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ABSTRACT
We report from a usability study of Digital Television (DTV) with 30 subjects. It was found that content and interface elements should be evaluated in terms of concrete and conceptual nearness with respect to all parts of the DTV experience. Additionally, several features of the DTV application interface were salient in user evaluations: navigation and structure, level of engagement, interface display and timing, responsiveness, and multimedia design.

Keywords
DTV, Digital TV, usability, interfaces, distance learning.

INTRODUCTION
The study was undertaken to guide The Swedish Educational Broadcasting Company (UR), a public service broadcasting institution, in designing user interfaces for distance-learning DTV. In this paper a Digital Television Package (DTP) is seen as consisting of three parts: the Digital Television Equipment (DTE) which includes a remote control and a set-top box, the Digital TV show (DTV show), and the Digital TV Application (DTA), e.g., an interactive service or a set of services for use with a DTV show. The DTA is in turn composed of content (DTA content) and a user interface (DTA interface) through which the content is accessed. The DTA is implemented by programmers using a DTA Software Development Kit (DTA SDK).

STUDY SETUP

Equipment
A Sagem™ development DTE was used. It looks similar to an ordinary Sagem™ DTE, but has added functionality. It is used by UR OpenTV™ developers and can be programmed with a standard PC running an OpenTV™ DTA SDK. The development DTE and the DTA SDK allow developers, not only to develop DTA:s, but also to test DTA:s in conjunction with simulated DTV shows. A video mixer was used to capture TV output and users on the same video tape, i.e., synchronously and side-by-side.

Subjects
20 males, and 10 female, age range 20-50. The subjects participated in pairs. Within pairs, subjects knew and felt comfortable with each other.

Procedure
A written scenario was presented to the subjects: they were part of a study group on digital media and next week they were going to discuss the digital TV service presented to them in the trial. Next, the subjects were given brief DTP-operating instructions and were asked to explore the "digital-TV service" so that they could report on it to the study group. The experimenters then left the room and subjects discussed their experiences while exploring the simulated DTP. All trials were video taped and at the end of each trial, the subjects completed a questionnaire. Lastly, the subjects were interviewed. Trials lasted for about 45 minutes (including a 15 minute interview).

RESULTS AND DISCUSSION

Quantitative Results From Questionnaire

Table 1 Selected results: navigation, organization, content, & engagement

	Disagree completely	Disagree partly	Agree partly	Agree completely
Easy to navigate	2	5	1	22
Clear organization	5	4	5	17
Reusable design	2	7	2	19
Good content	10	11	8	1
Engaging	21	3	6	0

Subjects found that the interface: was easy to navigate, had a clear organization, and that it should be used for other DTV-shows (table 1). Subjects were, however, dissatisfied with the content and the DTA was not perceived as engaging (table 1).

Qualitative Results From Tapes & Interviews
The most apparent problem that the subjects in the studies faced was with the display and timing of the DTA. When shown, the DTA appeared superimposed on the DTV show and covered it completely. This was cognitively

burdensome for the subjects who could not keep up with the DTV show while exploring the DTA.

It has been found that users generally are disturbed when software systems do not respond quickly to the user input [1]. Many subjects in the study confirmed this finding by complaining about the slow and jerky interaction experienced with the DTA. The delays sometimes approached roughly one second. Koller et al have also found slow responsiveness to be disliked by DTV users [3].

Some subjects were unable to quickly understand general design solutions of traditional multimedia, i.e., moving selection indicators (highlights), running a selection, and navigating in hypermedia.

The content of the DTA had been chosen to complement the information available in the DTV show, e.g., it expanded on the presented subject matter. The subjects did not report that the content was of low quality per se, but that it was unfitting. Within the context of the DTP, the content did not work well although it was conceptually close. Many subjects also thought that there was too little content and desired a richer information environment. There is, however a simple explanation for why the subjects reacted the way they did to the DTA content. During interviews it became clear that the subjects wanted a particular kind of "content nearness". This nearness we term *concrete nearness*. Such nearness can be distinguished from *conceptual nearness*. Something is concretely near to a DTV show if it elaborates on the concrete things, settings or people within the DTV show. So if a person is depicted in a DTV show as "John the carpenter in his carpenter shop", then content that is concretely near would involve John the carpenter and his carpenter shop. In contrast, conceptually near content could simply treat of carpentry in the abstract or other carpenters and/or carpenter shops. The subjects were generally in favor of content that manifested concrete nearness and they only advocated bringing in content manifesting conceptual nearness if it was of obvious instrumental value (i.e., contact information, and pointers to further information). One way to summarize this is to say that in absorbing the content of the DTA, the subjects were more willing to make concrete associations to the particulars of DTV shows rather than engage in abstract or conceptual associations.

CONCLUSION AND FUTURE WORK

The cognitive complexity involved in keeping track of a visually occluded DTV show while navigating a DTA interface made itself evident in the study. It may not be a cognitively adequate solution to present the DTV show in a small window on top of the TV show. Regarding the problem of presenting the DTA and the TV show in parallel, perhaps what is needed is not a solution, but a dissolution. One suggestion is to explore sequential ways of presenting the DTA and the DTV show. Thus if the DTA was available some time before and after the DTV show, then users could access the DTA at their convenience.

We also suggest a way to make DTA:s more attractive. The traditional approach has often been to include various appealing graphics. However, it was found that pictographical enhancement of a TV-guide was preferred by only half the subjects [4]. Our suggestion is that careful attention not only be given to the appearance and metaphorical meaning of included graphics, but that included graphics be evaluated in terms of concrete and conceptual nearness. Concrete and conceptual nearness will let the viewer accommodate more easily to the DTA since little is demanded mentally to do so. The viewer accommodates mentally to the TV-show, the DTA-interface and the DTA-content in unison.

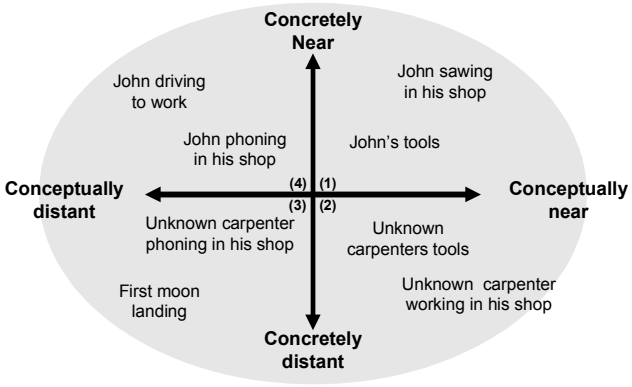

Fig. 1 Concrete and conceptual distance for a DTV show about "John the carpenter" at work in his shop

In figure 1, optimal accommodation occurs in quadrant one, one may call it the content accommodational quadrant. It is in this quadrant that the DTA elements are both concretely and conceptually near. With the term *accommodation* [2] we wish to draw attention to attitudinal and emotional issues of human-computer interaction that fall outside the scope of strict instrumental use. We plan to further explore the roles of concrete and conceptual nearness in DTV applications from the viewpoint of accommodation.

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