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Effects of accessible website design on nondisabled users: age and device as moderating factors

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ABSTRACT

This study examined how implementing recommendations from Web accessibility guidelines affects nondisabled people in different age groups using different technical devices. While recent research showed positive effects of implementing such recommendations for nondisabled users, it remains unclear whether such effects would apply to different age groups and kind of devices. A 2 × 2 × 2 design was employed with website accessibility (high accessibility vs. very low accessibility), age (younger adults vs. older adults) and type of device (laptop vs. tablet) as independent variables. 110 nondisabled participants took part in a usability test, in which performance and satisfaction were measured as dependent variables. The results showed that higher accessibility increased task completion rate, task completion time and satisfaction ratings of nondisabled users. While user age did not have any effects, users showed faster task completion time under high accessibility when using a tablet rather than a laptop. The findings confirmed previous findings, which showed benefits of accessible websites for nondisabled users. These beneficial effects may now be generalised to a wide age range and across different devices.

Practitioner Summary: This work is relevant to the design of websites since it emphasises the need to consider the characteristics of different user groups. Accessible website design (aimed at users with disabilities) leads to benefits for nondisabled users across different ages. These findings provide further encouragement for practitioners to apply WCAG 2.0.

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KEYWORDS
Web accessibility; nondisabled users; usability; WCAG 2.0

Introduction

Recommendations from Web accessibility guidelines aim to make websites more accessible to people with disabilities (e.g. Chisholm and Henry 2005; Henry 2006). Such accessibility recommendations include high contrasts between text and background (supporting users with impaired eyesight), captions for audio content (supporting users with hearing impairments) and operability via the keyboard (supporting users with motor impairments who cannot use a mouse) (e.g. Cooper, Kirkpatrick, and O Connor 2014). Although Web accessibility guidelines focus mainly on users with disabilities, recent research has broadened the scope by examining the possible side effects of accessibility recommendations for nondisabled users (e.g. Pascual et al. 2014). Side effects for nondisabled users are of particular importance to practitioners because most of the customers are usually nondisabled (Farrelly 2011). The consequences for nondisabled users are thus crucial when deciding whether to implement accessibility recommendations in practice. This reflected in strong concerns among practitioners about negative consequences for nondisabled users when implementing accessibility recommendations (e.g. applying the recommendations results in ugly, boring or dull websites) (e.g. Ellcessor 2014; Thatcher et al. 2006).

Recent empirical work did not support the negative beliefs held by practitioners because it found positive effects of accessible website design for nondisabled users in terms of performance, aesthetics and usability (Schmutz, Sonderegger, and Sauer 2016, 2017). Since there are only very few studies that focused on effects of making websites compliant with accessibility guidelines, the present work aims to continue this line of research by examining the influence of user age and types of device.

Web accessibility guidelines

Among the different accessibility guidelines available (e.g. U.S. Section 508 regulations, cf. https://www.section508.gov; IBM accessibility checklist, cf. http://www-03.ibm.com/able/guidelines/ci162/accessibility_checklist_web.html), there is one set of guidelines that is widely used

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in research and practice: the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) (Caldwell et al. 2008). The World Wide Web Consortium (www.w3c.org), an international consortium that provides Web standards, has developed these guidelines. Many countries around the globe have recognised the WCAG 2.0 as a reference for legal requirements in regard to accessibility (e.g. Australia, Canada, Germany, Switzerland, Japan, Hong Kong and the United Kingdom) (see Thatcher et al. 2006; www.powermapper.com/blog/government-accessibility-standards/(Thatcher et al. 2006). Furthermore, the International Organisation for Standardisation (ISO) acknowledges the WCAG 2.0 as their standard for accessibility (ISO/IEC 40500:2012, 2012). The WCAG 2.0 comprises 61 recommendations for accessible website design. These recommendations include: provide text alternatives for images, do not use colour as the only visual means of conveying information, do not use justified text and make all functionality of the content operable through a keyboard interface (see Cooper, Kirkpatrick, and O Connor 2014). A website's degree of compliance with the recommendations determines its level of accessibility. Four levels are distinguished: no accessibility (NA), low accessibility (A), high accessibility (AA) and very high accessibility (AAA) (see Caldwell et al. 2008). Hereafter the term 'accessibility' is used to refer to the compliance of a website with Web accessibility guidelines (i.e., WCAG 2.0) and its assignment into one of the accessibility levels (i.e. NA – AAA).

Web accessibility guidelines and web usability guidelines

In this context, we would like to point out some conceptual overlap between the concepts of accessibility and usability. Examining the design recommendations derived from these two concepts, there is substantial overlap between general recommendations for website design (e.g. Farkas and Farkas 2000; Nielsen, Tahir, and Tahir 2002; Shneiderman, Plaisant, and Cohen 2016; Spool 1999; Spyridakis 2000; Williams 2000) and accessible websites. For examples recommendations found in both fields refer to precise link descriptions, heading structures, consistency in design and text alignment. However, the WCAG 2.0 also comprises some very specific recommendations that are not found in the usability domain (e.g. providing text alternatives for images, providing visible cursor focus, use meaningful tab orders or particular thresholds for colour contrasts). Although there seems to be some overlap between recommendations in both fields, very little empirical research has examined possible spill over effects between the domains.

Accessibility and nondisabled users

Since only very few studies investigated effects of accessibility on nondisabled users, research evidence about possible consequences for this user group is scarce (e.g. Schmutz, Sonderegger, and Sauer 2016; Yesilada, Brajnik, and Harper 2011; Yesilada, Brajnik, Vigo, and Harper 2012). There is some debate about the role of accessibility for nondisabled users. The concepts discussed are typically accessibility and usability (e.g. Petrie and Kheir 2007; Thatcher et al. 2006; Yesilada et al. 2015). Usability is an established concept in the field of human–computer interaction, referring to the 'extent to which a product [or website] can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use' (International Organisation for Standardisation 2012, 2). When relating the concept of usability to accessibility, the wording 'specified users' is of particular interest. Since the term 'specified users' does not explicitly include or exclude certain user groups, usability would include people with impairments who could be described as 'specified users'. Nevertheless, the definition of usability is subject to an intensive debate (see Tractinsky 2017 for a comprehensive discussion). Furthermore, among researchers and practitioners, usability is usually related to nondisabled users (e.g. Petrie and Bevan 2009; Petrie and Kheir 2007; Thatcher et al. 2006; Yesilada et al. 2015). The relation between the two concepts is not yet fully clarified and discussed in the literature (e.g. Petrie and Kheir 2007; Thatcher et al. 2006; Yesilada et al. 2012, 2015). Some authors argue that the definition of Web accessibility should follow the ISO definition of usability and state that Web accessibility is 'the extent to which a product/website can be used by specified users with specified disabilities to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use' (Petrie and Kheir 2007, 397). Such a perspective implies that Web usability and accessibility are two distinct but still similar concepts, which differ only by the fact that accessibility focuses on users with impairments. Other authors argue that usability is an overriding concept, which includes accessibility (Thatcher, Waddell, and Burks 2002). According to their view, accessibility issues are a subset of usability issues, which implies that usability problems affect everyone, whereas accessibility problems are only of concern to people with impairments. However, Shneiderman (e.g. 2000, 2003) argues that accessibility is a necessary prerequisite for successful usage. This suggests that accessibility is the overriding concept that encloses usability, which is a perspective contrary to (Thatcher, Waddell, and Burks 2002). It is to conclude that there are differing opinions about the relationship between Web accessibility and usability. A consensus on this issue would facilitate communication

and cooperation among researchers and practitioners (e.g. Yesilada et al. 2012, 2015). Therefore, empirical research should advance the understanding of both concepts and their relationship to each other.

Although there seems to be a vivid discussion about the overlap between the two concepts, very little empirical research has examined possible spill over effects between the domains. The few empirical studies on this issue showed that nondisabled users performed better (i.e. lower task completion time and higher task completion rates) (Disability Rights Commission 2004; Pascual et al. 2014) and gave better subjective ratings (e.g. higher perceived usability, higher perceived aesthetics or lower perceived workload) (Huber and Vitouch 2008; Schmutz, Sonderegger, and Sauer 2016) when using websites with high compliance to accessibility guidelines compared to websites with low compliance. One study even showed that the positive effects of accessibility on performance and subjective evaluations were similar for nondisabled users and users with visual impairments (Schmutz, Sonderegger, and Sauer 2017).

While first evidence indicated rather beneficial effects of implementing accessibility for nondisabled users, it has been argued that some factors may influence the beneficial effects of high WCAG 2.0 compliance on nondisabled users. These factors include the age of users (i.e. nondisabled users of old age particularly benefit from accessible website design) or the type of device people use (i.e. nondisabled users particularly benefit from WCAG 2.0-compliant website design when they use a mobile device) (e.g. Carter and Markel 2001). These two user groups are of particular importance for the HCI community because of demographic and technical changes, which indicate that the number of elderly users and the number of mobile devices will strongly increase in the near future (e.g. Jacko 2012; Vu and Proctor 2011).

Accessibility and elderly users

There are at least two reasons why we should assume benefits of accessible website design for elderly users. First, with increasing age, physical and cognitive functioning may decrease. This includes a decline in visual, auditory and motor abilities as well as a decrease in working memory and memory capacities (e.g. Arch 2008; Hanson 2009; Seidel et al. 2009). These impairments may lead to similar needs of older people and people with disabilities (e.g. high contrasts for better visibility or captions for audio content) (e.g. Arch 2008). Second, older users usually have less experience with using websites than younger users (e.g. Chadwick-Dias, Tedesco, and Tullis 2004). Since the lack of experience among elderly users is often the cause for problems in using websites (Loos 2009), accessibility may support such users by providing clear and consistent design (e.g. clear link text for better predictability or error identification in forms). In line with these assumptions, the authors of the WCAG 2.0 have argued that the accessibility recommendations provided by the guidelines would be also helpful for older users (Cooper, Kirkpatrick, and O Connor 2014).

To examine these assumptions, an experiment investigated the effects of two WCAG 2.0 recommendations on elderly users (Sayago, Camacho, and Blat 2009). Since WCAG 2.0 recommends meaningful and predictable link text and operability via keyboard, the experiment tested different link designs and keyboard-based navigation with 11 elderly users, aged 65–80 years. While elderly users evaluated meaningful and predictable link texts as very supportive and 'good for old folks' (Sayago, Camacho, and Blat 2009, 81), they did not consider operability via keyboard as an important feature because they preferred to use a mouse to navigate websites. These results illustrate that some (though not all) WCAG 2.0 recommendations may support elderly users. A further study dealt with Web accessibility for elderly users aged 65–78 years (Petrie, Kamollimsakul, and Power 2013). As WCAG 2.0 recommends text that is not justified and a line spacing of at least space-and-a-half, the study compared two types of text alignment (justified vs. left aligned) and three levels of line spacing (single, space-and-a-half and double). The results showed that text alignment and line spacing did not affect performance but elderly users preferred space-and-a-half or double spacing to single spacing, which is in line with the WCAG 2.0 recommendations. As in the previous study, these results indicate that some WCAG 2.0 recommendations may be supportive for elderly users, while others are not. The reason why the recommendations from WCAG 2.0 match well the needs of elderly users may be due to a considerable similarity between website design guidelines for elderly users (e.g. Kurniawan and Zaphiris 2005) and the WCAG 2.0 (see Arch 2008). Although there is evidence that certain aspects of WCAG 2.0 may support elderly users, some authors are rather critical of this view and believe that additional criteria are necessary to improve the benefits of WCAG 2.0 for elderly users (e.g. Affonso de Lara et al. 2010; Sayago, Camacho, and Blat 2009). Based on the literature reviewed, we conclude that there is little empirical research that has focused on this issue and there are contradictory opinions about the effectiveness of WCAG 2.0 for elderly users. Therefore, further experimental research with elderly users is needed.

Accessibility and mobile device users

Apart from the elderly users, the use of mobile devices has also become an important issue for practitioners because

the number of users browsing websites with a mobile device has strongly increased over recent years. Recent data have shown that in 2016, users browsed more websites by mobile devices than by desktops (51.3% vs. 48.7%, see http://gs.statcounter.com/press/mobile-and-tablet-internet-usage-exceeds-desktop-for-first-time-worldwide). There may be benefits of WCAG 2.0-compliant website design for mobile device users because there is considerable similarity between designing usable websites for mobile devices and accessible website design (e.g. Sears and Young 2003; Thatcher et al. 2006). For instance, high contrast between font and background can support a user with a visual impairment but also a user employing a mobile device outdoors in poor lighting conditions (see http://www.w3.org/WAI/bcase/soc for more examples). Accordingly, previous work has shown that there is a significant overlap between guidelines for designing usable mobile websites and the WCAG 2.0 (Chuter and Yesilada 2009; www.w3.org/WAI/mobile/experiences). There is also an empirical study that supported this view (Yesilada, Brajnik, and Harper 2011). In this study, 19 experts and 57 non-experts examined four websites with the barrier-walk-through-method (e.g. Brajnik 2006; Yesilada, Brajnik, and Harper 2009). This method is based on a heuristic evaluation to detect accessibility barriers on websites. The participants had to identify possible barriers for two user groups: users with disabilities (i.e. visual impairments, blindness and motor impairment) and mobile device users. Afterwards, the authors compared the results for the two user groups, which showed an overlap of 58%. The authors have concluded that many barriers concern both user groups but there are also a considerable number of specific ones. The review of the work indicated that researchers seem to agree on possible benefits of accessible website design for mobile device users, but to our knowledge, there is no study that conducted a usability test to examine this issue.

The present study

The present study extents previous work by considering the influence of user age and device when examining effects of accessible website design on nondisabled people. A website was manipulated to obtain two levels of compliance with WCAG 2.0: NA and AA. A group of younger and older users tested the websites either with a laptop or a tablet device. The dependent variables task completion time, task completion rate and user satisfaction were measured.

Based on the literature review, we made a number of predictions. First, we predicted benefits of the AA website, as compared to the NA website, for both age groups. Second, we expected the positive effects of the AA website to be of greater magnitude for older users than for younger users, regardless of device. Third, we presumed that the benefits of the AA website would be stronger when using a tablet device than when using a laptop, regardless of user age. Fourth, we assumed that the advantageous effects of the AA website for older users would be greater (compared to younger users) when using a tablet device than when using a laptop.

Method

Participants and design

A total of 110 participants (49.1% women) took part in the study. Participants were not paid for taking part in the experiment but six psychology students received course credits for their participation. Participants were required to be healthy for their respective age (i.e. no diagnosis of any disease). No medical test was conducted.

In a $2 \times 2 \times 2$ between-subjects design, the three independent variables were accessibility, age and device. To manipulate accessibility according to the WCAG 2.0, two versions of a website were used. While the 'no accessibility' (NA) version of the website considered only very few WCAG 2.0 criteria, the 'high accessibility' (AA) version of the website shows high compliance with the guidelines. The independent variable age comprised a group of 'younger' users, aged from 19 to 30 years ($n = 55$; $M = 23.7$, SD = 2.6), and a group of 'older' users, aged 55–82 ($n = 55$; $M = 62.3$, SD = 6). In order to manipulate the device, the testing was conducted either using a laptop or a tablet. We randomly assigned participants to the conditions accessibility and type of device.

The websites

The websites were based on an existing municipal website of the country of Liechtenstein (Europe). This website contained typical governmental information, such as descriptions of the administrative staff, waste disposal, educational institutions, historical facts, registration and taxes. The information on the website was presented in text or pictorial form. The website did not contain any video material or elements of advanced user interaction (e.g. interactive maps, drag and drop or sliders). The original website was manipulated according to the criteria of WCAG 2.0. The manipulation resulted in two versions of the same website (NA and AA), which differed solely in their compliance with WCAG 2.0 criteria (see Appendix 1 for an overview of the criteria manipulated). Apart from these criteria, no changes were made, which ensured that solely the level of accessibility was manipulated (see Figure 1 for screenshots). The design of the website was

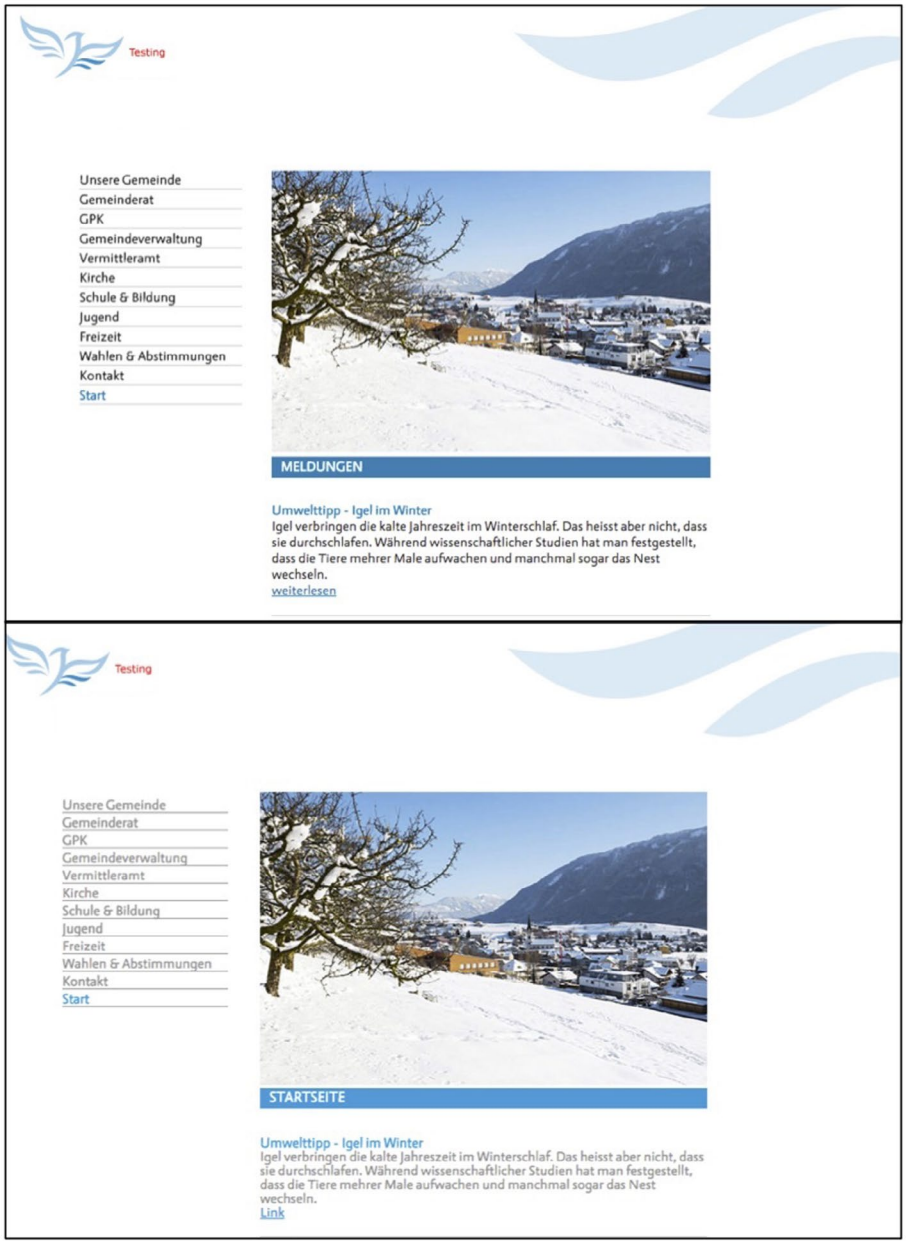

Figure 1. Screenshots of the home page of the websites used for testing (top: WCAG 2.0 level AA, bottom: WCAG 2.0 level NA).

responsive, which allowed a usage with the tablet. More detailed information about the websites and their validation including a manipulation check may be found in Schmutz, Sonderegger, and Sauer (2016).

Materials

For browsing the websites participants used either a laptop (DELL Latitude E7240, 12″) or a tablet (Samsung Galaxy Tab 2, 7″).

Measures

Three dependent variables were measured: task completion rate (%), task completion time (s) and user satisfaction. To measure satisfaction the participants completed the German-language version of the Website Analysis and MeasureMent Inventory (WAMMI; Kirakowski, Claridge, and Whitehand 1998). This questionnaire contained 20 items (Cronbach's $\alpha = .93$) (e.g. 'Using this website for the first time is easy') and answers were given on a five-point Likert scale ranging from 'strongly disagree' to 'strongly agree'.

Procedure

The testing sessions were conducted in a quiet room, furnished with a table and a chair. Participants did the testing either using a laptop or a tablet device. At the beginning of the testing, we instructed participants in the tablet condition how to use a tablet. These instructions comprised touchscreen gestures for clicking, magnifying and scrolling and information on how to type in text on the tablet. These gestures were demonstrated and practiced on the website of the University of Fribourg. We then briefly showed the municipal website to the participants to ensure that no one had seen the website before. Thereafter, the participants had to complete five tasks (see Table 1) either on the laptop or the tablet. Each task had to be completed within 5 min. If participants did not complete a task within five minutes, the experimenter asked them to move on to the next task. In such a case, task completion time was set to 5 min and task completion was scored as being unsuccessful. A screen recording software logged the testing session, measuring task completion time and task completion rate. After finishing the tasks, every participant filled in the WAMMI questionnaire on the laptop.

Table 1. Tasks to be completed on the website.

Task	Description
1	Find the number of people living in this town
2	Find the motorway that connects this town with Switzerland
3	Find the email address of the person responsible for education in town
4	Fill out a form to order firewood from the municipality
5	Find the bus service that will take you to the sports centre

Data analysis

A three-factorial analysis of variance was conducted with accessibility (NA vs. AA), age (young vs. old) and device (laptop vs. tablet) as independent variables. One video file was lost due to technical problems. The task completion time of this participant was thus not included in the analysis.

Results

Task completion rate

Table 2 shows the means for task completion rate as a function of accessibility, age and device. For accessibility, the means indicate that the task completion rate was higher in condition AA (M = 89.1%, SD = 17.9) than in condition NA (M = 81.8%, SD = 19.8). This difference was statistically significant, $F(1, 102) = 4.107$, $p = .045$, *partial* $\eta^2 = .039$. In regard to age, the task completion rate was higher for the younger participants (M = 90.4%, SD = 15.3) than for the older participants (M = 80.6%, SD = 21.3). This difference was significant too, $F(1, 102) = 10.814$, $p = .001$, *partial* $\eta^2 = .096$. Concerning the device, the means showed that the task completion rate was higher in the laptop condition (M = 92.4%, SD = 15.2) than in the tablet condition (M = 78.6%, SD = 21.3). This difference was highly

Table 2. Outcome measures as a function of accessibility, age and device.

			NA			AA			Overall		
			Laptop: *M* (SD)	Tablet: *M* (SD)	Total: *M* (SD)	Laptop: *M* (SD)	Tablet: *M* (SD)	Total: *M* (SD)	Laptop: *M* (SD)	Tablet: *M* (SD)	Total: *M* (SD)
Task completion rate											
	Overall:		89.23 (18.09)	75.17 (19.02)	81.82 (19.73)	95.17 (11.53)	82.31 (21.22)	89.09 (17.88)	92.36 (15.15)	78.55 (20.22)	85.45 (19.09)
		Young:	96.92 (11.09)	81.33 (15.98)	88.57 (15.80)	98.46 (5.55)	86.43 (18.23)	92.22 (14.76)	97.69 (8.63)	83.79 (16.99)	90.36 (15.27)
		Old:	81.54 (20.76)	68.57 (20.33)	74.81 (21.19)	92.5 (14.38)	77.50 (24.17)	86.07 (20.25)	87.59 (18.06)	72.69 (22.19)	80.55 (21.29)
Task completion time											
	Overall:		84.32 (33.24)	124.77 (41.11)	106.05 (42.52)	91.73 (49.52)	94.85 (28.44)	93.20 (40.60)	88.30 (42.54)	110.62 (38.45)	99.57 (41.87)
		Young:	69.30 (28.05)	102.33 (32.13)	86.99 (34.16)	57.14 (21.00)	88.52 (27.44)	73.41 (28.90)	63.22 (25.06)	95.66 (30.25)	80.32 (32.13)
		Old:	100.60 (31.56)	148.82 (36.39)	126.57 (41.57)	119.84 (48.43)	102.23 (28.95)	112.29 (41.51)	111.60 (42.46)	127.31 (40.23)	119.16 (41.77)
User satisfaction											
	Overall:		3.20 (0.69)	3.21 (0.76)	3.21 (0.72)	3.76 (0.62)	3.33 (0.80)	3.56 (0.74)	3.50 (0.71)	3.27 (0.78)	3.38 (0.75)
		Young:	3.16 (3.35)	3.50 (0.76)	3.35 (0.73)	3.79 (0.66)	3.59 (0.66)	3.69 (0.66)	3.55 (0.70)	3.48 (0.73)	3.51 (0.71)
		Old:	3.24 (0.72)	2.89 (0.65)	3.06 (0.70)	3.74 (0.62)	3.04 (0.87)	3.44 (0.80)	3.52 (0.70)	2.96 (0.75)	3.25 (0.77)

Note: NA = very low conformance; AA = high conformance.

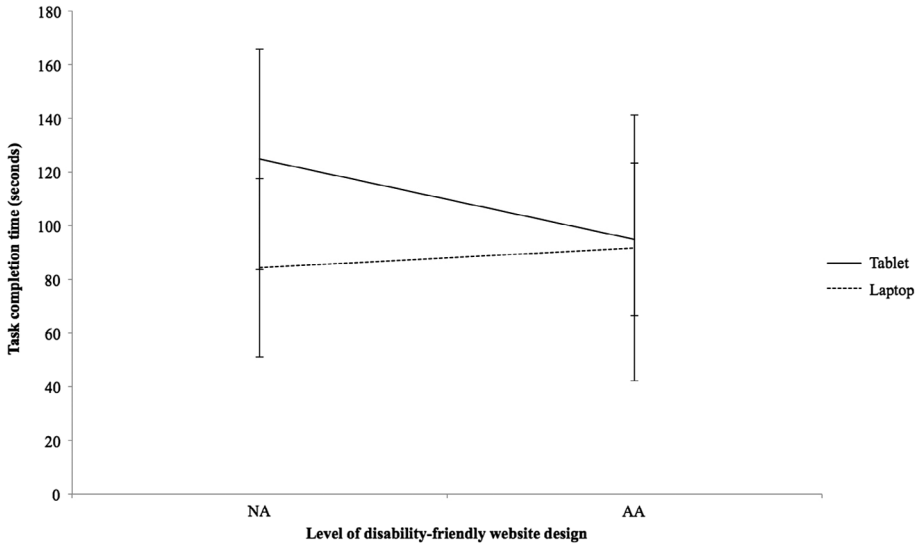

Figure 2. Task completion time as a function of accessibility level and device.

significant, $F(1, 102) = 18.042$, $p < .001$, *partial* $\eta^2 = .150$. There was no significant interaction ($F < 1$).

Task completion time

Table 2 provides the results for task completion time as a function of accessibility, age and device. The means of the accessibility conditions indicate that participants completed tasks faster in the AA than in the NA condition. This difference was statistically significant, $F(1, 101) = 4.345$, $p = .040$, *partial* $\eta^2 = .041$. For the variable age, the means revealed that young participants completed tasks faster than elderly users. This difference was highly significant, $F(1, 101) = 36.334$, $p < .001$, *partial* $\eta^2 = .265$. For considering the device, the results indicated that people using a laptop were faster than participants using a tablet. This difference was also highly significant, $F(1, 101) = 13.794$, $p < .01$, *partial* $\eta^2 = .120$. Figure 2 shows a significant two-way interaction, which occurred between accessibility and device, $F(1, 101) = 6.959$, $p = .010$, *partial* $\eta^2 = .064$. This interaction indicates that tablet users were faster under AA, while laptop users were not faster in the AA condition. Finally, the three-way interaction between accessibility level, age and device was significant as well, $F(1, 101) = 6.292$, $p = .014$, *partial* $\eta^2 = .059$. Figure 3 shows a comparison of the task completion time between the younger and elderly users as a function of WCAG 2.0 level and device. In case of younger users, higher WCAG 2.0 conformance led to lower task completion times when using a laptop or a tablet device, whereas for elderly users, higher WCAG 2.0 conformance

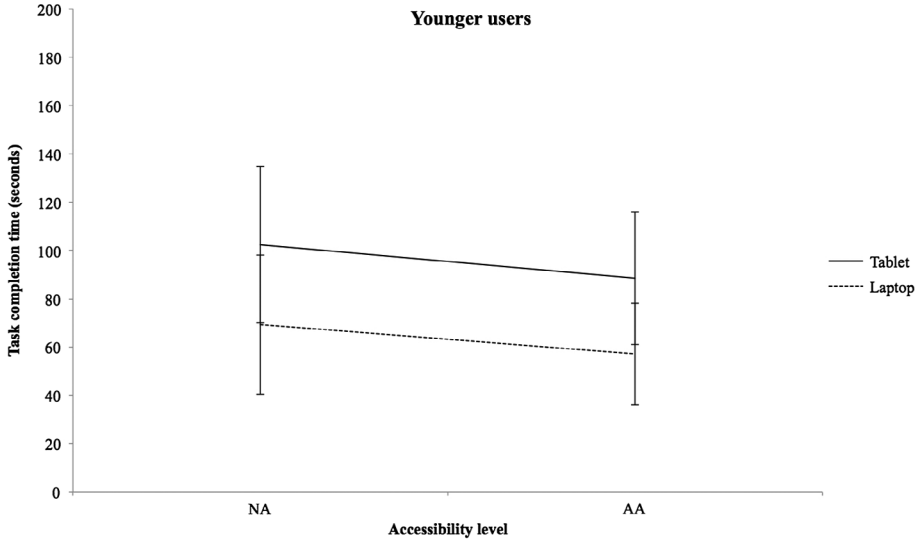

Figure 3. Task completion time as a function of accessibility level, device and age (Younger users).

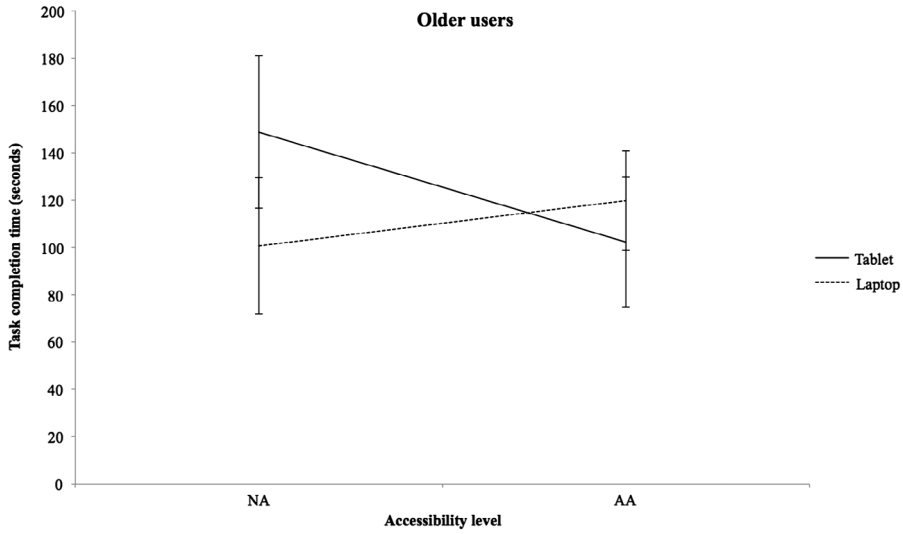

Figure 4. Task completion time as a function of accessibility level, device and age (Older users).

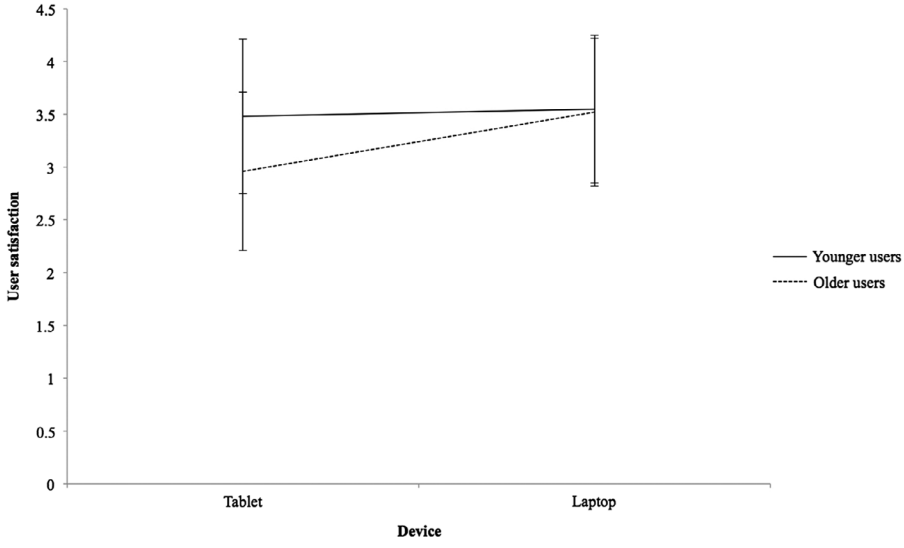

Figure 5. User satisfaction as a function of device and age.

lead to lower task completion times when using the tablet but not when using the laptop.

User satisfaction

Users who employed the AA website gave higher satisfaction ratings than users of the NA website (see Table 2). This difference was statistically significant, $F(1, 102) = 6.396$, $p = .013$, *partial* $\eta^2 = .059$. In regard to user group, the results revealed a significant difference in satisfaction ratings between younger and older users, $F(1, 102) = 4.432$, $p = .038$, *partial* $\eta^2 = .042$, showing that younger users gave slightly higher ratings in satisfaction than older users (see Table 2). There was a significant two-way interaction between age and device, $F(1, 102) = 4.909$, $p = .029$, *partial* $\eta^2 = .046$ (see Figure 4). Whereas elderly people preferred to use the laptop, the younger users showed similar satisfaction for both devices.

Discussion

The study aimed to investigate possible effects of WCAG 2.0 recommendations on nondisabled users as a function of age and the type of device they use. The results partly confirmed our hypotheses by revealing benefits of the AA website, as compared to the NA website, regardless of age and device for each of the three dependent variables. Furthermore, the AA website reduced task completion time compared to the NA website when participants used a tablet but not when they used a laptop. It also

emerged that younger users were faster in solving tasks when using the AA website compared to the NA website with both devices, whereas older users only benefitted from the AA website when using the tablet but not with the laptop. Finally, younger users liked the websites more when presented on the tablet rather than the laptop while older users liked the websites more when using the laptop rather than the tablet.

The effects of accessibility on elderly users are partly in line with previous work dealing with accessibility and elderly users. AA websites showed benefits for task completion rates, task completion time and user satisfaction for younger and older users alike. This is in accordance with our hypothesis and previous work that showed benefits of WCAG 2.0 recommendations for nondisabled users (e.g. Huber and Vitouch 2008). However, against our expectations, participant age did not modify the effect of accessibility for nondisabled users in the present study. This finding is in line with some previous work that showed that both younger and older users can benefit from certain website characteristics, such as consistent link design, meaningful link texts and structure text with titles (Chadwick-Dias, McNulty, and Tullis 2003). However, some other work also postulates stronger benefits of accessible website design for older users (e.g. Arch 2008; Thatcher et al. 2006). We have concluded from the present results that WCAG 2.0 compliant website design may be beneficial for nondisabled users independent of their age but further research on this issue may be needed.

With regard to the device, the results were in line with our assumptions. People especially benefitted from the AA website when using a tablet rather than a laptop. This finding corresponds to previous work, which found that accessible website design is of particular benefit to users of mobile devices (e.g. Brajnik 2006; Chuter and Yesilada 2009; Sears and Young 2003; Thatcher et al. 2006; Trewin 2006; Wobbrock 2006; Yesilada, Brajnik, and Harper 2009). The positive influence of accessible websites on task completion time was particularly strong for older users employing the mobile device. While younger users solved tasks faster on the AA website (compared to the NA website) with both devices, elderly users were faster on the AA website when using a tablet but not when using a laptop. It is interesting that elderly users solved tasks faster on the tablet than on the laptop when using the AA websites, but they still preferred the laptop to the tablet. This may suggest that fast task completion is of less importance for elderly users. A similar finding emerged in a previous study where younger users were compared to elderly users in a usability test with mobile phones (Sonderegger, Schmutz, and Sauer 2016). We have therefore concluded that being able to complete a task quickly does not contribute to product satisfaction for older users.

Considering the conceptual relationship between accessibility and usability (e.g. (Petrie and Kheir 2007; Shneiderman 2000, 2003; Thatcher et al. 2006; Yesilada et al. 2012, 2015), the present results indicate that accessibility and usability seem to be similar concepts. This conclusion is in line with the view of other authors who argued that accessibility and usability have different roots but are overlapping concepts (e.g. Petrie, Hamilton, and King 2004; Petrie and Kheir 2007).

Limitations and future research

For this work, we deliberately chose an experimental manipulation of a single website to increase internal validity and control for possible confounding variables. However, by doing so we were not able to investigate different kinds of websites (e.g. social media platforms, online shops or online newspaper), as previous work in the field of accessibility typically did (e.g. Disability Rights Commission 2004; Petrie, Hamilton, and King 2004). In our opinion, both are valid and important approaches, which should not be considered as contradictory but rather as complementary. Future work on accessibility should thus consider both methodological approaches to advance the field.

We acknowledge that the age groups recruited were dissimilar with regard to the age ranges (i.e. 19 – 30 vs. 55 – 82). Since recruiting older participants for an experiment of considerable size is rather challenging, we decided to accept the difference in the age ranges. Furthermore, it is to point out that there is only a difference of 3.4 years (i.e. 2.6 vs. 6.0) with regard to the standard deviations of the two groups. However, it is possible that the different age ranges may have influenced the results. Furthermore, it has to be acknowledged that the wide range of abilities and experience of the older participants may have influenced the present results. Future studies should thus try to recruit only age groups with the same age ranges. They should also consider possible differences in abilities and experience of older users.

With regard to the effects of device type, the size of the screens (which differed for tablet and laptop) might have also contributed to the present results. Since tablets and laptops (or desktops) typically differ in the size of their screens, we believe that we carried out a realistic comparison of devices. However, future work should consider standardising screen sizes, which would indicate whether the screen sizes or the kind of navigation (i.e. touch control vs. navigating the cursor with the mouse) is responsible for specific results. Furthermore, future research should expand the present work by examining further devices, such as smartphones and desktops.

Implications for practitioners

This study provides some important implications for practitioners. Implementing WCAG 2.0 recommendations may not only support users with disabilities (i.e. the actual purpose of the guidelines), they may also benefit nondisabled users from young to old age and particularly to mobile device users. Using the WCAG 2.0 as a standard when designing websites seems thus to be a worthwhile approach. This is because the WCAG 2.0 is an effective tool that results in increased user satisfaction across different ages, which offers economical advantages for practitioners.

According to the present results, the WCAG 2.0 seems to be a powerful tool for developers to create websites that meet the needs of a broad range of users. Developers should apply the guidelines when designing websites and should not be overly concerned about possible negative outcomes. The results suggest that user-centred design including user testing should be the method of choice. Such an approach provides helpful insights into the user perspective, which might not always be consistent with the expectations of developers.

For managers the present results indicate that applying WCAG 2.0 could be a promising business opportunity by offering products or services via accessible websites. Customers with various characteristics could be approached including people with and without disabilities. Furthermore, it may have a positive effect on the image of the organisations because considering needs of people with impairments in products and services would indicate social commitment.

Although several countries already provide legal standards for accessible website design (Thatcher et al. 2006; www.powermapper.com/blog/government-accessibility-standards/, the present results emphasise the importance and feasibility of using accessible website design according to the WCAG 2.0. A strict implementation of the law is advisable because current results indicate that the consequences of doing so are rather positive.

Conclusion

The present study examined the effects of implementing accessibility guidelines for nondisabled users rather than users with disabilities, which is an important issue that has been neglected so far. Furthermore, the study investigated whether the findings can be generalised to nondisabled users of different ages and when different devices are used. This allows conclusions to be drawn that are relevant to practice because older, as well as mobile device users, represent an important part of contemporary Web users. Considering the present results, we conclude that there may be benefits of accessible website design for laptop and mobile device users of different ages. While the present work builds on previous research on effects of accessible website design on nondisabled users (Schmutz, Sonderegger, and Sauer 2016, 2017) by being the first that examined effects on elderly users and mobile device users. Therefore, the present findings make an important contribution that may encourage practitioners to follow Web accessibility guidelines, which may lead to a Web that considers the needs of a wider range of users and thus promotes equality in society.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix 1. Overview of website characteristics manipulated

Success criterion (WCAG 2.0 level)	AA website	NA website	Comments – reference to the document Understanding WCAG 2.0
1.1.1 Non-text content (A)	Every image on the website has an appropriate text alternative	For every image the text alternative 'image' was used	The manipulation is based on common failures F30 and F39 (Manipulated for further studies – Did not affect nondisabled users)
1.3.1 Info and relationships (A)	Required fields in the contact form were labeled with bold text and with an asterisk whose text alternative says, 'required'	Required fields were labeled only with bold text, whose text alternative did not say, 'required'	The manipulation represents a violation of the sufficient technique G117
1.4.3 Contrast (Minimum) (AA)	The contrast between headings and background was 4.5 : 1 (#007FAF | #FFFFFF); The contrast between text and background was 21.0 : 1 (#FFFFFF | #000000)	The contrast between headings and background was 3.9 : 1 (#007FEF | #EFFFFF); The contrast between text and background was 4.0 : 1 (#FFFFFF | #7F7F7F)	The manipulation represents a violation of the sufficient technique G18. The chosen contrasts seem to be realistic since the screening revealed that there are plenty of websites containing contrasts about 3.0:1 or lower
1.4.4 Resize text (AA)	Text can be resized without assistive technology up to 200% without loss of content or functionality	Resizing text to 200% caused text passages to be truncated or obscured	The manipulation is based on common failure F69 (Manipulated for further studies – Did not affect nondisabled users because nobody resized text)
1.4.8 Visual presentation (AAA)	Text blocks had a maximum width of 80 characters and were left aligned	Text blocks had a maximum width of 90 characters and were justified	The manipulation is based on common failure F88 as well as a violation of sufficient technique C20
2.4.3 Focus order (A)	Focusable components receive focus in an order that preserves meaning and operability	Some fields in the form did not receive focus in a typical order via tabbing (i.e., skips between fields in different sections of the form. Focus moved from the name field to a checkbox above, then to the street address)	The manipulation is based on common failure F44 as well as example 5 of understanding SC 2.4.3
2.4.4 Link Purpose (in context) (A)	Links for sending an email to a certain person were presented as mail address (e.g., john.smith@example.com – the purpose can be determined from the link text only)	Links for sending an email to a certain person were labeled 'link' within the same paragraph as the description of the respective person (the purpose cannot be determined with certainty form the link text together with its context)	The manipulation is based on common failure F88 as well as a violation of sufficient technique C20
2.4.6 Heading and Labels (AA)	Heading and labels describe topic and purpose	Some headings were shortened to be less descriptive (e.g., from 'information about the town Eschen' to 'general information')	The manipulation represents a violation of the sufficient technique G117
2.4.7 Focus visible (AA)	Keyboard focus indicator was visible	Keyboard focus indicator was not visible	The manipulation is based on common failure F78
2.4.10 Section Headings (AAA)	Section headings were used to organise the content	Some section headings were removed	The manipulation represents a violation of the sufficient technique G141 & H69
3.2.3 Consistent navigation (AA)	Navigational mechanisms occurred in the same relative order	Some navigation links were not presented in the same order on some webpages but only in the HTML file (i.e., remarkable when using a screen reader). The change in position was not visible due to holding the position via css	Not remarkable without using screen reading software. The manipulation is based on common failure F66
3.4.4 Consistent Identification (AA)	Links are designed consistently bold, in blue colour and underlined	Links differ in design: links were either blue and not underlined or underlined and in the same color as text. Links were also not consistently bold	The problem frequently occurred in the screening
3.3.1 Error identification (A) & 3.3.3 Error suggestions (AA)	If an input error in the form was automatically detected, the item that was in error was detected and described by the user in text (i.e., the field was marked with a red square and a textual suggestion on how to complete the field)	There was no error identification used in the form	The manipulation is based on a violation of sufficient technique G83

Note. Common failures and sufficient techniques are mentioned referring to the document Understanding WCAG 2.0 (Cooper, Kirkpatrick, & O Connor, 2014; http://www.w3.org/TR/UNDERSTANDING-WCAG20/).