



Web accessibility gaps in online video platforms: video services ahead of the European Accessibility Act (EAA)

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Abstract

Web accessibility enhances the usability of websites for persons with disabilities, who make up about 16% of the global population, including 87 million in the European Union (EU). To protect against discrimination, laws and regulations have been enacted worldwide, including digital types such as websites, apps, and software. The Web Content Accessibility Guidelines (WCAG) provide a standardized framework that is important in EU legislation. Currently, a directive mandates accessible digital services for public entities in the EU. The forthcoming European Accessibility Act (EAA), effective June 2025, will require all companies operating in the EU to comply with accessibility regulations, affecting a broad range of goods and services, including digital products. This study evaluates the web accessibility of four popular online video platforms in Austria - Amazon Prime Video, Disney Plus, Netflix, and YouTube - using their desktop web versions and mobile apps. The evaluation involved two phases: an automated test using the WAVE evaluation tool and a manual examination based on a checklist of 53 criteria grounded in WCAG 2.1. The analysis revealed significant accessibility issues across all platforms, particularly keyboard navigation, color contrast, responsive content, screen reader compatibility, and media alternatives. Many problems were device-independent, highlighting the need for improvement. The study suggests further research for a deeper evaluation of content and additional devices.

Keywords Web accessibility · WCAG · European Accessibility Act (EAA) · Online video platforms · Accessibility evaluation

1 Introduction

Approximately 16% of the world's population, or more than 1 billion people, have some form of disability, according to the World Health Organization (WHO). In the European Union (EU), this is equivalent to about 87 million people. Regarding the situation in Austria and a total population of around 9 million, the figure mentions approximately 1.4 million persons with disabilities. Furthermore, most people will experience a temporary or permanent disability at some point [1–3]. For decades, legislators around the

world have been insisting that people should not be discriminated against. One form of discrimination, among many other characteristics, is discrimination based on physical or mental impairments. For example, public buildings or even means of transport should be accessible to everyone, regardless of whether they are, for example, in a wheelchair or on foot; this is referred to as *accessibility* [4, 5]. Since the invention of the Web, many approaches and functionalities have been developed to increase the accessibility of this medium for persons with disabilities. As a standardized guideline, the Web Content Accessibility Guidelines (WCAG) are considered in legal texts or guidelines, such as the European Union Directive on accessible access to public websites and mobile applications [6].

WCAG 2.1 includes a number of recommendations to make web content more accessible. The principles are divided into four technology-independent categories, *Perceivable*, *Operable*, *Understandable*, and *Robust*, each containing guidelines and testable success criteria. The purpose of adhering to this standard in web design is to ensure better

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usability of content in general; this is particularly beneficial for persons with disabilities, such as blind or deaf persons, persons with motor restrictions, or those with cognitive impairments [7].

The issue of inadequate implementation of accessible offerings is also addressed in journalistic reporting. Although an increasing improvement in accessibility is noticeable or being implemented in web offerings from government agencies, there are no or only conditional legal bases in other areas that demand barrier-free access [8].

Consequently, the EU proposes the European Accessibility Act (EAA) as a means to counteract this trend. As of 2025, the directive is intended to make digital products and services more accessible to all [9].

The EAA also recommends that companies in the private sector be required to eliminate barriers in their (digital) products and services. There are also efforts being made in this direction in other countries around the world. In addition, interest groups are taking legal action to enforce certain accessibility functions. A notable example is the 2011 lawsuit filed by the US National Association of the Deaf¹(NAD) against Netflix. In an official statement from 2011, the NAD reports on their claim and a filed lawsuit alleging that Netflix violated the Americans with Disabilities Act (ADA) by failing to provide subtitles for most of its movies and series [10].

The streaming provider now emphasizes its efforts to improve accessibility in its external communications, such as on Global Accessibility Awareness Day in May 2022. At least in their external presentations, (media) companies are generally moving toward accessibility and inclusive design; Spotify is a further example [11, 12]. Although these efforts appear to be highly commendable from the outside, this study aims to determine to what extent accessibility is actually ensured.

As a standardized international guideline, the WCAG² provides a framework for analyzing and evaluating web offerings. Accessibility studies have been conducted on the websites of public authorities, government agencies, and educational institutions [13–15].

The focus on this area can be traced back to the legal basis that requires a certain degree of accessibility for public organizations' and institutions' websites. As with the EU Directive 2016/2102, this is the case. Furthermore, individual EU member states have their own legislation. Austria has implemented the *Web-Zugänglichkeits-Gesetz* (WZG) [16]. For example, Italy has the Stanca Act [14].

However, accessibility affects all areas of the Web, including private sector offerings. Online shops, travel

portals, and entertainment offerings, to name a few, are examples of these. In this study, we focus on the private entertainment industry. An analysis of the most frequently used online video services in Austria is conducted to determine whether they meet the success criteria of the WCAG. Various devices are usually supported by entertainment providers. Web browsers or native applications are used on computers, smartphones, or tablets with different screen sizes to consume media offerings through streaming. As part of this study, empirical analyses were performed to determine to what extent accessibility features differ depending on the device or technology. Additionally, we examined how they use or benefit from accessibility features integrated into smartphone operating systems such as Apple's iOS³.

To conduct the empirical study, two research questions were formulated and derived. First, *to what extent do Austria's most popular online video services meet the success criteria of the WCAG 2.1?* Second, *to what extent does the satisfaction of the success criteria of WCAG 2.1 differ between different devices?*

In view of the upcoming EAA, the purpose of the study is to determine the current state of accessibility in selected online video services (including selected devices). The study provides an overview of the current accessibility status of entertainment services, especially online video.

2 Literature review

Scientific studies have extensively monitored website accessibility for years, with a clear focus on the public sector. This particular emphasis is certainly a result of the legal initiatives discussed above, which require a certain degree of accessibility from public institutions (such as ministries, state and local administrations, or other state-sponsored institutions). The chapter begins by presenting selected works in the *public sector* (including universities that may not be publicly funded for the sake of clarity⁴), then discusses the *private sector*, and concludes with a discussion of web accessibility as a whole.

2.1 Public sector

For the public sector, İşeri et al. [17] examined the websites of higher education institutions in Cyprus. Using several evaluation tools, 38 websites were automatically tested for

¹ <https://www.nad.org>.

² <https://www.w3.org/WAI/standards-guidelines/wcag/>.

³ <https://developer.apple.com/accessibility>.

⁴ There are also studies that examine the web accessibility of educational institutions like universities. This section examines universities in general, since they may also be non-public (i.e., private universities) depending on the region and educational structure of the country in question.

accessibility using WCAG 2.0. No website passed the test without errors. Furthermore, most of the websites examined did not have an acceptable level of accessibility.

The accessibility of 182 Polish local authority websites was examined using software support in a study by Król and Zdonek [15]. Accessibility errors were found on all pages examined. According to the study, 93% of serious problems were reported, and persons with disabilities were unable to use the websites in question. The most common difficulty was insufficient contrast between text and background, such as light gray text on a white background or, generally, text on a photo.

Another study by Acosta et al. [13] examined the accessibility of YouTube videos from 113 top universities. A manual evaluation of 91,421 videos was performed using WCAG 2.1. However, only those WCAG guidelines relevant to moving images were evaluated. In particular, there were 11 success criteria: Six focused on the accessibility of video content and five on the video player, the application used for playback. Closed captions were also tested, with only about 13% (12,257) of the videos examined providing captions. Nearly a quarter of the most recently published videos have captions as well. According to the authors, the higher the conformity a success criterion has, the less likely it is to be met. However, it was also noted that the failure to meet success criteria was partly due to the platform itself - at the time of the study, YouTube did not have any functionalities to provide media alternatives to users, such as sign language descriptions of content or audio descriptions.

The very first report by the *Österreichische Forschungsförderungsgesellschaft mbH* (FFG)⁵ [18] on the accessibility of public authorities' websites and mobile applications in Austria was published by the end of 2021. Its results are required to be reported to the European Commission every three years, according to EU Directive 2016/2102⁶. A total of 253 simplified checks⁷ and 23 in-depth checks, in which experts manually reviewed websites, were carried out over the course of 12 months, along with five manual tests of mobile applications from government agencies. Approximately half of the websites examined (51%) met the WCAG criteria. However, not one website met all the success criteria. The most frequently unmet criteria extend across all four WCAG principles (*Perceivable*, *Operable*, *Understandable*, and *Robust*), including problems with

text alternatives, meaningful titles, multiple languages on the same page, and errors in the correct marking of names, roles, and values of website elements.

Ezell et al. [19] used content analysis and automatic accessibility testing to evaluate accessibility pages from US university libraries in their study. More than half of the pages examined had structural problems and contrast errors, with the latter often attributed to the university branding and its color scheme as the source of these problems.

In their study, Valtolina and Fratus [14] examined the accessibility of local government websites in Italy. According to this study, the authors automatically analyzed the websites of the 7,713 municipalities in the country; however, they only examined the homepages for cost reasons. Specific criteria of WCAG 2.0 and the Italian law on accessibility in IT systems, the Stanca Act, were checked. The websites examined had a low accessibility level: Approximately 88% contained errors. As the authors noted in this context, this number could increase if categories that cannot be analyzed with software support were manually reviewed. However, automated testing alone found that more than half (53%) of the errors were associated with WCAG guideline 1.4 Distinguishability, which is primarily related to color contrast errors. However, navigation problems or missing text alternatives were also common.

2.2 Private sector

A comprehensive study conducted by Wild [20] examined the accessibility of 37 of the most important video players (both free and paid), encompassing desktop and mobile testing. Multiple phases of this evaluation targeted severe accessibility errors (including those identified by WCAG 2.0) through specific knockout criteria (called showstoppers). The study also included persons with visual impairments and used assistive technologies such as screen readers. Although all other players tested were deemed *insufficiently accessible*, the HTML5 players *Able Player*⁸ and *OzPlayer*⁹ were considered the most accessible.

Based on the WCAG 2.1 framework, Acosta-Vargas et al. [21] used an automated testing procedure to analyze the accessibility of the 50 best e-commerce websites globally ranked. As a result of the study, Sainsbury's Supermarkets, Walmart, Target, Macy's, and IKEA ranked highest on the list of the *most accessible websites*. However, the overall accessibility level was low. More than half of the issues were related to color contrast errors and the lack of alternative text. Accessibility errors were discovered to cover all WCAG principles, with approximately 83% related to the

⁵ Translation: Austrian Research Promotion Agency; FFG is Austria's central agency for the promotion and financing of research, development and innovation.

⁶ Web Accessibility Directive - Monitoring reports. (2022). <https://digital-strategy.ec.europa.eu/en/library/web-accessibility-directive-monitoring-reports>.

⁷ Note: Only automated tests are referred to as simplified checks in the report.

⁸ <https://github.com/ableplayer>.

⁹ <https://www.accessibilityoz.com/product/ozplayer-free>.

principle of perceivability, which disproportionately affects visually impaired individuals. In their study, the authors emphasize the importance of improving the accessibility and inclusion of e-commerce websites.

The accessibility of 39 Indonesian e-commerce websites was evaluated by Hafiar et al. [22]. An automated software tool based on WCAG 2.0 was used for the evaluation. The report identified a variety of accessibility errors, including inadequate color contrast, incorrect use of landmarks, and missing alternative text.

2.3 Synthesis

According to the studies referenced in the present article, web accessibility is insufficient and thus improvable. The significant results suggest that the distinction between public and private offerings is irrelevant, although it is important to note that there is considerably less scientifically supported evaluation and literature available for websites operated by private companies. Most studies in this area focus on e-commerce websites.

The most commonly found accessibility errors also follow a similar pattern: Not only are a few of the inspected websites entirely error-free, but they also largely exhibit the same problems. The most common issues include insufficient contrast between text and background, missing text alternatives or descriptions for media (such as closed captions, audio descriptions, and sign language), navigation problems, and non-descriptive hyperlinks. It is crucial that these issues are addressed so that persons with disabilities can use these websites more effectively or even access them.

Most evaluations followed the WCAG; this is not surprising since these guidelines are referred to as technical specifications in many laws worldwide. For example, harmonized European standards, such as EN 301 549, adhere to the World Wide Web Consortium (W3C) standard. Additionally, accessibility assessments of the Web often rely solely on automated testing. Despite resource limitations, comprehensive manual inspections are rarely performed. Due to this, many accessibility errors cannot be identified at all or only to a limited extent. Furthermore, most studies still evaluate desktop websites using a computer or laptop. Scientific assessments of mobile websites or native applications (apps) are scarce.

In most studies on web accessibility, text and image content make up the majority of content, with video content being incorporated sporadically. The authors are unaware of publicly accessible scientific work on websites that heavily use multimedia content, such as video portals. Compared and thematically relevant studies were found only for individual components, such as the YouTube video player [13, 20]. As a result, there is a lack of comprehensive exploration of websites and their multimedia content (especially videos), including how they integrate with mobile applications. The purpose of this article is to fill this gap.

3 Methodology

The study employs a two-stage research design to evaluate the web content of selected online video services, which is based on the *Explanatory Sequential Mixed Methods Design* as outlined by Creswell and Creswell [23]. This type of mixed methods approach combines research methodologies in sequential order, starting with the first phase, which involves collecting and analyzing quantitative data through a software-assisted automated testing procedure. This is followed by the second phase, which entails the collection and analysis of qualitative data through manual website reviews (content analysis). Finally, both phases are integrated into the interpretation of the results to develop a comprehensive understanding of the research problem [23]. Using this combined approach, the study aims to provide a holistic view of accessibility issues. As illustrated in Fig. 1, the sequence of the Explanatory Sequential Mixed Methods Design is depicted according to [23].

According to the design, the quantitative results of Phase 1 could have yielded surprising, unusual, or significant findings that required further explanation. The qualitative approach of Phase 2 ensured this explanatory and deepening function. In the study context, one case for such a necessary deepening could have been the assessment of color contrast on websites, as not all aspects of the required color contrast thresholds could be automatically evaluated, such as text over gradients or graphics. Other scenarios included criteria that needed to be further assessed using assistive technology, such as the correct website structure with the support of a screen reader - these could not be assessed in the first

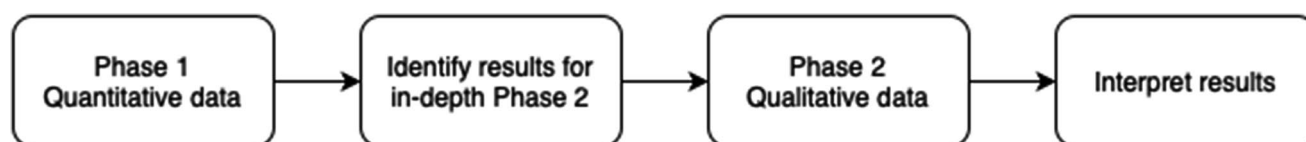


Fig. 1 Flow of the Explanatory Sequential Mixed Methods Design. Adapted from Creswell and Creswell [23]. *Alt text:* A flowchart of the Explanatory Sequential Mixed Methods Design with four items: (1)

Phase 1: Qualitative data, (2) Identify results for in-depth Phase 2, (3) Phase 2: Qualitative data, and (4) Interpret results

phase. Consequently, a deeper evaluation was required here, carried out through manual analysis, i.e., qualitative data collection in Phase 2.

3.1 Data collection and instruments

The framework for evaluations is WCAG version 2.1. The target compliance level is defined as *AA*, as this often serves as the minimum compliance level in legal regulations and is recommended by the W3C, according to WCAG 2.1. All evaluations are performed on macOS Ventura (Version: 13.5.2) and Google Chrome (Version: 117.0.5938.88) or iOS 17.0 and the native applications of the respective online video portals. Additionally, where platform-specific support is available, the following software and hardware are used to assist in conducting the evaluations and subsequent analysis of the Web content. These tools include the WAVE Web Accessibility Evaluation Tool¹⁰ as a Google Chrome plugin (Version: 3.2.3.9), the WebAIM Contrast Checker¹¹ (Bookmarklet) for manual color contrast verification, and the Text Spacing Editor¹² as a Google Chrome plugin (Version: NA) to manipulate text spacing. Assistive technology is also utilized, particularly keyboards and the integrated VoiceOver screen reader on macOS and iOS. Finally, MAXQDA 2022 from VERBI Software GmbH is used to encode and analyze the manual findings.

3.2 Procedure for data collection

In Phase 1, the desktop versions of the online video portals were automatically evaluated using the WAVE evaluation tool. Subsequently, in Phase 2, the desktop versions and mobile applications were manually reviewed. These two investigation phases correspond to the phases of quantitative data collection (automated testing) and qualitative data collection (manual review) of the *Explanatory Sequential Mixed Methods Design*. Data collection took place in September and October 2023, using the versions of the desktop websites and native mobile applications available at that time from the online video services offered in Austria, including Amazon Prime Video, Disney Plus, Netflix, and YouTube.

3.2.1 Phase 1: testing with the automated web accessibility tool (desktop only)

Due to the importance of accessible web applications, various tools have been developed to automatically examine

websites for the most common accessibility issues. In the context of this study, WAVE was used as the software for automated evaluation. This tool has been used in many studies and is recommended for automated testing [21]. Specifically, the respective investigation object was accessed in the Web browser (Google Chrome) and evaluated using the WAVE plugin, as shown in Fig. 2. The identified errors were verified, analyzed, and documented with screenshots.

The number and categorization of errors were transferred to a spreadsheet. Memos of anomalies or areas that require special attention in subsequent manual tests were also noted. Due to limitations, particularly the lack of access to the source code of mobile applications, automated testing could not be performed on the test smartphone. Consequently, only manual investigations were conducted on the iOS platform.

3.2.2 Phase 2: manual examination (desktop & mobile)

The respective object of investigation was reopened in Google Chrome or its corresponding mobile application. Then, an inspection was carried out manually using a checklist. This checklist focuses on those WCAG success criteria that cannot or can only be very limitedly automatically assessed by software. The results of the manual investigation were documented in the checklist (spreadsheet), and the identified accessibility issues (including coding and screenshots) were analyzed in MAXQDA.

3.2.3 Sample

Neither manual nor automatic examination of all pages of the online video portals under investigation was feasible due to their extensive scope. According to Salvador-Ullauri et al. [24] and Lawton Henry & Abou-Zahra [25], a sample was defined to represent the wide range of content types users could encounter during their customer journeys. In this regard, use cases were also defined. Therefore, Table 1 shows the types of content selected for the research design.

Except for test tasks 4 and 5 (content consumption), all selected websites were automatically and manually tested on the desktop version. When focusing on content (particularly closed captions and audio description) and the operation of the video player, as in test tasks 4 and 5, automated evaluation was not feasible due to the limitations of software-assisted evaluation tools— in these cases, only manual assessment was conducted. The platform-specific subpages, depending on the type of content (for example, the content detail page 1 in Netflix *Community*), were randomly selected by the authors or based on the algorithms of the respective online video portals, which tailor their displayed catalog for each user.

¹⁰ <https://wave.webaim.org>.

¹¹ <https://webaim.org/resources/contrastchecker/>.

¹² <https://chromewebstore.google.com/detail/text-spacing-editor/hgiaebohdkgnobadgihbamocckjpeca>.

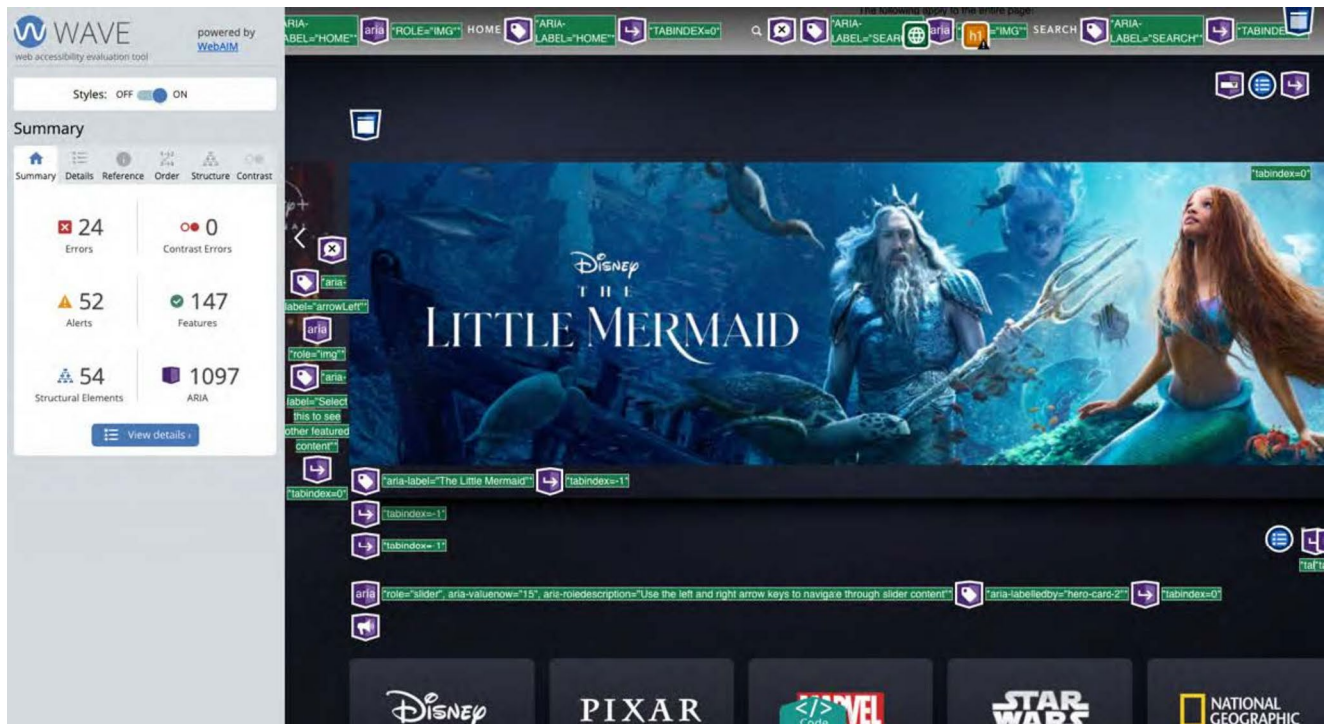


Fig. 2 Example of an automated test with the WAVE plugin. Screenshot of the WAVE Web Accessibility Evaluation Tool (Disney Plus as a test object). *Alt text:* A screenshot of the WAVE Web Accessibility Evalua-

tion Tool, particularly the results of an automated test. It shows, among others, the total number of errors, contrast errors, and alerts. The object tested is the Disney Plus homepage

Table 1 Selected content types

1	Homepage of the online video portal (incl. “Discover the media catalog”)	The homepage is of significant importance because its lack of sufficient accessibility can prevent users from using the website completely or accessing other subpages from it [17].
2	Content detail page 1 (content type A, last title consumed)	The content detail page is relevant because the user decides whether he/she wants to (continue to) consume the content based on the information provided there.
3	Content detail page 2 (content type B, free choice of title)	The task is similar to test task 2, but in contrast to task 2, a title is selected that the user has not yet seen. In addition, a different content type is selected (e.g., if a series was selected in task 2, then a movie is selected here and vice versa).
4	Consumption Content 1	The accessible functionality of the video player is essential for the content (same content as in test task 2) to be consumed at all. Additionally, the content is evaluated regarding the presence (and quality) of closed captions (descriptive) and an audio description. Like test task 4 (with different content; analogous to test task 3).
5	Consumption Content 2	
6	Login User Account (form/form fields for user data)	Core functionality, as a login is usually necessary to use or view the website and its catalog (focus on form fields/keyboard operation, screen reader).
7	Support/FAQ-Page	Relevant content category for users who need support for platform-specific issues (focus on text-heavy content, screen reader).

3.3 Data analysis

As part of this study, the values of the collected data were evaluated in the automated test procedure (Phase 1) in statistical tabular form to determine the absolute frequency of accessibility problems. Graphics such as bar graphs or overview tables were used to visualize these frequencies. A qualitative and interpretative evaluation was conducted in

the manual test phase (Phase 2), also based on the results of the automated test phase.

General and exceptional statements about the accessibility of the websites examined were documented, including screenshots and screen recordings.

Considering that the present study used a mixed methods approach for collecting and analyzing both quantitative and qualitative data, linking the data from both research strands

Table 2 Evaluation criteria overview

Identifier	Description	# Sub-categories (Test Criteria)
T	Keyboard and controls	-
T1	Keyboard focus (general)	2
T2	Navigation (general)	3
T3	Dialog boxes and pop-ups	3
T4	Forms	3
T5	Media control (such as video, audio, animations, image galleries)	1
T6	Gestures used to control	3
V	Visual	-
V1	Coloration	3
V2	Zooming, scaling, and displaying of text	8
V3	Structure	9
V4	Transactions	2
V5	Media display (such as video, audio, animations, image galleries)	3
C	Content	-
C1	Content comprehension	5
C2	Handling of errors	3
C3	Media alternatives (types)	5

was generally recommended through a joint display, for example, in tables or a textually described general conclusion [23, 26].

The WCAG guidelines are used to evaluate the study material. By doing so, the authors followed established evaluation criteria when performing their manual analysis. Kuckartz and Rädiker [26] indicate that these evaluative scaling categories are associated with a defined number of values. This study uses a dichotomous rating scale:

The “test statement met” (YES) indicates that accessibility is provided in the category, whereas the “test statement not met” (NO) indicates that an accessibility problem exists in the category.

It is important to note that categories that are not relevant or testable for the content type being examined (for example, audio and video content on text-only pages) are marked with “Not Applicable” (NA) and are therefore omitted from further analysis.

Three test categories are used for the evaluation: *Keyboard and controls*, *Visual*, and *Content*. These categories also served as the main categories. Three levels of hierarchy are used to sort the evaluation categories. A total of 53 test criteria are used to evaluate the content.

Table 3 Frequency of accessibility errors and warnings. *Note.* Automated test results (Phase 1)

Online Video Service	Total Errors	Total Contrast Errors	Total Alerts
Amazon Prime Video	83	36	323
Disney Plus	54	0	67
Netflix	25	17	39
YouTube	112	7	359

4 Results

As the study follows a two-phase model, the results of the automated testing procedure (Phase 1) are presented first. Subsequently, the findings of the manual testing procedure (Phase 2) are visualized. Finally, the results of both phases are integrated, i.e., combined to create a final result.

4.1 Phase 1: automated testing procedure

The study material was initially evaluated using the WAVE Web Accessibility Evaluation Tool (Google Chrome plugin). Specifically, four desktop websites were examined, excluding test tasks 4 and 5 (content consumption). The total errors, the total contrast errors, and the total warnings are based on this sample. In Table 3, we present the frequencies of the Phase 1 results.

In general, Netflix found the fewest accessibility errors in the automated testing process, with 25 errors. Regarding the alerts (39), Netflix is ranked first. An alert is a problem that requires further (manual) investigation. It is not always the case that these problems result in actual accessibility errors, but they frequently do. Although it had more than twice as many errors (54), Disney Plus stood out with regard to contrast errors (0).

Amazon Prime Video is ranked in the middle of the field with 83 errors but had the highest contrast error value of the four online video portals in this category, with 36 errors. Comparatively, 323 alerts represent a very high number.

Based on the automated testing process, YouTube had the highest number of web accessibility issues, with 112 errors. Additionally, YouTube is ranked last in terms of alerts (359), indicating possible accessibility issues. On the other hand, with only seven contrast errors, the online video portal had the second lowest value of the entire study material.

Phase 1 results indicate that insufficient color contrast is an issue on most websites (except for Disney Plus). The problem occurs in some instances systematically, such as Amazon Prime Video, which employs white text on a light-colored background when displaying the age rating, or Netflix, which uses a problematic combination of text and background color.

As shown in Fig. 3, Netflix labels are not sufficiently contrasted. In this example, gray text on a dark background is

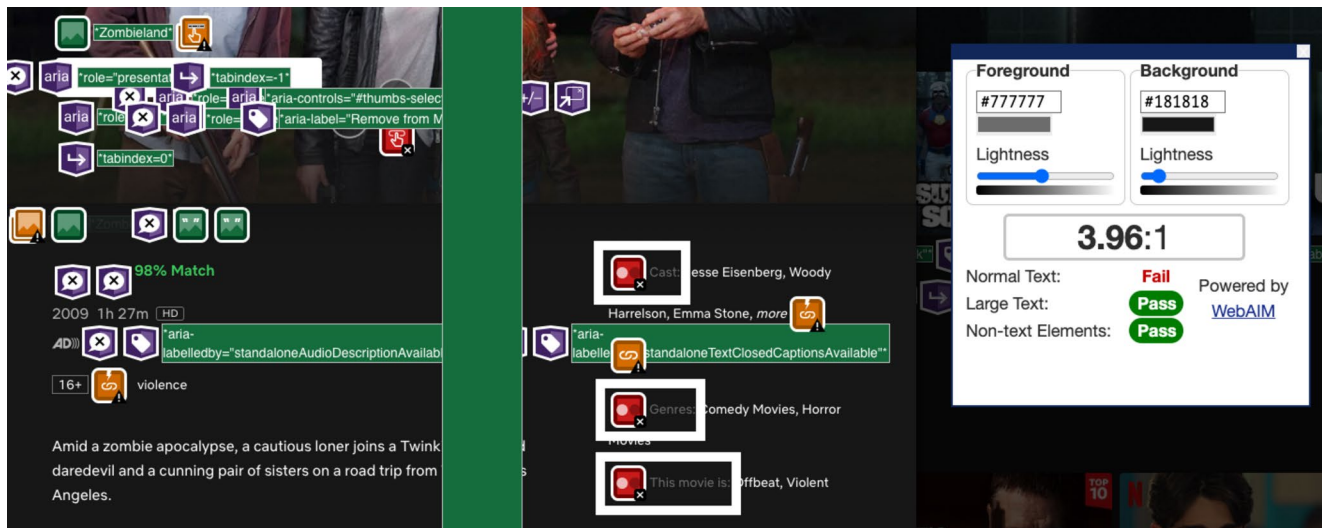


Fig. 3 Example of insufficient contrast ratio for text (Netflix). Screenshot from netflix.com. *Alt text:* A screenshot of the Netflix user interface, particularly a movie details page with information about the

movie’s storyline, cast, genres, and characteristics. The labels for cast, genres, and characteristics are gray in front of a dark background, resulting in a failing contrast ratio of 3.96:1

Table 4 Testing criteria non-completion by main category. *Note.* Frequency of manual test results (Phase 2)

Online Video Service	1. Key-board and Controls	2. Visual	3. Content	Total Counts
Amazon Prime Video - Desktop (web)	10	28	7	45
Amazon Prime Video - Mobile application	9	14	2	25
Disney Plus - Desktop (web)	10	42	6	58
Disney Plus - Mobile application	10	25	3	38
Netflix - Desktop (web)	8	32	5	45
Netflix - Mobile application	5	18	6	29
YouTube - Desktop (web)	3	21	12	36
YouTube - Mobile application	7	16	10	33

used to depict the terms “Cast”, “Genres”, and “This movie is”. However, the contrast ratio is only 3.96:1.

As a result, the minimum value of 4.5:1 defined in WCAG 2.1 is not met. In addition, certain content types, such as non-descriptive links and media alternatives, should be reviewed separately with a screen reader to determine whether they are problematic. Finally, the Phase 1 results indicate that exclusive keyboard control of the content is only possible to a limited extent. Therefore, Phase 2 focuses on issues that cannot be adequately addressed through automated testing: Among the items examined are color contrast of text in front of images and gradients, non-text content, keyboard operation, logical navigation order, descriptive hyperlinks, media alternatives such as alternative text

for images, as well as captions and audio descriptions for motion pictures.

4.2 Phase 2: manual testing procedure

During Phase 2, the test material was manually evaluated according to 53 criteria. In Table 4, we provide an overview of the test criteria that were not met in absolute frequency, separating them by desktop versions (web) and mobile applications of the online video portals.

The results show that more nonfulfilled test criteria were found in the desktop version (web) than in the mobile application. However, fundamentally better web accessibility in the smartphone apps examined is irreducible as the results of the devices are not necessarily comparable, particularly since not all test criteria could be examined equally in the smartphone apps as they were in the desktop version.

Regardless, the results can be compared within desktop version (web) and mobile application categories. With 36 failures in the desktop version category, YouTube had the lowest number of failed testing criteria. Amazon Prime Video and Netflix followed with 45 each. Disney Plus failed a total of 58 test criteria.

In the mobile application category, Amazon Prime Video’s smartphone application (iOS) came in first place (25 test criteria were not met). Subsequently, Netflix had 29 criteria not met, and YouTube followed with 33 criteria not met. With 38 unfulfilled criteria, Disney Plus is once again ranked last. In terms of content, the most common problems are related to keyboard operation, color contrast, responsive design, screen readers, and media alternatives. Therefore,

the three main categories of test criteria (keyboard and controls, visual, and content) are equally affected.

With the exception of Disney Plus, all of the online video portals examined have issues with the keyboard focus indicator order, which is not always reasonable for users: When switching between content elements with the TAB key in desktop versions, the keyboard focus indicator repeatedly changes to another element. For example, this is a problem with Amazon Prime Video, as its content catalog is integrated into the Amazon shopping site. In other words, the navigation menu problems on the shopping site are also present in the online video portal (in particular, jumping to elements that are not visible to the user). However, the picture is reversed in mobile applications: Only the Disney Plus app has an incomprehensible sequence of keyboard focus, which unexpectedly jumps to the share button when controlling the content tabs of a movie or a series page.

Insufficient color contrast is evident in all online video portals (both desktop and mobile): This problem can be seen in many different variations, starting with text on a single-colored background, as pre-noted in Phase 1, when Netflix consistently utilizes gray font color on dark, black-gray backgrounds for specific texts (as shown in Fig. 3), or when Amazon Prime Video displays the age rating of content in white font on a colored background. WCAG 2.1 requires a contrast ratio of 4.5:1 for normal text, but this often results in a contrast ratio that is (significantly) below that.

Text in front of images is another problem regarding color contrast, such as teaser texts for movies or series displayed in front of preview images (usually a picture of a scene from the respective title). Depending on the background color and the text positioning, these teaser texts on preview images often result in a color contrast that could be improved or even falls below the color contrast threshold. The thumbnails used in the examined online video portals belong to the same issue: Disney Plus, for instance (Fig. 4), visualizes the textual title *Star Wars: Tales of the Jedi* in a brown font with a gradient color on a dark background. Due to this arrangement, there is insufficient color contrast, especially in the lower part of the font, where the gradient ends very darkly. Using similar colors in the foreground and background severely impairs readability for persons with moderate vision who do not use assistive technology (such as screen readers). Since there are a large number of thumbnails in online video services, we were unable to investigate the color contrast of all thumbnails systematically. However, insufficient color contrast has been consistently observed on all online video portals (irrespective of device type).

In addition, online video portals have difficulty ensuring a sufficient contrast ratio for non-text content, such as buttons, drop-down menus, form fields, icons, and keyboard focus indicators. According to WCAG 2.1, this content requires a threshold of at least 3:1 for neighboring colors. Netflix, for example, clearly does not meet this requirement with its drop-down menu to change the language in the

Fig. 4 Example of insufficient contrast ratio for text in thumbnails (Disney Plus). Screenshot from disneyplus.com. *Alt text:* A screenshot of the Disney Plus user interface, particularly the thumbnail of the series *Star Wars: Tales of the Jedi*. With its brown title in front of a dark background, this thumbnail has an insufficient contrast ratio of only 2.2:1

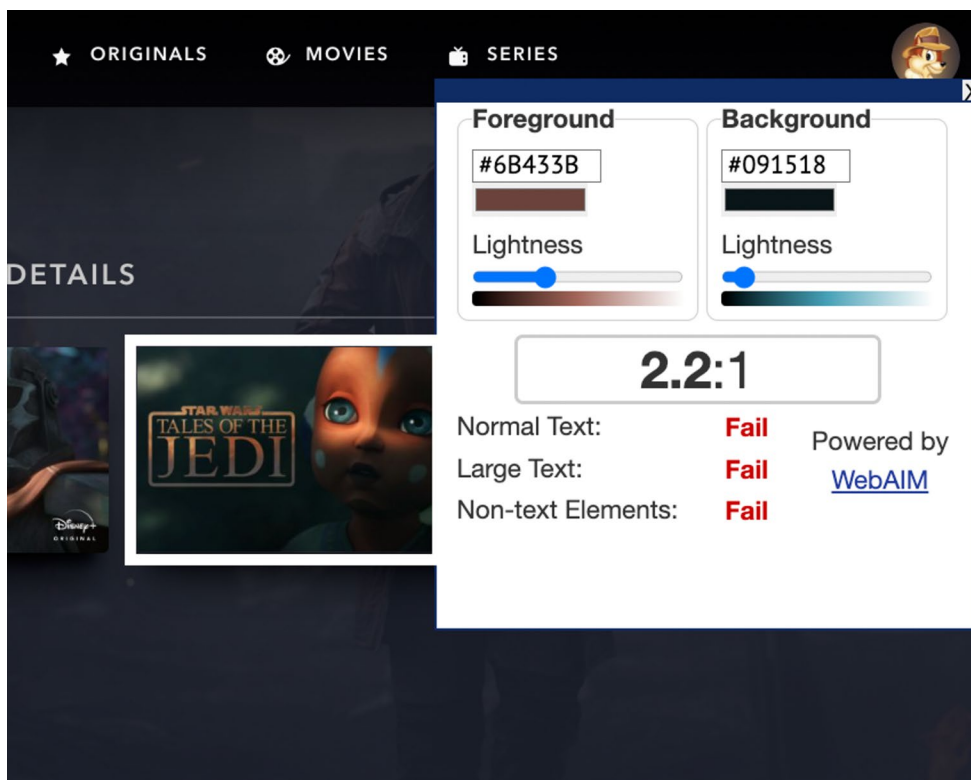
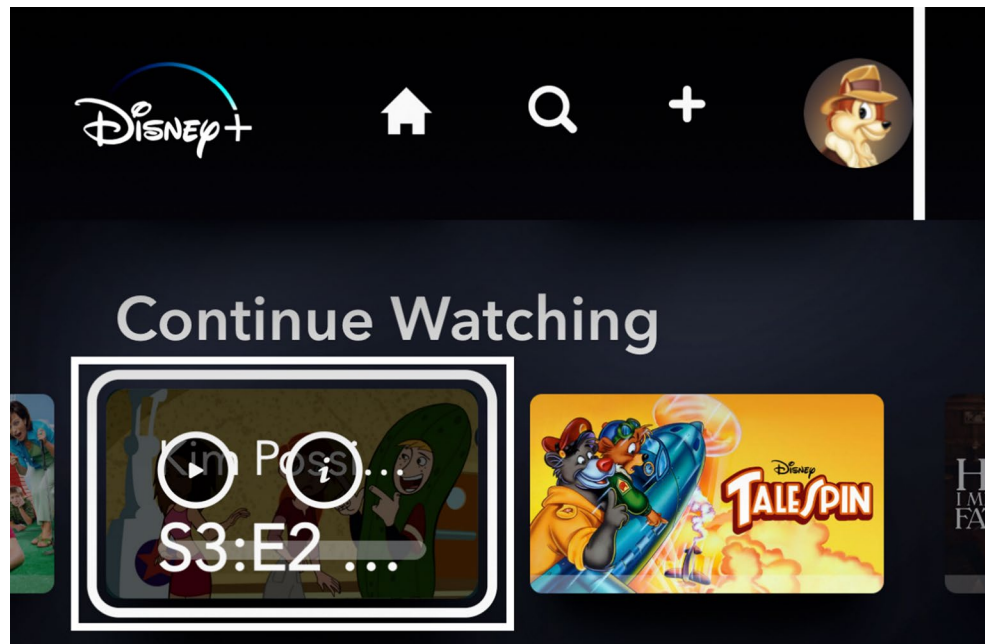


Fig. 5 Example of inadequate responsiveness in the desktop version (Disney Plus). Screenshot from disneyplus.com. *Alt text:* A screenshot of the Disney Plus user interface, particularly the “Continue Watching” section with the elevated item *Kim Possible*, where the text of the series title and episode title is cut off. Additionally, the buttons “Play” and “Info” overlap with the series title



footer. It is difficult to read the content given the contrast ratio of 1.66:1. Another aspect is the keyboard focus indicator, which must be visible to the user and, therefore, has a minimum level of color contrast. YouTube, for example, displays a gray keyboard focus indicator on a white background in its desktop version, which, at 1.3:1, is well below the threshold for non-text content.

The use of inadequate or faulty responsive design (both in depiction and functionality of the content) is widespread and affects all online video portals examined to varying degrees, but only the desktop version.

In some cases, navigation menus, body text, and interactive elements are cut off or completely inaccessible. Disney Plus, for example, generally has a high degree of responsive content (most content types adapt according to the respective zoom level or display size and the available space); however, the series and episode titles in the “Continue Watching” area are usually difficult to read due to a limited amount of available space. Additionally, the “Play” and “Title Info” buttons are overlaid on the text (Fig. 5). As a general matter, this overlay of controls is a problem not only with Disney Plus but also with Netflix. Because of this overlapping, users are not always able to activate the appropriate function according to their use case, such as rating a title or muting an autoplay preview video.

The manual testing process also included the use of a screen reader to help the user understand the content being read out and navigate the site. All online video portals have been identified to have problems with screen readers; some issues are so severe that users who rely on them are prevented from using the desktop version. Hidden content is often read out and displayed in incorrect order. The same

applies to unexpected jumps (back) to specific elements. Furthermore, there are no labels that indicate the type of content, such as the drop-down menu to select seasons on Netflix. Only by reading out the contents of the drop-down menu (such as “Season 1”, “Season 2”) will the user be able to determine which functionality is provided. Screen reader issues were only identified in the desktop version. In terms of testability, they could not be detected in mobile applications (iOS).

Another key issue concerns the provision of media alternatives, including alternative text for images, as well as closed captions and audio descriptions for motion pictures. According to the test criterion *Alternative text for images*, images with only generic descriptions were found on all online video portals except Netflix. For example, the Prime channel logo of Amazon Prime Video is referred to only as “Channel logo”. As a result, users with screen readers cannot determine which channel they are on or to which channel the selected movie or series belongs to. Since Amazon Prime Video offers other (paid) channels in addition to its own Prime Channel, this information is essential for users. However, the proportion of images with generic alternative text is small in relation to the total number of images. The thumbnails of movies, series, or videos are well described by default since the name of the respective title serves as the alternative text.

The availability of closed captions must be distinguished into two categories: On the one hand, on Amazon Prime Video, Disney Plus, Netflix, and YouTube (within the *YouTube Movies* program, through which movies are available for purchase or rental, author’s note), closed captions are available by default in the video player for movies and, if

available in the catalog, series. Additionally, to German, the language relevant to the Austrian market, many other languages are available as closed captions. On the other hand, the second characteristic applies only to YouTube since every registered user can upload video content to this platform (user-generated content). Hence, it is also the responsibility of the user to upload closed captions to provide an appropriate textual alternative to the video's audio track. We examined two videos in detail from a media company and a professional YouTuber, neither of which provided closed captions. In this case, YouTube automatically generates closed captions in German and other languages. Nevertheless, the quality of these automatically generated captions is often questionable since there are a few moments in the video when no captions are displayed, even though spoken text can be heard. Furthermore, other auditive types (such as sound effects and music) are not always reliably displayed as a text alternative. As a result of this lack of quality, YouTube cannot be considered to meet the testing criteria.

The situation concerning audio descriptions for motion pictures appears inconsistent: At the time of the investigation, YouTube did not offer any option for providing audio descriptions in user-generated content. Amazon Prime Video, Disney Plus, and Netflix offer audio descriptions in their content catalogs, but availability varies from title to title. Various movies and television series are audio-described, while others are not. The same applies to YouTube's movie catalog, where movies can be rented or purchased directly through the video portal. Additionally, audio descriptions are often only offered in English and not in German. From the user's perspective, this situation is incomprehensible and significantly limits their access to content.

4.3 Phase-by-phase integration

Generally, the results of the first phase were confirmed in the second phase of the study, but some were contradicted. The limitations of operating online video portals exclusively with the keyboard have been confirmed: Not all elements are always accessible, and the order of navigation or movement of the keyboard focus is often incomprehensible to users. Color contrast is a significant problem, especially when displaying text in front of images (thumbnails of movies, series, videos) or non-text content (e.g., dropdown menus, buttons, icons). All desktop versions of the online video portals were found to have insufficient or faulty responsiveness. Hidden content is read out by a screen reader, or the order is not always distinct for the user. Phase 1 indicated that there may be a problem with hyperlinks that do not provide descriptive information, but this was not confirmed. Closed captions are usually available in several

languages (including German, the language relevant to Austria) as appropriate media alternatives for movies and series. Audio description is not available for all titles; most of the time, it is only available for a few or even just one language (e.g., English). YouTube's user-generated content does not always include closed captions. In that case, AI-generated captions are provided but are of insufficient quality. At the time the study was conducted in 2023, YouTube did not support audio descriptions for user-generated content.

4.4 Bias and limitations

The literature frequently recommends involving persons with disabilities, mainly through user testing. Thus, in addition to compliance with web accessibility guidelines such as the Web Content Accessibility Guidelines (WCAG), the perspectives and needs of those affected can also be considered. Despite compliance with a specific policy, content can cause problems for users when used in applications. However, extensive user testing requires a significant amount of time and resources. Therefore, the present study excluded work with those affected and focused on the conformity of the content with WCAG.

Various testing approaches were employed on the two device categories: The desktop versions (web) were automatically evaluated using the WAVE evaluation tool and manually in more detail. However, mobile applications were only analyzed as part of the manual investigation. This inconsistent approach has been adopted due to the lack of access to the source code of iOS applications. For that reason, no software-supported evaluation could be conducted. Furthermore, not all test criteria could be manually evaluated since access to the code is also required for individual categories (including the technical structure of the app). It was necessary to exclude criteria that cannot generally be tested in a smartphone application. Consequently, no statement can be made regarding these criteria. Due to these differences in research approaches and the technical exclusion of test criteria, desktop and mobile results cannot be directly compared. It is only possible to depict a (limited) picture of the web accessibility status independently.

Various consumption models are available for the online video portals studied. For example, YouTube offers content both with advertising (free version) and ad-free (through the paid subscription *YouTube Premium*). Subscription plans with advertising offered by the other online video portals (Amazon Prime Video, Disney Plus, and Netflix) were unavailable in Austria at the time of the study. To ensure that the results are largely comparable (except between devices), the online video portals were analyzed in their ad-free versions (for example, YouTube in its premium version). In the case of offers with advertising (for example, banners

or videos before content intended to be consumed (pre-roll advertising) or interruptions), these additional content types can, under certain circumstances, lead to different results in terms of web accessibility.

Online video portals contain a large amount of content, making it challenging to comprehensively evaluate individual content types. Due to resource constraints, we were unable to evaluate the color contrast of thumbnails (preview images) on the homepage of the examined online video portals in a broader approach. Additionally, it is essential to note that Netflix, for example, displays thumbnails to users in a personalized manner so that the thumbnail matches the user's preferences. In some cases, this could result in a multitude of different thumbnail designs for the same title, such as the Netflix series *Stranger Things* [27]. However, it is sufficient to identify a corresponding problem by detecting a low contrast ratio in a few thumbnails (if a user cannot perceive a title correctly due to the problematic color contrast, an accessibility barrier exists). Further content types are closed captions and audio descriptions; in the present study, these have only been evaluated in terms of content to the extent necessary to verify the corresponding test criteria and the defined study materials (individual movies, episodes of series, and videos available through an online video portal).

The test criterion, which addresses moving and flashing content, was only checked on the selected content pages (the home page, the content detail pages, the login user account, and the support/FAQ page). Consequently, motion pictures, especially movies, series, and videos, were not analyzed for moving and flashing content according to the criterion due to a lack of personnel and technical resources. A comprehensive and content-related analysis of motion pictures would undoubtedly justify a separate study.

Persons without disabilities are less likely to find themselves in the same situations when using websites as persons with disabilities (for example, persons with sensory or cognitive impairment). It should be noted that exclusive keyboard operation, as used in the present study to assess test criteria, has an entirely different relevance for those dependent on it. This relevance effect was increased using the checklist (and test statements and use cases included). On the contrary, the checklist was used to assess compliance with the WCAG. This difficulty also applies to other content types, such as media alternatives (alternative text for images, closed captions, and audio descriptions). For this reason, it cannot be overemphasized that affected users must be involved in comprehensive web accessibility evaluations. Doing this makes it possible to directly validate and expand the assumptions made by an evaluator in the analysis.

5 Conclusions

The results of the study indicate a lack of accessibility on the examined online video portals Amazon Prime Video, Disney Plus, Netflix, and YouTube. None of these online video portals met all success criteria of WCAG 2.1 at the AA conformance level, regardless of whether the desktop version (web) or the mobile application. Several accessibility errors have been identified in detail, some so severe that they may prevent users from accessing the content. This is primarily due to the faulty keyboard operation of websites and apps. An incomprehensible sequence or a focus on an unexpected element can lead to user confusion. Another critical difficulty is the inability to access individual elements via the keyboard. In effect, this means that users who prefer to use the keyboard to operate the online video portal will be unable to trigger the desired actions and, as a result, will not be able to consume content (if the "Play" button is not accessible). Users with poor eyesight may not be able to recognize or receive relevant information if there is insufficient color contrast. A common effect of this is on the thumbnails of titles appearing on online video portals: the text in these thumbnails is often not sufficiently contrasted with the background color. The alternative text is usually provided as an accessible name, not visible on the screen but displayed by assistive technology (e.g., a screen reader). Unless the users use one, they are only dependent on adequate color contrast in thumbnails. If a website is only partially responsive or is not responsive at high zoom levels, users must scroll horizontally at least to view all relevant content. As a worst-case scenario, the website can no longer be used if textual descriptions and functions (such as navigation menus, buttons, drop-down menus, and form fields) are superimposed or separated due to the high zoom level and the window size and, therefore, cannot be activated. In the online video portals examined, several critical problems were identified in the desktop versions that affect the screen reader. For example, incorrect hidden content was repeatedly read out. For blind users, such error-prone output makes it difficult or even impossible to understand the content and operate the application. Furthermore, there is a need to address the lack of alternative media; this is particularly important for an online video portal, as video is the primary content consumed by users. Users are explicitly excluded if not enough high-quality closed captions or audio descriptions (in languages relevant to the respective market) are available.

Many success criteria were not met regardless of the device (i.e., they occurred in both the desktop version and the mobile application), such as color contrast (especially in thumbnails), exclusive keyboard control, and the availability of media alternatives. At the same time, some problems

appeared or were only relevant for one device type, such as inadequate content responsiveness at high zoom levels in the desktop version. Another example was the functionality of the screen reader, which worked flawlessly on smartphones, while the desktop versions often had great problems reading the correct content. However, due to the limitations of the study, the results cannot be compared between the categories of devices.

As a result, providers who offer their content on various devices and in different formats (for example, in a web browser and as an app) face considerable complexity. However, it is necessary to have a minimum level of accessibility available on all relevant devices so that as many users as possible can take advantage of the services.

The errors discussed were particularly prevalent (affecting all the online video portals examined to varying degrees) and were classified by the authors as having a significant impact on users. Meanwhile, the study identified other issues that may pose (albeit more minor) user barriers. An ideal situation would be one in which all defects are fixed in order to ensure full compliance with the WCAG on the one hand and to provide the best possible user experience on the other. However, due to the large number of errors, prioritization is recommended. Consequently, online video portals should first focus on eliminating the most critical barriers. As a result, persons with disabilities have much easier access to services or even can do so in some cases.

With the findings of insufficient accessibility and the categories of errors detected most frequently, the present study can be compared with the results of comparative studies. The most common problems are insufficient color contrast, a lack of media alternatives, and navigation problems (especially with assistive technology or exclusive keyboard operation). Consequently, it does not matter whether the websites or applications belong to the public or private sector. The results are fundamentally similar, except for individual content type specifics (such as focusing on media alternatives due to the examination of online video portals in the present study).

Quantitative and qualitative approaches have been used, resulting in a quantitative evaluation in Phase 1 and a qualitative content analysis in Phase 2, significantly contributing to the scientific evaluation of web accessibility. Comparative studies typically use only automated testing procedures. In such cases, only errors that can be detected by software are usually documented. Potential problems that require manual review by an evaluator are not considered. Additionally, accessibility studies frequently focus on desktop websites. This focus is probably related to the ease of implementation of such an analysis, as several reliable tools are available for desktop web browsers that enable evaluations with relatively limited effort. To evaluate native mobile applications

(such as smartphones), access to the source code is usually necessary to use analysis tools. External evaluators, such as the authors of the present article, may not always have access to the source code. Although this can be countered by a manual and visual assessment, this will require considerable additional effort, and not all aspects can be examined from multiple perspectives and at the same depth (especially those criteria concerning the technical structure of an application).

It is evident from the results of this study and those of the comparative studies discussed that there is a considerable need to improve web accessibility. Therefore, this imperative occurs independently of industries and is apparent not only in the frequently studied web offerings in the public sector and e-commerce but, as the present study demonstrates, also in the entertainment industry, especially in online video portals.

Research into web accessibility, particularly in evaluating websites and apps, will intensify, according to the article's authors. In recent years, there has been a significant increase in the number of studies in this area, in part due to the growing attention brought on by legislation. The introduction of the EAA will further intensify work on this topic, similar to what occurred in data protection with the General Data Protection Regulation (GDPR) of the European Union. However, this development should be viewed positively because not only persons with disabilities, but all users will benefit from the best possible accessibility.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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