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EXCLUSION BY DESIGN: AN ASSESSMENT OF THE ACCESSIBILITY OF DIGITAL TELEVISION SET-TOP BOXES

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1. Introduction

The aim of the study reported in this paper was to investigate the accessibility of Digital Television (DTV) technology, focussing on the current generation of set-top boxes (STB) which provide 'free to view' services [DTI 2003]. The objective of the study was to identify specific causes of concern with regard to user interaction with DTV that might lead to exclusion, i.e. situations where users may be unable to use the new technology. In particular, it was important to identify challenges presented to users by DTV that are not found when using the current analogue equivalent.
The number of STBs is increasing rapidly, but for the purposes of this study, efforts were focused on looking at just two set-top boxes that will be referred to throughout the paper as STB1 and STB2. STB1 was selected because it was being marketed as 'easy-to-use', while STB2 was chosen because it was the market leader at the time. Note: the assessments described in this report were performed over the period April to June, 2003, and thus all comments expressed are derived from the services available during that time period. With the continually evolving nature of DTV, some of the interaction details will have changed by the time that this paper is published.

2. Background

The objective of this study was to identify specific causes of potential user exclusion with regard to current DTV. The STB, satellite or cable box and its remote control form only a part of a larger system, which also includes the television itself and the service providers.
In assessing DTV it is important to understand the contribution of each of the elements to the potential for exclusion. The system must be tested as a whole and in a way that represents 'normal' use. As a result, a number of use scenarios were used to investigate the accessibility of DTV focusing on the purchasing, installation and use of STBs. These included:

- choosing which STB to buy in a shop or from a web-site (e.g. which one is easier to use? etc.);
- identifying the set-up requirements (e.g. what cables do I need?);
- installing the STB;
- tuning the STB (or re-tuning, if after installation);
- re-ordering the TV channels (setting up a list of favourites);
- finding out what's on and selecting the desired channel (using the programme guide/by surfing);
- using subtitles, accessing additional settings, navigating the menu structure;
- accessing interactive content (e.g. Teletext, BBCi).

The investigation needed to focus on identifying the broad steps involved in the interaction between the user and the STBs. The aim was to establish the potential causes of exclusion that may prevent users from interacting with the STBs effectively.

3. User observation sessions

The accessibility of DTV systems was analysed by a series of user observation sessions. User observations are an invaluable tool when assessing both the usability and accessibility of a product [Nielsen 1993].

3.1 Sampling users

Ideally, the users sampled for participation in product assessments should represent the full range of end-user capabilities that can reasonably be expected to be found in the intended target population. However, to achieve statistical significance at all possible levels of capability across the target users would require a large number of participants. So, methods of reducing the number of users are needed. The most popular approaches to sampling issues are to either find users that represent a spread across the target population [Grundy et al. 1999], or else to find users that sit at the extremes of that population [Keates and Clarkson 2003]. The advantage of working with users that represent a spread across the population is that they ensure that the assessment takes the broadest range of needs into account. The disadvantage, though, is that there is not much depth of coverage of users who may experience difficulties in accessing the product.

The advantage of working with the extreme users is that the user observation sessions will almost certainly discover difficulties and problems with the interaction. However, the disadvantage is that there is a real danger of discovering that particular users cannot use the product, and little else beyond that. For example, giving an instruction book to a user with complete sight loss yields the obvious difficulty arising from the inability to read the text. Of more use is to identify users who are more likely to be 'edge-cases', those who are on the borderline of being able to use the product.

Going back to the example of someone with a visual impairment attempting to read an instruction book, while someone with complete vision loss would certainly not be able to use the instructions, someone with only partial sight loss may be able to do so. Even more interestingly, that person might be able to read some bits and not others and thus it is possible to begin to infer a wide range of very useful data from such a user. On top of that, if the user cannot read the instructions, then it may be inferred that any user with that level of sight loss or worse will not be able to use them, automatically encompassing the users with complete sight loss in the assessment of product exclusion. Figure 1 summarises the different approaches to sampling the users. The implication of this is that whichever group of users participates in the assessment, it is important that their capability profiles are known so that it is known how many users share the same characteristics.

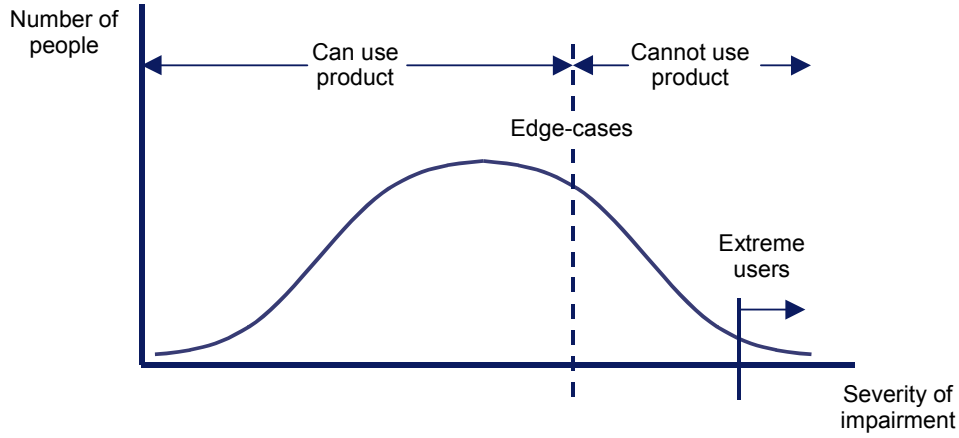

Figure 1. The different approaches to sampling the users

3.2 User selection

Thirteen users were recruited for the observation sessions. The users were identified based on a number of criteria, primarily focused around whether they were strong candidates for being edge-cases in terms of their ability to interact with STBs. Based on the results of the earlier assessments, it was decided to focus on recruiting older adults not living in residential care. As discussed in the Sampling Users section above, more extreme users could have been selected for the user group, however, the level of information that can be obtained is then limited.

Older adults typically exhibit a range of different kinds of capability loss and are more likely to show multiple minor impairments. This is important because most assistive products are aimed at single major impairments and thus users with multiple minor impairments are less likely to be able to find assistive products to aid them should they encounter severe difficulty interacting with a product.

The decision to select users still living in private homes, rather than residential care was based on the desire to have users who still have enough functional capability to support independent living to some degree. They should therefore be able to perform tasks such as operating a television on their own. If they experienced significant difficulty, then it could be argued that the STBs are causing undue exclusion. For comparison, a more severely impaired younger user was also recruited to highlight whether a more extreme user would also encounter the difficulties experienced by the older adults.

During the recruitment process efforts were made to ensure that the users exhibited a range of capabilities. Care was taken not to skew the sample towards any particular capability loss, rather to provide a balanced sample of motion, sensory and cognitive losses. Table 1 shows the users selected.

Table 1. The user observation participants

User	Age	Gender	DTV owner?	No. of hours TV watched per evening	PC user
1	85	M	No	<1	Yes
2	82	F	No	1 to 2	No
3	65-69	F	No	2 to 4	No
4	80-84	F	No – analogue cable	>4	No
5	69	M	Yes – STB	1 to 2	Yes
6	62	F	Yes – STB	1 to 2	Yes
7	65-69	M	Yes – satellite	>4	Yes
8	65-69	M	Yes – iDTV	1 to 2	Yes
9	60	F	No – analogue cable	2 to 4+	Yes
10	70-74	F	No	2 to 4	No
11	70-74	F	No	>4	No
12	70-74	F	No	>4	No
13	24	M	No	<1	Yes

It is worth noting that a range of user capabilities was observed. Two users showed no obvious impairment on the UK Office of National Statistics (ONS) data scales [Grundy et al. 1999], four showed single impairments and the remaining seven exhibited multiple impairments. Three of the users reported a loss of dexterity at levels expected to cause difficulties using DTV. Five of the users reported a loss of intellectual functioning, of which three were at levels that might also be expected to cause difficulties. A number of PC-literate and DTV users were recruited to investigate the effect of prior experience of DTV and PC-based menu systems on the use of otherwise unfamiliar STBs.

3.3 Methodology

The user observation sessions were organised to be a subset of the usage scenarios described earlier, focusing on the functional stgaes of common interaction, rather than issues such as installing an aerial. Each user session was limited to 2 hours to ensure that user fatigue was kept to a minimum. Thus the user activities were restricted to those operations that could be considered fundamental to watching

television, such as the ability to change channels, and also to those advanced features that could be explored within the available timeframe. 2 STBs were assessed (STB1 and STB2), to ensure a balance between breadth and depth of study. The STBs reflected different design approaches, with one focused more on ease-of-use and the other on functionality.

Initially the users were interviewed for 30 minutes to find out their capability profiles and also background information on their attitudes towards television use and exposure to DTV. Two or three observers attended each interview, each recording the user responses. Following the interview, the users began an equipment trial. This began with a familiarisation exercise with the analogue television set being used. All users used the same television and remote control. They were asked to perform basic operations, such as changing channel and volume. They were also asked to use teletext services and to call up subtitles.

The users were then asked to choose which of the two STBs being assessed they would prefer to buy. This involved showing them the external packaging and then the STBs themselves. The next stage was to provide the users with the installation instructions for their chosen STB and to ask whether they would install the box themselves. Those users who felt up to doing so were encouraged to connect up the STB to the television. For those users who declined to do so, the STB was connected for them. This was followed by simple television operations such as changing channels and channel-hopping. Users were encouraged to use the on-screen electronic programme guide (EPG) for one of the channel hops.

The more advanced interaction activities included finding weather and television programme guide information from both Teletext and BBCi, as well as calling up subtitles. The equipment trial took an average of one hour to complete. Finally, a closing de-brief session was held, that lasted approximately 15 minutes. During this session, the users were asked what they thought of their experience with the STBs.

3.4 Observations

Throughout the assessment on accessibility of DTV set-top boxes, interaction was considered in terms of the sensory, cognitive and motor demands placed on the users. Table 2 provides a summary of the incidence of difficulties experienced. Common sensory problems included finding/reading buttons on the remote controls, reading on-screen text, and swapping between the two (especially for users with distance and reading glasses). These problems are made worse in comparison to analogue television because of the increased functionality leading to the need for more (and hence smaller) buttons and also increased use of on-screen text displays. Users with hearing impairments would find the presence of an explicit subtitle button on the remote control for STB1 very useful, but would be disadvantaged by the on-screen menu approach of STB2, where the user had to navigate through several levels of menu to reach the subtitles option.

The most common source of motor difficulties was pressing the buttons on the remote control. Again, while this is a common task for both analogue television and the STBs, it is made more difficult for the latter by the need for more (and hence smaller) buttons and also increased levels of user interaction. However, while there was an increase in both the vision and dexterity demands made upon the users, by far the biggest cause of exclusion noted during the user observation sessions was the cognitive demands. The inherent increase in user cognitive effort associated with having to use two remote controls (or a single remote control with multiple modes) rather than a single remote control is further exacerbated by the mismatch between the users' mental models of the interaction and the interaction paradigms adopted. For example, users are familiar with the concept that pressing a button on a television remote control has an immediate effect on what they see on the screen. For example, pressing a channel number button causes the television to immediately tune to that channel. Thus a strong link between cause and effect is observed, and a solid user mental model of the interaction is developed.

The STBs, though, present the users with numerous new interaction paradigms, such as pop-up menus, combined with weakened cause and effect. For example, nothing happens when an item is highlighted on a pop-up menu until the OK/SELECT button is pressed (another new concept). The situation is worsened further by the seemingly arbitrary inconsistencies in language and interaction between

similar purpose entities of the interface. For example, in BBCi the 'menu' option is called 'menu', whereas in Teletext it is 'control'. On one remote control the SELECT button was called just that, whereas on the other it was denoted OK. To enter BBCi, the user has to press the RED button, while for Teletext it is the TEXT button. These inconsistencies present unnecessary usability hurdles to the users. These differences breach one of the central tenets of usability theory, namely that of the need for consistency.

Table 2. The distribution of causes of difficulty

	Activity	Having difficulty	Motion problems	Sensory problems	Cognitive problems	Number of problems
Analogue TV	Switching on	8	1	-	1	2
	Changing to a specified channel	1	1	-	-	1
	Channel-hopping	-	-	-	-	-
	Changing volume	-	-	-	-	-
	Using teletext	6	1	3	3	7
	Using subtitles	-	-	-	-	-
Digital TV STB	Connecting up the STBs	4	1	-	1	2
	Switching on the television	1	1	-	-	1
	Switching on the STB	6	-	1	2	3
	Changing DTV channels	3	-	1	2	3
	Changing volume	7	-	-	1	1
	Changing channel number	10	2	2	2	6
	Changing channel via the EPG	13	3	4	6	13
	Teletext	13	2	4	12	18
	Subtitles – button (STB1)	6	-	1	1	2
	Subtitles – menu (STB2)	13	-	1	4	5
	BBCi	13	2	1	6	9
	Switching off	5	-	-	2	2

The prevalence of the cognitive difficulties encountered by users with no discernible loss of cognitive capability suggests that the levels of population exclusion predicted using data from the 1996/7 Great Britain Disability Follow-up Survey [Grundy et al. 1999] alone are demonstrably conservative. Many of the cognitive difficulties experienced were not directly attributable to any kind of 'medical model' impairment. Instead, lack of experience with, and mental model of, the interaction paradigms used in digital television was the principal cause of the difficulties encountered.

3.5 Discussion

The user observations showed that interacting with the STBs was more difficult than interacting with traditional analogue television services. Indeed, the typical digital system is likely to exclude at least twice as many users as the typical analogue system for basic operations such as channel selection [DTI 2003]. Thus the STBs are excluding potential users who at the moment are able to access and use the available television services. The additional exclusion arose from two principal causes. First, the basic operations, such as changing channel or volume, switching on or off, or calling up subtitles are all made fundamentally more complex by the presence of either two remote controls, or a single remote control with multiple modes of operation. Second, digital television offers increased functionality and thus places additional burdens on the user. For example, when changing channel on an analogue television, the user only has the option of using a single remote control. This limits the amount of cognitive effort required by the user, as no decision as to which remote control to use is required. When an STB is present, the user is faced with the additional decision of which remote control to use as well as the additional motion requirement to swap between the two remote controls.

Some STB manufacturers have responded to this difficulty by supporting both television and STB operation into a single remote control that operates in dual modes. However, unless some kind of

affordance is provided indicating which mode the remote control is in (STB or television), the user can only find out by pressing a button and then seeing and interpreting the response. If the response was not the desired one, then the user needs to undo the action, change the mode and then perform the desired action a second time. Consequently, STBs will only cease to exclude more people than analogue televisions when their operation is completely transparent from the user's point of view. Integrated digital televisions (iDTV) appear to manage to achieve this level of transparency for basic functions by using only a single remote control with minimal need for mode changes.

However, even iDTVs exclude more people than analogue televisions when considering the full range of operation. Put simply, digital television offers more functionality, and thus requires more cognitive effort to learn and operate. For example, if a user wishes to use the full functionality of DTV, then there is a greater need to be able to read the on-screen display and to swap to reading the remote control (vision demand). Similarly, the users need to be able to operate the arrow buttons and SELECT/OK, rather than just the channel numbers. The increase in number of channels means that users have to enter more double-figure channel numbers, with the inherent time-out limitations increasing the dexterity demand still further.

Only if all of the additional functionality is as accessible and usable as interacting with an analogue television, will digital television be at least as inclusive as analogue. This is a tough target to aim for, but a necessary one unless it is to be accepted that not all users will have access to all of the emerging digital services.

4. Conclusion

The predominance of exclusion arising from the differences between the users' mental models and the interaction paradigms within the interface affects far more users than those that would typically be classed as a stereotypical 'special needs user'. This is well illustrated by the comparative lack of difficulty with the interaction experienced by the youngest participant who had the most severe vision impairment of any of the users, but who nonetheless experienced little difficulty completing the tasks, most probably because of his wide experience with high-technology products.

Consequently, manufacturers should be encouraged to look beyond the stereotypes of young, severely, impaired people when considering who may have difficulty using their STBs and to also consider the needs of older adults and those who may not be familiar with the interaction paradigms used. There is also a clear need to standardise within those paradigms to minimise the cognitive demand placed on the users and to make interaction with the STBs as transparent as possible.

Ultimately, what is being advocated is not special purpose design for a small market sector, but rather good 'design for all'.

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