Do dynamic text–only web pages improve usability for PDA users?

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Abstract:
Text transcoders are proxy–like systems that respond to requests sent by user's browsers, strip images, multimedia objects, JavaScript code and change the page layout, and return the modified page. Although the potential benefits of text transcoders as mechanisms to provide alternative and robust user interfaces are multifaceted, at the moment their benefits on users of small mobile devices are not clear.

This paper describes an experiment aimed at evaluating usability of web pages used with PDAs when processed by a text transcoder. Results based on subjective and objective data show that effectiveness, productivity and satisfaction can be improved. Furthermore, the needed transformations are simple to implement, and achievable by many text transcoders and content management systems.

Keywords: transcoders, usability, PDA, retargeting, re-purposing.

1. Introduction

Transcoders are proxy-like systems that respond to requests sent by the user's browsers; they relay these requests to an ordinary web server, collect the requested pages, transform, and finally return transformed pages to the browser. In particular, a *text transcoder* strips images, multimedia objects, JavaScript code from the pages, changes its layout, and returns the remaining contents.

Besides affecting accessibility of a web application delivered through a text transcoder (that often is improved [4,3]), there are other potential benefits of this approach that can be exploited.

First, text transcoders are a technically viable solution when retargeting of the user interface [16,14,7] or re-purposing of the content are needed. For example, normal graphical pages can be transformed so that the visual layout, and possibly the interaction structure, can better adapt to specific devices used by visitors (*e.g.* using mobile devices). This happens because *user bandwidth*[2] can be increased by removing, rearranging or modifying the page contents or the

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[2] User bandwidth refers to the information processing rate for a human input or output channel [13]. User bandwidth is measured in bits/seconds and depends on task difficulty (measured in amount of information to be processed) and time to complete the task. The higher the bandwidth is, and the more effective the interaction is.

interaction structure (*e.g.* by modifying the sequence of steps, decisions and actions that are needed to accomplish a goal). In fact a text–only version of the web site can be an opportunity to customize web contents, navigation and presentation so that it can better suit certain types of users and usages, such as those bound to low–bandwidth connections (like slow modems), limited interaction and display tools (like PDAs or cell phones), alternative channels (like screen–readers). In these situations, text transcoders that are flexible enough to support required customization features, offer an additional way in which a web site can be used in a device–independent manner [3].

Second, text transcoders may be configured so that they remove or reformat the original textual information, in addition to the non textual information that gets removed by default. A possible useful deployment is for local governments that might be interested in providing a very simple and robust user interface so that people can easily access emergency warnings and escape instructions when in need, and through any sort of web–connected device. In this way government agencies could avoid incurring in the costs and risks of developing two redundant versions of the content. In fact, since the transcoder is external to the web server, its deployment does not require changes to any of the tiers on which the web application is based, not even its more external layer.

On the other hand, performance, robustness, and reliability of transcoders, and interoperability, maintainability, security, and usability of transformed pages may reduce applicability of this technology. We believe usability is the most important factor to be investigated at the moment. Because text transcoders drop part of the original content (*e.g.* images, Flash, applets, scripts), because they dramatically change the layout and structural HTML of pages (*e.g.* removal of layout tables), and because the customization that they support is somewhat limited, it is not yet clear whether resulting pages are beneficial at all. In fact so much is changed, and so many things have been removed, that it is possible that many user goals which could have been reached in the original web site, would become unachievable. For this very reason, text–only pages are often considered very poor relatives of the original web pages: second–level web sites for second–level citizens.

Several myths are claimed for text–only pages, all of which fall apart against a rational discussion. One myth is that text–only pages are, by their very nature, already accessible[3]: this might not be the case if the page contains inaccessible tables, forms, unskippable navbars, ambiguous link labels. Another myth is that text–only pages are a second, redundant web site[4] (which is false unless one develops them by hand; if a transcoder or a CMS is used, then text–only pages are just another user interface for the web site). A third myth is that these pages are useless to people with no vision (which is false because content can be moved, reorganized, added, labeled specifically to improve the user experience for those users). Finally there is the myth that text–only pages are detrimental to sighted users (which is false because a simpler layout may lead to fewer navigation errors, to a better understanding and to a faster download time).

Thus, before text transcoders can be reliably included in the set of tools and techniques normally used for the deployment of web sites and applications, this uncertainty needs to be reduced. In particular, an important empirical research question is: *what kind of impact has a text transcoder on users?*

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[3] A paper similar to the present one was rejected at a major conference on the WWW because two reviewers claimed that "... it is known that text–only pages are already accessible; so why is this research important at all?"

[4] See for example http://www.webcredible.co.uk/user-friendly-resources/web-accessibility/text-only.shtml

In this paper we describe an empirical research aimed at determining if the use of text transcoders leads to any difference in usability of web sites as experienced by users of PDAs. Statistically significant results are then discussed and appropriate conclusions are drawn.

2. Research and Question

The purpose of the study is to determine whether text–only pages that are dynamically created through text transcoders are beneficial to users of PDAs. We framed this question into a comparative experiment for measuring usability under two experimental conditions: use of the original web site *vs.* use of the web site through an appropriately customized text transcoder.

2.1. Transformations Achieved by Text Transcoders

Transcoders, differently than gateways, apply a number of transformations to normal web pages and HTTP headers and return the transformed page and headers to the user's browser. Transcoded pages depend on three factors that affect them (see figure 1): (i) built–in transformations that remove contents (*e.g.* for text transcoders, images are removed); (ii) built–in transformations that change the page structure and layout (*e.g.* producing a liquid layout by removing layout tables and replacing original CSS code); and (iii) customized transformations driven by annotations or filters (*e.g.* adding textual equivalents to original images). As a consequence, difference in usability (between the two experimental conditions) can be determined by any combination of these factors.

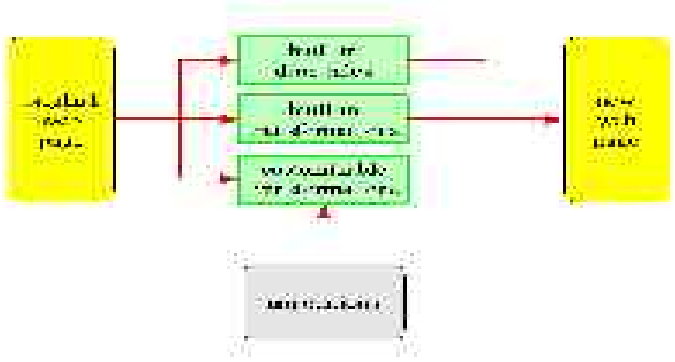

Figure 1. The three mechanisms that affect transcoded pages.

The transformations that were used in the study are representative of the ones that are usually implemented for accessibility purposes in order to remove barriers and smooth users experience:

- transcoded pages are stripped of all the original CSS and JavaScript code, and simple CSS rules are added that yield a liquid design of the page and of the text;
- automatic redirects are replaced by server–side redirects;
- textual links that are too close each other are separated by white space and by printing characters (through annotations);
- scripts and event handlers are removed; when appropriate they are replaced with content of NOSCRIPT clauses;
- frames and framesets are replaced by corresponding contents; frames can be viewed simultaneously;
- layout tables are removed and their content is linearized, whereas data–tables are preserved;

- images are replaced by their ALT or TITLE; imagemaps are replaced by lists of links;
- ALT for image buttons are added (through annotations);
- titles for pages and frames are added (through annotations);
- navigation bars are reformatted to be displayed horizontally to better use the available screen space (through annotations);
- certain controls in the page (*e.g.* search box or navigation bars) are moved to its bottom (through annotations);
- page headings (H1 to H3) are added (through annotations);
- forms are linearized and labels are properly positioned; form control titles are also used when appropriate (through annotations);
- objects and applets are replaced with their textual equivalent if any; they are stripped otherwise.

Several text transcoders exist [18,2,11,10,1,8,9,5,6] which, in principle, are able to achieve the transformations described above. In addition, appropriate customization of content management systems should be equally viable solutions. We used LIFT Text Transcoder (LTT) [18] because of its flexibility and availability to us.
LTT was applied to a web site of an Italian local government agency[5] that was not accessible. LTT was installed on servers that were physically located in UK and therefore on a remote location compared to participants (university labs in Italy) and to the original web server (a different town in Italy).

2.2. Customization of the Text Transcoder

The original web pages of the test site miss textual alternatives for iconic buttons, are poor in terms of liquid layout and resizable text, some areas of the pages feature a low foreground/background contrast, forms controls are not appropriately labeled, and no intra–page navigation is supported (*e.g.* sectioning, skip–links links [17], links with non–unique text labels). Figure 2 shows the home page of the tested web site.

Annotations for LTT[6] were limited to process existing content of web pages and smooth out some of the accessibility barriers. The only new content added through annotations was page and frame titles, page headings, ALT for iconic buttons, hidden skip–links links, access keys for global navigation links, and a small table of contents on each page.

In this way the original content and information architecture of the web site was not affected by annotations and the transcoder was tested in a typical deployment situation, where a web master is expected to adapt the transcoder to the specific coding conventions of the site and fix most common accessibility barriers. Other than following generic accessibility requirements specified by accessibility guidelines, pages were not customized to fit PDAs browsers. Figure 2 (bottom) shows a transcoded page.

[5] http://www.regione.fvg.it

[6] Annotations for LTT are XML fragments, stored in files that are separate from the original web pages and owned by the administrator of LTT. Each annotation refers to an element type (*i.e.* a tag name) of the DOM of the document (the target of the annotation), it can be page–specific (*i.e.* restricted to a single URL) or site–wide, it has a match condition specified through an XPath expression, and a transformation section. The transformation section says how to transform target elements matching the expression and belonging to documents on which the annotation applies. For additional details see [3].

Figure 2. Screenshot of the original page http://www.regione.fvg.it/welcome.asp (top) and the text-only version produced by the transcoder (bottom). The effect of some annotations can be noticed on the horizontal layout of navigation bars, in the initial table of contents with accesskeys, in the sectioning of the page contents (bold text is coded with HTML headings H1, H2, H3).

Figure 3 shows how the Pocket IE micro browser renders an original page and its transcoded version.

Figure 3. Screenshots of how Blazer and IE display transcoded pages.

2.3. Experimental Plan

The experiment involved 40 undergraduate science or technology students that were split into two groups: one used Pocket Internet Explorer on a Pocket PC 2003 SDK emulator and the other ones used Blazer 2.0 on a Palm OS 6.0 emulator. As a screening criterion we required that all participants had prior experience with computers and with Internet. No prior experience with a PDA was required.

As summarized by figure 4, the age of the 40 subjects (19 females and 21 males) ranged from 19 to 33 (median=24.5, Q1=22 and Q3=25.25, mean=24.2); the hours spent using a PC ranged from 1 to 50 (median=12.4, Q1=3.37, Q3=20, mean=12.4); the hours spent using the WWW on a PC ranged from 0.5 to 50 (median=4, Q1=1.875, Q3=8, mean=7). 3 subjects have used a PDA on the WWW; 4 of them actually own one. 12 users (30%) visited the tested web site in the previous 12 months.

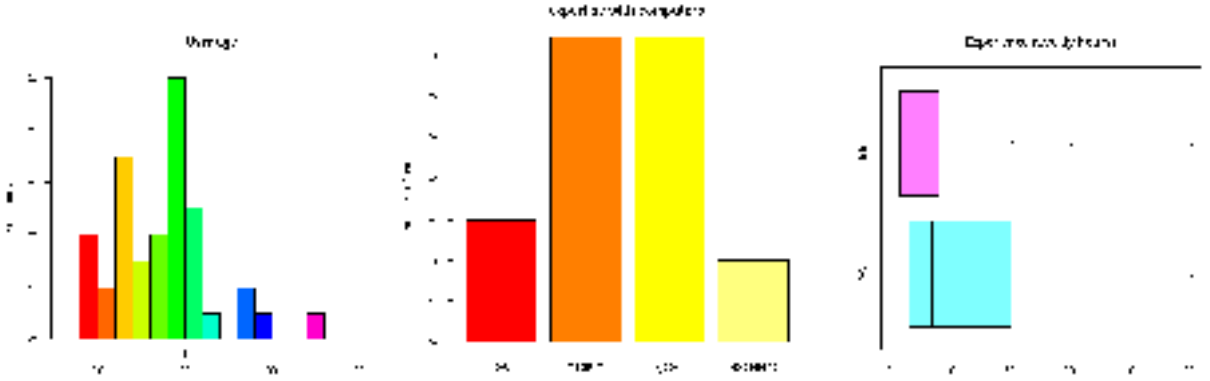

Figure 4. Distribution of participants according to age (left), of self-assessed levels of expertise using the Internet (center) and boxplot of the weekly hours of use of PC and Internet (right). In the boxplots, whiskers represent the minimum and maximum values, dots are outliers, and rectangles represent the 3 quartiles.

Each participant was asked to carry out (in random order) 5 information finding tasks, two with LTT, two without and one with another transcoder (Access Gateway [5,6]). The latter task was needed in order to reduce the test effect by simulating a one–way blind test: subjects were not sure of which was the actual transcoder we were experimenting with, and this limited their bias when expressing their opinions. The outcomes of this task were not used to draw any conclusion because it represented a spurious experimental condition that we weren't interested in investigating. Furthermore such a task was simple enough so that it would not contribute too much in increasing the overall work session time and effort. In addition it is performed on a section of the web site that is unrelated to those on which the other tasks focused on.

We split the 4 main tasks (with/without LTT) into two pairs: one pair of tasks were simpler than the others, and required subjects to browse 2 or 3 pages to find the required information; the other tasks required in addition to fill in a form (see figure 5 for details). In order to balance the learning effect, we randomized both the difficulty level of tasks and the treatment (with/without LTT). The extra 5th task with Access Gateway was randomized with the 4 main tasks.

task	level	short description

A	Simple	find postal address and telephone number of *Ufficio Regionale della Protezione Civile*
B	Simple	find the URL address of *Agenzia Regionale della Sanità*
C	Complex	find job opportunities in administrative fields applied to health management
D	Complex	find addresses of farm holidays in the area of Bertiolo

Figure 5. The four main tasks (the actual formulation was in Italian, which included a more detailed 5 lines scenario description)

Sessions were videotaped and a post–task questionnaire was submitted to each subject. The purpose of the questionnaire was to elicit information about satisfaction and perception of effectiveness and productivity. Most answers were framed as 5–point Likert scales. The independent variables included whether LTT was used during execution of a task, the type of tasks (easy *vs.* complex) and the kind of micro–browser being used. The dependent variables characterizing usability included subjective ones (*e.g.* opinions asked to the participant, like how easily the information was found) and performance–related ones (*e.g.* time to complete a task, level of completion). The dependent variables were associated to the basic usability attributes as shown in tables 1 and 2: we describe only results with statistically significant difference (we used Wilcoxon test for paired samples; the minimum significance level we considered is 5%).

In tables 1 and 2, *Completion level* refers to the accuracy of solution that participants were able to reach for a task (for example, a level of 100% means that all the required information was correctly found and identified). *Completion reason* refers to why a participant quit working on a task: because it was completed, because he/she reached the maximum allowed time, or because he/she gave up.

Other variables (besides the ones listed in tables 1 and 2) were considered, but they led to non significant differences. These variables included agreement levels to "*I always understood what the meaning of links was*"; other objective variables were: number of times users gave up, n. of times users timed-out on a task, task completion time given a certain level of completion, n. of visited pages given a completion level, n. of errors, n. of errors per hour, n. of followed links.

variable		type	NO LTT mean	LTT mean	NO LTT median	LTT median	p–value
Q_1	*I easily found the required information (1-5, 1 is better)*	simple	3.2	2.3	3	2	<0.011
		simple, BP	3.5	2.4	3	2	<0.034
		complex	3.8	2.7	4	2	<0.002
		complex,BP	4.2	2.8	4.5	2	<0.002
		all	3.5	2.5	4	2	<0.001
Q_2	*I was tempted to go elsewhere to find the answer (1-5, 5 is better)*	simple, BP	2.6	4.1	2	5	<0.007
		complex	3.2	3.8	3	5	<0.024
		complex,BP	2.7	3.5	2.5	4	<0.027
		all	3.3	3.9	4	5	<0.020
Q_3	*I always knew where I was within the site (1-5, 1 is better)*	simple	2.4	1.8	2	1	<0.041
		simple, BP	2.7	1.8	2.5	1	<0.028
		complex,BP	2.7	2.1	3	1.5	<0.029

Q_4	*I easily detected links (1-5, 1 is better)*	simple	2.3	1.5	1.5	1	<0.008
		simple, IE	2.4	1.3	1	1	<0.012
		complex	2.2	1.4	2	1	<0.009
		complex,BP	2.6	1.5	3	1	<0.004
		complex, IE	1.8	1.2	1	1	<0.045
		all	2.3	1.4	2	1	<0.001
Q_6	*I'm satisfied with the solution I found (1-5, 1 is better)*	simple	3.1	2	3	1	<0.003
		simple, BP	3.2	1.8	3	1	<0.008
		simple, IE	3	2.1	3	1	<0.036
		complex	3.2	2.2	3	2	<0.002
		complex,BP	3.4	2.5	3.5	2	<0.005
		complex, IE	3	2	3	1	<0.035
		all	3.1	2.1	3	2	<0.001
Q_7	*Rank the tasks by difficulty (1-4, 4 is better)*	simple	1.2	1.5	1	1.5	<0.036
		complex	1	1.3	1	1.5	<0.034
		all	1.1	1.4	1	1.5	<0.008
Q_8	*Evaluate the presentation quality (1-7, 7 is better)*	all	4	5.4	4	6	<0.001
		BP	3.7	5.4	3.5	6	<0.001
		IE	4.2	5.5	4	6	<0.008
Q_9	*The download time was very long (1-5, 5 is better)*	all	1.72	3.8	1	4	<0.001
		BP	1.6	3.8	1	4	<0.001
		IE	1.8	3.9	2	4	<0.001

Table 1. Dependent subjective variables, their associated usability factor and results (Q_i means question, BP stands for Blazer Palm, IE stands for Pocket IE). Type *represents the type of tasks being used: simple, complex or both. For questions Q_1... Q_6 the answer scale is: 1*=strongly agree*, 2*=agree*, 3*=undecided*, 4*=disagree*, 5*=strongly disagree*; for Q_7: 1*=difficult...*4*=easy, for Q_8 1=very bad, 7=very good *and for Q_9: 1*= too long... *5*=quick.

Figure 5 shows graphically the differences in the means for each of the row presented in table 1.

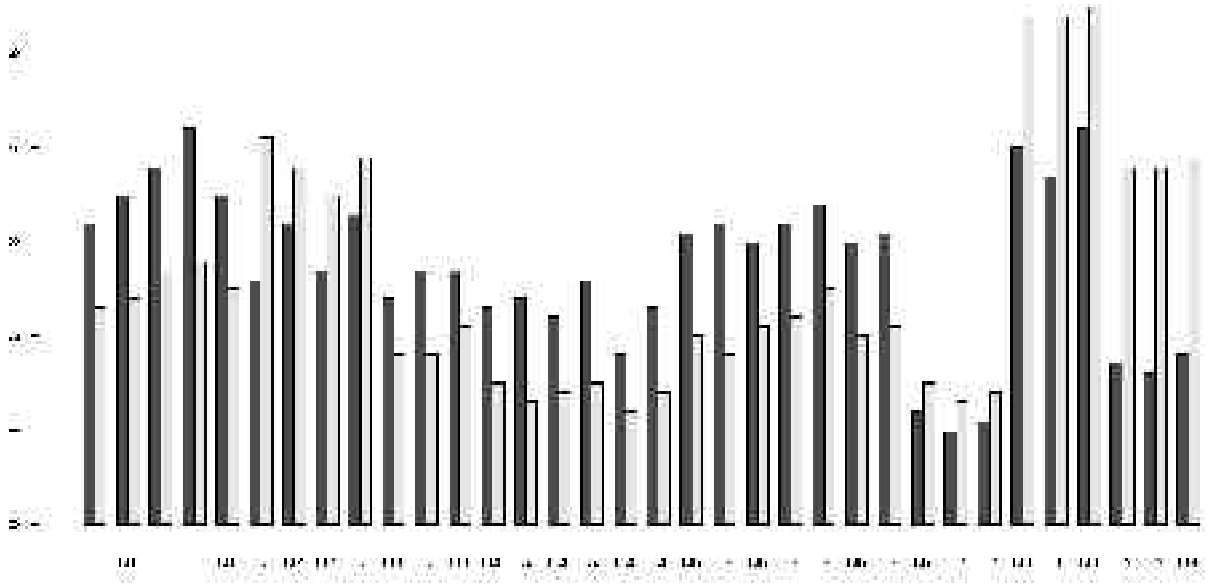

Figure 5. A graphical illustration of the differences in the means for the variables shown in table 1 (each pair of bars is associated to the corresponding row of the table). Dark bars refer to the LTT condition, while light grey ones refer to the NO LTT condition.

	Variable	Type	NO LTT mean	LTT mean	NO LTT median	LTT median	p–value
CL	*Completion level*	complex	0.7	0.8	0.8	0.1	<0.007
		all	0.7	0.8	0.9	1	<0.006
Q_{10}	*Proportion of users that would choose LTT NO LTT for a next visit*	all			0.2	0.8	<0.001
		BP			0.1	0.9	<0.001
TS	*Task duration (sec.) when completion level >50%*	simple	417	216	418	185	<0.001
		complex	578	520	550	530	<0.001
		all	597	323	483	294	<0.001
T	*Task completion time in sec.*	simple	415	240	418	218	<0.001
		complex	568	420	550	336	<0.002
		BP	455	339	425	293	<0.013
		IE	528	321	546	304	<0.001
		all	491	330	483	304	<0.001
NB	*Number of* back	simple	2.4	1	1	0	<0.019
		all	2.7	1.2	1	0	<0.008

Table 2. Results for the dependent objective variables.

3. Analysis of Results

We report a summary of the results organized around three important usability factors.

3.1.1. Factor 1: Effectiveness

- LTT improves Q_1 ("*I easily found the required information*"), under several conditions. The difference is stronger for complex tasks; it is not significant for users of Pocket IE.
- LTT improves also Q_2 ("*I was tempted to go elsewhere ...*"). This is especially strong for simple tasks when using Blazer; no significant difference when using IE (higher values are better because the answer was framed in terms of 1 is "strong agreement" and 5 is "strong disagreement).
- LTT improves Q_3 ("*I always knew where I was ...*"); no difference when using IE or when dealing with complex tasks.
- LTT improves Q_6 ("*I'm satisfied with the solution ...*"); the difference is more or less uniform under several conditions.
- LTT improves Q_7 ("*Rank the tasks by difficulty*") for complex tasks or overall. No difference between browsers or for simple tasks.
- LTT leads to improvements of *CL* (completion level) for the complex tasks ($p<0.007$).
- LTT leads to improvements of *NB* (Number of activations of the "Back" button $p<0.019$)
- other differences were not proved by the experiment.

3.1.2. Factor 2: Productivity

- LTT improves *T* (completion time) overall and for complex tasks (*e.g.* median time with LTT is *218 s* compared to *418 s*); this holds also across both browsers; no difference found for simple tasks.
- LTT was preferred for Q_4 ("*I easily detected links*") ($p < 0.045$) except when using Blazer on simplest tasks for which there is no difference;
- LTT improved Q_9 ($p<0.002$), independently from the browser. The explanation is that the reduced size of text–only pages far better compensates the additional network latency due to the extra HTTP connections.
- LTT improves also *TS* (completion time for those that reached at least 50% of success);

3.1.3. Factor 3: Satisfaction

- LTT was preferred for Q_1, Q_2, Q_3 ;
- LTT was preferred for Q_4 ;
- LTT was preferred for Q_6, Q_8 on all the tasks and for both browsers; and finally
- LTT was the preferred modality for a possible future visit on the site (80% overall, 90% for those using Blazer, not significant difference otherwise).

Especially users of Pocket IE did not like the poverty of text–only pages (they preferred seeing images, icons, and colors). Users of Pocket IE liked the fact that no horizontal scrolling was necessary. Few users activated the skip–links or the links in the table of contents that were added through annotations.

3.2. Discussion

The results presented in previous section show a general marked improvement when users access the web site through the transcoder. As discussed in section 2, this is due to the built–in and customized transformations, that were limited to accessibility improvements in general.

Despite the poverty of text–only pages, all significant differences are in favor of using LTT. Objective variables regarding effectiveness show significant differences mainly for the complex tasks, and other effectiveness indexes did not show any difference under the two treatments. When there are differences between the two browsers, the most positive effect of LTT can be detected when using Blazer rather than Pocket IE. This is due to the different capabilities of the two micro browsers: Blazer did not cope well with frames and by default it linearized the page content, leading to a bad layout in the case of the graphics-based page. Due to the limited size of our sample, we cannot provide more specific and significant data for the subset of users that used Blazer or Pocket IE.

No variable we considered (either subjective or objective) resulted in a difference that is in favor on the "NO LTT" condition. We believe this is due to the simplified layout embedded in text-only pages and the accessibility fixes that were added through annotations (like text titles to sections of the page, text labels to links).

We weren't able to detect any usability difference due to the addition of access keys, of skip–links links and table of contents, as these features where very seldom used. This suggests that unless users are trained in using these features of a web site, they won't see them or they would skip them.

We believe that these differences apply to a larger population than just the 40 users of our sample, provided that such a population shares the same characteristics of our sample, since it was not

random. Namely: being science or technology university students, 21-26 years old, and novice with respect to PDAs, with some experience in using the web. Although our sample is very biased towards young and technology oriented people, their experience with the site and with the specific PDAs we considered was limited (as shown in section 2.3). Therefore we believe similar results should apply also to a population that has different age or attitudes. In fact we think that the simpler layout produced by transcoders would benefit even more users that are less technology oriented than our students.

We would expect to find similar results also using other transcoders, different than LTT, provided that they can implement the same transformations we used. The same is true for CMS (Content Management Systems) capable of performing those transformations.

Similar results should also be obtainable from informational web sites that are not accessible. However, as the complexity of using the web site increases, and as its usability decreases, it is likely that the advantages of using a text transcoder decrease. This can be explained by the strong negative impact brought by usability barriers (like misunderstanding link labels, or page organization, or navigability obstacles); no matter how much accessible a web site is, these barriers will always affect users performance and satisfaction.

On the other hand, web sites that are already accessible would not benefit from a text transcoder unless the web architect would like to provide an alternative user interface with significant changes in content (like is often done for web sites designed to be used through micro browsers). In such a case a transcoder is a viable server-based solution independent from the capabilities of the micro browsers, unlike the use of appropriately designed CSS stylesheets. So far, transcoders are not a viable solution when the web architect wants to provide an alternative web site with a *different* information architecture or interaction structure. Since transcoders are basically limited to a 1:1 page translation, transforming a page that supports some complex interaction through a combination of forms and JavaScript into a number of interrelated pages cannot be done.

4. Conclusion

This experiment demonstrates that minimally configured text transcoders do not reduce usability of pages used via PDAs for information finding tasks, and indeed they are effective under many conditions. By fixing basic accessibility defects of a web site, and without requiring any change to the original web application, satisfaction, productivity and effectiveness can be improved especially in most difficult tasks and with less sophisticated micro-browsers. Although no customization specific to PDA needs to be implemented to achieve this, any specific adaptation of transcoded pages to PDA browsers is likely to dramatically increase usability. Furthermore, even though text transcoders remove contents from pages (*e.g.* images, scripts), unless this content is essential for certain tasks, its removal does not affect usability of transcoded pages.

We believe the key features of LTT that support these findings are: simultaneous rendering of frames, liquid layout with resizable text, customizability via annotations for horizontally laying out navigation bars, adding ALT text to image buttons and images in general, adding page headings, and labeling form controls. Therefore, in principle, we would expect to find similar results also with text transcoders other than LTT.

In our study we did not consider other quality–related properties of transcoders that are important choice factors, namely: their robustness, how easy it is to write and test new filters/annotations, and how robust these filters are.

Understanding which images and icons to add and how to use colors effectively within automatically generated text-only pages in order to increase further their usability is the subject of future research. Another research venue is to measure the change in satisfaction, pleasure and other emotional dimensions [12] induced by transcoded pages and to measure the effects of decreased interactivity [15] offered by transcoded pages.

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