

# Re-Examination of Human-Computer Interaction Methodology in the Domain of Interactive TV Applications

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## Abstract

The user-centric mentality is usually materialized into the usability engineering techniques. In Human-Computer Interaction (HCI), the generic user-centric approach includes the following activities: 1) user studies and evaluation, 2) user analysis and modelling, 3) prototyping, and 4) implementation. These activities are highly iterative with the exception of user studies and implementation, which are performed less frequently during the product lifecycle. There is an extensive body of previous research in user-centric methods and techniques for personal computers and internet applications, but there is limited research about interactive TV applications. This work investigates the question: 'How does the generic notion of 'user-centric' translate into specific actions for interactive TV (ITV) user interface (UI) design, development and evaluation?'

## Introduction

The user-centric mentality is usually materialized into the usability engineering techniques. Accordingly, previous evaluations of popular ITV applications, such as the Electronic Program Guide (EPG) and digital video navigation, have employed task efficiency concepts. Since ITV applications gratify entertainment needs and leisure activities in a domestic environment, there is a need to re-examine the suitability of the traditional usability engineering conceptualizations.

It is argued that the UI in ITV applications should move beyond the productivity paradigm implied by the contemporary notion of usability. Media studies literature was investigated, in order to augment the user-centric approach with a toolset of concepts, methods and techniques that are suitable for interactive TV. Indeed, the media studies field is very relevant to the analysis of TV and it has been highlighted as a significant area for further research in HCI (Macdonald 2004).

The rest of the paper is structured as follows: Section 2 presents the motivation for re-examining the traditional usability engineering approach.

Section 3 explores the dimensions of the quality of an ITV UI. In Sections 4 to 8, the usability engineering techniques for UI design, development and evaluation are re-examined, under the light of the new definitions for UI quality in ITV applications. Finally, Section 9 provides a brief future research agenda.

## Previous research

Previous approaches to popular ITV applications (e.g. EPG) have employed concepts, such as task efficiency and effectiveness. Indeed, the usability of the EPG is very similar to the usability of productivity software, because it involves more information processing than enjoyment of ITV content. Several aspects of EPG navigation can be modelled after the traditional HCI tasks and goals. Nevertheless, there are some aspects of the EPG design, and many other types of ITV applications that would benefit by a consideration of the affective dimension of the UI.

Most notable among the recent findings for ITV applications is the realization that users' subjective satisfaction is at odds with the established metrics of efficiency. A usability test of three video skipping UIs revealed that user satisfaction was higher for the UI that required more time, more clicks and had the highest error rate. In other words, the most efficient UI was not the most favoured one. This result is opposite to the assumptions of the efficient usability paradigm, which conceives the efficient as more usable and thus preferable.

The satisfaction questionnaires exposed that the users regarded their preferred UI as more fun and relaxing compared to the most efficient one (Drucker et al. 2002). Accordingly, Chorianopoulos and Spinellis (2004b) let their subjects use a video skipping application without specifying any task, besides the suggestion to 'watch TV for a period of time.' Moreover, they employed the hedonic quality construct (Hassenzahl et al. 2001) and validated that users preferred a video skipping UI, although it was coupled with a dynamic advertisement insertion feature, which increased the total number of advertisements they were exposed to.

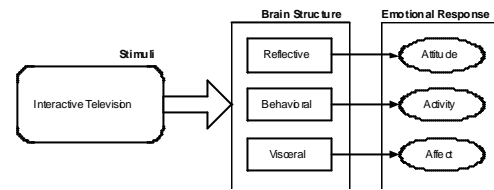
**Table 1 Methodological issues in ITV UIs compared to traditional domains (PC, Web)**

HCI concepts/Domain	PC, Web	Interactive TV
User, context	PC user, work	Viewer, domestic (leisure time)
Goal	Effectiveness, efficiency, productivity	Entertainment, relaxation
Activities	Task execution	Free exploration
Techniques	Task completion, errors, efficiency	Affective state, emotions

In summary, the majority of previous studies have considered only the efficient aspect of the ITV UI. Since ITV applications gratify entertainment aspirations, in a leisure context of use, for a wide diversity of users, there is a need to extend the HCI toolset, so that it also considers the affective quality of an ITV UI (Table 1).

### User interface quality

It has been argued that people spend most of their leisure time trying to moderate their moods. Daniel Goleman (1995, p.57) 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.’ Television entertainment is a multidimensional construct that cannot be measured as such, but consists of several parameters that could be measured (Vorderer 2001). For example, Reeves and Nass (1996) assert that a mediated experience elicits an emotional response, which is partly valence (pleasure) and partly arousal. There are also additional elaborate models of the uses and gratifications when watching TV (Lee and Lee 1995, Rubin 1983). Therefore, the UI of an ITV application could be conceptualized as an additional —to channel changing and program selection— means to moderate the mood of the TV viewer.



**Figure 1 The ITV entertainment experience elicits three types of emotional responses (attitude, activity, affect), which correspond to the three-level model of affect —adapted from Norman et al. (2004)**

According to Norman 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 behavioural level, which contains the brain processes that control everyday behaviour and 3) the reflective level, which is the contemplative part of the brain. Each level could be associated to a different class of constructs, which could then be employed to evaluate the differences between the emotional responses to alternative UI designs (Figure 1). For example, an ITV application may elicit enjoyment (e.g. pleasure, or arousal) at the visceral level. Then, the user may continue using the ITV application for a long time and become emotionally absorbed (e.g. involvement and engagement). Finally, the user may decide that she likes the specific ITV application, which leads to the formation of an attitude (e.g. program liking).

The emphasis on an affective conceptualization for ITV applications does not entail a complete abandonment of the efficient usability 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 and navigation. The same application, used in the evening after returning home from a long day at work, should be more automated and encourage relaxed use (Steve Draper, personal communication). In general, the UI evaluation should be regarded to have both an affective and an efficiency dimension. In the ITV case, the leisure context of use and the need for gratifying entertainment goals might push the balance towards the affective dimension of the UI. UI designers should explicitly set the goals of each UI depending on the nature of the ITV application and then they should employ the appropriate assortment of efficient usability and affective quality methods for the evaluation.

Besides media studies, there might be alternative paradigms for conceptualizing the affective dimension of an ITV UI. ITV applications are supposed to offer more than just an improved

version of the traditional TV experience. One potential benefit of ITV applications would be the creation of optimal experiences through flow (Csikszentmihalyi 1991), which requires the establishment of a match between the viewer skills and the challenge posed by the ITV application. There are also a few additional paradigms that should be investigated in the context of ITV applications. For example, the HCI research is gradually diversifying its focus, in areas such as: 1) influencing the user through persuasion (Fogg 2002), which offers concepts related to the trust in ITV applications that have an advertising and commerce characteristics and 2) video-games and fun (Draper 1999), which offers concepts related to the game-play dimension of ITV usability.

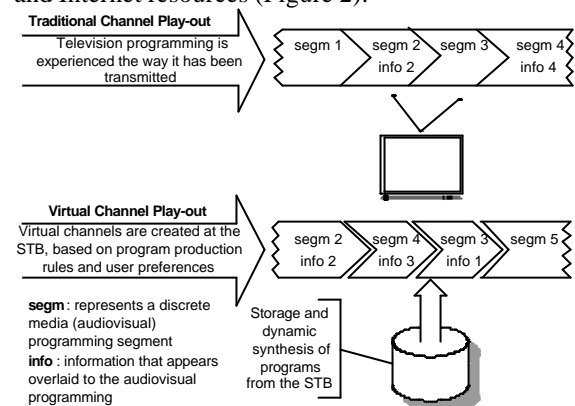
In brief, depending on the application domain (e.g. entertainment, learning, e-commerce, game-play, information) the design and evaluation of ITV applications should employ the most suitable UI conceptualization, instead of employing implicitly on the traditional usability engineering mentality.

### Conceptual models

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. Instead, the development of conceptual models for ITV should be based on the identification of: 1) the familiar patterns) and 2) the emerging usage patterns. Moreover, designers should distinguish between two levels of conceptual models: 1) operating system and 2) application. In this way, many types of ITV applications could be modelled and approached in a consistent way. For example, ITV news and music could be organized in virtual TV channels.

The Virtual Channel is a conceptual model for UI design; it augments the familiar access method to broadcast programming (i.e. the notion of a channel), to an integrated model for accessing interactive audiovisual content from diverse sources, which supports the emerging usage patterns (e.g. digital video recording). First, the organization of digital media content into a small number of spatio-temporally personalized virtual channels simplifies choosing from a vast array of available broadcasts, stored programs and Internet resources. Second, presenting media programming from Virtual Channels gives more control to the user, who can actively shape the content flow. The virtual channel model suggests only a minimal shift from current media use, while it focuses further research on the design of a content-specific UI (e.g., music TV).

A virtual TV channel is a TV channel that is not a fixed video signal shared by all viewers in the same way, but a dynamic synthesis of discrete video, graphics, and data controlled by a computer program, which runs on each digital set-top box (Chorianopoulos 2003). The traditional television experience consists of video and overlaid graphics-text 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 shifts the decision-making about TV programming from the media source to the set-top box (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 (Figure 2).



**Figure 2** Generic model of a system with the virtual channel metaphor, in contrast to the traditional broadcasting scheme

The main implication for practice is that neither the vision of 500 channels, nor that of a single personalized channel is suitable for giving consumers access to the digital STB. Instead, it is proposed that a small number of dynamic virtual channels could offer enough choices for serendipity in media experiences, while simplifying access to vast and diversified sources of interactive multimedia content. The Virtual Channel model has been applied to personalized advertising (Chorianopoulos and Spinellis 2002) and to interactive music TV (Chorianopoulos and Spinellis 2004b).

### Principles and guidelines

User interface principles enable the translation from the semantic level of the conceptual model to the syntactic components of the system's functionality (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, a

generic principle is that ‘a UI should provide visibility of the current status.’ 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, HCI has grown up alongside the desktop PC and most of the current UI principles reflect a productivity context of use, instead of considering the domestic entertainment activities, such as ITV.

ITV usability fits within the broad continuum between the traditional TV and the desktop PC-Web user experience. Therefore, the ITV experience may be considered as the gamut of different combinations between the traditional TV and the interactive PC-Web UI principles. The UI principles were formulated after a critical review of previous research in: 1) mass communication, 2) advertising and 3) usability for the PC and the Web. The principles are presented as trade-offs, in order to allow ample space for the selection of the most appropriate UI design (Table 2). This list of UI principles for ITV has been applied to personalized advertising (Chorianopoulos and Spinellis 2002) and to interactive music TV (Chorianopoulos 2004).

**Table 2 User interface principles for interactive TV applications**

<b>Design Factor</b>	<b>Description</b>
Low Vs High Attention	A viewer may sit down and watch a TV program attentively, or leave the TV open as a radio
Group Vs Individual Watching	Distinguish between group and solitary use
Planned Vs Impulse Program Selection	Consider multiple levels of planning: from channel surfing to appointment viewing
Real Time Vs Time Shift	Both stored and broadcast content and applications should be available and complement each other
Entertainment Vs Information	Support a wide variety of user goals, from entertainment to information
Interactive Vs Passive	Support the predominately passive patterns of use, but offer the option for interactivity
Computer generated Vs fixed content	Replace static video elements (channel logo, ticker, info, sport statistics, etc) with computer generated content
Computer Vs	Enhance, but do not replace, the

Television Visual Design	main TV elements (characters, stories) with PC elements (objects, actions)
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Before applying the principles to practical design problems, it should be made explicit that the design of a UI for an ITV application is very different from that for a PC application. The major difference 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. From that perspective, UI design for ITV is very similar to UI design for the Web, in which each Web site has different content, structure and navigation.

The ITV UI principles were presented as a list of high-level and generic design factors, although UI principles are usually more specific and concern particular parts of the interaction, such as dialog box, menu, icon etc. Moreover, there are UI guidelines, which are quantitative reformulations of principles. For example, the generic principle ‘respond fast to user commands’ may be transformed to ‘respond in less than 1sec to user commands’ as a guideline for a specific system. Then, the high-level ITV UI trade-off for ‘multiple levels of attention’ may be transformed to a more specific UI 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 after 3-5 seconds.’ Therefore, further research should refine the proposed set of UI design trade-offs into longer lists of more specific principles and guidelines for particular types of ITV applications.

### Prototyping techniques

Previous studies with ITV applications have revealed that whatever is presented on the TV screen is assessed in comparison with the current television experience. Computer-like menus, toolbars, scrolling pages and form-navigation look irrelevant on a TV screen, even when used by experienced computer users. Before a high-fidelity prototype is presented to users, there is a clear need for television-values content development.

The main requirement for an ITV prototyping platform is that it imitates the look and feel of everyday TV by employing (Chorianopoulos and Spinellis 2004a): 1) remote control and TV screen connected to a portable PC, 2) audiovisual content

(e.g. video clips) and 3) TV-language rules and aesthetics (e.g. transparent overlays, smooth transitions).



**Figure 3 Experimental set-up for unobtrusive and seamless usability evaluation of ITV applications**

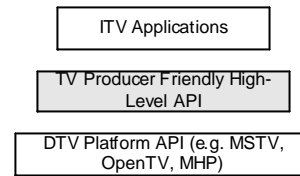
The central element for the above experimental set-up was a portable PC. The ITV application was designed to run in full-screen and windowless mode and was set to give audiovisual output to a TV set. The PC's serial port was connected to an infrared sensor (<http://www.evation.com/irman/>) that receives the signals from the remote control. The whole set-up was unobtrusive and seamless to the television viewer (Figure 3). When the portable PC was hidden away, the only item of the set-up that was left hanging around was the small black box of the infrared sensor.

### User interface toolkits

The development of an ITV application is usually reflective of an IT developer viewpoint, instead of that of a TV producer. The creative part of the development process has a subordinate-decorative role, because the requirements in technical knowledge for using the popular authoring tools demand a strong IT background. Despite the progress, most of the contemporary ITV authoring tools 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 design ITV authoring tools that make ITV application development more accessible to TV producers. Chorianopoulos and Spinellis (2004a) have designed a high-level ITV Application Programming Interface (API), which facilitates the workflow of the TV producer and is based on the properties of the Virtual Channel model, described earlier. In the following paragraphs, the Virtual

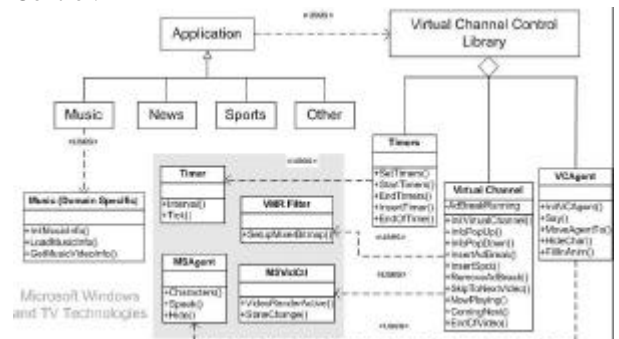
Channel Control Library (VCCLib) is briefly presented.



**Figure 4 Using a high-level API to make ITV development accessible to TV producers**

The 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 (Figure 4). A partial class diagram of the VCCLib is provided (Figure 5), so that it becomes feasible to employ it in ITV application development and for realizing in other contexts, with alternative implementation tools and platforms. The Virtual Channel Control is the central element of the VCCLib and provides methods and events for handling the flow of a virtual channel.

Event-driven computer programming might feel familiar for the majority of developers who have used object-oriented languages to build interactive applications. Nevertheless, event-driven programming of ITV applications might be different from that of productivity applications, in the sense of being more time-driven than user-action-driven. ITV applications are in need to organize the UI and the user experience temporally, instead of spatially, which has been the norm for computer application development so far. Therefore, an API for ITV applications should support the programming of time-driven UIs. The Timers Control is based on the Timer Control and enables the definition and handling of pre-scheduled (author) events. The VCAGENT Control is a simple wrapper-class around the MS Agent Control.



**Figure 5 Class diagram for the Virtual Channel API with references to a MSTV implementation**

An example interactive music TV application has been developed with the aid of the VCCLib

(Chorianopoulos and Spinellis 2004a). The application allows a television viewer to skip a music video clip—an action that comes at the cost of watching a targeted advertisement. In addition to clip skipping, video overlays were used to superimpose information over the music video. Music information provides trivia about the artist, biographical information and discography.

### **User studies and evaluation**

The selection of a UI evaluation method depends on the type of the research problem. For example, an ethnographic study may provide in-depth insights about the uses of TV in everyday domestic life (O'Brien et al. 1999). Then, a survey may reveal relationships between the uses and the type of the family or the viewers' profile, and to give quantitative results (Freeman and Lessiter 2003).

Previous findings demonstrate that the consumers' perceptions are very elastic and prone to change with the passage of time (Petersen et al. 2002). Therefore, a longitudinal study may be used to study the evolution of important variables for longer periods of time (Kubey and Csikszentmihalyi 1990). Furthermore, focus groups and interviews have been used in ITV research. The latter methods are useful for requirements collection and for investigating the long-term effects of ITV applications, while usability tests are more appropriate and cost-effective during the development process.

The majority of UI evaluation studies have been conducted in the laboratory with experimental methods. Mass communication research employs large (compared to HCI experiments) samples of people, in order to study the effect of features that exist in TV content. On the other hand, HCI research focuses on informing product development and employs small numbers of subjects iteratively with discount usability engineering techniques (Nielsen 1994).

Maguire (2002) raised the research question: 'Should tasks be fixed or should users be allowed to use the service as freely as they wish?' It has been argued that the users should be allowed to use the service for a predefined but flexible duration of time (e.g. 15-30 minutes), without any particular task to complete (Chorianopoulos and Spinellis 2004). In this way, the traditional usability test reflects the tradition of the selective exposure paradigm (Zillmann and Bryant 1985), which has been also used to study the media effects of interactive products in contemporary mass communication research (Knobloch and Zillmann

2002). Since viewers select TV channels and watch TV programs to their discretion, without performing any particular task, then the evaluation of an ITV UI should facilitate free exploration and enjoyment of the ITV application.

The evaluation methods employ one or more data collection techniques, which may be qualitative, or quantitative. Many UI evaluation studies are qualitative (e.g. observation, thinking aloud, interview, focus group), but some of them (e.g. thinking aloud) may not be suitable for ITV (Maguire 2002). The quantitative methods provide explicit results for formulated hypotheses and concrete UI issues, while the qualitative methods are used to reveal UI issues that have not been identified by the designers. Ideally, the qualitative measurement techniques should be used to complement the quantitative ones (Eronen 2001). Chorianopoulos and Spinellis (2006) have identified and suggested constructs that are relevant to the affective quality dimension of an ITV UI and presented the respective measuring instruments. These instruments are easy to administer and are compatible with popular UI evaluation methods, such as the usability test.

### **Future research agenda**

Further research should consider the emerging paradigms in the HCI discipline, such as persuasion, and play. Further application areas should consider the design of UIs for novel ITV delivery channels, such as mobile and peer-to-peer networks. Moreover, ITV should be considered in the context of an ecosystem of consumer devices, such as mobile phones, PCs, video-game consoles, home media servers, portable media players and information appliances. Peer-to-peer (P2P) technologies such as Bittorrent are currently employed by early adopters in order to gain prompt access to TV content. In the legitimate side of P2P delivery, BBC is employing a PC-based P2P client in order to give access to its vast archive of audiovisual content. Moreover, all major search engines are augmenting their systems to support video searches of broadcast and user contributed video. Then, the research question is: What is an ITV UI for P2P delivery of multimedia content? Similar research questions apply also to Internet delivery, cross media delivery and user-contributed ITV content.

In conclusion, the employment of the HCI theory and methods in the ITV field is a worthwhile area for research and practice. The implications of further research will have a significant impact on the HCI theory, media industry and consumers.

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