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Impact of accessibility barriers on the mood of blind, low-vision and sighted users

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Abstract

Two versions of a website, a non-accessible site (NA-website) and an accessible site (A-website), were tested by 13 participants who were: a) blind users, b) low-vision users and c) users without identified disabilities. The mood of the users and their interaction efficiency, effectiveness and satisfaction were recorded as they encountered several web content accessibility barriers. Results show which elements were the major causes of frustration to each user group, and how blind users displayed less criticism than expected to the barriers.

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Keywords: accessibility, blind users, low vision users, mood user, user test.

1. Introduction

Despite legal accessibility requirements, a significant number of websites currently still present many accessibility barriers and people with disabilities often have a hard time or no opportunity to use them. The World

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Report on Disability [29] estimates that between 15% and 19% of the population has some type of disability problem. This is a substantial consumer segment that should not be ignored.

Moreover, when many developers think of an accessible website, they think of a perceivable, operable system with easy access for people with a sensory, motor or cognitive disability. However, they forget the side benefits of accessibility and how this improves usability for every user. Taking this into account**,** web content usability [13] and accessibility [10] deserve special attention and collaboration in order to improve the quality of websites.

This article evaluates the mood of a group of users while they interact with two parallel websites (A-website, an accessible website, and NA-website, a non-accessible website). Both websites had similar content but opposite characteristics of accessibility (one being full of accessibility barriers, and the other being correct). The final objective of the evaluation is to collect experiential information from users with disabilities, and communicate this information empathically to non-technical web content authors, such as Web 2.0 users who do not usually have a great deal of knowledge about web accessibility [20]. The complete research is divided into four phases, each involving the same websites being evaluated by users with different disabilities: cognitive (phase 1), impaired sight (phase 2), motor (phase3) and impaired hearing (phase 4). This document shows the results of phase 2 involving users with visual impairments.

2. Related work

Disabled users interact with websites in different ways [27] and it is necessary to analyse their particular features in order to understand which access barriers have more impact in each case. Usually, web accessibility is gauged using the success criteria of the Web Content Accessibility Guidelines (hereinafter, WCAG) [4][6], published by the World Wide Web Consortium, and now accepted as ISO standard: ISO/IEC 40500:2012 [14]. Alternatively, accessibility is supposed to comply with reasonably equivalent regulations that are adopted by every country [2].

However, WCAG guidelines are primarily a legal instrument and compliance with them does not guarantee real website accessibility in all cases, as several authors have pointed out [7], [9] and [22]. For example, in the opinion of some authors [21], only 50.4% of problems encountered by blind users were covered by WCAG 2.0 success criteria. Consequently, although WCAG guidelines provide an important starting point, user testing is richer and more informative [11], [3].

Previous research has evaluated the frustration and errors made by users without disabilities [15] and blind users [16], [17] on websites and desktop applications. Other research derives the needs of users with disabilities from user tests results [21], [12] and [28]. However, there are few studies focusing on the analysis of mood while confronting barriers in web browsing.

An accessibility barrier is any condition that makes it difficult for people to achieve a goal while they are using the website with the use of specific assistive technology [1]. In contrast to barriers, good accessibility improves efficiency and the autonomous operation of users with cognitive disabilities [19], and of users with any kind of disability. Accessibility of content and user agents increases people's self-determination and autonomy, two key aspects in their welfare and quality of life [24], [26].

3. Study context

A-site[1] and NA-site[2] were developed and published in the Wordpress content management system. Both websites had parallel content and were organized into 4 pages related to tourist information: city, monuments,

[1] A-site: http://193.144.12.82/accesibilidad/wpB
[2] NA-site: http://193.144.12.82/accesibilidad/wpA

accommodation and contact. Several elements with known potential accessibility problems were deliberately included. The purpose was to analyse how a barrier could influence various user groups differently and how the users' ability, assisted technology and browser could help or hinder eventual access to the information.

The A-site was created following the methodology indicated [18] and the Wordpress environment was set up with maximum accessibility properties. Accessible templates (TwentyTenFive [3]) and (Accessible-five[4]) were used. The capabilities of the web editor were complemented with fully compliant HTML code as required and the CCPlayer[5] plug-in was included to improve video accessibility. The NA-site was created using the standard Wordpress configuration with a predefined template (Twenty Twelve) and no external plug-ins. The content was added directly using the web editor without further editing. Specific barriers were knowingly implemented on the NA-site: missing icons, too many links, too short timings, a text-only page and complex sites.

The level of accessibility of both websites was checked against WCAG guidelines using automatic evaluators (eXaminator[6] and TAW[7]) and manual review with the support of the WAT[8] IExplorer and Firefox Web Developer toolbar[9]. The result was that the NA-site showed many accessibility issues related to the template and the content added with the text editor, and it failed HTML and CSS validation. In contrast, the A-site did not display accessibility barriers. Table 1 details the content of each site and the WCAG 2.0 accessibility problems found on the NA-site.

3.1. Participants

Thirteen participants took part in the research from March to May 2013. There were five blind users, four low-vision users and four users without identified disabilities. The average age of all participants was 40 years old, and ages ranged between 20 and 70. Two blind participants had no residual vision and three had only light/dark perception. One of the low-vision users had wavy vision, blind spots, blurriness, impaired colour vision and difficulty adapting to dim light. Another vision-impaired participant had a very little central vision and the other two had blurriness and need to look at objects very closely. Two of the users without disabilities had myopia and wore glasses (that did not affect the interaction), and the other two had no vision impairment. All of the blind participants went blind as adults, while the low-vision participants had suffered a gradual loss of vision since birth. All of the blind and low-vision participants are members of the National Organization of Spanish Blind People (Organización Nacional de Ciegos Españoles - ONCE)[10].

All of the blind participants used JAWS[11] screen reader, but they did not know how to use all of the software's features. Participants with low vision used features of the operating system to enlarge text and web content. Most of the participants (10 of 13) had been using the Internet for five years or more. Internet Explorer was the most popular browser used by blind participants. Firefox was the most popular browser used by low-vision participants. Firefox and Google Chrome were the most popular browsers used by users without disabilities. Table 2 gives a more detailed description.

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[3] TwentyTenFive: http://www.twentytenfive.com/
[4] AccessibleFive: http://accessible.sprungmarker.de/2011/04/accessible-five/
[5] CCPlayer: Closed Caption Subtitle Player http://www.ccplayer.com/
[6] Examinator: http://examinator.ws/
[7] Test de accesibilidad Web (TAW) http://www.tawdis.net/
[8] WAT de IExplorer: http://www.paciellogroup.com
[9] Firefox Web Developer: http://chrispederick.com/work/web-developer/
[10] ONCE (Organización Nacional de Ciegos Españoles): http://www.once.es/
[11] JAWS, Freedom Scientific Inc.; see http://www.freedomscientific.com/

Table 1. List of web elements and code of WCAG 2.0 success criteria with errors

Pages	NA-site	A-site
All pages	No web map (2.4.5) Page without titles (2.4.2) Skip links not implemented (2.4.1) No page headings (1.3.1, 2.4.10) Insufficient visual contrast: menu and links (1.4.3, 1.4.6) No visible focus (2.4.7, 2.1.2) Relative units (1.4.4 and 1.4.8) No line spacing (1.4.8) Font text: 'Times New Roman', grey 10px (difficult to read) Source HTML not validated (4.1.1, 4.1.2) Keyboard non-operable (2.1.1, 2.1.2)	Web map Pages with appropriate titles Skip links implemented Page headings Sufficient visual contrast Visible focus Zoom to page appropriate Paragraph spacing appropriate Correct spacing Font text: 'Georgia'.1.1em Source HTML and CSS validate Access to functionality with Keyboard
The city	Complex graphs (1.1.1, 1.2.1, 1.2.9, 1.3.1, 2.4.10) Images (1.1.1, 1.2.1, 1.2.9, 4.1.1) Complex text (3.1.5) Abbreviations (3.1.4) Complex data tables, no summary and no structural relationships (1.3.1, 1.3.2) Lists without bullets (1.3.1) Video player non-accessible (2.1.2) Video without subtitles and audio description (1.2.1, 1.2.2, 1.2.3, 1.2.5)	Simple graphs Images with alt text Simple text Meaning of abbreviations Simple data tables List with bullet points Accessible Video player (CCPlayer) Video with subtitles and audio description
Monuments	Generics links (2.4.4, 2.4.9) Images (1.1.1, 1.2.1, 1.2.9, 4.1.1) Table layout (1.3.2, 1.3.1)	Informative text on links Images with alt text Layout without tables
Accommodation	Complex text (3.1.5) Abbreviations (3.1.4) Images without contrast (1.4.3, 1.4.6) Images without alt text (1.1.1)	Simple test Meaning of abbreviations Images with contrast Images with alt text
Contact	Form controls (1.3.1, 4.1.2, 2.4.6) Form with information (3.3.1, 3.3.2) Image of button without contrast (1.1.1, 1.2.1, 1.2.9, 1.3.1, 1.3.2, 1.4.1, 1.4.4, 1.4.5, 2.4.7, 1.4.8 and 1.4.9) Order focus (2.4.3) Required form labels with colour (1.4.1)	Form controls identified Image of button with contrast Focus without order Required form labels with text elements

Table 2. User characteristics in the case studies. AD: advanced; IM: intermediate; M: men; W: women; IEx: Microsoft Internet Explorer (6, 7 or 8); FX: Mozilla Firefox; CH: Google Chrome; SF: Apple Safari

Users	Experience	Sex	Age	Diagnosis	Schooling	Browser	Experience with the Computer
Blind users	AD	M	41 - 50	Pigmentary Retinitis	University degree	IE6, IE9	Longer than 5 years.
	AD	W	61 - 70	Glaucoma	University degree	IE9, FX	Longer than 5 years.
	IM	W	41 - 50	Pigmentary Retinitis	Elementary school	IE8	Longer than 5 years.
	IM	W	51- 60	Pigmentary Retinitis	High school	IE8	Longer than 1 and less than 5 years
	IM	M	51 - 60	Pigmentary Retinitis	University degree	IE7	Longer than 1 and less than 5 years
Low-vision users	IM	M	51 - 60	Glaucoma	Elementary school	FX	Longer than 1 and less than 5 years
	AD	W	20 - 30	Pigmentary Retinitis	High school	IE8, FX, CH	Longer than 5 years.
	IM	W	20 - 30	Pigmentary Retinitis	Elementary school	FX	Longer than 5 years.

	AD	M	51 - 60	Stargardt disease	High school	IE7, FX	Longer than 5 years.
Sighted users	AD	W	20 - 30	No disabilities	Doctorate	FX, CH	Longer than 5 years.
	AD	M	31 - 40	Myopia but wears glasses	University degree	FX	Longer than 5 years.
	IM	W	31 - 40	Myopia but wears glasses	University degree	FX, CH, SF	Longer than 5 years.
	IM	M	31 - 40	No disabilities	High school	FX	Longer than 5 years.

3.2. Equipment and software

The evaluations were performed on a personal computer running the Windows 7 Operating System (Service Pack 3). It was equipped with speakers, standard keyboard and 2-button mouse with scroll wheel. It was also equipped with version 14.0 of the JAWS screen reader. Participants could choose between the web browsers Internet Explorer 9.0 or Firefox 7.0.1. Morae 3.1[12] was used to record the participants with a 'talking aloud' protocol, their facial expressions and the computer desktop.

Before the start of each test, every participant was asked to customize the computer set-up in order to adapt the test environment to their needs as adequately as possible. Special attention was paid to the keyboard for blind users and only one user (who regularly uses a laptop keyboard) added stickers to the standard keyboard on the main JAWS keys ('insert' and 'tab'). No user changed the set-up of the screen reader speed. Special attention was paid to the screen position with low vision users, who moved the screens a little closer to their faces. One low-vision participant used the operating system magnifier, while the other three only configured the browser text size. Only one user with low vision set up a black and white screen. Sighted users did not require any additional configuration.

3.3. Methodology

For this study, we followed the methodology proposed by Rubin [24]. The test was carried out in the laboratory UsabiliLAB[13] (GRIHO research group's usability laboratory) and consisted of a set of tasks selected according to the user profile (see Table 3). The users with low vision only performed 8 out of a total of 10 tasks. Tasks T9 and T10 were not performed in order to reduce the total test time and also because similar barriers were included in the other tasks. Users with low vision and sighted users did not do T5 task as it was not relevant to them. Websites were shown in an alternating order to users in order to minimize bias caused by fatigue or repetition.

Table 3. List of tasks evaluated according to the profile of each participant.

Task	Description	Web page	Blind	Low vision	Without disabilities
T0	Accessing the 'City' page	Home	x	x	x
T1	Looking up an autonomous community	The City	x	x	x
T2	Accessing links for more information	The City	x	x	x
T3	Looking up a graph	The City	x	x	x
T4	Looking up data in a data table	The City	x	x	x
T5	Looking up a text in another language	The City	x		
T6	Looking up a map	The City	x	x	x
T7	Playing a video file	The City	x	x	x
T8	Sending a form	Contact	x	x	x
T9	Looking up the street address of a monument	Monuments		x	x
T10	Booking a room	Accommodation		x	x

[12] Software Morae. http://www.techsmith.com/morae.asp
[13] GRIHO research group's usability laboratory: http://www.griho.udl.cat/about/Usabililab.html

The efficiency, effectiveness and satisfaction were measured as in classic usability tests. Satisfaction was measured against a custom-made questionnaire with Likert scale questions about how easy the tasks were. During the user test we considered the emocional aspects together with efficiency and effectiveness.

Before starting the test, participants were asked to answer a pre-test questionnaire to obtain their user profile. After every task participants were asked to describe their emotional state with emoticards [8] as it was before, during and after the task. The average duration of the tests was two hours in the case of blind users, one and a half hours in the case of users with low vision, and only forty-five minutes for sighted users.

4. Results

Before the test, participants were asked to report their mood on previous experiences interacting with either accessible or non-accessible websites. Figure 1 shows that all participants reported a negative mood when they visited a websites with accessibility problems (Figure 1 a), and a more positive mood when they interacted with websites without accessibility problems (Figure 1 b).

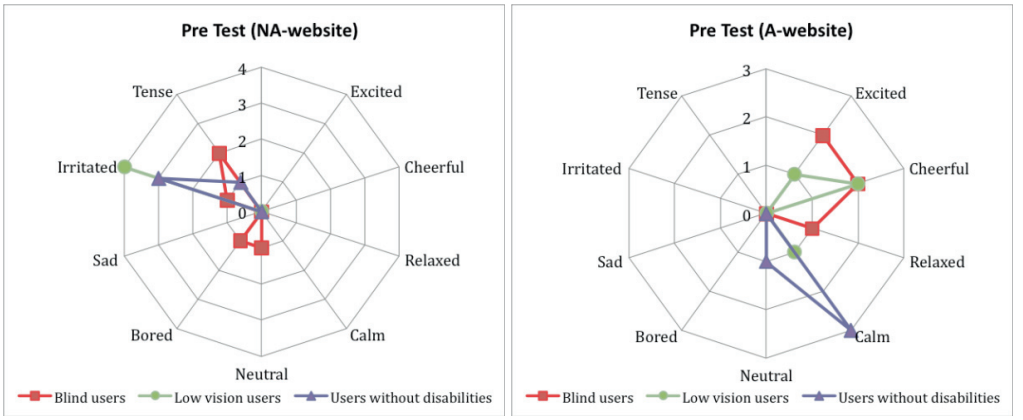

Fig. 1.Emotional evaluation in pre-test questionnaire (a) NA-website; (b) A-website

4.1. Efficiency

Efficiency was measured by determining how quickly users were able to complete tasks. Table 4 shows the average duration measured in minutes that each group of participants needed to perform each task. This time should be considered with caution as a 'thinking aloud' protocol was used during the test. Nevertheless, it provides enough information for comparison between the two websites.

As can be seen in Table 4, in the case of low-vision users, the time required to perform a task reduced by 56.87% when interacting with A-website. Meanwhile, the time required by blind users fell by 10.46%, while sighted users need 5.82% less time. The difference between groups was also evident and the time spent by sighted users on the A-website was 76.31% shorter than the time spent by blind users.

Table 4. Average task duration (in minutes).

	Participants\Task	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Total
NA-site	Blind users	2.65	2.25	3.43	0.62	2.53	1.27	0.63	1.14	6.08	-	-	20.60
	Low vision users	0.31	1.81	1.29	1.57	2.45	-	2.61	0.79	2.58	3.32	2.63	19.36
	Users without disabilities	0.08	0.25	0.83	0.25	0.21	-	0.48	0.17	0.88	0.3	1.19	4.64
A-site	Blind users	1.12	1	1.28	1.15	2.14	0.55	1.29	5.67	4.25	-	-	18.45

Low vision users	0.3	0.96	0.43	0.75	0.6	-	1.3	1.04	1.17	0.72	1.08	8.35
Users without disabilities	0.08	0.24	0.31	0.3	0.16	-	1.02	0.23	1.03	0.37	0.63	4.37

4.2. Effectiveness

Effectiveness is a way of gaining a better understanding of how successfully users will use a website. Table 5 shows the percentage of users with tasks completed. As expected, better results are observed on the A-website than on the NA-website.

All participants without disabilities were able to execute all of the tasks completely on the A-website, while blind users had difficulties to accomplish tasks T3, T4 and T6 on the NA-website, as these tasks contained visual elements (graph, tables and map). The same tasks did not present serious problems on the A-website. Tasks T7 (playing a video) and T8 (sending a form) were difficult for blind users on both websites, due to the interactive elements. Users with low vision had a hard time with tasks T4 (data tables) and T6 (text in a different language) on the NA-website. These users can only visualize a part of screen and they could not see data adequately when zooming out. Task T9 (monument address) and T10 (booking a room) showed the worst efficiency on the NA-website for users with low vision. Sighted users had minor difficulties to complete task T2, (accessing links) on the NA-site.

Table 5. Percentage of users to complete tasks

	Participants\Task	**T0**	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**
NA-site	Blind users	100%	90%	40%	0	20%	50%	0	50%	30%	-	-
	Low vision users	100%	67%	67%	67%	0	-	0	100%	50%	17%	33%
	Users without disabilities	100%	100%	83%	100%	100%	-	100%	100%	100%	100%	100%
A-site	Blind users	100%	100%	100%	88%	88%	100%	75%	50%	38%	-	-
	Low vision users	100%	100%	100%	67%	100%	-	33%	100%	100%	100%	100%
	Users without disabilities	100%	100%	100%	100%	100%	-	100%	100%	100%	100%	100%

4.2.1. Satisfaction

Results on the questions about satisfaction given to participants at the end of every task are displayed in Table 6. They have been grouped according to the different user profiles. As expected, there is a clear correlation between the results in Table 5 and Table 6.

The results of the post-task mood questionnaire are shown in Figures 2a and 2b. As users could not make comparisons between the two test websites before answering these questions, the results are not significantly different. However, when participants were able to compare both websites and were asked the question: “What webpage seems more accessible?”, all of them chose the A-Website without hesitation. Results from the post-task questionnaire are shown in Figures 3a and 3b.

Table 6. Results of satisfaction of blind users (BU), low vision users (LVU) and users without disabilities (UWD). 0: Impossible; 1: Very difficult; 2: Difficult; 3: Easy; 4: Very easy

		NA-website			A-website		
Task	Objective	BU	LVU	UWD	BU	LVU	UWD
T2	Understanding the link destination	0	3	2	4	4	4
T3	Understanding graph	0	3	3	3	3	4
T4	Understanding a table of temperatures	0	0	3	3	4	4
T5	Checking a quote	2	-	-	3	-	-
T6	Consulting a map	0	1	3	3	2	3
T7	Playing a video file	1	4	4	0	4	4
T8-1	Forms: Understanding the label required	0	4	3	4	4	4
T8-2	Entering data in the text boxes on the form	3	4	4	3	4	4
T8-3	Sending the form	1	4	4	4	4	4
T9	Accessing a monument	-	3	3	-	4	4

T10	Booking a room	-	1	4	-	4	4

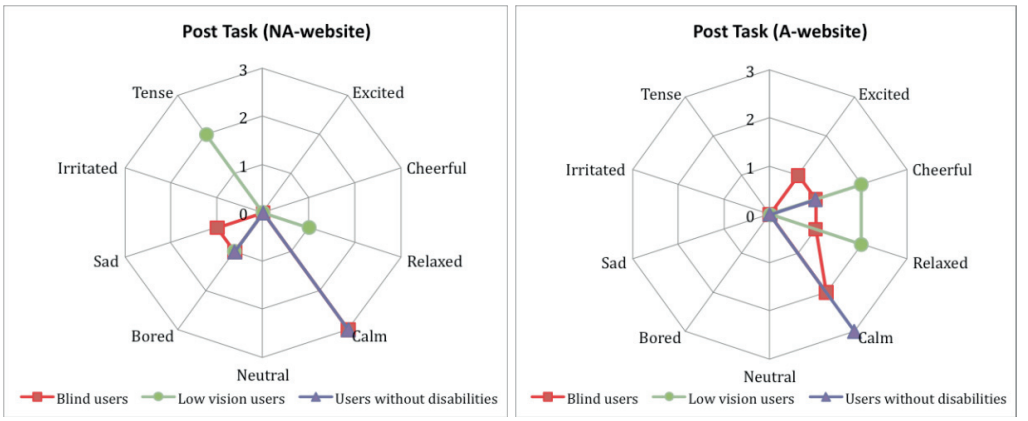

Fig. 2. Emotional evaluation in post-task questionnaire, not being able to compare websites. (a) NA-website; (b) A-website

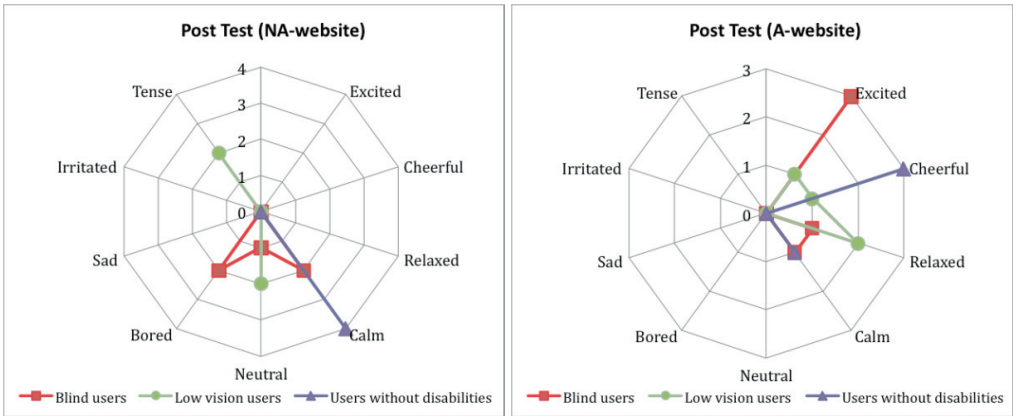

Fig. 3. Emotional evaluation in post-test questionnaire, being able to compare websites (a) NA-website; (b) A-website

5. Conclusion

The main aim of the study was to evaluate the mood of users with disabilities while interacting on two websites with parallel content, but opposite accessibility characteristics. The results confirm that the A-website had better results than the NA-website in terms of efficiency, effectiveness and satisfaction.

The three kinds of participants – blind, low-vision and sighted users – displayed significant differences in terms of their web interaction. The first group (blind users) learn about real life by hearing and they approach the information from the parts to the whole. In contrast, users with low vision and sighted users interact with greater sensory integration with their environment, as it is facilitated by their visual perception. A detailed analysis of efficiency and effectiveness revealed significant differences between blind and low-vision users. Blind users experienced worse efficacy, efficiency and satisfaction and needed more assistance than low-vision users. Low-vision users appeared to be more self-sufficient in terms of understanding and perceiving website information compared to blind users. Sighted users displayed better results in both websites.

It was noted that all users were in a better mood when interacting on the A-website than when interacting on the NA-website. However, it is worth mentioning that blind users, who faced much more difficult interaction in general, were very tolerant to frustrations and weariness, as has already been noted by other authors [22], [16]. In comparison, blind users complained much less than users with low vision and sighted users (see Fig. 1, 2, 3).

A possible explanation for this behaviour is learned helplessness [5]. These users had learned from previous experiences that an aggressive reaction had no effect. In contrast, low-vision users and users without disabilities display more criticism when faced with accessibility barriers.

Some of the usability errors on the NA-website, such as images without contrast, links not differentiated by format or text type with small fonts, did not impact interaction significantly and were not mentioned by users. A possible explanation for this was the users' capacity for adaptation.

Meanwhile, many of the most common causes of frustration (e.g. unlabelled forms, inaccessible multimedia elements, missing or confusing alt text) are easily solved from a technical point of view [17]. Authors believe that better communication with web authors regarding accessibility barriers and solutions could easily solve these obstacles and greatly improve web accessibility.

Although we did not a correlation study between results of emotion state and efficiency or effectiveness, but we observed more negative moods when effectiveness was low.

The user test was conducted with a low number of participants. In consequence, the results are poor but it is more difficult to conduct a user test with users with disabilities than with sighted users. In future, the research will be followed up with other user groups and complete evaluations of the impact of barriers will be measured in each case.

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