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To cite this article: Evelina Patsoule & Panayiotis Koutsabasis (2014) Redesigning websites for older adults: a case study, Behaviour & Information Technology, 33:6, 561-573, DOI: 10.1080/0144929X.2013.810777

To link to this article: <https://doi.org/10.1080/0144929X.2013.810777>



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Accepted author version posted online: 03 Jun 2013.
Published online: 06 Aug 2013.



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Redesigning websites for older adults: a case study

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(Received 19 September 2012; final version received 27 May 2013)

Website redesign is a complex task that requires the organised use of design methods and guidelines as well as meaningful assessments. An important reason for website redesign is to enhance the usability and accessibility for ‘non-traditional’ user groups like the older population. The paper presents a case study of the redesign of a touristic web portal in order for it to be senior-friendly. The redesign process involved: (a) identification of a set of 7 principles and 45 guidelines (7p/45g) for web design for older adults; (b) heuristic evaluation of the original website on the basis of the identified 7p/45g set; (c) redesign of the website in an interactive online prototype; and (d) comparative summative usability evaluation, which involved 12 older users and post hoc interviews and questionnaires. The results showed that the redesigned website was significantly more usable and acceptable than the original. This study makes two contributions in the field: first, it outlines a web redesign process for older adults, which is effective in terms of time and cost, making use of various assessments of experts and users; second, it presents the application of this process in a manner that can be adopted and repeated in other redesign cases.

Keywords: web redesign; older adults; principles; guidelines; online prototyping; comparative evaluation

1. Introduction

It is widely acknowledged that websites have to be usable and accessible for the widest set of users, including older adults. The ageing of population worldwide is increasing and will continue to do so for the next decades: according to the United Nations (Enhancing the voice of older persons: <http://www.un.org/en/development/desa/news/social/older-persons.html>), by 2025, there will be around 1.2 billion persons aged 60 years and over, and this will reach to approximately 2 billion by 2050. Consequently, an increasing number of senior citizens use the Web to enhance their independent participation in society, while it has been reported that older adults now make up the fastest growing consumer segment of Internet users (The demographics of aging: <http://transgenerational.org/aging/demographics.htm>). Besides the social benefits of web design for seniors, the older population presents a sizeable market segment for the IT industry. Thus, the study of computer use by older adults has received increasing attention in various scientific areas like Human–Computer Interaction, Gerontology, Healthcare, Business, and Psychology (Wagner *et al.* 2010).

The issue of how web technologies can effectively incorporate the requirements of older adults is an important concern of designers for some time now. Related work has developed in various dimensions: many studies of older adults’ use of the web have identified respective

requirements and obstacles in use (e.g. Becker 2004, Priest *et al.* 2007, Sayago and Blat 2009); a number of design and development guidelines have been proposed (Kurniawan and Zaphiris 2005, Morrell 2005) to enhance the usability and accessibility of the Web for older adults; several websites have been evaluated on the basis of guidelines (Chisnell and Redish 2005, Hart *et al.* 2008, Zaphiris *et al.* 2009); and last but not least a number of websites have been developed and evaluated for/with older adults’ participation (Chadwick-Dias *et al.* 2003, Newell *et al.* 2006, Given *et al.* 2007, Subasi *et al.* 2011).

The redesign of websites for older adults stands in between all these works: it is a process that starts with the evaluation of the existing website and builds on the evaluation results to propose a new version that needs to be comparatively evaluated before technical implementation. Web redesign is a complex task with challenges related to addressing the new requirements and re-thinking current user interactions and interfaces (Goto and Cotler 2004); it requires fast delivery times and low cost and programming effort and rests on user acceptance of the redesigned version. Relevant literature is focused on approaches related to either guideline generation/validation or website evaluation/development, but does not present integrated case studies of web redesign for older adults.

In this paper, we present a case study of the redesign of a **touristic web portal that presents holiday destinations**

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and supports online hotel booking. The redesign process is holistic, in the sense that it incorporates all main aspects of a web redesign project, including (a) the identification of a set of 7 principles and 45 guidelines (7p/45g) for web design for older adults; (b) the heuristic evaluation of the target website on the basis of the identified 7p/45g set; (c) the redesign of the website in an interactive online prototype; and (d) the comparative summative usability evaluation, which involved 12 older users and post hoc interviews and questionnaires. The results showed that the redesigned website was significantly more usable than the existing one, and the whole redesign process (excluding the first step of guideline generation) lasted for a short time of about three weeks. We envisage that this work can provide a useful case for web designers about how to incorporate the requirements of older adults into the web development life cycle.

2. Related work

2.1. Web design for older adults: relevant guidelines

The ‘Seven Principles of Universal Design’ from the Center for Universal Design at NC State University (1997) are relevant to web design for older adults since they are generic and can be adapted to any environment, product or service. Wobbrock *et al.* (2011, p. 9:5) remark that the universal design principles ‘were mainly concerned with physical spaces and physical tools, although they are applicable to many areas of design’. It is indicative that these principles have been considered for developing inclusive practices in a range of domains including web services like e-learning (Seale 2004) and e-voting (Yee 2007), vehicular technology (Vrkljan and Miller-Polgar 2005), and ambient assisted living environments (Jiménez-Mixco *et al.* 2009).

Web Content Accessibility Guidelines have been developed by Web Accessibility Initiative (W3C/WAI) and constitute the basis of web accessibility policy worldwide. A considerable part of the second edition’s guidelines, WCAG 2.0 (2008), specifically addresses constraints that senior users face incorporating the results of the WAI-AGE project (Ageing Education and Harmonisation: <http://www.w3.org/WAI/WAI-AGE>). WCAG 2.0 includes four principles ((1) Perceivable, (2) Operable, (3) Understandable, and (4) Robust) and a total of 12 guidelines. The specification has a highly technical orientation and requires good knowledge of web technologies for its comprehension and application (Koutsabasis *et al.* 2010), while a good portion of the proposed guidelines can be technically validated (Vigo and Bajnik 2011). Web accessibility guidelines are being employed at the late stages of website development and tend to reveal complementary design and implementation issues to those emerging from usability studies. This counts for other well-established sets of web accessibility guidelines like those proposed by the WebAIM project (<http://webaim.org>). For example, in the study of Petrie and Kheir (2007), the accessibility and usability of two websites

with six disabled (blind) and six non-disabled (sighted) people were investigated and problems encountered by the two groups comprised two intersecting sets, with approximately 15% overlap. The consideration of web accessibility issues for designing for older adults is required but does not suffice since ‘it is important to consider that there are users who are not primarily confronted with problems caused by limited technical accessibility, but with problems which are a result of different reasoning strategies, different perception models or different experiences’ (Subasi *et al.* 2011, p. 391). Similar results are reported in Hart *et al.* (2008, p. 191) who suggest that it is important ‘to use both guidelines and usability testing when designing websites for older adults’.

In addition to accessibility, it is important to consider usability issues when redesigning for older adults. The ‘Research-Based Web Design and Usability Guidelines’ have been assembled by the Department of Health and Human Services (HHS 2006) in the USA, in order to provide practical, yet authoritative guidance on a broad range of web design and communication issues. This set comprises a total of 18 principles and 209 guidelines, and each guideline has been evaluated according to the criteria of ‘relative importance’, that is, the opinions of 16 experts (web designers and usability professionals) and ‘strength of evidence’, that is, respective documentation in scientific literature. According to Petrie and Bevan (2009) ‘while no set of guidelines can be totally comprehensive, the HHS guidelines appear to be more complete and easier to use than the equivalent ISO standard 9241-151’. Therefore, even though this is an essential reference for any website redesign project, it does not specialise in aspects of designing for seniors.

Kurniawan and Zaphiris (2005) have developed a set of 38 design guidelines under 11 category headings suitable for web applications targeting older adults. The guideline development process was research based, including (a) extensive review of the HCI and ageing literature, (b) employment of classification methods (card sorting and affinity diagrams), and (c) evaluation of the guidelines by a group of older web users in two websites. This set of guidelines has significantly contributed to the raising of awareness of web designers about older people’s use of the web. One issue identified is that not all guidelines scale up to established design and usability principles, due to the fact that the ‘category headings’ emerged from the card sorting method employed. For example, heading 2 refers to ‘use of graphics’ and heading 4 to ‘browser window features’; these categories are not really connected to established design and usability principles and this can be an important issue for a web redesign process: designers are better inclined to use well-established usability and design principles that are provided to them with guideline interpretations concerning their redesign goals. A similar issue exists for the set of check list items proposed by the National Institute of Aging and the National Library of Medicine (Morrell 2005). Thus, in our approach we have chosen to identify a small set of

important usability principles first and then to interpret them according to guidelines for older adults found in literature review.

2.2. *Application of guidelines: evaluation and/or design of web applications for older adults*

There are many studies presenting evaluation of websites for older adults; earlier studies involved usability testing with representative user groups (Chadwick-Dias *et al.* 2003, Becker 2004), while more recent studies also include the conformance with relevant guidelines (Hart *et al.* 2008, Zaphiris *et al.* 2009).

More specifically, Chadwick-Dias *et al.* (2003) have conducted two usability studies to investigate how redesigns can improve performance of senior citizens. Results indicated that senior users (55 years or older) had significantly more difficulties than younger users, while in redesigned versions their performance was significantly improved. Becker (2004) presents the usability evaluation of 125 websites offering health resources based on the National Institute on Aging Web guidelines; results showed that many of the sampled sites were not senior-friendly.

Hart *et al.* (2008) present two evaluation studies of websites for older adults. In the first study, 40 websites designed for older adults were heuristically evaluated based on their adherence to usability guidelines derived by the National Institute on Aging and the National Library of Medicine. In the second study, three websites with varying levels of guideline compliance were evaluated by older adults in a usability test. Results from these studies indicated that the website most compliant with the 'senior-friendly' guidelines resulted in higher task success, but did not result in significantly better efficiency, satisfaction, or preference. These findings demonstrate the importance of using both guidelines and usability testing when designing websites for older adults; this is also the approach taken under consideration in our work. In addition, Zaphiris *et al.* (2009) report on an evaluation of a set of age-centred web design guidelines with 24 older web users. As a result of the experiment, 36 out of the original 37 guidelines were accepted, 1 guideline was disagreed with, and 5 new issues that were not covered by the guidelines were identified.

Another branch of related work is about the design of new web services for older adults. Morrell (2005) presents the NIH (National Institutes of Health) Senior Health Project by the initial development of research-based guidelines on how to make websites accessible to older adults and then the implementation of the guidelines in the construction of a website for older adults to locate health information. Newell *et al.* (2006) present the design and development of prototype email, web search, and navigation systems for users over 60 years old who were inexperienced in using computers and had never used the Internet. The project was carried out by a mixed team involving industry and academia and involved specific

challenges of designing for and working with older people. Given *et al.* (2007) present an image-based retrieval interface for drug information, focusing on usability for seniors, on the basis of qualitative, task-based interviews that examined participants' health information behaviours and documented search strategies.

These studies refer to the issues of either website evaluation or design and development for/with user adults. However, few of these works demonstrate some interleaving of evaluation and design that is required in a case of redesigning an existing website.

2.3. *Scope of our work*

A web redesign process incorporates all aspects of related work outlined above: it has to consider respective guidelines, to evaluate the target website against the requirements of older adults, to meaningfully incorporate the results of the evaluation into a new design that has to be comparatively evaluated and accepted; and all these at a minimum time and effort. In practice, the effectiveness of the redesign process is an issue that holds off web owners from taking the decision to redesign, even when problems may have been met in everyday experience. There are practical questions in the redesign process: Which method(s) are most appropriate to evaluate the existing website? How to translate the problems identified to design directions and solutions? To what extent should the design/development of the new version be before proceeding to implementation? How to evaluate the redesigned version?

The paper presents a case study of a redesign process that makes an organised and careful use of user-centred design and evaluation methods and can be taken up by other practitioners. The redesign process followed involved (Figure 1):

- identification of a set of 7p/45g for web design for older adults, based on an extensive literature review;
- heuristic evaluation of the original website on the basis of the identified 7p/45g set with the participation of three experts on web usability and accessibility;
- redesign of the website in an interactive online prototype on the basis of identified problems of the original site;
- comparative usability evaluation, with the participation of 12 older users that included both controlled usability testing (summative) and formative assessment with post hoc interviews and questionnaires.

3. *The redesign process and outcomes*

3.1. *Target website*

The target website is a touristic and geographical guide of Greece; a thematic portal presenting holiday destinations and supporting online hotel booking. The website is one

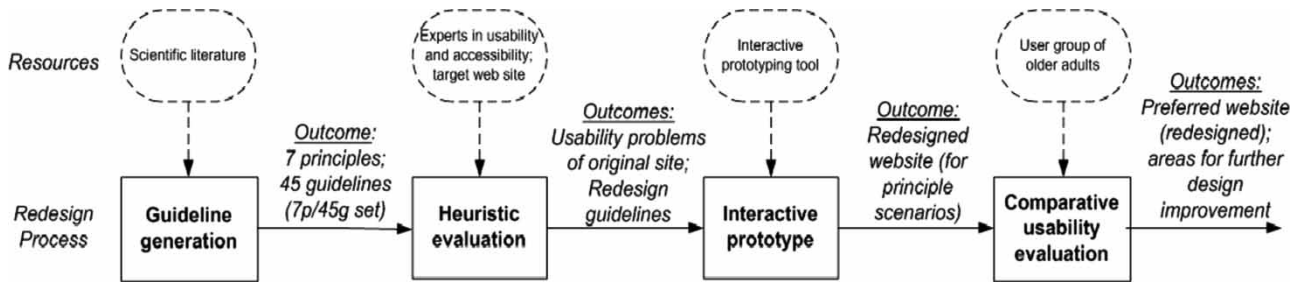


Figure 1. Web redesign for older adults: process, resources, and outcomes.

of the most popular in its kind in Greece, and it is targeted primarily to Greek users including destinations for both summer and winter holidays. Older adults are one of the primary user groups of this online service; however, the design of the website did not take into account related requirements and guidelines at the first place and the owners became aware of usability issues in this respect gradually, from everyday experience. The website has not been substantially redesigned since its launch in 2005 and the owners were keen to investigate the feasibility of the requested change through a redesign study.

3.2. Identification of a set of design principles and guidelines

Our literature review revealed that several sets of principles and guidelines for older adults complement each other. In addition, a considerable number of more general web design principles and guidelines are not directly relevant to older adults. Moreover, previous work on such sets does not specialise in redesign processes but instead focuses on corrective approaches. For those reasons, we developed a list of heuristic principles directly related to older adults' requirements to be employed in website redesign processes. Careful selection, abstraction, differentiation, and integration were made from related work: the proposed principles and guidelines were grouped according to similar semantic topics and overlaps were removed. The set of 7p/45g is outlined in Table 1 (including references to background work).

3.3. Heuristic evaluation of the target website

3.3.1. Process and participants

The target website was evaluated with a heuristic evaluation (Nielsen 1993) that made use of the 7p/45g set. The heuristic evaluation was followed for various reasons. First, it is a well-known, effective, and rapid usability evaluation method. Furthermore, the evaluators can assess the heuristics focusing on specific issues that older adults face on the basis of previous sets of guidelines and other related work. In addition, in heuristic evaluation experts are encouraged to make a holistic account of problems found (they work on the basis of specific tasks partly to avoid free-form exploration) in contrast to usability testing that emphasises task

performance. We also considered that the existing version of the website would have yielded a very large number of problems to older adults if a usability test was conducted that might have been hard to manage.

Three evaluators participated in the heuristic evaluation. They were all researchers with at least 10 years of experience in design and usability evaluation of websites and usability (i.e. 'double experts' according to Nielsen 1993). Each of the evaluators was provided with an evaluation report which included the goal of the research and six specific tasks to be carried out in that website. They were also provided with the 7p/45g set with corresponding examples for each guideline together with a relevant form, which had to be completed by them. The results were collected in a five-day period.

The main purpose of heuristic evaluation was to identify the usability problems of the target website and suggest redesign solutions. However, heuristic evaluation was also used to confirm that the 7p/45g set is well organised, useful, and relevant for designers to use.

3.3.2. Initial validation of the 7p/45g set

To verify the relevance of the set, an adaptation of the approach suggested by Zaharias and Koutsabasis (2011) was taken into account. According to this, the 7p/45g were matched with the usability problems detected by the evaluators using the criteria of coverage, distribution, and redundancy. With regard to the first criterion, the seven principles exhibited high coverage, incorporating 50 out of 52 (96%) of the usability problems identified (notably, the 2 problems not matched with the principles were minor problems). This implies that the set is highly robust without omitting important usability issues. With regard to distribution, all principles attracted usability problems, with visibility (23%) and efficient design (21%) attracting most problems. With regard to redundancy, 4 out of 52 (8%) usability problems were reported in more than one principle, which reveals that it was particularly straightforward to match usability problems to a single principle alone. Thus, the heuristic evaluation confirmed the usefulness of the 7p/45g set and led to useful conclusions on redesigning the website evaluated. The set was slightly reformed especially with respect to the guidelines and constituted the guide for website's redesign.

Table 1. Set of principles and guidelines for the redesign of websites for older adults.

Principles/guidelines	Suggested/implied by representative literature
<i>P1 Visibility:</i> All interactive elements, information, user choices, and feedback should be clearly visible throughout the website whenever required	Nielsen (1993)
<i>G 1.1:</i> All the elements of the website should have suitable default size	14th heuristic (Chisnell and Redish 2005)
<i>G 1.2:</i> There should be appropriate form of feedback with clear indication of any change that may happen	'Observability' and 'responsiveness' (Dix <i>et al.</i> 2004), 'efficient to use' (Nielsen 1995), third guideline (Kurniawan and Zaphiris 2005)
<i>G 1.3:</i> The most important content of the website should be visible and directly presented, where possible	Fourth heuristic (Chisnell and Redish 2005), Eighth section (HHS 2006)
<i>G 1.4:</i> The colours, textures, and graphics should be properly chosen	'Perceived information' (WAI-AGE), third section (HHS 2006)
<i>G 1.5:</i> There should be blank space, properly sited between the elements of the website	'Size and space for approach and use' (The Center for Universal Design)
<i>G 1.6:</i> The text content should be easily readable	16th section (HHS 2006), 13th heuristic (Chisnell and Redish 2005)
<i>G 1.7:</i> All interactive data should be visible	Third heuristic (Chisnell and Redish 2005)
<i>P2 Ease of understanding:</i> The presentation of information, content, and available user actions should be understandable and effective throughout the website, regardless user's experience, knowledge, reading ability, and level of concentration	'Simple and intuitive use' (The Center for Universal Design) (Nielsen 1995)
<i>G 2.1:</i> The content should be provided in a format that does not require great user experience and advanced reading literacy	10th and 20th heuristic (Chisnell and Redish 2005), 'understandable information' (WAI-AGE)
<i>G 2.2:</i> Each interactive element should be perceived and be understandable, without the need of documentation	Nielsen (1993)
<i>G 2.3:</i> There should be clear indication of the action that the user should do to interact effectively	'Robustness' (Dix <i>et al.</i> 2004)
<i>G 2.4:</i> There should be clear indication of whether a mandatory or an optional action is requested by the user	13th section (HHS 2006)
<i>G 2.5:</i> The content should be presented in the best possible way depending on the case as to achieve the desired objective	14th section (HHS 2006)
<i>G 2.6:</i> The content should be presented in a normal and conceptual form and sequence	Second heuristic (Nielsen 1993)
<i>P3 Control and flexibility:</i> The user must always exert control of the interaction and the website should offer the user a range of individual choices and alternative modes of action according to his/her preferences, expectations, and capabilities	'Flexibility in use' (The Center for Universal Design), 'flexibility and efficiency of use' and 'user control and freedom' (Nielsen 1993), 'flexibility' (Dix <i>et al.</i> 2004), (Nielsen 1995), sixth heuristic (Chisnell and Redish 2005), 11th guideline (Kurniawan and Zaphiris 2005)
<i>G 3.1:</i> There should be controlled navigation at all times	'Operable user interface and navigation' (WAI-AGE), seventh section (HHS 2006)
<i>G 3.2:</i> There should be controlled actions in dynamic content (e.g. sounds, videos, etc.)	Seventh guideline (Kurniawan and Zaphiris 2005), second section (HHS 2006)
<i>G 3.3:</i> The size of all elements of the website should be adjustable in accordance with user's requirements	'Flexibility' (Dix <i>et al.</i> 2004)
<i>G 3.4:</i> There should be an option to choose alternative ways of presenting non-text elements of the website	'Perceptible information' (The Center for Universal Design), 'provision of appropriate alternative text' principle (WebAIM), 'perceivable information and user interface', and 'operable user interface and navigation' (WAI-AGE), third section (HHS 2006)
<i>G 3.5:</i> There should be a possibility to correct or cancel any action	'Error prevention' (Nielsen 1993), 'understandable information and user interface' (WAI-AGE)
<i>G 3.6:</i> There should be an option to overcome any repeatable element or action	Seventh principle (WebAIM)
<i>G 3.7:</i> There should be a possibility to control the unexpected changes that may occur during the interaction	'Understandable information and user interface' (WAI-AGE)
<i>G 3.8:</i> There should be an option to select ways of searching content according to user preference	17th section (HHS 2006)
<i>P4 Static and dynamic help:</i> Assistance should be provided to users when asked or at any time required while interacting, throughout the website	Second section (HHS 2006)
<i>G 4.1:</i> Assistance should be provided during navigation	14th heuristic (Chisnell and Redish 2005)

(Continued)

Table 1. Continued

Principles/guidelines	Suggested/implied by representative literature
<i>G 4.2:</i> Assistance should be provided in the execution of an operation	Seventh heuristic (Nielsen 1993)
<i>G 4.3:</i> Assistance should be provided while performing an incorrect action	'Tolerance for error' (The Center for Universal Design), ninth heuristic (Nielsen 1993)
<i>G 4.4:</i> Assistance should be provided while searching	17th section (HHS 2006)
<i>G 4.5:</i> Assistance should be provided while completing forms	13th section (HHS 2006), third principle (WebAIM)
<i>G 4.6:</i> Major helping elements should be provided for inexperienced – with the web users	9th and 11th heuristics (Chisnell and Redish 2005), 11th guideline (Kurniawan and Zaphiris 2005)
<i>P5 Consistency of organising information:</i> All interactive elements should be functionally and visually consistent throughout the website. The layout, information, and content should be coherently organised throughout the website	Nielsen (1993), 'learnability' (Dix <i>et al.</i> 2004), 'understandable information and user interface' (WAI-AGE), 1st, 9th, and 13th heuristics (Chisnell and Redish 2005), 6th, 11th, and 16th sections (HHS 2006), 'organization of content in a standard format' (Morrell 2005)
<i>G 5.1:</i> All elements of the site should be consistently displayed	13th section (HHS 2006)
<i>G 5.2:</i> There should be a layout consistency	'Increasing the ease of navigation' (Morrell 2005), fifth guideline (Kurniawan and Zaphiris 2005)
<i>G 5.3:</i> The conceptual organisation of information should be consistent	6th and 15th section (HHS 2006)
<i>G 5.4:</i> There should be navigation consistency	'Understandable information and user interface' (WAI-AGE), 'increasing the ease of navigation' (Morrell 2005), third guideline (Kurniawan and Zaphiris 2005), seventh section (HHS 2006)
<i>G 5.5:</i> The actions required should be consistent	'Learnability' (Dix <i>et al.</i> 2004)
<i>G 5.6:</i> The design style and format should be consistent	Nielsen (1993), first heuristic (Chisnell and Redish 2005), 11th section (HHS 2006)
<i>G 5.7:</i> There should be terminology consistency	Usability heuristic (Nielsen 1993), fifth guideline (Kurniawan and Zaphiris 2005)
<i>P6 Efficient design:</i> The design of the website should be lean, predictable, functional, and attractive to the user creating a pleasant, friendly mood and inspiring confidence, both for the user's effective and satisfying interaction with the website	'Efficient to use' and 'pleasant to use' (Nielsen 1995), 'operable user interface and navigation' (WAI-AGE)
<i>G 6.1:</i> There should be wise selection of the components in the website. Any distraction should be avoided	6th and 11th section (HHS 2006)
<i>G 6.2:</i> Efficient ways to perform any action should be provided	11th heuristic (Chisnell and Redish 2005), 13th section (HHS 2006)
<i>G 6.3:</i> The content should be presented in a diffuse spirit of friendliness	19th heuristic (Chisnell and Redish 2005)
<i>G 6.4:</i> The design should be predictable with regard to the way of performing actions	'Predictability' (Dix <i>et al.</i> 2004)
<i>G 6.5:</i> Any surprises in the design should be avoided	5th section (HHS 2006)
<i>G 6.6:</i> The design should inspire trust	5th section (HHS 2006)
<i>P7 Focused design:</i> The design should be effective, focusing on the object of the website, without presenting unnecessary information	19th heuristic (Chisnell and Redish 2005), 9th section (HHS 2006)
<i>G 7.1:</i> The purpose of each component that constitutes the website as well as the overall purpose of the website should be clear	First section (HHS 2006)
<i>G 7.2:</i> The function and content of each element should be clear	10th heuristic (Chisnell and Redish 2005)
<i>G 7.3:</i> Locating specific information should be easy	'Easy to learn' (Nielsen 1995), 18th heuristic (Chisnell and Redish 2005)
<i>G 7.4:</i> The presentation of the most important information for the success of the purpose of the website should be unequivocal	Sixth section (HHS 2006), fifth guideline (Kurniawan and Zaphiris 2005)
<i>G 7.5:</i> The information should be displayed in a hierarchical way of importance through the website	'Operable user interface and navigation' (WAI-AGE), sixth section (HHS 2006)

3.3.3. Usability problems found

The main goal of the heuristic evaluation was to identify the usability problems of the target website and suggest possible redesign solutions. The heuristic evaluation resulted in a list

of positive elements of the website as well as a sorted number of problems. The positive elements included (1) very rich content, (2) good use of language; (3) warm and welcoming website in terms of icons and colours used; and (4)

structured and detailed user review of rooms that helps users get a detailed overview according to their requirements.

With regard to the usability problems found, there were a total of 52, out of which 9 were considered severe and should be fixed immediately, 25 were major and should be given high priority, and 18 were minor usability problems that could be given low priority. The nine severe usability problems found were (1) overload of graphics and texts throughout the website; (2) visibility problems of important user information in various pages; (3) not satisfactory information organisation with regard to main user tasks; (4) not self-explanatory text for important hyperlinks and buttons; (5) not clear confirmation of booking reservation; (6) unnecessary steps/options in several pages of the booking process; (7) homepage's inability to serve the purpose of the website in terms of message and look; (8) too many steps for important user tasks; and (9) absence of quality and credibility presented by many graphic elements and low visibility of page updates.

3.4. Redesign guidelines and interactive prototype

During the redesign process, each usability problem found was paired with its respective guidelines and design ideas were generated to address it. Design ideas were written down and/or sketched in paper. Furthermore, web user interface design patterns (Zajicek 2004, Tidwell 2010) were sought that fit each idea generated. The main directions for the redesign of the target website can be outlined as follows:

- (1) Global navigation as tabbed browsing, to address issues of consistency of presentation and user orientation into the wealth of textual and visual content.
- (2) Elaborate options for search, to better help older users specify particular requirements for potential touristic destinations.
- (3) Simplify user input (at registration and booking pages) to allow users to enter required information as intuitively as possible.
- (4) Provide consistency for styles and typography to enhance user comprehension.
- (5) Fix some other important accessibility issues throughout the site such as minimise the need for scrolling, set visible default sizes for all content, minimise animations or add user controls, etc.

After an iterative process of writing down ideas and generating user interface and interaction elements, a rough version of the prototype was prepared. Then, the web prototyping tool Pidoco (<https://pidoco.com>) was used to construct a working prototype of the redesigned website (Figures 2 and 3). Pidoco allows fast construction of interactive (clickable) wireframes and HTML prototypes that can be used for user evaluation. For the purpose of the case

study, the redesign procedure focused on the pages considered essential for the users to perform typical tasks that would be later employed in the evaluation.

3.5. Comparative evaluation

In order to evaluate the redesign we conducted a comparative evaluation of the two websites. The evaluation methods used were controlled usability testing and post hoc interviews and questionnaires.

3.5.1. Participants and procedure

Twelve older adults were recruited for the evaluation (60–75, eight men and four women). All users were capable computer users in the sense that they could use the mouse and the web. From this end, their expertise varied: four of them were just familiar with desktop applications, another four could make good use of desktop applications and e-mail as well and only four of them had booked a hotel or ticket from a website before. Apart from the differences recorded in web experience, all 12 participants came from similar occupational and educational backgrounds and experience, since they all had (previously or currently) experience in information work.

The experiment followed a within-subjects design, comparing both websites with the same set of participants. The order in which participants were performing the tasks as well as the order in which the two versions of the website were presented to them was randomly selected. This counterbalance was intended to avoid 'carryover effects' that could potentially impact the performance from one task to another (Blandford *et al.* 2008). Each of the participants was provided with a set of instructions before the beginning of the experiment.

All users were asked to perform six tasks and to answer the same questionnaire at the end of each website interaction. The tasks were

- (1) locate the user guide for this website;
- (2) locate a particular hotel at a specific destination;
- (3) locate specific services and affordances concerning older users of that hotel;
- (4) locate all accessible hotels in a specific destination;
- (5) register to the website and apply for e-mail notifications about specific destinations;
- (6) apply for booking at a particular hotel at a specific destination.

During the experiment, each task was timed and recorded via the Snagit Editor. In parallel, notes were taken on the task success, the time of completion of each task, and other relevant comments in a metric diagram. After the completion of each task a short conversation between each participant and the researcher was carried out and recorded. Through this retrospective probing technique (Birns *et al.* 2002), the users externalised their thoughts and comments.

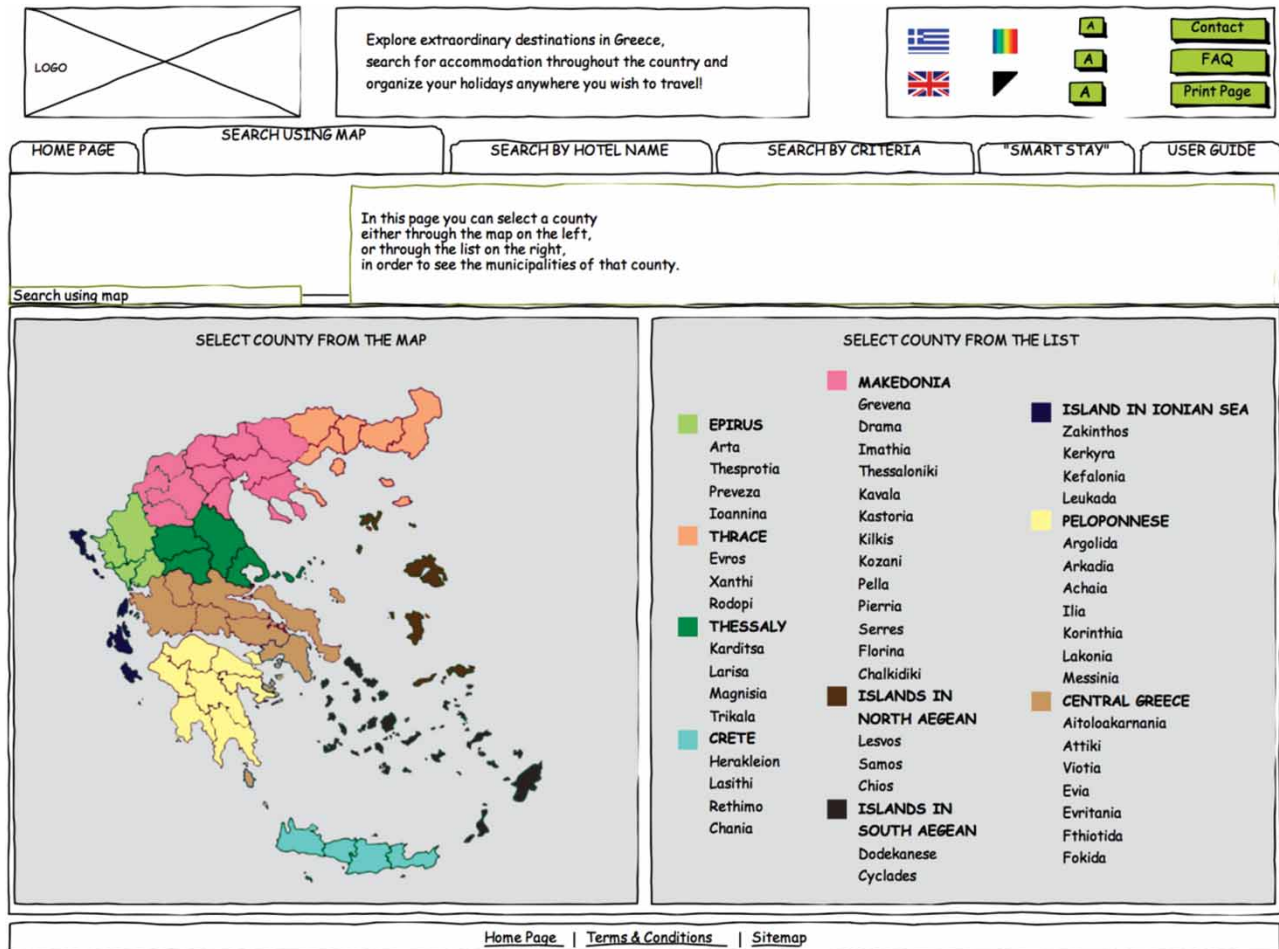


Figure 2. Aspect of the redesigned website in a wireframe showing global tabbed navigation.

After the completion of all six tasks with each website, a questionnaire was completed. The duration of the entire process (including user preparation, task performance for two websites, and post hoc questionnaires and short interviews) for each participant ranged from one to two hours, depending mainly on their level of experience and their personal pace of work. This variation in the duration of the testing process was not significant and was mainly caused due to the variation of computer experience capabilities among users; that meant it was necessary to provide more background information and assistance to users in some cases. However, to complete a multi-method test procedure within one to two hours is perfectly normal, and this was achieved since all users had some essential computer skills. The other elements of the metric diagram (the number and types of errors and the level of lostness) were completed by the researcher at the end of the experiment and after having processed the recorded interaction of each participant.

3.5.2. Usability metrics

The usability metrics (dependent variables) of the experiment were selected from the most typical in measuring the user experience (Tullis and Albert 2008):

- (1) Task success, as a binary metric: each user could either succeed or fail on each task.
- (2) Time on task: measured through timekeeping.
- (3) Errors: measured through video recording and observation. In order to determine what could constitute an error, four different types of errors were defined as follows: navigation error, selection error, insertion error, and interpretation error.
- (4) Efficiency: measured through the indicator 'lostness' (Smith 1996), that is, the extent to which a user may be lost while navigating in a website. Lostness is calculated by the formula:

$$L = \text{sqrt} \left[\left(\frac{N}{S} - 1 \right)^2 + \left(\frac{R}{N} - 1 \right)^2 \right],$$

where N is the number of pages visited while performing a task, S is the total number of pages visited while performing the task, counting revisits to the same page, and R is the minimum (optimum) number of pages that must be visited to accomplish the task.

Explore extraordinary destinations in Greece, search for accommodation throughout the country and organize your holidays anywhere you wish to travel!

HOME PAGE SEARCH USING MAP SEARCH BY HOTEL NAME SEARCH BY CRITERIA "SMART STAY" USER GUIDE

Search using map
Ioannina county
Ioannina county accommodation, Metsovo
"Katogi Averof" hotel
Booking request for "Katogi Averof"

In this page you can book a room at the hotel "Katogi Averof", which is located in Metsovo, Ioannina county, by filling in the information required in the form and selecting to send these information.

PERSONAL DATA AND CONTACT DETAILS

Mandatory fields:

Name:

Surname:

Address:

City:

Telephone:

E-mail:

Optional fields:

Country:

Postcode:

FAX:

Preferred way of communication:

ACCOMMODATION DETAILS

Mandatory fields:

Arrival date:

Departure date:

Number of nights:

Number of adults:

Number of kids:

Optional fields:

Type of room:

Additional information and comments:

SECURITY CODE

Mandatory field:

3 1 5 8 2 4

Fill in the numbers appearing in the image on the left

SUBMIT THE FORM TO SEND THE BOOKING REQUEST

Reset all data and fill in the form from the top:

RESET FORM

Home Page Terms & Conditions Sitemap

Figure 3. Aspect of the redesigned website in a wireframe showing the registration form.

A lostness value less than 0.4 is considered satisfactory, while a value greater than 0.5 indicates that users have experienced lostness.

3.5.3. Results

Overall, the results of the comparative evaluation strongly suggest that the redesigned website was considerably improved from the original version. More specifically, binary success for the redesigned version of the website was higher than that of the redesigned for all users and tasks

(Table 2). Furthermore, the amount of time spent on each task for all participants was measured separately (time on task). This was found considerably lower in the redesigned version of the website for all tasks. Figure 4 provides an overview of these results. For example, we see that users spent an average of 136 seconds to perform the first task at the original website and 37 seconds, respectively, at the redesigned website. For this metric, a *t*-test was also conducted, the results of which indicated that for the first three tasks, the difference between the two versions of the website was statistically significant ($p < .02$).

Table 2. Binary success for each task.

Mean	Task					
	1	2	3	4	5	6
Original version	11/12 (92%)	10/12 (83%)	10/12 (83%)	10/12 (83%)	8/12 (67%)	9/12 (75%)
Redesigned version	12/12 (100%)	12/12 (100%)	12/12 (100%)	10/12 (83%)	12/12 (100%)	11/12 (92%)

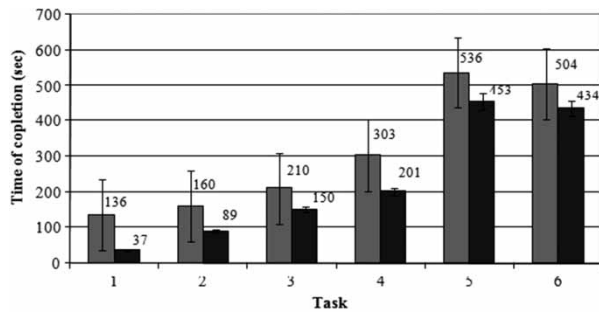


Figure 4. Comparative average time on task both in original and redesigned website.

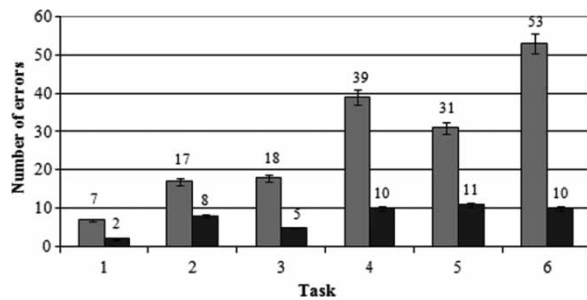


Figure 5. Comparative number of errors both in original and redesigned website.

In order to determine quantitatively the difficulty experienced by the participants during their interaction with both versions of the website, the number of errors was recorded. For all tasks, users performed more errors during their interaction with the original website. Figure 5 provides an overview of errors for both websites: for example, we can see that for the first task users made seven types of errors at the original website and two at the redesigned website. The error occurrences were also combined to task completion times (time to task) with scatter plots, which also revealed that users' performance was significantly improved in the redesigned website. Figures 6 and 7 show two scatter plots for task 4, where the spread of errors for time on task is much wider for the original website in comparison with the redesigned one. This was the general picture for all tasks, indicating that design errors severely affected user performance at the original website in comparison with the redesigned one.

In order to assess the overall efficiency of the interaction of users with both websites, we combined again the

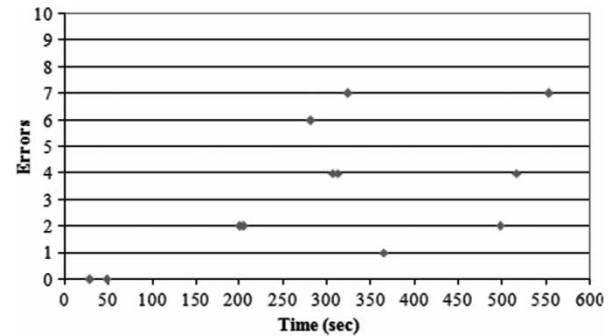


Figure 6. Scatter plot showing the errors carried out by users in relation to time spent for task 4 in the original website.

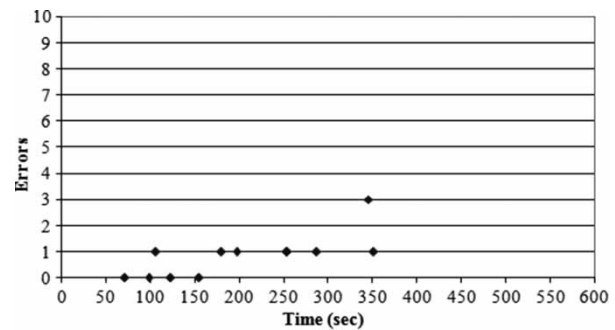


Figure 7. Scatter plot showing the errors carried out by users in relation to time spent for task 4 in the redesigned website.

time-on-task metric with the calculation of the lostness metric in scatter plot diagrams. This combination provides a descriptive indication of user disorientation during navigation (Figures 8 and 9). For the original version of the website, the lostness rate was increased and consequently that increased the time on task. In the redesigned version, the level of lostness remained lower despite the limited increase in time on task. This finding reveals that participants were disoriented at the original website, which was not the case for the redesigned version.

In addition to the above metrics, qualitative data were gathered both through the retrospective probing technique and the questionnaires that were completed by the participants. We designed a Likert scale questionnaire that included a total of 14 questions, each pair of which corresponded to 1 of the 7 principles for redesign (the list of questions is shown in Table 3). Likert scale questionnaires are most commonly used attitude/opinion scales; however,

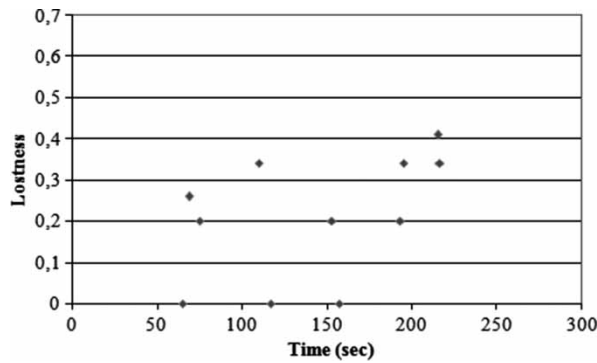


Figure 8. Scatter plot showing the lostness of users in relation to time for task 2 in the original website.

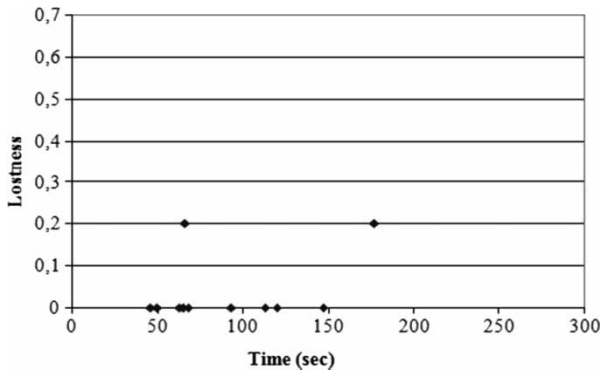


Figure 9. Scatter plot showing the lostness of users in relation to time for task 2 in the redesigned website.

Table 3. List of questions provided to participants.

- (1) All elements were clearly visible throughout the website
- (2) I could always receive feedback with clear indication of my actions and my location on the website
- (3) The information presented was understandable and effective throughout the website
- (4) I could perceive and understand the elements of the website without further documentation
- (5) I had control over my preferences while interacting with the website
- (6) I had control over my navigation while interacting with the website
- (7) I received help any time I required while interacting with the website
- (8) I received help to execute particular operations
- (9) There was functionally and visually consistency throughout the website
- (10) The conceptual organisation of information was consistent throughout the website
- (11) The website was not complicated
- (12) The overall feeling of the website was positive
- (13) The purpose of the website was clear
- (14) Most important information was displayed in a hierarchical order

there are different versions of this scale used in questionnaires (Adams and Cox 2008). We asked users to provide their responses with respect to each one of the two websites to allow for a comparative evaluation. Users filled in

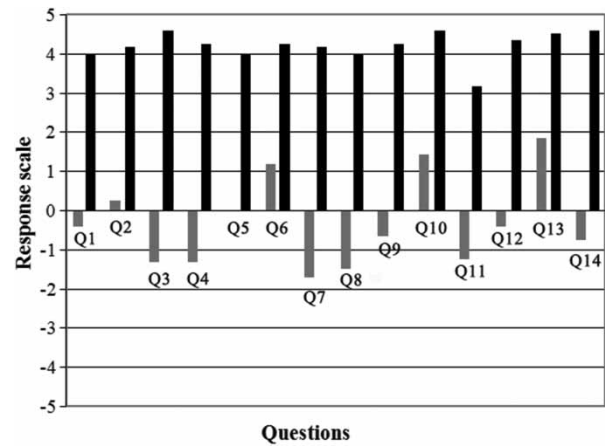


Figure 10. Average scale of responses on 14 questions both in original and redesigned website.

a two-sided 10-point scale ranging from -5 (Completely Disagree) to $+5$ (Completely Agree) for each question. The questionnaire survey was again supportive of the redesigned version of the website for all questions, as shown by the means of their responses in Figure 10.

In addition, the comparative evaluation made the participants realise that the difficulties they had to face when completing a task in any website were not due to their weaknesses or inabilities, but due to the way that the information in the website was presented to them.

4. Discussion and conclusions

The paper presented a case study of web redesign for older adults that spans from identification of a set of principles and guidelines to the comparative usability evaluation of the two websites (existing and redesigned) with the participation of older adults. The results showed that the redesigned website was considerably more usable and satisfactory than the existing one.

The paper contributes to the development of a practical approach to redesigning websites for older adults that comprises the following steps:

- (1) Identification and validation of a set of principles and guidelines for web design for older adults; the proposed set complements related work, it is validated via heuristic evaluation, and it can provide web designers with an additional resource that may be used to principally redesign websites for the older population.
- (2) Evaluation of the target website: this was achieved through heuristic evaluation on the basis of the 7p/45g set.
- (3) Iterative redesign and construction of interactive prototype; the design directions identified from the examination of usability problems found in pair with guidelines and principles; furthermore, design

ideas were created and matched to user interface and interaction patterns where possible. An online prototyping tool was employed to construct an interactive version.

- (4) Comparative usability evaluation has been performed by testing the usability of the two websites on the basis of important metrics: task success, time to task, errors and efficiency, as well as on qualitative user responses.

With respect to the practice of redesigning websites for older adults, we have seen that the whole process of evaluation and redesign of a website can be rather fast. Provided that the design team is familiar with the set of guidelines and that there is availability of experts and users (for heuristic evaluation and user testing, respectively), the whole process involving the heuristic evaluation, the construction of the working prototype, and the comparative evaluation can last for two to three (at the most) working weeks. This, of course, can vary depending on the usability problems identified and the required alterations. Thus, in this time-frame, the design team can reach to a user-centred and documented proposal for web redesign that will be ready for implementation.

An important aspect of the redesign approach followed was online prototyping, which offered several advantages including no technical development, direct transfer from paper mockups, and wireframes to an interactive version. The most important advantage of the online prototype was the affordance for comparative and summative usability testing. However, online prototyping has a few drawbacks since it still presents a portion of the final version and a limited one in terms of colours and some interactive elements, that is, those not supported by the online prototyping tool objects and stencils. Thus, a further usability test is still needed to fine-tune the final version of the website (after development).

We envisage that this work can inform the practice of inclusive web redesign by demonstrating the use of user-centred methods with the participation of older adults.

Acknowledgement

We would like to thank the anonymous reviewers for their useful comments that improved the quality of our work.

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