial and 2) temporal personalization. The Virtual Channel model allows broadcasters to exploit their current strengths within digital technologies in a comprehensive way. At the same time, IT developers benefit from a clear, although different to theirs, vision for designing suitable ITV applications. The Virtual Channel model was validated by employing it in the design and the development of a music ITV application.

A conceptual model is of limited practical usefulness, unless it is supported by the respective software architecture. For that purpose, a programming library was designed and implemented in line with the properties of the Virtual Channel model. The programming library was implemented on the Microsoft TV and Windows technology, but further research should consider additional OS and DTV platform. The

Virtual Channel programming library employs a terminology that is familiar to the TV producers, and at the same time, it implies a major shift in the mentality of the traditional fixed TV experience. Finally, it was successfully employed in the implementation of the music ITV application, thus validating its usefulness in the high-level development of ITV applications.

User interface principles encapsulate in a short list the experience of designers that was gained through previous efforts in developing analogous interactive systems. The majority of the principles available in HCI are either too generic or too focused on the productivity paradigm to be of any use for the case of ITV UI design. A set of ITV UI principles was formulated after a multidisciplinary literature review that addressed TV content production, delivery and consumption. The principles demonstrate the design trade-offs that should be considered in the development of an ITV application, in an explicit way. Finally, the principles were applied successfully to the design of the music ITV application.

Prototype development for ITV is a novel situation, but it was found that most of the classic HCI techniques apply here, too. Scenario writing was employed to describe the past, the present and the envisioned future uses of ITV. Then, high-fidelity prototype development was used to create an ITV application, which provided a seamless ITV experience to the consumers, despite the fact that it was based on common PC H/W and S/W platform.

Multiple usability evaluation methods were used and were augmented with data collection instruments drawn from other disciplines. The qualitative research methods were the most effective for improving the understanding of the research problem and for gaining insights into consumer desires for the development of future ITV services. It is suggested that further research should reside on longitudinal studies by employing questionnaires and log file analysis. Moreover, an alternative conception of usability was developed based on the established communication theory from previous TV research. In addition, the measurement instruments were structured inside an evaluation framework that addresses the emotional responses to design. Still, further work should address additional dimensions of usability for computer-mediated television, such as persuasion and play.

Last but not least, there are a number of issues that concern the features of ITV applications. The animated character was compared with the traditional transparent information box for the presentation of related information and the former was found to elicit positive emotional attitudes from consumers. Similarly, consumers' emotional attitudes were significantly more positive for the video-clip track-skipping

compared with the traditional linear music TV channel. It is worthwhile observing that the presentation of related information and the video-skipping issues correspond to the spatial and temporal personalization properties of the Virtual Channel model respectively (Figure 29). Since alternative UI treatments for each one resulted in different affective usability scores, then it can be inferred that the respective properties of the model may be addressed in order to influence the affective usability of an ITV application. Finally, dynamic advertising was conceived as a novel format of TV advertising and it was positively evaluated by the consumers, thus opening-up new opportunities for the advertising industry and the respective scientific discipline.

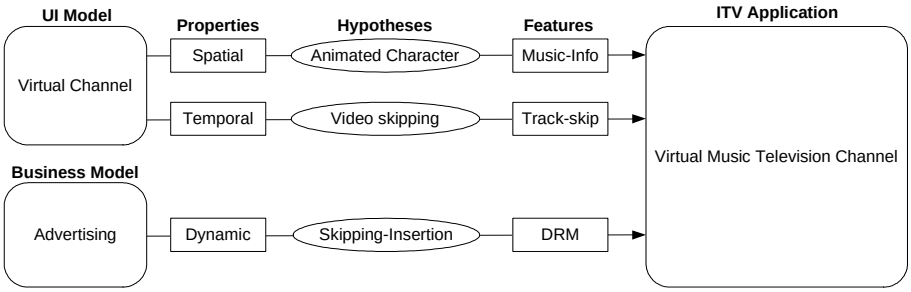

Figure 29 Holistic UI design for ITV applications: The UI model and the business model are systematically mapped and validated in the music ITV application

8.2 RE-DEFINING INTERACTIVE TELEVISION

The design of a UI for ITV is a complex problem that demands a variety of disciplines, in order to be addressed fully. Previous research treated ITV from a single perspective (be that technical, psychological, business), thus making the results unusable in a practice that requires an integrated product design. The present research took a holistic approach to a set of contemporary ITV UI issues (Figure 29). The approach was in accordance with the established theory and it addressed the prominent themes in HCI. The majority of previous HCI research regarded ITV as a medium that manages the choice of TV content, but in the present work, it was argued that ITV can also be a totally new medium that will integrate the qualities of the TV, the DVR, the Internet and computer generated content for the benefit of both the consumers and the media industry.

Previous ITV application design was done without a clear direction and it was a derivative from analogous mediums. Application designers invested their efforts in trying to transfer Internet applications (like email and web browsing) to the TV audi-

ence, which has traditionally been seeking for entertainment and passive information exploration. In contrast, the Virtual Channel is an appropriate model for extending TV entertainment into the digital age of Internet, DTV, and DVR. ITV researchers and practitioners should employ the Virtual Channel mentality in their designs and perform usability evaluations with consumers, using a seamless experimental ITV set-up.

In the future, the TV experience is going to be mediated through a computer program, thus making possible any kind of manipulation or control of the TV content. Being able to control remotely the TV experience at consumers' households has considerable ethical implications. Computer programs in digital STBs may store and analyze a wide variety of interactions for every household. Then, the interactions may be connected to personality characteristics, which is a major privacy issue. For example, the music ITV application may reveal a great deal of musical tastes, which are associated with personality traits and affective state. On the other hand, the availability of detailed user models makes possible a personalized approach for each individual, thus improving a medium, which has been characterized as mass and passive. Therefore, the balance between privacy and personalization features will be a major issue as ITV becomes more widespread.

In conclusion, the Virtual Channel model and the case study of music TV entail two seemingly antithetical suggestions for the future of the TV broadcast industry. On the one hand, TV content should be annotated and linked with external resources, and indexed at the video-clip level, which suggests more freedom for consumers to manipulate the TV experience. On the other hand, the need to protect copyright might force the broadcasters to devise new forms of advertising, like the dynamic advertising insertion, which are strongly coupled with the TV content at the application level meaning that consumers have less freedom over what to watch. It is argued that the broadcast operators should balance the two extremes, in order to devise service offerings that are desirable by consumers. For example, a subscription scheme may offer total freedom for recording and skipping TV content in exchange of a high fee. At the other end, free TV may be offered with support from intrusive advertising similar to the contemporary free Web sites. In between the two extremes, lies a multitude of possibilities for the broadcasters and consumers to select. In the end, market dynamics will decide which ITV service offerings are the most viable.

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A BUILDING THE PROGRAMMING LIBRARY

This appendix presents the development process of the Virtual Channel programming library and draws generic technical requirements for its implementation on different platforms.

The Virtual Channel model is primarily a mentality that can be exploited for the design of appropriate ITV applications. In addition, for the purpose of the present research, there was a need to assess the feasibility of the Virtual Channel model in a hands-on way. The implementation was based on the reference architecture elements requirements. The description makes references to the MSTV and Windows platforms and lower-level APIs, in order to draw the technical requirements for future implementations of the Virtual Channel model. It is beyond the scope of the present thesis to evaluate fully the respective platforms or to propose the definite implementation of the programming library, since the focus is on the UI for the consumer not the one for the developer.

A complete reference of the Microsoft Controls that were employed can be found on the MSDN (http://msdn.microsoft.com/). In the next sections, the specific features of the MSTV components used for the construction of a high level ITV API are presented.

A.1 SPATIAL PERSONALIZATION

For the implementation of the spatial personalization property there is a need to: 1) perform video mixing in real-time and 2) display an animated character. The former was implemented using the Video Mixing Renderer Filter found in Direct X 8.1. For the animated character there was no need to mix it into the video, since the Microsoft Agent is designed to appear on-top of other windows.

A.1.1 Video Mixing Renderer Filter

The Video Mixing Renderer (MSVidVideoRenderer) offers many features for manipulating video content and for displaying video overlays. The SetupMixerBitmap method configures the Video Mixing Renderer (VMR) to display an alpha-blended static bitmap on top of the video. The VMR was used to implement a method that instantly displays a transparent overlay rectangle with text information, which is blended at the bottom of the running video. The first step is to load a bitmap (System.Drawing.Image.FromFile) that will define the background rectangle area to hold the text information. Then, the Graphics object is taken from the respective image object (Graphics.FromImage). Now, the Graphics object can be used to write the text on the image (Graphics.DrawString), and for applying text formatting —font type, color, size. Since the VMR SetupMixerBitmap method expects an IPicture object, the final image has to be converted (AxHost.GetIPictureFromPicture), before applying the transparency effect. In this case, one limitation of the VMR is that it applies the transparency effect to the whole image, thus making less legible the text —especially on video frames that have the same color as the text. If an application requires the image to contain embedded alpha information, it must place the image data in a DirectDraw Surface. This functionality is more complex, but it enables the display of non-rectangular images and the creation of compelling television user interfaces.

A.1.2 Agent Control

The MS Agent Control has been developed and evaluated for usability in the context of desktop computing and productivity applications. When applied for ITV applications, there are a few shortcomings and areas that need improvement. Most notable is the balloon dialog that displays the text, expressed by the character. The balloon dialog appears over the head of the character, thus taking up considerable TV screen real estate. Even though, the balloon dialog can be adjusted in size, its position is set by default and it cannot be changed. Thus, it would be preferable if there was a property for setting the position of the balloon dialog. Furthermore, the balloon dialog background is solidly colored and there is no option for changing the color and the opacity, in order to make the video behind the dialog partially visible.

A.2 TEMPORAL PERSONALIZATION

For the implementation of the temporal personalization property there is a need to: 1) perform dynamic concatenation of video-clips and 2) manage the flow of the ITV experience. The former was implemented using the Video Control found in the MSTV platform. The latter was implemented using the Timer Control, which is a common control in the Visual Studio IDE.

Event-driven computer programming might be familiar to the majority of developers who use object-oriented languages to build interactive applications. Nevertheless, event-driven programming for multimedia and ITV applications is different from productivity applications, in the sense of being more time-driven than user-action-driven. ITV applications have a greater need to organize the UI and the consumer experience temporally, instead of spatially, which has been the norm for computer application development (Green and Jacob 1991; Guimarães et al. 1992). Therefore, an API for ITV applications should support the programming of time driven user interfaces.

A.1.3 Video Control

The Video Control (MSVidCtl) is an ActiveX control that applications use to create and manage analog and digital TV filter graphs. In the present design, a pre-recorded pool of music video clips residing in a directory was assumed and the Video Control used employed for playing video files from local storage. Controlling file playback with the Video Control requires getting an object reference to the File Playback Device (MSVidFilePlaybackDevice). The File Playback Device exposes methods for controlling the flow of video, like pause, step, stop, and it has properties that return the length of the video and the current position. The most useful characteristic of the File Playback Device is an event that is raised when a video ends (MSVidFilePlaybackDevice_EndOfMedia). Unfortunately, this event could not be used for handling the end of a video in the present VB.NET implementation. Instead, this limitation was tackled by using a lower-level event that is raised to report a change of the state of the Video Control (MSVidCtl_StateChange). Thus, an additional event handler was implemented, which uses the previous and current states of the Video Control to infer whether video file playback has ended. In this case, a custom made event is raised to indicate to the hosting application that video file playback has ended.

When used to play local video files, a limitation of the Video Control that was encountered in a laptop configuration (1GHz P3 CPU, 512MB RAM, ATI Radeon Mobility-P) was a two-second delay between the end of playing a video file and the beginning of the next one. Attaching an external Firewire 400 hard-disk (7200 rpm, 2MB cache) reduced the delay by half (i.e. at one-second), so the delay can be partially attributed to the storage bandwidth. On an alternative desktop configuration (1GHz P3 CPU, 512MB RAM, NVidia GeForce2, 7200rpm 2MB cache ATA100 HD), the same one second delay was manifested as a pause of the last playing video, while on the laptop the delay was manifested as a dark pink screen. Still, there was a visible gap between two consecutive videos. There was no chance to test the Video Control on a more powerful configuration, yet the problem may reside on the graphics card sub-system, either due to the video card (S/W and H/W implementation) or due to the Video Control implementation for local file playback. If the problem is due to shortcomings of the Wintel architecture when accessing the hard disk then the only realistic solution would be to build a software cashing scheme for preloading the upcoming video files. In conclusion, continuous playback of consecutive video-files that resembles the flawless broadcast experience is a new requirement for ITV platforms, which, so far, have successfully supported only the real-time broadcast decoding and the individual file playback.

Besides playing local video files, the Video Control has many features for controlling broadcast TV and data, regardless of being analog or digital. It tunes into and records live television broadcasts enabling the implementation of a DVR, like TiVo, using PC components.

A.1.4 Timer Control

The Timer Control is a simple control available to the Visual Studio IDE, but its importance in the design of ITV systems is instrumental. Time-driven user interfaces require methods for defining events, for handling defined events in the passage of time and for identifying the time-state of the ITV application. A Timer Control is used to set and to raise an event at pre-defined intervals. The Timer Control was used to construct an object that keeps track of time-instances and raises an event when the Timer reaches the threshold defined for each instance. For that purpose, a Timer with a one-second interval (Timer.Interval = 1000) was defined, in order to handle the Tick event (Timer_Tick) and to check whether any of the pre-defined thresholds has been exceeded, before raising an EndOfTime event, together with the

identifier for the respective time-instance. The encapsulating object also holds the references to the required actions for each event.

B DATA TABLES FROM USABILITY TEST

This appendix presents the results from the usability evaluation tests.

B.1 ATTITUDE

There were two types of attitude data collected: 1) hedonic quality and 2) program liking. The hedonic quality metric revealed significant differences between alternative UI manipulations, while the program liking metric was not affected by the addition of interactive elements.

It had been predicted that there would be a difference between a traditional music video television channel and one that features track-skipping of music videos. It was found (Table 13) that the hedonic quality score for the traditional one is close to neutral (average 5.1/10), which is quite expected, since music video television is a pervasive experience and feels familiar to young adults. In contrast, track-skipping (average 7.5/10) allowed consumers to watch the preferred music video clips and despite the dynamic insertion of ads the hedonic quality score was significantly higher (two tailed t–test, p=0.002, n=21).

Hedonic Quality (0-10) (n=21, p=0.002)	Average	Std Dev
Traditional	5.1	2.1
Track-skip	7.5	1.6

Table 13 Hedonic quality scores for the track-skipping music video television are significantly higher when compared with the traditional one

It had been predicted that there would be a difference in the perceived entertainment value between the animated character and the transparent box for the related information presentation style. It was found that the hedonic quality for a music video television channel is significantly higher (two tailed t–test, p=0.0002, n=21) when using an animated character (average 7.0) for presenting dynamic video overlays compared with the traditional transparent information box (average 4.4). Again, consumers were neutral toward the traditional information box, since it is a widely

used and familiar presentation style for information related to music video clips (Table 14).

Hedonic Quality (0-10) (n=21, p=0.0002)	Average	Std Dev
Animated Char.	7.0	1.5
Box	4.4	2.0

Table 14 Hedonic quality scores for the animated character compared to the traditional overlay box

The addition of a UI and the presentation of related information may have an impact on the program liking as a whole. Hedonic quality scores had established the —predicted— preference of consumers toward the optional track skipping UI, in place of the fixed linear music TV channel. Nevertheless, it was not clear whether the presentation style for the additional information would make any difference to the program liking. It was found there was no significant difference in program liking between the animated character and the transparent overlay box, when used for the presentation of related information.

Program liking (6-42) (n=21, p=0.73)	Average	Std Dev
Animated Char.	35	4
Box	34	4

Table 15 Program liking for the animated character compared to the traditional overlay box

In conclusion, besides the program liking metric, the attitude results have revealed that there are important perceived differences between different UI approaches.

B.2 BEHAVIOR

It would be interesting to find out how many ads users would be willing to watch, as a consequence of using the music video clip skip feature. In a traditional music video TV channel the proportion is approximately 12 ads for each hour of TV video [Executive of a major European music video television channel, personal communication]. Therefore, for 15 minutes of TV watching (which was the average watching time during the experiment), nobody would be keen to watch more than double the normal amount, which is approximately 3 ads. The analysis of the log files revealed that nobody watched more than 10 advertisements (a session might had last up to 20 minutes) and that the average was 6 ads, which is double the

amount of the traditional TV broadcast over fifteen minutes of television watching. In general, users were positive to the concept of watching one short ad, when they used the video clip skip feature, and everyone considered it to be a fair trade-off for skipping over disliked music video clips. Interestingly, according to the log files, some users also tried to skip over the ads, with no effect since the application was programmed to ignore the video skip when inside an ad.

Advertisements (No of Ads/15min) (n=42)	Average	Std Dev
Traditional	3	0
Dynamic insertion	5.9	2.4

Table 16 Number of advertisements that consumers watched for the virtual music channel compared with the traditional one

The time spent with each UI is associated with the interest in the respective UI (Malone 1982). It was found that there is no significant difference for the time spent using each of the two UIs, although participants spent on average approximately 1 minute more with the Box UI.

Time spent (600-1200 sec) (n=21, p=0.405)	Average	Std Dev
Animated Char.	861	194
Box	912	234

Table 17 Time spent using the animated character UI compared with the traditional overlay box UI

There was no difference in the number of the music video clips that the participants watched using either of the two UIs.

Video Clips (No) (n=21)	Average	Std Dev
Animated Char.	7	2
Box	7	1

Table 18 Number of video clips that consumers watched with the animated character UI compared with the traditional overlay box UI

The number of video clips that consumers watched in a predefined period of time with the track-skipping UI may be indicative of how much they like a dynamic music program, when compared with the traditional linear music TV channel, which provides no affordance for avoiding specific music clips —apart from channel changing. It was found that consumers watched almost the double amount of video clips, which leads to the conclusion that almost half of the music video clips of a broadcast are of no interest to consumers.

Video Clips (No) (n=42)	Average	Std Dev
Traditional	4	0
Track-skip	7	2

Table 19 Number of video clips that consumers watched for a traditional music TV channel compared with the track-skipping UI

There was no significant difference in the reported involvement between the two UIs.

Involvement (20-140) (n=21, p=0.51)	Average	Std Dev
Animated Char.	104	12
Box	101	13

Table 20 Involvement of consumers with the ITV program for the animated character compared to the traditional overlay box

B.3 AFFECT

Emotion is usually decomposed to two dimensions: 1) pleasure and 2) arousal. Arousal can be decomposed to two bipolar dimensions: 1) energetic/tired and 2) tense/calm. Emotion was measured using the SAM instrument and the dimensions of arousal were measured using the AD ACK instrument. The AD ACK did not provide any significant results for any of the dimensions between the two UIs. It was also found the SAM is simpler to administer and has given results that are close to significant, despite using a very small sample size, during the second part of the experiment.

Energetic (5-20) (n=21, p=0.78)	Average	Std Dev
Animated Char.	14	3
Box	13	3

Table 21 Energetic level of consumers for the animated character compared to the traditional overlay box

Tired (5-20) (n=21, p=0.87)	Average	Std Dev
Animated Char.	9	3
Box	9	3

Table 22 Tired level of consumers for the animated character compared to the traditional overlay box

Tense (5-20) (n=21, p=0.65)	Average	Std Dev
Animated Char.	8	2
Box	9	2

Table 23 Tense level of consumers for the animated character compared to the traditional overlay box

Calm (5-20) (n=21, p=0.48)	Average	Std Dev
Animated Char.	11	4
Box	12	3

Table 24 Calm level of consumers for the animated character compared to the traditional overlay box

The PAD model was only employed during the second part of the experiments, as an alternative approach to explain and validate the results from the other approaches. The PAD model was measured through the SAM instrument. The SAM instrument has proven to be more valuable compared to the adjective checklists used to measure arousal, because the users liked it more and because it has given results that are very close to being significant, although sample size (n=10) was very small to draw any confident conclusion.

Pleasure (1-9) (n=10, p=0.12)	Average	Std Dev
Animated Char.	5.6	2.2
Box	6.9	1.3

Table 25 Pleasure score for the animated character compared with overlay box UI

Arousal (1-9) (n=10, p=0.07)	Average	Std Dev
Animated Char.	5.3	1.9
Box	3.7	1.7

Table 26 Arousal score for the animated character compared with overlay box UI

Dominance (1-9) (n=10, p=0.53)	Average	Std Dev
Animated Char.	5.5	3
Box	4.8	1.6

Table 27 Dominance score for the animated character compared with overlay box UI

In summary, it was not possible to retrieve significant results from the emotion and the involvement instruments used. This may be due to the manipulation of the UI having no effect on the respective constructs or because the sample size was not sufficient for statistical significance. Further research is required, before a final conclusion can be reached.

B.4 QUALITATIVE

The qualitative results (observation, interview) are summarized in the table below (Table 28) and then they are presented in more detail.

Research Issue	Findings
Prototype	Employing a consumer TV set with a remote control, ensuring a continuous video flow on the screen, and using TV production quality overlays will result in a seamless consumer experience for ITV applications
Video Skipping	Video clip skipping, when available, has the potential to replace channel changing
Dynamic advertising	Short advertisements between two video clips do not have good recall rates. Avoiding a disliked video clip or getting to a favorite one is a justifiable trade-off for watching a dynamic advertisement insertion.
Animated character	There is a love or hate relationship with the animated character. Previous experience with the animated character on the PC is transferred to the TV.

Table 28 The qualitative (observation, interview) results in brief-format

Despite the prototype not being perfect (in terms of the audiovisual quality and the existence of a visual gap between two consecutive videos) none of the test users complained about the fidelity of the prototype. Users who were not involved in computer research and development were asking how was video skipping possible and whether that was a commercially available product. Most of the other users were aware of an experimental system behind the TV program, but when asked whether they understood that there was actually a notebook running the system, users said that it looks and feels like normal TV. The use of a normal TV and a remote control played a major role in receiving the above evaluations, but they can be also attributed to the continuous video flow principle of the Virtual Channel model that delivers a familiar television experience. Therefore, the combination of the VCC API and an appropriate experimental set-up may be used to create high fidelity ITV prototypes that fit in the production process before writing the final code and just after the story boards have been approved.

In consistence with the selective exposure theory, users were actively seeking for the video clips and songs they preferred (Knobloch and Zillmann 2002). This kind of interactive television behavior may be due to the experimental setting and may not have external validity; users may have been more active than normal because the ap-

plication is novel to them and because they were asked to use a new system. Actually, a few users reported that they would normally leave the television open as a radio and would skip only when they disliked a particular song. During the experiment, they reported being more than normally attentive and interactive with the TV. Nevertheless, the users were asked to perform as they would normally do, while watching TV and use the video skipping only when they disliked a video clip or because they were very fond of the upcoming one. Correspondingly, they reported that they used the skip functionality mainly to by-pass a music video that they disliked and at a lesser extent to get to a favorite one. Either way, the video skipping feature was a favorite, despite the ad insertion, and provides relaxed control of the interactive music TV application, based on the local storage of the music video clips.

In the context of advertising research, the most surprising and accidental finding, concerns the use of the short advertising inserts that were placed dynamically between music video clips, when the user pressed the video clip skip button. After interviewing a few users, it became evident that most of them had trouble recalling those ads, but, they were all able to recognize the respective advertisement video, when shown on the TV. Message recall and recognition are two very distinct constructs that correlate strongly with specific effects of TV advertising. For example, there are products that have low brand loyalty and are usually bought at the shelves of the store and they are favored by strong advertising message recognition. It is of great importance to marketing communications to identify the mediating factors besides the message content that reinforce either one of the effects. One explanation for this effect was the short length (10-15 sec) of the advertising clips that in most cases had a creative content that resembled that of a video clip. Since they were placed between two music video clips they could not stand out from the identical content at their sides and appeared to users like being part of the video clips. Nevertheless, further research is needed to measure and quantify the effects of the placement of short advertising messages between discrete TV content segments.

Those who have been exposed before to the Office Assistant (through the Microsoft Office suite of applications) recognized the similarity despite the use of a different character (the genie) and were most of the times very negative to the concept of the animated character. Therefore, it can be argued that the animated character from the desktop application has a carry-over effect to the ITV applications and those, who are already negative to it they will continue to be so, at the expense of the whole TV program liking. For those users, it is suggested that the animated character is an option and an alternative user interface is available to select. Nevertheless, most of the

users considered the character funny and less obtrusive compared with human presenters. Furthermore, the users asked for more characters and the option to select their favorite presenter. The users also asked for more control of the character, like changing its placement at the screen. Finally, most of the users disliked the solid balloon dialog that stands over the head of the character. According to their suggestions the best place for the animated character balloon dialog would be across the bottom of the screen.

The traditional information dialog box had its own share of evaluations, which were fewer and less strong than those for the animated character, probably because this type of video overlays is already familiar and well-developed in current TV content. The users asked to place the rectangle at the bottom of the screen and make it wider and at least one line shorter. Thus, the ideal information box would be 2 or 3 lines long and it would span across the bottom of the screen. At the beginning of each video clip, the information box reminded users that they could skip a video clip at the expense of watching an advertisement. Users mentioned that these directions could be shorter and actually embedded in the user interface (for example: 'next' to skip) with a different presentation mechanism, not to be confused with the use of the rectangle for additional information about the video clips. Since the fonts were blended to the rectangle before applying the transparency effect, sometimes users could not read them, especially over light video backgrounds. This technical problem could be resolved by employing images that support alpha blending for a specific background color, different from the color used for the fonts. Overall, users became immediately familiar with asking for information and deciding when to skip a video clip.

The users who stayed most attentive to the TV during the testing session were those who traced continuously the informational boxes. These users asked for more control of the flow of information. Especially, they asked for the option to select the type of information to attend to (for example: biographical, discography, trivia, concerts) and the option to browse through the available information at their own pace. Information browsing by type could be supported by using the 4 colored buttons of TV remotes and assigning each color on the respective types of information on the screen user interface. Consecutive information browsing could be supported by using the navigation (arrow) keys available TV remotes. Both comments confirm the validity of the arguments for using Internet resources for providing diverse types of continuously updated information and for applying local generation of dynamic computer graphics that suite each user. Furthermore, users reported that even after

selecting their favorite type of information to watch, or after having a short burst of information browsing, they would still prefer returning to the auto-pace style of information presentation, thus reconfirming the need for relaxed control and time driven user interfaces.

The most interesting suggestions for future improvements concerned the augmentation of the music video skip feature. Users familiar with the PC MP3 players asked for more options when skipping a music video, like repeat the same song, play a song from the same artist or play the same music genre. Moreover, a longer list of the upcoming music videos would be welcome and it would also allow organizing their time better, since they could leave the TV open and plan to return back when their favorite song is on. Using the television as a time tool to structure activities and organize time has been also document before at an ethnographic study of a STB trial (O'Brien et al. 1999). Therefore, providing on-demand information about the upcoming video clips would support the relaxed control of TV as a time management tool, while the ability to alter dynamically the upcoming play-list would support interactive behavior. For example, the user could bring up a play-list of 10 upcoming music videos and alter it dynamically along a number of parameters like genre, artist. Finally, the user could decide whether to skip directly to a music video by pressing the corresponding button on the numeric keypad.

Colophon

Considerable thought was put into the typesetting of this thesis. On the one hand, there was a clear requirement that it should print on single A4 pages, which is the output of most desktop printers. On the other hand, a lot of people now have access to double-sided printers, or may prefer to read it on a comfortable TFT screen. Furthermore, I had set the objective of a producing a legible text that would be in line with the established typographic tradition for PhD theses.

Having in mind the above conflicting requirements, I set-out to evaluate how other authors tackled these issues. I found many different approaches to the thesis report layout and typography, as many as the institutions. Nevertheless, all cases make the same assumption: they are prepared for printing and reading from a book. Every typographic element was implicitly assuming that the reader would print a copy of the thesis, either on double-sided paper, or on single-side paper. Printing on a single-sided printer a thesis that was prepared for double-sided printing would result in inconsistency for folios and headers. Therefore, there was a need for a flexible design that would facilitate the diversity of printing-reading methods.

The choice of the font for the body text was dictated by the following requirements: serif, legible on screen and on paper. The Palatino (Linotype) font, designed by professor Herman Zapf for Microsoft is a beautiful font that addresses all of these requirements. The body text was set at 11p and the line spacing at 17p. The Palatino (Linotype) font was used for the body text, table text, and captions. The headings were set with Times. The folios were set with Georgia. The layout of the page was dictated by the requirement for flexible printing and reading. Therefore the body text, the folios and the headers were centered in the page.

A few tools were used to produce the thesis document. The document was typeset electronically using Microsoft Word on a Windows desktop and on an Apple notebook computer. The vector figures were prepared using Microsoft Visio. The screenshots were edited with Microsoft Paint. The bibliography was prepared from BibTeX files and imported into Word using a conversion template provided by Diomidis Spinellis. I had to update one of the templates, in order to display the last name of the author first and then the initial of the first name. The backup mediums included a CDRW drive and two Firewire HDDs.

The tools and configuration used for the development and the experiments are reported in Appendix A.