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"Consent notices are obstructing my view": Viewing sticky elements on responsive websites under the magnifying glass☆

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ABSTRACT

The practice of using consent notices on websites has received much criticism and attention among researchers. Much of the research has addressed unethical aspects of consent notices while less attention has been devoted to implications for accessibility. This study thus set out to explore implications of such elements for low vision users who rely on browser magnification to access information on the web. A selection of the 100 most frequently used or formally important websites in Norway was manually studied with heuristic evaluation to assess their accessibility with high magnification. The results show that a large portion of the websites contained blocking consent notices that make the websites inaccessible while magnified. Also, most of the websites employed sticky permanent elements such as navigation menus that obstruct much, in some cases all, of the screen real estate in the magnified view. The study also uncovered patterns that preserve accessibility. A key implication of this study is that web developers should consider narrow use cases explicitly. Recommendations are provided on how to avoid inaccessibility for users relying on magnification in narrow viewports.

1. Introduction

Low vision users' challenges with access to the web is still an unresolved research problem (see for instance [1]), despite many technological advances during the last decade. Although new technologies and practices solve certain problems, they may inadvertently give rise to new challenges. This study addresses a relatively recent aspect of this research problem that has received limited attention, namely consent notices and sticky elements.

Legislation such as the European Union General Data Protection Regulations (GDPR) require website owners to solicit visitors' consent to track and store person-identifiable information about browsing behaviour [2,3]. Consent is frequently sought through consent notices which have become commonplace on the web [4]. These consent notices are commonly implemented as modal dialogue boxes that require users to make choices before proceeding to view website content. Most visitors probably find these modal consent notices to be a minor annoying nuisance that keeps the content a mouse-click away. Scholars have also raised ethical concerns regarding certain consent notice practices [5].

This study explores the implications such consent notices may have for low vision users. The term *magnification users* will be used to refer to the group of individuals with a reduced visual acuity after corrections. Magnification users prefer visual stimuli but require magnifications. According to the World Health Organization (WHO) 2.2 billion individuals worldwide have some near or distance impairment [6]. As vision naturally declines with age the potential cohort of users that need magnification is large.

Modern web technologies provide good support for magnification users [7]. Most browsers allow the user to quickly zoom in and out on the content with simple keystrokes (such as Control+/− or Command+/−), or touch gestures (such as two-finger expand/shrink), to find a magnification level that facilitates comfortable reading. Modern websites are often implemented with responsive content that reflows within the width of the viewport in response to the magnification adjustments. Such reflow mechanisms eliminate the need to scroll horizontally to access content [8,9]. A study conducted by the Institute for Disability Research, Policy, and Practice [10] showed that 44 % of low vision users utilised browser magnification and 36.7 % adjusted browser text size configuration. Both mechanisms affect the reflow mechanism within the browser.

This study set out to explore negative side effects of blocking consent notices on responsive websites when used with browser magnification. To the best of our knowledge this use-case represents a gap in the research discourse as it has not previously been explicitly addressed in

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the research literature. Scopus searches did not uncover any research published on consent notices and accessibility, nor did it uncover any published research on sticky elements on the web. However, the issue is occasionally discussed by practitioners in online forums such as Stack Overflow and on developer blogs (see for example [11,12,13]). Note that the Scopus search was just part of an overall exhaustive search for related literature including eyeballing the table of contents of key conferences proceedings and journals, examining the references cited in relevant standards (WCAG), inspecting the references in key papers identified, and reviewing the works citing these key publications.

The research problem is illustrated by the following two examples (see Figs. 1 and 2). Imagine that the blocking consent notice is implemented to respond to the users' magnification choices such that consent contents, including text, scales up in size in accordance with the chosen magnification level. One consequence is that important elements of such modal dialog boxes, including instructions and the controls, become inaccessible as they are pushed outside the visible viewport. Fig. 1(a) shows a consent notice without magnification. Both the instructions and controls (link and button) are fully visible. Fig. 1(b) shows the same consent notice with magnification. The instructions are partially obscured by the viewport borders. Controls (link and button) are not visible at all. Additionally, there are no scrollbars for panning the magnified view. The user is thus unable to read the instruction and unable to give consent (by clicking on the button). Consequently, the website contents become inaccessible to the user.

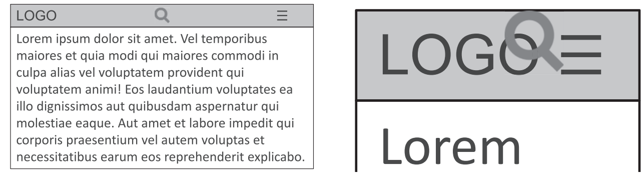
The second example (see Fig. 2) illustrates how magnification may conflict with so-called sticky elements on web pages such as navigation bars that are always visible in the viewport regardless of where the user is on the page. Fig. 2(a) shows the entire sticky menu bar at the top and the underlying content. While scrolling through the text, the menu bar stays fixed at the same position in the viewport. Fig. 2(b) shows the same page with magnification. The area of the sticky menu element has grown and consumes most of the viewport real-estate thereby obstructing the website contents. Additionally, the menu elements including the logo, the search icon, and hamburger icon are scrunched together making them hard to read.

Note that in web markup terminology such elements are referred to as either *fixed* or *sticky* with some subtle technical differences in how they behave with scrolling. For simplicity, *sticky elements* will be used herein to encompass all elements permanently sticking to the viewport including CSS *fixed* elements.

Based on the attention consent notices have recently received in the research community more generally [4,5] and the specific accessibility challenges discussed among practitioners (e.g. [11,12,13]) it seemed relevant to collect empirical evidence to enhance our understanding of accessibility challenges posed by consent notices and sticky elements. Although previous works have mapped consent notice implementation patterns these have mostly been through the lens of ethics and manipulative design. It is therefore relevant to extend previous work by studying their accessibility. As illustrated by the previous examples, consent notices and sticky elements present accessibility challenges. Such insight is a prerequisite for identifying effective solutions that can contribute to making the web more accessible for all. The following research questions were therefore formulated:

(a) Default view (no zoom) (b) high magnification

Fig. 1. A blocking (modal) consent notice with a) default zoom level and b) high magnification.



(a) Default view (b) high magnification

Fig. 2. A sticky element with a) default zoom level and b) high magnification.

RQ1: How prevalent are blocking consent and sticky elements on common websites?
RQ2: How do developers typically utilise blocking and sticky elements in website implementations?
RQ3: What types of hindrances do blocking consent and sticky elements cause with magnification?

The remaining sections of this paper are organised as follows. The next section reviews related works. This is followed by details about the methodology, results, and discussions. The main findings and its implications are summarised in the conclusions.

2. Related work

Research related to this study can be broadly classified into three categories: research into consent notices on the web, research into accessibility for low vision users, and research into magnification technologies. Each category is reviewed in the following sections.

2.1. Consent notices on the web

The introduction of the General Data Protection Regulations (GDPR) in the European Union [2,3] led to a significant rise in so-called consent notices [4,5]. The phenomenon has been extensively studied using website evaluations (automated web scraping), controlled experiments, user studies, and questionnaires.

By scraping consent mechanisms from 10,000 websites in the UK Nouwens et al. [14] found that just over 10 % met the minimum legal requirements. They also conducted a field experiment with 40 participants which showed that notification style (notice vs barrier) had no effect on choice, removal of the decline option led to higher consent ratios, and multiple options resulted in lower content ratios.

Other studies have reported similar findings. For example, using web crawlers Matte et al. [15] uncovered both consent nudging and websites that registered positive consent even when such consent was not given. Urban et al. [16] investigated how information gathered from such consents are shared between third parties. They measured a drop in information sharing following the introduction of GDPR.

Based on a sample 1000 consent notices in the EU Utz and colleagues [4] identified five consent patterns: (a) no option notices that informs the users that by using the website they are giving their consent, (b) confirmation only notices containing a simple "I agree" option to confirm consent, (c) binary notices with options to accept or decline consent, (d) category-based notices allowing the user to accept or decline consent for specific types of cookies and a strictly necessary cookies which cannot be unselected, and (e) vendor-based cookies that give users even more detailed control of cookies for third-party services used by a website.

Utz et al. [4] also conducted an experiment with 80,000 users on a German website examining the effects of consent notice position, consent framing, and choice type. Their results showed that small design decisions can have a large effect on user decisions. More specifically, they found the lower left part of the screen to be the most effective, binary choices were preferred over multiple alternatives, and nudging had a strong effect on the users' choices.

Machuletz and Böhme [17] conducted a consent decision experiment with 150 university students in two countries to assess the effect of the number of choices. Their results show that the participants viewing an "accept all choices" notice were more likely to accept more cookies than participants viewing individual choices. Those who selected all were also less able to recall what they had accepted and subsequently regretted their choice.

The manipulative aspects of consent notices and so-called *dark patterns* have received much attention [5,18]. Soe et al. [19] studied five distinct dark patterns in context of GDPR, namely nagging (minor redirection in interaction), obstruction (forcing an action by stopping the interaction flow), sneaking (hiding or delaying the disclosure of information), interface interference (manipulating choice), and forced action (required choice).

In a laboratory user study with 24 participants of website privacy choices Habib et al. [20] observed that participants struggled with finding relevant information in conjunction with written opt-out requests. Their participants found it easier to use options in account settings than settings in privacy policies. The authors concluded that in practice it is difficult for consumers to select common privacy choices.

A survey by Bongard-Blanchy et al. [21] involving 406 respondents showed that a majority of those asked were aware of the manipulative designs used on websites, but especially the young respondents were less aware of the potential harms that such designs may cause. Habib et al. [22] recommended that users should have the opportunity to modify their consent choices. They argue that a solution in which inline consent choices are accessible through a persistent button meets several design objectives.

2.2. Accessibility challenges for low vision users

A careful review of the literature was unable to identify published studies on how invasive consent mechanisms on the web affect accessibility. However, there is a vast body of research into various aspects of web accessibility generally, and challenges related to low vision specifically [1,8–9,23–39]. Of relevance to low vision magnifier users is research on the legibility of text through sufficient text size and sufficient colour contrast [23–25].

The Web Content Accessibility Guidelines (WCAG) recommend that users should be able to adjust the text size [26]. One consequence of changes to text size is the reflow of layout where the goal is to prevent users from having to scroll both vertically and horizontally [8]. Reflow has been observed to shorter task completion times [9]. Reflow is especially relevant on small form factor devices such as smartphones. Smartphones present specific issues related to viewing contents in portrait or landscape orientation [27]. It is thus essential that websites are implemented with responsiveness and reflow. Fortunately, the implementation of responsive websites [28] has become commonplace.

Responsive websites and layout reflow may result in certain challenges such as reduced reading speeds caused by word hyphenation [29] and layout failures if the responsiveness is not implemented properly [30]. There are thus many proposals for automatic testing tools for identifying responsive layout failures [30], cross browser inconsistencies [31], and accessibility problems [32]. Such tools typically analyse the Document Object Model (DOM) or use image processing to analyse visual renderings of the interface [33,34].

The idea of responsive reflow has also been extended beyond the web. There are several accounts of experimental prototype implementations capable of reflowing non web contents such as scanned/raster documents [7,35,36], reflow of text with annotations [37,38], and performance optimizations for reflow on resource constrained devices such as eBook readers [39].

2.3. Digital magnifiers

Research into digital magnifier technology has focused on how magnifiers are used and the exploration of new interaction mechanisms for magnifiers. The early studies by Peterson et al. [40] and the review by Blenhorn et al. [41] explored general screen magnifiers. Blekhorn and Evand gave informative insight to the technical challenges associated with implementing general screen magnifiers [42].

Studies of magnifier usage includes the large cohort study by Lou [43] who uncovered that handheld electronic magnifier users used their device on average three minutes a day for mostly near reading and sometimes distance reading tasks. Lee et al. [44] found that it is beneficial to place controls close to the elements they control in magnified views. Zhao et al. [45] studied the preferred magnifying modes, colour enhancement mechanism, and modalism among older magnifier users. They recommended using yellow backgrounds with black (Chinese) text, audio, and overlapping zoom mode. In a study of handheld video magnifier use Lou [46] observed that users mostly viewed non-textual objects.

The Institute for Disability Research, Policy, and Practice collected statistics on assistive technology for low vision web browsing [10]. In their uncontrolled study involving 248 low vision users, 44.7 % reported having very poor vision, 29.9 % having poor vision and 25.4 % having moderate vision. The study conducted in 2018 was a follow up of a similar study conducted in 2013. Their study showed that the needs of low vision users are diverse. For instance, they observed that 21.7 % of the respondents did not enlarge web content and attribute this to tunnel vision where the users may have full visual acuity within a narrow region of the field of view. Moreover, 45.2 % of the respondents used screen readers suggesting a preference for non-visual browsing. They also observed that many users depend on a mixture of assistive technologies such as screen readers, screen magnifiers, and browser magnification to access the web. Of the users who enlarge web contents 30.7 % employed less than 200 % magnification, 29.7 % relied on magnification in the range of 200–400 %, while 17.9 % needed 400 % magnification or more. Next, 71.2 % of the respondents preferred bright text on a dark background, 25.6 % preferred dark text on a bright background, while 3.2 % preferred low contrast themes.

Proposals of new magnifier interaction modes include Billah et al. [47] experimentation with a magnifier that shows zoomed versions of prominent regions in a linear manner. Hence, the cognitively demanding two-dimensional panning task was reduced to a simpler one-dimensional panning task. Using a smartphone camera Shirehjini et al. [48] implemented a magnifier that automatically panned a zoomed region of printed text by tracking a finger moving along the text on paper. Aydin and colleagues [49] described a system for magnifier users that would identify regions of interest in videos and automatically zoom into these regions during video playback. Unlike most studies that treat the magnification level as a fixed Woodruff et al. addressed magnification level changes and proposed the concept of constant information density in zoomable interfaces [50].

In the context of browser magnification on the web Lee et al. [51] described a system for summarising connected elements spread on a website into a more compact form. Related elements were placed in near proximity to each other thereby reducing the need for panning. Lee et al. [52] explored the challenges faced among magnifier users in collaborative writing activities in web interfaces.

Online forums show that sticky elements and consent notices have caught the attention of practitioners and professionals (see for instance [11,12,13]). Moreover, a draft of the upcoming W3C WCAG 2.2 [53] guidelines reveal the proposal of an AA-level success criterion "focus not obscured" (2.4.11) meaning that controls receiving focus must not be hidden behind other contents such as sticky elements and consent notices.

Despite the interest among practitioners and professionals, reviews of previous work did not uncover any publications on the accessibility of consent notices, nor any work on sticky web elements. A Scopus search of titles, abstracts and keywords using '"consent notice"' revealed 15 publications, but '"consent notice" AND accessibility' gave zero matches. Next, the search queries ‘sticky AND accessibility AND web’ gave zero matches, ‘sticky AND menu AND web’ gave zero matches, while ‘sticky AND interface AND web’ gave 17 matches, of which none were relevant. Other approaches were also pursued to identify relevant literature such as eyeballing recent accessibility journal issues and conference proceedings, inspecting references lists in recent web accessibility reviews, wide Google Scholar searches and narrow ACM digital library searches. These search results thus suggest that there is a gap in the research knowledge with regards to accessibility of consent notices and sticky elements.

3. Method

To answer the research question on how sticky elements affect responsive websites viewed with magnification it was decided to employ first-person manual heuristic evaluations of websites. Nielsen [54] gives an insightful account of the strengths and weaknesses of heuristic evaluation of user interfaces. Lumma and Weger [55] provides a comprehensive overview of first-person approaches to research and their benefits most notably that it allows the study of phenomena that otherwise would remain inaccessible to theorising. The heuristics were defined to focus specifically on the high magnification use case. Low vision users may employ one of many possible coping strategies to access contents on inaccessible websites, such as using separate screen magnifiers (assistive technology), relying on accessibility plugins, examining the html source, or even making manual page adjustments via the browser console. Although relevant, coping strategies are not the focus of this study. One key premise of this study is that users must be able to access the content using regular browser interactions only without having to rely on workarounds or additional (assistive) technology. The heuristics were designed to be deterministic, unambiguous, and easily replicable, such that the results would be similar if repeated by other evaluators.

3.1. Materials

A total of 100 Norwegian websites were selected. The inclusion criteria were as follows: First, the websites had to have high traffic or its content being of official importance such as government websites. Second, primarily Norwegian websites were chosen as these represent a coherent sample that must also adhere to the European General Data Protection Regulations (GDPR). The list was compiled from several lists including Norway’s most frequently visited websites [56], most popular online retail websites [57], online banks [58], major public governmental websites, and the websites of the key higher education institutions. Non-Norwegian websites, such as Facebook, were excluded. The list of 100 websites were classified into six content categories comprising 24 online banks, 20 retail websites, 19 news websites, 17 public/government websites, 16 higher education institution websites, and 4 other websites representing popular starting pages. A website list is provided in the appendix.

The observations for specific websites were anonymized in this presentation as the purpose of this study is not to critique specific websites but rather to identify common patterns from which we can learn. The illustrations provided herein are thus simplified reconstructions capturing the essence of actual observations. Only the landing page of each website was evaluated.

3.2. Equipment

The experiments were run on a Lenovo laptop running Windows 10 with an external 24″ monitor, keyboard, and mouse. The display was configured to 1680×1050 pixels and the element scaling factor (device pixel ratio) was set to 175 % in the operating system. These settings are consistent with previous observations of typical low vision browser configurations [10]. Tests were performed using the Google Chrome web browser version 103.0.5060.134 as Chrome was found to be used by a majority (37.5 %) of low vision users [10]. The browser window was maximised with the browser magnification set to 500 % (maximum) as a starting point for each website. The browser viewport width was thus 192 CSS pixels.

There are few official statistics available regarding typical magnification levels used by low vision users. The magnification level will depend on several factors related not only to vision but also display hardware and viewing conditions. WCAG 2.1 criterion 1.4.4 suggests that text should withstand a magnification of 200 % without assistive technology, but this relative limit will not help low vision users if the original text is specified with a small absolute text size. WCAG 2.1 criteria 1.4.10 recommends that content should be reflowed to support minimum viewport widths of 320 CSS pixels. The W3C documentation gives an example where a 320 CSS pixels viewport is equivalent to 1280 CSS pixels viewport magnified at 400 %. A magnification of 300 % with the current setup matches the WCAG limit of 320 CSS pixels. The W3C documentation does not describe how this value was determined, but this width matches that found on several smartphones.

Third party professional magnification products offer much higher magnification rates. For instance, ZoomText, MAGic, and Supernova offer magnifications up to 3600 %, 6000 %, and 6400 %, respectively. Even though only a small statistical portion of users may rely on 500 % magnification (or more), these users have the same rights to access the web as everyone else.

3.3. Accessibility heuristics

The following heuristics were employed as the main structure during the testing of the websites with high magnification to assess whether they are perceivable and operable without reducing the zoom level:

READABLE-HEURISTIC: Are contents needed to make decisions readable? (by scrolling if necessary).
OPERABLE-HEURISTIC: Are controls needed to make decisions operable? (for example, the ability to give consent regardless of whether consent text is accessible or not).
CLOSABLE-HEURISTIC: Can sticky elements be closed?

3.4. Procedure

All the evaluations were carried out by the author. One evaluator was sufficient as the evaluation procedure was mechanical and deterministic without any subjective components requiring multiple assessors. The evaluator is a human–computer interaction and accessibility expert with reduced vision and a regular user of magnification technologies. The evaluations were conducted during August 2022.

A clean browser window was used to ensure that no existing cookies were associated with the list of websites. Each website was loaded into the browser using incognito mode. First the magnification level was set before the analysis began because the browser magnification level was not automatically transferred across different websites.

For most cases the test involved two phases. The first phase involved observing any temporary consent notices that usually first meets the user, and the second phase involved observing permanent sticky elements such as navigation menus that become visible once the consent choice is made.

The inspection of consent notices involved seeing if it was possible to read the necessary information (READABLE-HEURISTIC) and/or access the controls/select a choice (OPERABLE-HEURISTIC) with the current magnification level (by scrolling if necessary). Text was classified as readable if it was possible to view the text with or without scrolling within the viewport, and unreadable if the text was positioned outside the accessible viewport. Similarly, controls were classified as operable if they were clickable within the viewport area with or without scrolling. They were classified as inoperable if positioned outside the viewport (scrolling not available).

If it was necessary to zoom out to read or access the content the adjusted zoom level was recorded. Google Chrome does not zoom continuously, but in discrete steps. With the current configuration Google chrome provided the following zoom levels in decreasing order: 500 %, 400 %, 300 %, 250 %, 200 %, 175 %, 150 %, 125 %, 110 %, 100 %, 90 %, 80 %, 75 %, 67 %, 50 %, 33 %, and 25 %. This procedure allowed the identification of the critical magnification points where the responsive designs break.

A similar evaluation approach was applied in phase two. In addition, an assessment how the permanent sticky elements competed with the other contents for viewport real-estate. Especially, if mechanisms for closing the sticky element were provided (CLOSABLE-HEURISTIC). The observations were systematically recorded including the different patterns and implementation variations.

4. Results

4.1. Blocking consent and sticky element prevalence (RQ1)

Out of the 100 included websites 89 % contained some form of obstructive consent notice and/or permanent sticky elements. The sample contained 73 % of what can be defined as some consent mechanism, while 67 % of the websites had blocking consent, 70 % of some form of permanent sticky element.

Fig. 3 shows the distribution of blocking consent for different website types. Banks, news, and retail had the highest ratio of blocking consent (more than 70 %, while higher education institutions (37.5 %) and public organisations (17.6 %) had the lowest. The ratio of websites that used sticky elements varied less than those that employed blocking content (see Fig. 3), with banks having the highest ratio (83.3 %) and higher education institutions the lowest ratio (50 %).

4.2. Common implementation patterns (RQ2)

Most consent mechanisms observed can be classified as what Utz and colleagues [4] described as category-based notices (detailing the cookie types allowed). Binary choice (agree/decline) was the second most common pattern. In most cases the blocking mechanism was effectively a modal dialog implemented by placing the consent contents in front of the main website content thereby obstructing access. In one case the likely intention was to present a blocking consent box. However, the probably faulty implementation of responsiveness resulted in this consent form appearing as non-blocking outside view making the underlying document content accessible.

In one instance the consent message was briefly shown by automatically scrolling through the text. Unless the visitor was alert and read the scrolling message the user would have to zoom out to read the consent message.

Navigation menus were the most common sticky element found on the websites. In a few instances the sticky navigation menus were implemented in such a manner that they only became visible when scrolling upwards (towards the top of the page), hence not obstructing the view while scrolling downwards (ordinary page reading mode). In addition to permanent sticky elements, 7 % of the websites presented additional closable blocking windows including promotions, invitation to participate in surveys, invitation to subscribe to newsletter, and "get in touch" invitations.

The other types of permanent sticky elements included chat icons that would activate a chatbot or manual customer service chat (see Fig. 4), arrow up icons that would take the user to the top of the page from anywhere on the page (see Fig. 5), and "recycle" icons that gave access to the consent choice settings (see Fig. 6). Although different in visual appearance, in the magnified view these appeared vertically in the middle of the viewport on either left or right side superimposed on top of the webpage contents. Hence, the text contents were partially readable behind the sticky elements.

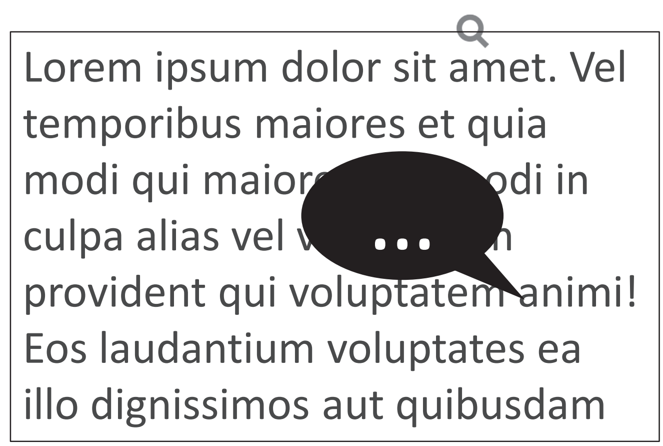


Fig. 4. Sticky chat icon in magnified view.

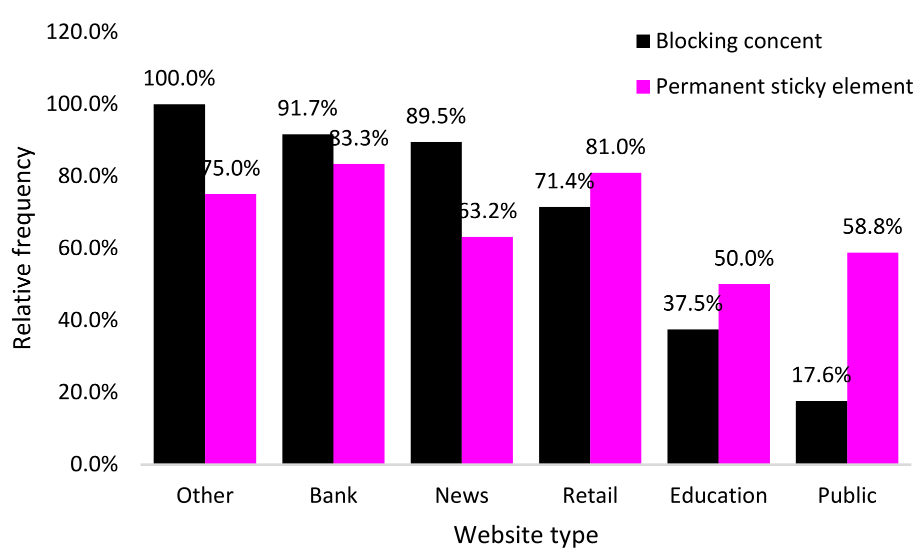


Fig. 3. Relative frequency distribution of obstructive elements according to website type.

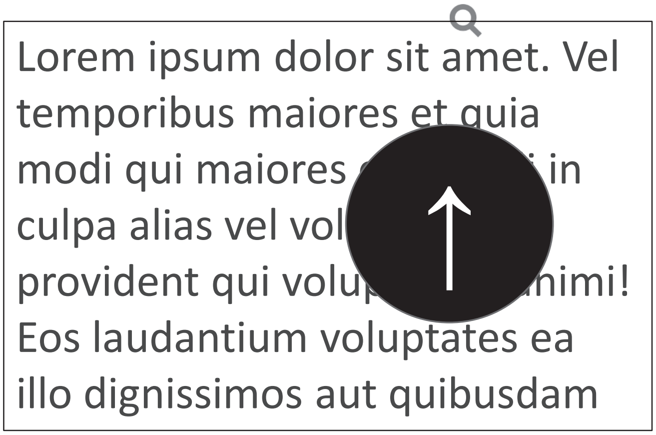


Fig. 5. Sticky up icon in magnified view.

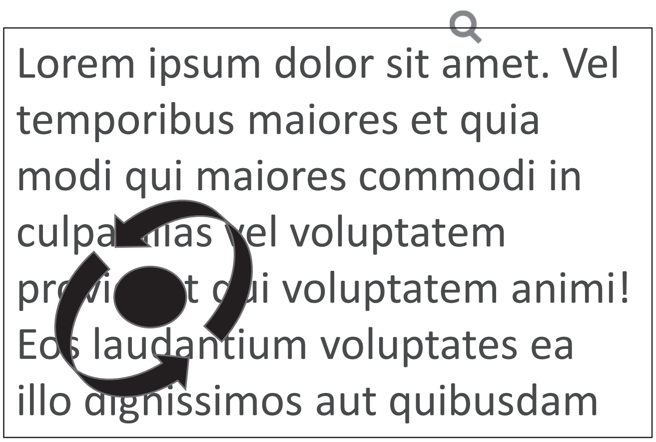


Fig. 6. Sticky update consent control (consent recycle icon) in magnified view.

Multiple instances of identical mechanisms for consent and sticky elements were observed for different websites indicating that several websites utilised the same underlying technical platforms (especially higher education institutions), same service providers (especially banks), and/or same owners (especially newspapers).

4.3. Accessibility with browser magnification (RQ3)

All websites responded to magnification adjustments, while some responded more than others. Some websites exhibited weaknesses in the implementation of the responsive layout causing visual rendering problems. Although these rendering problems were not aesthetically pleasing they cannot be classified as accessibility problems. Examples included contents overflowing their parent elements, problematic media-query breakpoints causing unexpected jumps in the layout, and confusing division of scrolling mechanism across page and menus.

Table 1 summarises the observed accessibility problems. Only 17 websites contained readable consent information (25.4 %), meaning that the consent information on 50 websites (74.6 %) with blocking consent were inaccessible in the magnified view. Next, 49 websites featured accessible controls (73.1 %) meaning that the consent choice could be selected irrespective of the accessibility of the accompanying message (see Fig. 7). This allows users to simply get rid of the blocking consent and proceed to the contents. In cases where consent content cannot be read the user will give uninformed consent. In the remaining 18 websites (26.9 %) the user would not be able to access the consent control and move on to the website contents (see Fig. 8).

Content overflow, that is, content occluded by the vertical sides of the viewport (not accessible through horizontal scrolling) was the most frequent cause of inaccessibility occurring on 51 websites (76.1 %). Occlusions resulting from elements scrunched together during the reflow process were less prevalent occurring only on 4 websites (6.0 %). One website introduced horizontal scrollbars in the magnified view

Fig. 7. Unreachable consent text due to a lack of scrollbars (uninformed consent).

Table 1
Accessibility problem statistics.

Interface category	Issue	Accessible		Inaccessible		Total Frequency
		Frequency	Percent	Frequency	Percent	
Blocking consent notices	Reading	17	25.4	50	74.6	67
	Controls	49	73.1	18	26.9	“
	Vertical border occlusion, no scrolling	16	23.9	51	76.1	“
	Scrunched contents	63	94.0	4	6	“
	Horizontal scrollbar	66	98.5	1	1.5	“
	Need to zoom out	12	17.9	55	82.1	“
Sticky elements	Reading	50	71.4	20	28.6	70
	Controls	52	74.3	18	25.7	“
	Overflow	48	68.6	22	31.4	“
	Occlusion	61	87.1	9	12.9	“
	Horizontal scrollbar	69	98.6	1	1.4	“
	Full page obstruction	54	77.1	16	22.9	“
	Partial page obstruction	57	r81.4	13	18.6	“
	Closable sticky elements	2	2.8	68	97.1	“
	Need to zoom out	43	61.4	27	38.6	“
Consent notices						73
(Blocking) consent notice or sticky element						89
Total websites						100

Fig. 8. Unreachable controls (button) due to a lack of scrollbars (user is locked out).

hence violating the reflow principle of keeping content within the horizontal bounds of the viewport. However, the information was still accessible via horizontal scrolling and was not labelled as an overflow in the classification used in this study.

On 55 websites (82.1 %) it was necessary to zoom out to access the consent message. Fig. 9 shows the distribution of minimum zoom levels needed to access the consent mechanisms. The median minimum zoom level that revealed the full consent information and controls were 200 %.

One specific consent mechanism stood out in that the text size decreased as a function of zoom level. From the 200 % zoom level break point the more the page was zoomed in the smaller the text became. Hence, the entire text was technically visible at all zoom levels but practically unreadable in the zoomed version due to the small text size. The underlying reason seems to be an unintentional side effect of a responsive design where the designers have not properly tested the narrow-width media query breakpoints.

Overall, the permanent sticky elements caused fewer problems than the blocking consent mechanisms. The contents of the sticky elements were readable on 50 websites (71.4 % of the websites with sticky elements) and not fully readable on the remaining 20 websites (28.6 %). Next, 52 websites (74.3 %) had accessible controls. In some instances the link for expanding the menu was not reachable. In other instances the control was reachable, but the menu was expanded out of view without access via scrolling. Again, overflow was the most frequent cause of inaccessibility (22 websites), followed by occlusions (9 websites) and only one website introduced horizontal scrollbars in the magnified view.

Although the sticky elements in most cases did not result in technical inaccessibility they resulted in practical inaccessibility as the sticky content grew and obstructed most of the view (see Figs. 4, 5 and 6). On 16 websites (22.9 %) the sticky elements obstructed most, or all, of the viewport real-estate (approximately 50 % to 100 %). On 13 websites (18.6 %) the sticky elements obstructed a notable portion of the display real-estate (around 10 %). Moreover, these were positioned in the middle of the viewport thereby drawing much attention and partially obstructing the webpage contents. Although the webpage contents were readable behind these elements, they are undeniably an irritating element analogous to "dirty windows" that reduced the web browsing experience. Only 2 websites had closable sticky elements (2.8 %).

On 27 of the websites (38.6 %) it was necessary to zoom out to access the sticky element contents. Fig. 10 shows the distribution of minimum zoom levels needed to access the consent mechanisms. The median minimum zoom level that revealed the full sticky element contents and controls were 300 %. A one-tailed Mann-Whitney test for independent groups showed that the minimum zoom level needed for the consent was significantly smaller than the minimum zoom level for the sticky elements ($W = 431.0$, $p = .028$, ES = -0.274). Note that the effect size (ES) is given by the rank biserial correlation.

Only 3 % of the websites did not cause any notable challenges based on the criteria defined herein and thus provide inspiration as exemplary examples to follow.

5. Discussion

5.1. Blocking consent and sticky element prevalence (RQ1)

The results support the claim that most websites contain both temporary blocking elements and permanent sticky elements. In too many cases, their implementation make content inaccessible when the content is magnified. Even more often the implementations lead to reduced usability.

One explanation for the observation that consent mechanisms are more common in the private business sector (retail, banks, and news) and less prevalent in public organisations (higher education institutions and government units), could be that public organisations are under stricter regulation and auditing than the private sector. For instance, public organisations may be more closely audited in terms of GDPR compliance. Moreover, the introduction of the Web Accessibility Directive (WAD) in Europe imposes stricter accessibility requirements on public organisations to serve all citizens of society.

There is also possibly a functional explanation in that businesses (such as retail, banks, and newspapers) rely on customers to survive and therefore have a stronger interest in collecting information about their visitors. In comparison the need to collect such information may be less crucial in organisations funded through taxpayers.

If no data is collected, there is clearly no need for data collection consent notices. One may therefore question the need to collect user data. On one hand commercial stakeholders may depend on funding low cost, or free, online services by collecting and trading user data. In other

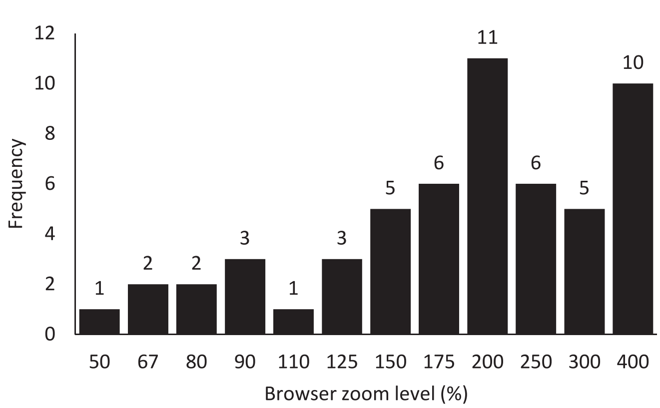


Fig. 9. Frequency distribution of minimum zoom level needed to access the consent mechanisms.

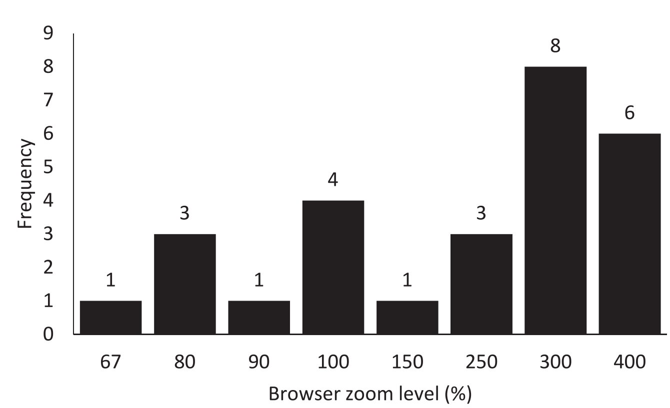


Fig. 10. Frequency distribution of minimum zoom level needed to access the permanent sticky elements.

instances, there may be no clear intention and purpose behind the data collection. In such cases, it may be worthwhile for the website owners to carefully deliberate over the benefits versus drawbacks of user tracking.

The prevalence of sticky elements across all the website types studied suggests that the sticky element pattern is an established component in contemporary web design. Web design is sometimes driven by trends to ensure that a website appears visually inviting, engages, and does not come across as outdated. One may ponder whether sticky elements are included because "others do it too" or whether it is a consequence of careful deliberations.

5.2. Common implementation patterns (RQ2)

The fight for visibility on landing pages is a well-known phenomenon. One can assume that organisations typically have careful processes deciding what information goes on which pages and why. However, the results may indicate that less thought has gone into considering the screen-real estate usage for magnification users. A navigation menu that gives instant access to important content may seem practical. Similarly, visible chat functionality for helping users also seems useful. However, the placement of consent and cookie recycle functionalities in prominent locations overshadowing the website contents seems problematic as such functionalities are probably less frequently used. One may argue that giving access to such functionality via a regular menu item would suffice thereby providing access to the functionality without interfering with the contents.

A similar question may be raised regarding the "take me to the top" arrow icons. On one hand a narrow-width viewport results in more vertical scrolling than a wider viewport, but these elements also obstruct more of the view in the narrow viewport than a wide viewport. It would be relevant to conduct a user study to assess to what degree such functionality is used and if it is perceived as useful. One may argue that most users know how to scroll to the top of the page and that they should learn to use the home-key (command arrow-up) shortcut.

5.3. Accessibility with browser magnification (RQ3)

It is a promising sign that most of the websites implemented responsiveness. Still, many websites exhibited problems with the implementation of the responsive contents, especially with narrow width viewports, leading to both aesthetical visual rendering failures and accessibility problems. It seems that the responsive problems are more prevalent in peripheral elements such as the blocking consent and sticky elements compared to the main contents. One may speculate that this is due to a lack of knowledge about the low vision magnification use case. Consequently, such use cases may not be adequately tested. Perhaps these are "peripheral extras" that are not integral to the main contents. An important principle is to try to fit the contents into the width of any given viewport in a meaningful way, and in cases when this is not possible at least the contents should be accessible through horizontal scrolling as a last resort. Inconvenient access is preferable to no access.

The observation that permanent sticky elements caused fewer problems than the initial consent mechanism may suggest that their respective implementations are handled separately. Perhaps more intense efforts have been devoted to the main content while consent mechanism may be more of an afterthought? A possible explanation is that developers forget to test the overall user experience of the consent mechanisms because these are often displayed just the first time the website is visited. It would have been interesting to explore if developers fully reset the browser state at the start of each test, that is, clearing browser cookies. It would be especially interesting to gain insight into how this is achieved with remote testing where users use their own machines.

The prevalence of sticky elements stealing valuable real-estate in a magnified view could indicate a lack of testing. Had the developers spotted these rendering problems it is likely that they would have corrected the problems. Several websites exhibited examples of practical patterns where the sticky element problem is avoided. Not having sticky elements in narrow viewports is one obvious strategy, or to only display the sticky elements when relevant (when scrolling upwards) is another pragmatic approach. A third approach is to implement closeable sticky elements. That only two of the 100 websites allowed the sticky elements to be closed suggest that closable sticky elements are not widely implemented.

On several of the websites it was necessary to zoom out to access the blocking consent and or sticky elements. A need to zoom out defies the purpose of magnification as zoomed out content may not be easily readable by the low vision users. One coping strategy for such situations is to zoom out within the browser and use a separate magnifying tool to help read the text. The combined use of a browser and separate magnifier adds to the browsing complexity as the user needs to pan simultaneously within both the browser window and within the area covered by the magnifier (see Fig. 11). Moreover, unlike the in-browser magnification which limits scrolling to one dimension (vertically only) screen magnifiers are panned in two dimensions [9].

Although the evaluations were conducted with a narrower viewport width (192 CSS pixels) than the minimum width of 320 CSS pixels specified in WCAG 2.1 [26] the zoom-out results reveal that several of the websites also did not meet the WCAG 1.4.10 reflow criterion. As much as 40 % of the websites exhibited inaccessible consent messages and 13 % of the websites had problems with sticky elements when the magnification was less than 300 % (more than 320 CSS pixels wide viewports). However, it must also be noted that in Norway WCAG 2.1 only applies to public institutions and the revised guidelines only took effect January 2022 as part of the European Web Accessibility Directive (WAD). This could explain the observed WCAG violations.

One may question whether the WCAG viewport width limit of 320 CSS pixels is a representative choice intended to include all users relying on their vision, whether it is a smartphone-centric value, or whether it is a pragmatic compromise that meets the needs of a majority user with uncorrected to moderately reduced vision where the remaining minority will have to rely on assistive technology?

The observations revealed signs of reuse practices where existing libraries, frameworks, and content management system templates were adapted. Reuse can contribute to accessibility if the source is accessible while reuse is obviously problematic it leads to inherited accessibility problems. Moreover, frequent uncritical reuse of inaccessible resources may contribute to the legitimization of undesirable practices. Ultimately, it is the website owner that is responsible for the resulting accessibility.

A potential consequence of the fact that consent controls were generally more accessible than the consent texts could indicate that some users give their uninformed consent. As most of these consent mechanisms are similar users become fatigued and simply want to access the contents. Such patterns are reported by several researchers [21,22].

Several of the studies of consent mechanisms describe these as often following dark patterns intentionally crafted to misguide or nudge visitors into certain choices [5,18]. The problems discussed herein however are probably not a result of sinister intent or questionable ethics, but rather a consequence of insufficient insight about how magnification users read web contents.

5.4. Contributions, implications, and recommendations

The main contribution of this study includes the following: First, the collected data documents the prevalence of sticky and/or blocking elements on the web (89 %). Specifically, 70 % of the websites contained sticky elements, and 73 % of the websites contained consent notices. The results suggest that the prevalence of consent notices varied across different website types while the prevalence of sticky elements was more

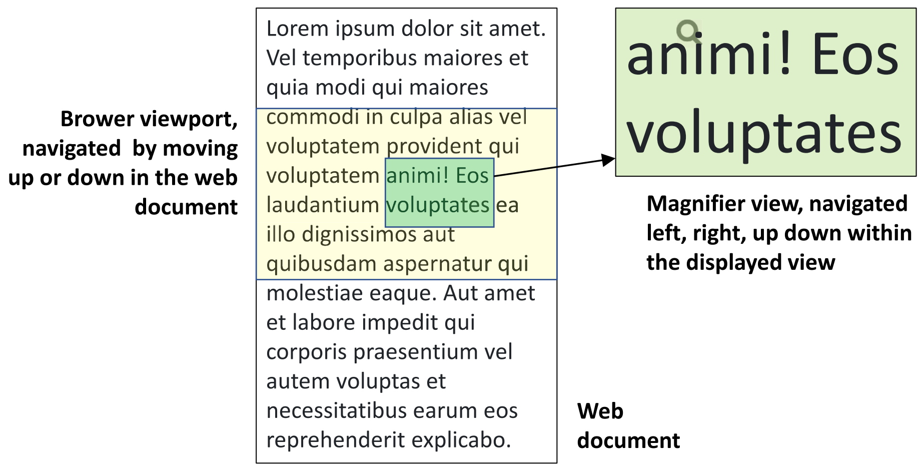


Fig. 11. A window inside a window: Coping strategy of using a magnifier with browser contents.

consistent. Sticky navigation menus were most common. There were also several instances of sticky promotions and invitations, shortcuts to chat functions, take-me-to-the-top shortcuts, and "recycle" consent notice settings.

Second, the data shows that several implementations of consent notices (67 %) and sticky elements (38.6 %) can become an accessibility problem for magnification users. Also, several of the observed websites resulted in presentation failures in the narrow viewport affecting their aesthetic qualities and usability.

Third, about three quarters of the consent notices had inaccessible content while one quarter had inaccessible controls. Non-scrollable contents overflowing and being obstructed by the vertical viewport borders were the most common accessibility problem. Approximately one quarter of the sticky elements had either inaccessible content or inaccessible controls due to overflow or obstructions. Moreover, 22.9 % of the sticky elements obstructed the entire viewport while 18.9 % of the sticky elements partially obstructed the viewport. Most of the sticky elements (97.1 %) could not be closed.

Finally, several best-practice examples were observed demonstrating that web developers and content owners have several pragmatic options for making websites more accessible to magnifier users. These best practices provide a basis for the following recommendations:

Design for narrow viewports: Web designers should explicitly consider and define how the content should appear in narrow viewports and include narrow viewports as an explicit test case. Simple narrow viewport testing can help identify basic accessibility problems without the help of magnification users. This recommendation is related to the WCAG 2.1 reflow criterion 1.4.10.

Avoid sticky elements with narrow viewports: A sticky element may be a useful mechanism when sufficient real-estate is available, but risk competing with other content when the viewport real-estate is limited. Websites should respond to narrow viewports by presenting such elements as an integral part of the contents instead of superimposing or stacking such elements on top of the contents.

No tracking, no consent: The challenges of blocking consent notices can be avoided by not collecting information about visitors in situations where such information is not needed. If no information is collected and stored, no corresponding consent is needed.

Allow sticky elements to be closed: When using sticky elements, the user should have the option to close unwanted sticky elements. This recommendation could be considered a special case of the WCAG bypass block criterion 2.4.1.

Only show sticky elements when relevant: The pattern of showing menu elements when scrolling upwards frees up valuable viewport real-estate when users read or scan the contents from top to bottom.

Allow scrolling access to content stacked vertically outside the viewport: With any content, including sticky contents, that does not fit vertically within the viewport should be accessible through vertical scrolling. This is related to the WCAG perceivable principle.

Moderation in horizontal contents: Several of the websites had too many visual elements cramped into vertical zones (logo, menu, and links) causing the elements to scrunch together and partially overlap. One should avoid such overlaps and ensure sufficient spacing between elements so that they can be identified as separate elements. This can be achieved by limiting the number of visual elements placed in one vertical zone. This is also related to the WCAG perceivable principle.

Reset browser state while testing: By resetting the browser for each test during development will allow developers to notice problems with cookie related content such as blocking consent boxes.

5.5. Limitations

This study is based on frequently visited Norwegian websites and the results therefore do not give explicit insight into the use of sticky elements globally. Still, it is argued that the results presented herein somehow generalise to global websites as web design and web technology exist in an international ecosystem, using the same resources as other web developers worldwide including web-standards and discussion forums such as Stack Overflow. Designers of Norwegian websites do not work in a national bubble, but rather are affected and inspired by patterns, practices, techniques, and solutions found on websites globally. Future work could however apply similar techniques to websites in other countries to confirm that the prevalence of sticky elements indeed is a global trend.

The scope of this study was limited to magnifier users. There may be other accessibility challenges with sticky elements for other user groups that were not uncovered. Future work could investigate how sticky elements potentially may cause problems for users with other types of reduced vision besides reduced visual acuity, users with reduced motor function, particularly those who require alternative input devices, or users with reduced cognitive function.

A key assumption herein is that browser magnification is used by low vision users. Data collected by the Institute for Disability Research, Policy, and Practice [10] indeed confirm the prevalence of browser magnification use among low vision users (44 %). Their results also show that a majority (48.4 %) of low vision users relied on screen magnifiers for browsing the web. The study does not give details as to how and when the screen magnifiers are used, but it is pointed out that 68 % of the respondents used 2 or more assistive technologies and 23 % used 4 or more technologies. It is therefore possible that some users use both browser magnification and screen magnifiers in combination. A lack of computer literacy could be an explanation for the use of screen magnifiers within browsers. However, only 1.6 % of the respondents reported being beginners while 69.8 % classified themselves as having advanced proficiency. Perhaps a more plausible explanation is that the use of screen magnifiers while browsing the web is a symptom of insufficient website accessibility?

Some users may use screen magnifiers all the time while others are likely to activate screen magnifiers when needed. Perhaps these users handle inaccessible blocking consent notices using the screen magnifiers as a coping strategy? Viewing a non-magnified consent notice page will not trigger the accessibility problems discussed herein although the usability will be low due to the panning challenges illustrated in Fig. 11. Consent notice implementations that more gracefully adapt to narrow viewports are likely to reduce the need for screen magnifiers. Ultimately, one could argue that it should be possible to browse the web without the need for additional screen magnification software.

It must also be noted that the Chrome web browser provides a maximum magnification of 500 %, while 8 % of the low vision respondents in [10] relied on a magnification of 600 % and more. Obviously, if operating system settings and browser magnification are unable to provide sufficiently large text the user will indeed need additional screen magnification software.

Further research is needed to get more complete and deeper insight into how different low vision cohorts digitally magnify web contents, and especially how, and why, screen magnifiers are used together with browser magnification. It seems particularly relevant to explore cohorts defined by age, education level, and computer literacy.

Finally, this study was limited to laptop/desktop browsers as low visual acuity users are more likely to prefer a larger display over small displays such as those found on smartphones. This limitation is aligned with previous findings [10] which showed that 82.3 % of low vision users used laptop/desktops as their primary device, while only 12.9 % used tablets, and 4.8 % used smartphones as their primary device for web browsing. However, the relatively large cohort of users with minor visual correction may also require increased text sizes on smartphones due to their small form factor. Future work could therefore investigate how blocking elements affect smartphone users with large text configurations. Some of the challenges with obstructing elements addressed herein are likely also relevant to smartphone use, i.e., sticky elements obstructing the view when applying a zooming gesture.

6. Conclusions

This study has provided new insight into how sticky elements can cause accessibility challenges for users that rely on magnification within the browser. A set of 100 websites drawn from the most frequently used websites in Norway were evaluated in terms of sticky element usage. Most websites were implemented with some degree of responsiveness although in a large portion of cases the design broke when viewed with a narrow viewport. Moreover, most of the websites were implemented with some form of either temporary blocking elements, permanent sticky blocking elements, or both. In a large portion of the cases these elements hindered access to the content when viewed with a narrow viewport. Additionally, in many cases the sticky element implementations lead to reduced usability due to the navigation workarounds required by the user. More accessibility problems were observed for the temporary consent notices compared to the permanent sticky elements. Permanent sticky elements were most frequently used for providing menus, and in some cases shortcuts to chat functionality, return-to-top and cookie configurations. This study also uncovered underused and simple best-practice patterns that prevent these problems from occurring demonstrating that web developers have several accessible alternatives at their disposal. Examples include the replacement of sticky elements with vertically stacked contents, only to show sticky elements when relevant (when scrolling upwards), and to allow sticky elements to be closed. A key implication of this study is that web developers should include narrow viewport use cases in their tests. Website owners should critically consider the costs associated with mechanisms that warrant consent notices, such as user tracking, on reduced accessibility and usability. Implications of the recommendations presented herein is that low-vision users will face fewer hurdles when browsing the web. Future work could explore the possibilities of making sticky element mechanisms an implicit part of the responsive framework where it is the user's personalisations that determine how the content is viewed in the browser. Another possible avenue for future work is to improve development tool support for narrow viewport use-cases.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix

List of evaluated websites (alphabetical):
News websites:

1. abcnyheter.no
2. adressa.no
3. aftenbladet.no
4. aftenposten.no
5. bt.no
6. dagbladet.no
7. dagsavisen.no
8. digi.no
9. dn.no
10. e24.no
11. finansavisen.no
12. khrono.no
13. kk.no
14. nettavisen.no
15. nrk.no
16. seher.no
17. tek.no
18. tv2.no
19. vg.no

Higher education institution websites:

20. himolde.no
21. hiof.no
22. hvl.no
23. inn.no
24. kristiania.no
25. nmbu.no
26. ntnu.no
27. oslomet.no
28. oslonyehoyskole.no
29. uia.no
30. uib.no
31. uio.no
32. uis.no
33. uit.no
34. usn.no
35. vid.no

Retail websites:

36. apotek1.no
37. ark.no
38. blivakker.no
39. cdon.no
40. clasohlson.com/no/
41. elkjop.no
42. ellos.no
43. felleskjopet.no
44. fjellsport.no
45. jernia.no
46. jollyroom.no
47. kicks.no
48. komplett.no
49. miinto.no
50. netonnet.no
51. norli.no
52. oda.no
53. vitusapotek.no
54. xxl.no
55. zalando.no

Public organizations:

56. fhi.no
57. hovedredningssentralen.no
58. konfliktraadet.no
59. lanekassen.no
60. lovdata.no
61. oslo.kommune.no
62. politiet.no
63. pst.no
64. regjeringen.no
65. sivilklareringsmyndighet.no
66. sivilrett.no
67. skatteetaten.no
68. stortinget.no
69. sysselmesteren.no
70. udi.no
71. une.no
72. uutilsynet.no

Bank websites:

73. aasen-sparebank.no
74. andebu-sparebank.no
75. asbank.no
76. aurskog-sparebank.no
77. banknorwegian.no
78. berg-sparebank.no
79. bien.no
80. birkenes-sparebank.no
81. bjugn-sparebank.no
82. blakersparebank.no
83. bnbank.no
84. danskebank.no
85. dinbank.no
86. dnb.no
87. gjensidige.no
88. husbanken.no
89. nordea.no
90. oasparebank.no
91. orklasparebank.no
92. orland-sparebank.no
93. orskogsparebank.no
94. sparekassa.no
95. storebrand.no/bank
96. ya.no

Other websites (miscellaneous):

97. finn.no
98. klikk.no
99. sol.no
100. startsiden.no

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