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**KEYBOARD ACCESSIBILITY OF PRODUCT FILTERS ON
FASHION E-COMMERCE WEBSITES**

Faculty of Information Technology and Communication Sciences

Master's Thesis

October 2023

ABSTRACT

Nelli Leinonen: Keyboard accessibility of product filters on fashion e-commerce websites

Master's Thesis

Tampere University

Faculty of Information Technology and Communication Sciences

Master's Degree Programme in Computer Science

Advanced Studies in Software, Web & Cloud

October 2023

As the e-commerce market and especially the fashion e-commerce is growing, the accessibility of e-commerce websites deserves more attention. This thesis is an expert accessibility evaluation of keyboard accessibility of the product filters on ten leading fashion e-commerce websites in Finland.

The World Health Organization (WHO) estimates that 16% of the global population have a disability, and even though not all disabilities affect the usage of information and communication technology, many users are excluded if accessibility is not taken into consideration. Among users with disabilities, the keyboard is a widely supported input method.

Web Content Accessibility Guidelines (WCAG), accessibility legislation like the European Accessibility Act (EAA) and a multitude of accessibility evaluation methods are there for web designers, developers and e-commerce business owners to support them in progress towards a more accessible e-commerce.

At the heart of e-commerce websites, there are product filters. Product filters play a crucial role in narrowing down the extensive product listing or sorting products based on certain features.

The results of this thesis indicate that there is a need for improvement in the accessibility of product filters. Nine out of ten fashion e-commerce websites have severe accessibility errors in their product filters which means that they violate the lowest level of WCAG success criteria and prevent users from using the feature. Even some common product filters are inaccessible on the majority of the studied websites. Improvements can be made, and in addition to improving the accessibility, they could have a positive effect on the user experience.

Keywords: web accessibility, keyboard accessibility, fashion e-commerce

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.

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1. Introduction

Web accessibility is about ensuring the inclusivity of all people in the modern world through creating web content in a way it can be used by everyone regardless of their abilities [W3C 2022; Patvardhan et al. 2022, 1]. The World Health Organization (WHO) estimates that 1.3 billion people have a disability. It means that 16% of the global population have a health condition which in an interplay with the environment often leads to limitations in everyday functioning. The number of people with disabilities is expected to grow in the future due to noncommunicable diseases and increased life expectancy. [WHO 2023]

Web accessibility improves especially the inclusivity of people with disabilities. However, in the context of web accessibility, all impairments are not in the center of the discussion [Wheeler & Kreps 2008, 325]. For example, a wheelchair user who does not have additional impairments is not in the spotlight in the same way as, for example, users with visual impairments or motoric impairments in their hands. This thesis focuses on keyboard accessibility as it is a universally supported and operable input method among users with disabilities and their assistive technologies [W3C 2016c, 2017c; Chiou et al. 2021, 855].

Discussion and legislation about web accessibility often focuses on the accessibility of the public services [e.g. Goodwin et al. 2011; Directive (EU) 2016/2102]. But a full inclusivity cannot be reached just by making the government services accessible. True inclusivity means that accessibility is taken into account everywhere on the web.

There exists plenty of research about web accessibility from multiple viewpoints. For example employment websites [e.g. Gilbertson & Machin 2012; Wheeler & Kreps 2008] and recurring elements like widgets [Watanabe et al. 2015] have been researched, but in recent years, the accessibility of e-commerce websites has gained growing interest among researchers [e.g. Acosta-Vargas et al. 2022; Almenara and Saltiveri 2021; Chiou et al. 2021; Patvardhan et al. 2022]. Making e-commerce websites accessible benefits not only the customers but also the businesses because private e-commerce websites get competitive advantage when taking accessibility into account [Wheeler & Kreps 2008, 327].

Growing interest towards the accessibility of e-commerce websites is welcome as the importance of e-commerce continues to grow [Insider Intelligence 2022; Acosta-Vargas et al.

2022]. In the world at large and also in Finland, fashion is the most popular business-to-consumer (B2C) e-commerce category [Statista 2023a, 2023b].

Fashion e-commerce websites and problems in their accessibility were briefly discussed in an accessibility awareness event in the spring 2023 hosted by a software consultancy company Futurice [2023]. The topic of this thesis was inspired by a notion in that event that there is a desperate need for accessibility improvements in e-commerce websites, and fashion e-commerce websites were used as an example of poor accessibility. The topic is current because the requirements for accessibility of e-commerce websites set by the European Accessibility Act (EAA) will come into force already in the summer of 2025 [Directive (EU) 2019/882].

This thesis will shed some light on the status of keyboard accessibility of product filters in leading fashion e-commerce websites in Finland. The focus will be solely on product filters as doing a comprehensive accessibility audit for multiple websites would lead to an excessive workload.

Product filters are one of the key elements of e-commerce websites. In usability testing, it is observed that users are fast to abandon the site completely in case they do not find a way to filter the vast amount of products effectively [Baymard Institute 2023, 2015b]. Narrowing down the selection of products is a central aspect of online shopping and the efficiency the filters provide should be available for all users regardless of the various kinds of ways the users operate their computers.

Peer reviewed research about product filters in e-commerce is scarce. However, there are plenty of studies and blog posts by industry specialists directed for e-commerce site owners, designers and developers about the importance of product filters [e.g. Baymard Institute 2023, 2015a, 2015b; Holst 2015; Stepanov 2020; Thomas 2021].

Drawing from this background, the main research question is:

What is the status of keyboard accessibility of product filters on the leading fashion e-commerce websites in Finland?

To answer the main research question in more detail, the following minor research questions are also covered in this thesis:

- *Are there keyboard accessibility violations in product filters?*
 - *What kind of accessibility violations can be found?*
 - *How can these violations be categorized?*
- *What improvements to keyboard accessibility of these filters can be recommended?*
- *How do potential accessibility violations can impact the user experience for individuals who rely on keyboard accessibility?*

The answer to the research questions is approached by first defining the accessibility and keyboard accessibility and taking a look into the accessibility guidelines and legislation. In addition to these, the second chapter of this thesis also covers the multitude of web accessibility assessment methods used in research and in web development at the moment as well as the significance of product filters and accessibility for e-commerce.

The third chapter is about method and data. The leading fashion e-commerce websites in Finland are identified, the chosen accessibility evaluation method – manual expert evaluation – is introduced in detail and the observed accessibility errors are presented.

The analysis and discussion can be found from chapters 4 and 5. In the analysis, the accessibility errors are categorized by their severity, and in each severity category, a more fine-grained categorization is provided. Also a WCAG (Web Content Accessibility Guidelines) criteria that each error is in violation of is detected and errors are further discussed from the viewpoint of the common accessibility guidelines. The accessibility of common filters are also compared between the e-commerce websites. In the discussion chapter 5, improvements for found accessibility errors are suggested and the possible impact on user experience is discussed.

The last chapter of this thesis is a conclusion where the need for further development for accessibility of product filters is summarized. Also the limitations of this thesis as well as further research topics inspired by the findings and limitations are described.

2. Accessibility and e-commerce websites

2.1. Web and keyboard accessibility

Web accessibility means that websites are designed and implemented so that people with and without disabilities can use them with ease. In an accessible web, all people can perceive, understand, navigate, interact and contribute to the web regardless of their potential auditory, cognitive, neurological, physical, speech or visual disabilities. Also slow internet connection, varying screen sizes, different input models, and changing abilities due to aging, situational limitations like bright sunlight or an environment which does not allow listening to audio are taken into consideration in accessible web. [W3C 2022]

In short, web accessibility is equal access to all areas of a website for all users regardless of their disabilities [Wheeler & Kreps 2008, 325]. All user groups benefit from accessibility and designing websites to be accessible often enhances their overall quality and user experience [Vollenwyder et al. 2023, 1–3].

Usability and inclusion are closely related to accessibility but they are not as focused on disability as the term accessibility is. While accessibility highlights the discriminatory aspects of the web for people with disabilities, usability often does not specifically address the needs of people with disabilities. Usability is about how effective, efficient and satisfying the service or tool is to use. [W3C 2016b; Sauer et al. 2020, 1208]

So even if there is no exclusion of people with disabilities or the usage of assistive technologies from the definition of usability, these aspects are often left aside when discussing usability [W3C 2016b; Sauer et al. 2020, 1208]. Exceptions exist of course, and for example, Paz and Paz [2021] focused on evaluating the relation between usability and accessibility of leading e-commerce websites in Peru. Their research results strengthen the view that usability and accessibility go hand in hand, and the more there are usability errors, the more there are accessibility errors as well [Paz & Paz 2021, 389]. Almenara and Saltiveri [2021] also compare the usability and the accessibility of e-commerce websites and they conclude that usability is more often taken into account than accessibility.

Like usability, inclusion is a broader concept than accessibility. Inclusion is about ensuring that everyone is included to the greatest extent possible. This concerns, for example, people

who are not fluent in the language in which the website is provided or people who use the website with mobile devices or with low bandwidth. [W3C 2016b]

Alongside usability and inclusion, user experience is also closely related to accessibility. User experience is a broad concept that refers to all the actions, sensations, considerations, feelings, emotions and sense making that the user experiences when using a service. It focuses on a highly subjective perspective neglecting objective perspectives like measured effectiveness, errors and efficiency. Web accessibility has been noticed to affect the user experience, for example, on e-commerce websites. [Sauer et al. 2020, 1209–1218; Vollenwyder et al. 2023, 3, 9]

In modern web development, it is understood that accessibility is the most cost efficient and easily attained when considered from the start [W3C 2022, Patvardhan et al. 2022, 1], and design is the first step of creating accessible websites. Web designers must consider the wide range of needs the diverse group of users have and the design must adapt to these needs and preferences. To create accessible and usable web designs, designers must consider not only the interface – which should provide self-explanatory controls and convey a purpose – but also the functionality and the content as well. Functionality means that the content of a website is accessible and its interactive components function as they should. All the content should be understandable in order to be accessible. [Horton 2006]

One of the aspects of web accessibility is keyboard accessibility. In a keyboard accessible website, all functionality is available from the keyboard [W3C 2018]. Keyboard accessibility deserves special attention because the keyboard is a universally supported and operable input method among users with disabilities [W3C 2016c; Chiou et al. 2021, 855].

Users with disabilities often utilize assistive technologies, such as screen readers, screen magnifiers or selection switches, for interacting on the web. Many of these assistive technologies output simulated keystrokes. [W3C 2016c; W3C 2017c]

Keyboard navigation is important for users with motor disabilities or tremors that take away the fine muscle control. Also users who can use their hands only a little or not at all and blind users commonly navigate with a keyboard, modified keyboard or other hardware that

mimics the functionality of a traditional keyboard. Also some users prefer keyboard navigation just for its efficiency. [WebAIM 2023]

Despite its importance, keyboard accessibility issues are common [e.g. Chiou et al. 2021; Watanabe et al. 2015]. Common problems faced by keyboard users are missing focus indicators, unlogical navigation order, inaccessible custom widgets, and lengthy navigation [WebAIM 2023].

When an element on a website has focus, it can be activated or manipulated using the keyboard [WebAIM 2023; W3C 2018]. Most often the focus is displayed as a border or outline around the focused element [WebAIM 2023; W3C 2018]. It is extremely important for a keyboard user to have this kind of a visual indicator on the element currently on focus in order to avoid unwanted actions from occurring by accident.

Intuitive and logical navigation order can be achieved if the keyboard focus follows the visual order of the elements on the page, and often problematic custom widgets can be made accessible with careful design and implementation that uses standardized keystrokes for operations. Lengthy navigation at the beginning of the page should be made skippable. Without a “skip to main content” link a long navigation is an annoyance that causes problems for keyboard users because unlike mouse users they must go through every interactive element of the page before getting to the main content. Additional keystrokes are especially troublesome for users with motor disabilities. [WebAIM 2023]

2.2. Accessibility guidelines

There are internationally used common guidelines created for web accessibility by the World Wide Web Consortium (W3C). W3C is an international organization developing web standards and guidelines [W3C 2023a]. The Web Content Accessibility Guidelines (WCAG) 2.0 that it has created is an international standard for web accessibility ISO/IEC 40500 [W3C 2008; ISO 2019].

The goal of W3C has been to create a universally embraced criterion for ensuring web content accessibility that fulfills the demands of individuals, institutions, and governments across the globe. The newest version WCAG 2.1 is published in 2018, 10 years after the

initial guideline. Version 2.2 is in the drafting phase and will be finalized in 2023. [W3C 2023b]

WCAG 2 is a technical standard that consists of recommendations for making the web more accessible. It is not technology-specific, and thus its testable success criteria can be used in every web project. The requirements are backwards compatible which means that the success criteria of earlier versions are included in the latter versions. Therefore, to meet the criteria of all versions of WCAG, only the latest criteria must be met. [W3C 2023b]

The WCAG criteria is intended to be a tool for evaluating web accessibility [W3C 2023b]. It is used for that also in this thesis. The criteria are a beneficial tool for web designers and developers in the designing and planning phase of a new project since incorporating accessibility to the project from early on already in requirements formation and design phase is the most cost-efficient way of ensuring accessibility of the site [Patvardhan et al. 2022, 1, 5; Abou-Zahra 2008, 81–82].

WCAG 2.1 standard introduces four high-level principles as a basis for web accessibility: perceivable, operable, understandable, and robust. Perceivable means that the information being presented on the website must be presented to users in ways they can perceive. Content is not perceivable if it is invisible to all of their senses. The second principle, operable, means that the interactions with the user interface components are possible to perform by the users. The third principle, understandable, states that the information presented and the operations required by the user must be in the scope of their understanding. The last principle, robust, makes sure that all kinds of user agents, including assistive technologies, can reliably interpret the content even in the future when the user agents have evolved. [W3C 2023d]

Under the four high-level accessibility principles there are 13 accessibility guidelines [W3C 2018]. Each guideline has a testable success criteria in three levels: A, AA, and AAA. When a website meets the success criteria of some level in full, or a conforming alternate version is provided, it is said that the website conforms to the WCAG at that level. The conformance of some level is only reached if all content of the website conforms to that level. Level AAA conformance for entire websites is not recommended as a requirement because some content can never satisfy all the level AAA success criteria. [W3C 2016a]

The guideline “2.1 Keyboard Accessible” is the most relevant to this thesis. It unambiguously states that all functionality should be available from the keyboard. The conformation to this guideline can be checked with four success criteria. Three of them are of level A and only one is of level AAA which indicates that keyboard accessibility is quite fundamental for accessibility. [W3C 2018]

The most important criterion under the guideline “2.1 Keyboard Accessible” in the context of this thesis is “2.1.1 Keyboard (Level A)”. Violations of it severely damage the operability of the website. The criterion says:

“2.1.1 Keyboard (Level A)

All functionality of the content is operable through a keyboard interface without requiring specific timings for individual keystrokes, except where the underlying function requires input that depends on the path of the user's movement and not just the endpoints.” [W3C 2018]

In addition to “2.1 Keyboard Accessible”, another relevant guideline to this thesis is “2.4 Navigable” [W3C 2018]. Navigable website has ways to help users in navigating, finding content, and determining where they are [W3C 2018]. The two following criteria concerning navigation are essential for this thesis:

“2.4.3 Focus Order (Level A)

If a Web page can be navigated sequentially and the navigation sequences affect meaning or operation, focusable components receive focus in an order that preserves meaning and operability.” [W3C 2018]

“2.4.7 Focus Visible (Level AA)

Any keyboard operable user interface has a mode of operation where the keyboard focus indicator is visible.” [W3C 2018]

The three criteria introduced in detail above will be subsequently examined in conjunction with the findings presented in the analysis chapter of this thesis.

2.3. Accessibility legislation

In addition to international web accessibility guidelines, there is also web accessibility legislation. So far, the European Union (EU) has published two directives concerning web accessibility that are relevant to this thesis: “Directive (EU) 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the accessibility of the websites and mobile applications of public sector bodies (Text with EEA relevance)” and “Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services (Text with EEA relevance)”.

Directives are EU legislation that set out goals which each of the EU member states must achieve. So, instead of applying the directive directly at the national level, each member state has the freedom to apply the objectives of the directive in the way that best fits their national context. [European Union 2023a]

The older of these EU’s accessibility directives, “Directive (EU) 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the accessibility of the websites and mobile applications of public sector bodies (Text with EEA relevance)”, is often referred as Web Accessibility Directive (WAD). The directive was adopted in 2016 and it came into full effect in June 2021. Its aim is to grant people with disabilities better access to websites and mobile apps of public services. [European Union 2023a; Directive (EU) 2016/2102]

In addition to making public sector websites and mobile applications more accessible, the Web Accessibility Directive (WAD) also harmonizes the varying standards within the EU. According to the directive, public sector bodies must regularly provide an accessibility statement where they report their compliance with the directive. For each inaccessible element, an explanation must be given as well as information on accessible alternatives. Users must be provided with an opportunity to report any failure of compliance of the directive and when they receive a response, they must be given a link to a complaint mechanism if they feel the response is inadequate. The public service broadcasters and non-governmental organizations are excluded from the scope of the directive if they do not provide essential services to the public. Also some content elements, like old office file formats and audio and video content, are excluded. [Directive (EU) 2016/2102]

The Web Accessibility Directive (WAD) is supported by a technical standard EN 301 549 “Accessibility requirements for ICT products and services” in which the technical requirements of accessibility are defined. The standard describes the minimum level of accessibility that the services must conform to. The member states can then impose stricter technical requirements in their own accessibility legislation. In practice, the Web Accessibility Directive (WAD) with its supporting standard requires compliance with the A and AA criteria of the international WCAG 2.1 guidelines. [EN 301 549 V3.2.1 2021; European Union 2023b]

The new accessibility directive of the EU, “Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services (Text with EEA relevance)”, is more commonly known as the European Accessibility Act (EAA). It complements the previous EU legislation on accessibility and requires that in addition to public sector actors also private sector actors must guarantee the accessibility of certain products and services. It covers, for example, services related to air, bus, rail and waterborne passenger transport, banking services, e-books, and e-commerce. The requirements of this directive will come into force in the summer of 2025. [Directive (EU) 2019/882]

In Finland, the Web Accessibility Directive was implemented as the Act on the Provision of Digital Services (396/2019). For the European Accessibility Act the old national law was amended and also a new Act on Accessibility Requirements for Certain Products (102/2023) was implemented in 2023. In addition to that, few other laws were amended to make the national legislation up to date with the European Accessibility Act. [Act on the Provision of Digital Services (306/2019); Laki digitaalisten palvelujen tarjoamisesta annetun lain muuttamisesta (104/2023)]

There exists accessibility legislation outside the European Union as well. Some digital accessibility laws are in place in many developed nations. In the United States, for example, the Rehabilitation Act of 1973 and precisely its Section 508 requires federal agencies to make their electronic and information technology accessible [U.S. Access Board 2023]. The accessibility of private websites is regulated with the Americans with Disabilities Act (ADA) which prohibits discrimination on the basis of disability [U.S. Department of Justice 2023].

For this thesis, in addition to the accessibility legislation of the EU, the legislation of China and Japan are interesting as some of the leading fashion e-commerce websites originate from there. In China, there is the Law on the Protection of Persons with Disabilities [China Disabled Persons Federation 2008]. It states that government agencies and businesses should not discriminate against individuals on the basis of disability [China Disabled Persons Federation 2008]. However, this law is not specifically created for ensuring web accessibility so digital accessibility is not explicitly required and the law does not contain references to WCAG guidelines. Instead, China has the Voluntary Web Accessibility Standard based on WCAG version 2.0 [Chinese Standard 2008]. But as the name implies, the standard is only a recommendation and conforming to it is voluntary [W3C 2017a].

Like in China, also in Japan there is a law for accessibility that does not specifically focus on web accessibility. The Basic Act on the Formation of an Advanced Information and Telecommunications Network Society covers both public and private sector but, as said, it does not concentrate on web accessibility nor does it mention WCAG guidelines [Cabinet Public Affairs Office, Cabinet Secretariat 2000]. Instead, Japan has a standard for web accessibility, Japanese Industrial Standards (JIS) X 3241-3 “Guidelines for older persons and persons with disabilities - information and communications equipment, software and services - Part 3: Web content”, which is equivalent to WCAG 2.0 [W3C 2017b]. However, compliance with the standard is voluntary [W3C 2017b].

2.4. The multitude of web accessibility assessment methods

To ensure the conformance to the needs of disabled people, accessibility guidelines and legal requirements, websites are evaluated for their accessibility. An accessibility evaluation is a process that aims to find accessibility problems and often also assess the level of accessibility [Abou-Zahra 2008, 79; Patvardhan et al. 2022].

The nature of web content is that it is constantly updated and changing. Usually, the majority of the functionality and content are published only during the operation and maintenance phases, so accessibility assessment and monitoring should be an ongoing process throughout the lifetime of the website. [Abou-Zahra 2008, 80–84]

There are various web accessibility evaluation methods, and combining them ensures the most accurate and comprehensive results. Accessibility testing techniques can be categorized in three types: automated testing, manual inspection testing and user testing. Each of them have their pros and cons. [Abou-Zahra 2008, 84–87; Paz et al. 2021 877–878]

Automated testing is carried out with software tools without the need for human intervention so they offer time and cost efficiency [Abou-Zahra 2008, 84–87; Paz et al. 2021 877–878]. The efficiency provides possibilities for not only the website developers to test the accessibility fast but they also provide researchers possibilities to evaluate the level of accessibility of tens of websites with a reasonable workload to get an overview of the accessibility status. For example, Acosta-Vargas et al. [2022] evaluated the accessibility of 50 e-commerce websites for one research with an automated tool called Web Accessibility Evaluation Tool (WAVE).

W3C [2023c] maintains a list of automated web accessibility evaluation tools. At the moment, the list contains 166 tools [W3C 2023c], and since the list is not exhaustive there certainly exists plenty of options. Different audiences use different tools but the purpose of all of them is to assist in accessibility evaluation by checking the HTML content or other web technologies, like CSS, and then to provide feedback on the conformation of accessibility guidelines [W3C 2017d].

However, not all the accessibility issues can be automatically detected since they might address natural language aspects or user interface interaction. For example, no automated tool can detect whether the visual presentation of the website actually matches with the markup of the HTML (HyperText Markup Language) document. [W3C 2022; Abou-Zahra 2008, 85; Gonçalves et al. 2018, 568]

Modern websites also have highly complex user interfaces with a plethora of responsive and dynamic elements and constantly changing user interfaces based on user actions. Thus, testing accessibility and especially the keyboard accessibility with only a static HTML analysis by automated tool is not enough. [Chiou et al. 2021, 855]

Chiou et al. [2021] have developed a new automated tool for detecting keyboard accessibility errors. The results are promising as their tool was able to effectively detect

keyboard accessibility errors [Chiou et al. 2021, 862–865]. They have also applied for a patent for their innovation [European Patent Office 2023]. However, despite the advancements in automated tools, a human evaluation is always required to determine the accessibility of the site because some aspects of accessibility, like understandability, are still impossible to detect with an automated evaluation tool [W3C 2022; Abou-Zahra 2008, 85; Gonçalves et al. 2018, 568].

Manual inspection testing is time consuming but it plays a large role in accessibility testing. Manual testing is carried out by expert or novice testers depending on the target and goal of the testing. Non-technical manual tests can be done by anyone, and in these tests things like alt-text conformance to image content can be checked. Technical checks, on the other hand, require basic knowledge about web development and accessibility. Usually web developers conduct tests like this when they check compatibility with assistive technology or check the markup and document structure of the page. [Paz et al. 2021, 877; Abou-Zahra 2008, 86]

The most advanced type of manual testing is expert testing. Evaluators conducting expert testing have a profound understanding on how people with disabilities use the web and they can find out the issues that the end-users might encounter on the website. They often use assistive technology while collecting the findings. The expertise of the evaluators affect the results and the level of details collected. [Paz et al. 2021, 877; Abou-Zahra 2008, 86]

Conformance reviews for websites are included in the category of manual testing conducted by accessibility experts. In conformance review, an accessibility expert evaluates the website against the chosen checklist or guidelines like WCAG and produces a list of violated guidelines and what parts of the website did not conform to them. [Brajnik 2008, 113–114]

For conformance reviews, W3C [2014] has created the Web Accessibility Conformance Evaluation Methodology (WCAG-EM) to determine the degree in which the website meets the WCAG criteria. The methodology defines five phases for evaluation: 1) define the scope of the evaluation, 2) explore the target website, 3) select a representative sample, 4) audit the selected sample and 5) report the evaluation findings [W3C 2014]. The evaluation phases are discussed in more detail in the method chapter of this thesis.

The third type of accessibility evaluation is user testing. In formal user testing, real end-users are testing the website in a controlled setting. User testing complements automated testing and manual testing, and even though accessibility was considered from the start and professional standards for creating accessible websites were followed, user testing is an essential adjunct for ensuring the accessibility of the website. User testing will most often find accessibility errors that would otherwise go unnoticed but it is also the most expensive approach. Recruiting users is also laborious since, in optimal settings, many user profiles should be covered. [Paz et al. 2021, 878; Wheeler & Kreps 2008, 331; Abou-Zahra 2008, 86–87]

As mentioned, the best result from accessibility assessment is achieved by combining the different evaluation methods. For example, Patvardhan et al. [2022] combined manual testing and automated testing when they evaluated the accessibility of top e-commerce websites in India. Paz et al. [2021] only used automated tools in e-commerce website accessibility evaluation but combined multiple of those as the results still vary between the different tools.

Gonçalves et al. [2018] took the most profound approach and applied all three methods: automated tool, heuristic evaluation by usability specialists and user tests. They found out that automatic tools revealed only some non-conformities with WCAG guidelines scores for the Portuguese e-commerce websites that they were evaluating, while the manual heuristic evaluation pointed out more accessibility errors. Some issues that were left unnoticed with both of the previous methods were found during the user tests. [Gonçalves et al. 2018]

Also members of different roles in software development teams use and prefer using different accessibility testing methods. That enriches the variety of accessibility issues found during the development. [Bai et al. 2019, 5–13]

2.5. E-commerce and the significance of product filters and accessibility

E-commerce (electronic commerce) means that services are provided at a distance mediated by websites or mobile applications [Directive (EU) 2019/882]. E-commerce is purchasing, selling and advertising goods and services to consumers via the web [Patvardhan et al. 2022,

1]. This thesis focuses on e-commerce between organizations and end customers, i.e. B2C (business to consumers) e-commerce [Rosita 2023, 35–36].

The evident advantage of e-commerce compared to brick-and-mortar stores is that it offers a convenient shopping experience and consumers can shop regardless of space and time [Rosita 2023, 35–36]. COVID-19 accelerated the growth of the e-commerce market and the e-commerce sales are expected to rise also in the following years [Insider Intelligence 2022; Acosta-Vargas et al. 2022].

Nowadays, fashion is the largest business-to-consumer (B2C) e-commerce category [Statista 2023a]. Even though e-commerce has expanded to cover a multitude of industries, clothing and shoes are the two most popular categories for online purchases also among Finnish consumers [Statista 2023b].

The significance of fashion e-commerce is also indicated by the amount of interest it has gained among the researchers, since a large amount of research around the topic has been conducted from multiple points of view. Many researches focus on, for example, analyzing the consumer behavior in fashion e-commerce [e.g. Sutinen et al. 2021; Gabrielli et al. 2013; Sundström et al. 2019; Saarijärvi et al. 2017] or comparing different consumer groups [e.g. Boardman & McCormick 2023; Fares et al. 2023].

Methods and systems to advance the sales in e-commerce are constantly enhanced, and for example, recommender systems in fashion e-commerce have gained notable interest. The books composed by Pampín et al. [2023] and Dokoohaki et al. [2022] present proceedings from the conferences in the field of recommendation systems in e-commerce, retail and fashion in recent years. The recommender systems for fashion e-commerce are constantly improved. For example, Naham et al. [2023] created a multi-task learning and gender-aware fashion recommendation system. Sridevi et al. [2020] focus on providing a recommender system solution that gets a product image from the user as an input and generates recommendations based on that.

Recently, research about augmented reality in beauty and fashion e-commerce has also been conducted [Gabriel et al. 2023]. The importance of other customers' text and image reviews for the purchase decisions is understood and researchers have come up with new

review image ranking methods [Jaiswal et al. 2023]. All this interest around fashion e-commerce proves that the industry is well alive and constantly evolving and thus, it is a great topic for research.

Fashion and other e-commerce websites can have thousands of products, and for a good user experience – and successful sales – the stores must provide convenient ways to narrow down the selection of products [Baymard Institute 2023; Holst 2015; Stepanov 2020; Thomas 2021]. In general, website content can be categorized based on their function. The two basic functions of a website are communication and interaction [Horton 2006]. Communication is serving something static – for example text, images or charts – for the user to digest, while the interactive elements require the user to take action [Horton 2006]. Product filters fall in the category of interactive elements.

Product filter is a feature on an e-commerce website that allows users to limit the amount of products in the product listing or sort products based on certain features. Only the products matching the filter criteria are displayed to the user on the front-end. [Ansari 2022; Friedman 2021]

It is hard to find peer-reviewed research focusing on product filters in e-commerce. However, industry specialists have a consensus that product filters are a must for successful e-commerce sales and online shopping experience. There are plenty of studies and blog posts directed for e-commerce site owners, designers and developers about the importance of product filters [e.g. Baymard Institute 2023, 2021, 2020, 2015a, 2015b; Holst 2015; Ansari 2022; Friedman 2021; Stepanov 2020; Thomas 2021]. The significance of product filters is proven by the observation that the users often abandon the site, if they are unable to filter the products in a way that meets their needs [Baymard Institute 2023, 2015b; Stepanov 2020].

Product filters should be well-designed and they should have the relevant options and predictable logic. Successful e-commerce websites have category-specific filters with relevant options, since a few general filters will not help the customer much. Highlighting the important filters is an advantage as it helps users to pick the filters they use. Users also want to apply multiple filter values of the same type and use thematic filtering. The selected filters should be displayed in two places – in their original position as well as an overview –

but to keep the amount of information on the site reasonable, the filter options should be truncated if the list is long. Users also expect that the filtering history is saved to the browser history so that they can get back to the previously selected filters by using the back-button of the browser. The filters should have a comfortable range of options and sliders should have text input fields and steppers as an alternative way of control. [Baymard Institute 2015a; Holst 2015; Thomas 2021; Friedman 2021]

When considering the page layout, one of the challenges for product filter designers remains to be the positioning of the filtering options. The traditional left-hand vertical sidebar is often ignored by the users or considered as the navigation element of the whole site. But due to limited space, horizontally over the product listing positioned filters are a viable option only if there are naturally only a few relevant filters for the products. [Baymard Institute 2015b]

As important as product filters are for e-commerce, so is the accessibility. A well designed and accessible website supports the business goals by improving the user experience and satisfaction of all user groups and by extending the market reach [W3C 2022].

For users with disabilities, accessibility of e-commerce platforms serve as a one form of economic independence [Patvardhan et al. 2022, 1]. For these customers there are many benefits of shopping online compared to going to a physical store. But an inaccessible website easily excludes people with disabilities and in the worst case, prevents them from using the inaccessible e-commerce website entirely. Accessible product filters are valuable for keyboard users as by navigating through pages, keyboard users face a lot of unnecessary scrolling through pages anyway.

As the awareness about the importance of accessibility of e-commerce spreads, a growing amount of research is conducted on the topic. E-commerce websites around the world have been evaluated for accessibility in recent years [e.g. Hafiar et al. 2023; Acosta-Vargas et al. 2022; Paz et al. 2021; Patvardhan et al. 2022].

The bad news is that none of the four main international e-commerce websites [Paz et al. 2021, 879–880], the top ten e-commerce websites in India [Patvardhan et al. 2022] nor the 39 popular e-commerce websites in Indonesia [Hafiar et al. 2023] got peculiarly flattering

results from accessibility evaluation. However, the evaluation of 50 leading e-commerce websites around the world gave some promising results as 44,2 % of the sites were concluded to comply with WCAG level A and 55,8 % with level AA [Acosta-Vargas et al. 2022, 17]. But it must be noticed that all of the aforementioned accessibility evaluations on large amounts of websites are conducted only with automated tools, which can only detect some of the accessibility issues. So when reading the results, one can get an overly optimistic view on the topic.

Not all e-commerce accessibility research focuses only on offering overviews of the current situation. For example, there exist suggestions on how to improve the accessibility of e-commerce websites by implementing the best practices of game accessibility design in e-commerce websites [Abdalla et al. 2021]. These few highlights from the vast amount of research around e-commerce accessibility in recent years indicate that there is still room for research and additional attention on different aspects of accessibility of e-commerce websites.

3. Method and data

3.1. Leading fashion e-commerce websites in Finland

The data for this research will be collected from 10 fashion e-commerce websites. By e-commerce net sales, the ten leading fashion e-commerce websites in Finland identified by Statista [2023c] are

- zalando.fi
- hm.com
- boozt.com
- zalando-lounge.com
- uniqlo.com
- stockmann.com
- ellos.fi
- shein.com
- aboutyou.fi
- xxl.fi.

As zalando-lounge.com is part of Zalando, it is left out and replaced with sokos.fi. Sokos is one of the largest department stores in Finland along with Stockmann that was in the list already. Sokos renewed their website in the beginning of 2023 [SOK 2023]. In the light of the forthcoming accessibility requirements for e-commerce in the EU, it is interesting to evaluate how accessibility is taken into account in the freshly renewed website.

3.2. Manual expert evaluation

This thesis follows the Web Accessibility Conformance Evaluation Methodology (WCAG-EM) [W3C 2014]. It has five phases for executing the evaluation. Each of the phases and how they are employed in this thesis are discussed below.

3.2.1. Define the scope of the evaluation

In this phase, the parts of the websites evaluated are selected and the target conformance level of WCAG is defined [W3C 2014]. This thesis focuses on the product filters of the ten

leading fashion e-commerce websites in Finland and offers a focused accessibility assessment of the product filtering functionality.

Focused accessibility assessment means that only a specific aspect of a website is examined in detail with the aim to improve or optimize the accessibility of that particular functionality or content, and this type of assessment is most often done for websites in operation phase [Abou-Zahra 2008, 83–84]. The websites are evaluated up to the conformance level AA, which is the recommended level [W3C 2016a].

3.2.2. Explore the target website

The second step of evaluation is to explore the target website and identify common pages on the site as well as the essential functionality [W3C 2014]. Based on e-commerce website exploration, previous research and industry experts' focus on product filters, the product filters were selected as the evaluation target.

3.2.3. Select a representative sample

The evaluators should select a representative sample of web pages including pages for common and essential functionality as well as some random sample pages from the website. The recommendation is to include some complete process that the user could conduct on the website to the evaluation. [W3C 2014]

This step of the methodology is not completely followed in this thesis since the aim is not to provide a comprehensive accessibility assessment of a single website but rather an overview, comparison and classification of the state of keyboard accessibility of a clearly defined functionality in multiple similar websites. But in the context of this thesis, the representative sample can be seen as the ten leading websites in the chosen industry.

3.2.4. Audit the selected sample

In this phase, the evaluator carries out the detailed evaluation of the selected sample. A detailed evaluation is called an audit. [W3C 2014]

The keyboard accessibility issues of product filters of the selected fashion e-commerce websites are identified by manual expert inspection. As the WCAG guideline “2.1. Keyboard Accessible” states, all functionality should be accessible by keyboard [W3C 2018].

In particular, attention is paid on if all functionality is operable with the standard QWERTY keyboard interface without specific timings for individual keystrokes. Also any keyboard traps are noted and the intuitiveness of filter usage by keyboard is evaluated.

The standard keyboard interactions are presented in Table 1. This summary of standard keystrokes for the most common online interactions is an adapted version from the keyboard testing instructions written by WebAIM [2023].

Interaction	Keystrokes
Navigate to interactive elements	<ul style="list-style-type: none"> - Tab - navigate forward - Shift + Tab - navigate backward
Link	<ul style="list-style-type: none"> - Enter - activate the link
Button	<ul style="list-style-type: none"> - Enter or Spacebar - activate the button
Checkbox	<ul style="list-style-type: none"> - Spacebar - check/uncheck the checkbox
Radio buttons	<ul style="list-style-type: none"> - Spacebar - select the focused option (of not selected) - Arrow keys - navigate between options - Tab - leave the group of radio buttons
Select (dropdown) menu	<ul style="list-style-type: none"> - Arrow keys - navigate between options - Spacebar - expand - Enter/Esc - select option and collapse
Dialog	<ul style="list-style-type: none"> - Esc - close
Slider	<ul style="list-style-type: none"> - Arrow keys - increase or decrease slider value - Home/End - beginning or end
Scroll	<ul style="list-style-type: none"> - Arrow keys - scroll vertically and horizontally

Table 1. Common online interactions and the standard keystrokes for them.

During the accessibility audit, the following procedure was followed when collecting the data:

Step 1: Open the frontpage of the website.

Step 2: From the frontpage, navigate to the product filtering view only using the keyboard. Tab key is used to navigate forward and the enter key is used to activate the link or the button that leads to the product filtering page.

Step 3: Go through and test all the filters by using only the keyboard. Keystrokes are selected depending on the style of the interaction element in the filter. The keystrokes that are used are listed in Table 1.

Step 4: Take screenshots and write down observations of any keyboard accessibility issue on the product filters.

In order to answer the research questions, the analysis will summarize and categorize the found keyboard accessibility errors. Each error is rated for its severity.

The severity rating has three levels:

1 - high: A very severe and critical problem that prevents the user from using the feature.

2 - medium: An inconvenience that prevents the optimal usage of the feature and may cause unnecessary trouble and annoyance for the user but does not completely prevent the user from using the feature.

3 - low: A cosmetic problem that gives an unfinished impression but does not prevent the user from using the feature.

These severity rating levels are a modification from the “Severity Matrix” created by the Digital Accessibility Services (DAS) of Harvard University. In Harvard University, a three-level accessibility rating is used when assessing the accessibility of websites. [Digital Accessibility Services (DAS) of Harvard University 2023]

In addition to severity, each error is examined against the WCAG criteria it violates. The errors are further categorized to more detailed categories in order to better formulate the possible improvements. Also, as the aim of this thesis is to evaluate the status of keyboard

accessibility of product filters on multiple websites, the accessibility of common filters are compared between the websites.

3.2.5. Report the evaluation findings

The evaluators must report the findings after the audit [W3C 2014]. The findings are reported in the analysis and conclusion chapters of this thesis.

3.3. Data

The data was collected between 21.7.–13.8.2023 with Google Chrome version 115.0.5790.170 (Official Build) (arm64). Google Chrome was chosen because it is currently the most popular web browser [Similarweb 2023]. A standard QWERTY keyboard was used when navigating the websites.

The focus of this research is on the product filters, including the product category and sort order selectors which – at least in most of the studied websites – were implemented a bit differently than the rest of the filters. Figure 1 displays an example of how the filters were implemented in one of the websites and which parts of the website were included in this research.

Everything marked with red borders in Figure 1 is included: the product category selection list on the left side of the page, the sort order dropdown selectors on the right, and the rest of the product filters and the show more filters button in the middle. Like in Figure 1, most often the product filters and sorting are implemented as a horizontal bar or a left-hand vertical sidebar in e-commerce in general [Baymard Institute 2015b].

The difference between filtering and sorting is the boundaries they set to the result list. Sorting only rearranges the product list by some attribute, which can be considered as a soft boundary, while filtering sets hard boundaries limiting the scope of the results [Friedman 2021]. Both of these are relevant for comfortable user experience and thus they are both included in this research.

Appendices 1–10 contain screenshots of all the product search pages and filters in them. From Figure 1 and Appendices 1–10 we can see that it is popular to have the product filters

implemented as lists of options, dropdown and accordion menus, toggle switches, sliders and radio buttons. These can all be created with basic HTML elements and they can be made accessible.

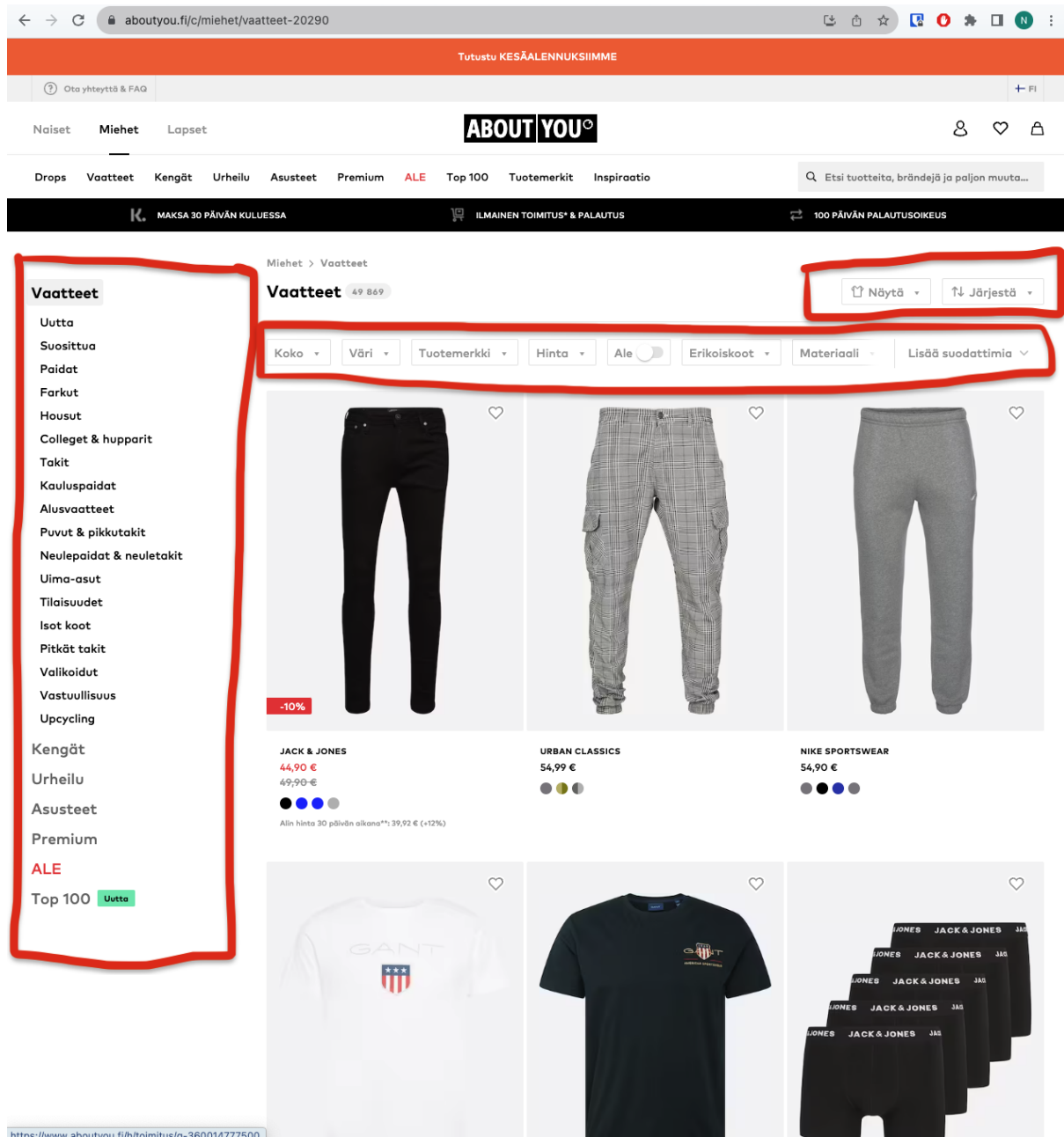


Figure 1. The product filters of aboutyou.fi.

All the found keyboard accessibility errors are presented in Tables 2–4. Each error is given a unique error number to make it easier to refer to the error later in text. The error description is best understood when looking at the screenshot of that particular error on the side. The exhaustive collection of screenshots can be found from Appendices 1–10.

Appendices 1–10 also include overview pictures of the product filtering pages of each website so it is easier to put the error screenshots into context.

Website and date	Error number	Error description	Screenshot
zalando.fi 21.7.2023	zalando-E1	The focus is not indicated when browsing the items on the sort order ("Lajittelu") filter.	Appendix 1, Figure 3
	zalando-E2	In the search bar of the brand ("Merkki") filter the "X" button does not do anything. However, this is a general bug because the button does not work for mouse users either. Users can erase the text with backspace.	Appendix 1, Figure 4
	zalando-E3	The filter dropdowns are not automatically closed when the focus moves forward.	Appendix 1, Figure 5
	zalando-E4	The focus jumps to an unexpected place – the browser address bar – after the last dropdown filter item if no items are selected.	Appendix 1, Figure 6
	zalando-E5	By continuously pressing the tab key on an open dropdown menu, the focus unexpectedly jumps to the address bar instead of continuing to the next element (zalando-E4). If the user continues pressing tab from the address bar wishing to get back to the filter dropdowns, the main menu opens under the already open dropdown menu. The main menu stays open even if focus gets to the elements under it preventing the user from seeing which element is in focus.	Appendix 1, Figure 7
	zalando-E6	The focus is not indicated when it is on the remove selections ("Poista valinnat") button of filter dropdowns.	Appendix 1, Figure 8
hm.com 21.7.2023	hm-E1	The sort order ("Lajittelu") filter dropdown options are inaccessible by keyboard.	Appendix 2, Figure 11
	hm-E2	Each list item with a checkbox has two focus areas instead of one which causes unnecessary clicks for a keyboard user.	Appendix 2, Figures 12 and 13
	hm-E3	When multiple filters are selected, some of the selections are hidden inside an accordion element. There is a button to open the accordion, but the focus reaches the button only after going through the whole list of selected filters. This causes the focus to be invisible while going through the list of selected filters.	Appendix 2, Figure 14

Table 2. Accessibility errors of the product filters of zalando.fi and hm.com fashion e-commerce websites.

Website and date	Error number	Error description	Screenshot
boozt.com 13.8.2023	boozt-E1	The filter dropdown menus cannot be scrolled down with a keyboard while they are open. Thus, only the first items of the list are visible even though the focus goes down the list. It is impossible to know which element is in focus when the current focus is not visible. This problem is evident in the brands ("Brändit") filter as the list of brands is long.	Appendix 3, Figure 16
	boozt-E2	The color ("Väri") dropdown options are inaccessible by keyboard.	Appendix 3, Figure 17
uniqlo.com 24.7.2023	uniqlo-E1	The focus is not indicated on the filters.	Appendix 4, Figure 20
stockmann.com 24.7.2023	stockmann-E1	Users can not access any other filter except the category filter that is open by default. The focus moves right to the product listing after passing the category filter. The focus never gets to the other filters.	Appendix 5, Figure 22
	stockmann-E2	The focus is not indicated on the sort order filter.	Appendix 5, Figure 23
ellos.fi 7.8.2023	ellos-E1	When pressing the filter opening button, filters appear before the filter opening button, category selection and the breadcrumbs of the page. The navigation order gets unintuitive and the user must understand navigating backwards to get to the filters.	Appendix 6, Figure 25
	ellos-E2	The focus is not indicated when it is on the filters.	Appendix 6, Figure 26
	ellos-E3	The focus is not indicated on the filter options of size ("Koko") and material ("Materiaali") filters.	Appendix 6, Figure 27
	ellos-E4	The focus never gets to the prize slider by keyboard.	Appendix 6, Figure 28
	ellos-E5	The last elements of size ("Koko"), material ("Materiaali") and brands ("Merkit") filters are invisible even if focus is on them.	Appendix 6, Figures 29 and 30

Table 3. Accessibility errors of the product filters of boozt.com, uniqlo.com, stockmann.com and ellos.fi fashion e-commerce websites.

Website and date	Error number	Error description	Screenshot
shein.com 7.8.2023	shein-E1	The focus is not indicated when it is on the filters.	Appendix 7, Figure 32
	shein-E2	None of the filters work for keyboard users because the filter options cannot be selected by keyboard.	Appendix 7, Figure 32
	shein-E3	The sort order dropdown menu is inaccessible by keyboard. It seems that the focus never gets to the element but this cannot be confirmed because the focus is not indicated (shein-E1).	Appendix 7, Figure 33
aboutyou.fi 7.8.2023	aboutyou-E1	The focus never gets to the view type selection ("Näytä") filter dropdown options.	Appendix 8, Figure 35
	aboutyou-E2	The focus never gets to the sort order ("Järjestä") filter dropdown options.	Appendix 8, Figure 36
	aboutyou-E3	The focus is not indicated on size ("Koko"), color ("Väri"), brand ("Tuotemerkki"), special sizes ("Erikoiskoot"), material ("Materiaali"), pattern ("Kuvio"), responsibility ("Vastuullisuus"), sleeve length ("Hihan pituus"), neck ("Pääntie"), package ("Pakkaus"), and length ("Pituus") filters.	Appendix 8, Figure 37
	aboutyou-E4	By default, some of the filters are hidden and the show more filters button is placed after the hidden filters. The focus is lost in the hidden elements while the user navigates to the button.	Appendix 8, Figure 38
	aboutyou-E5	The filter and product listing element gets misaligned when hidden filters are browsed or opened before clicking the show more filters button.	Appendix 8, Figure 39
	aboutyou-E6	Focus is not indicated when it is on the show more filters button.	Appendix 8, Figure 40
xxl.fi 7.8.2023	xxl-E1	Each option in product category ("Tuoteryhmä"), size ("Koko"), color ("Väri"), fit ("Istuvuus"), usage ("Käyttö"), brand ("Tuotemerkki"), and quality ("Laatu") filters has two focus areas instead of one which causes unnecessary clicks for a keyboard user.	Appendix 9, Figure 42
	xxl-E2	The focus is not indicated when it is on the empty all filters ("Tyhjennä") button.	Appendix 9, Figure 43
	xxl-E3	The focus never gets to the availability selection radio buttons.	Appendix 9, Figure 44
sokos.fi 13.8.2023	sokos-E1	The focus is not indicated on the items of the sort filter ("Järjestä").	Appendix 10, Figure 46
	sokos-E2	The focus never gets to the filters for brand ("Brändi"), color ("Väri") and size ("Koko").	Appendix 10, Figure 47

Table 4. Accessibility errors of the product filters of shein.com, aboutyou.fi, xxl.fi and sokos.fi fashion e-commerce websites.

4. The accessibility of product filters

4.1. Severe accessibility errors and violations of WCAG criteria

The accessibility errors of product filters vary in their severity: some errors totally prevent the usage of the functionality while others are mainly cosmetic problems. For this reason, every observed accessibility error is given a severity rating. Assigning severity ratings to issues is also a way to mark the priority order of them, so that in web development projects, the most critical issues are addressed first [Digital Accessibility Services (DAS) of Harvard University 2023].

As described in the methods chapter, a three-level severity rating is used in this research. Tables 5–8 display a severity rating for each detected accessibility error. The violated WCAG criteria are also included in the tables.

From Tables 5–8 we can conclude that 14 of the total of 33 observed accessibility errors were highly severe, 18 were medium and 1 was low in their severity. When looking at the WCAG criteria column, we can see that in total, three different WCAG criteria were violated. The violated criteria, 2.1.1 Keyboard (Level A), 2.4.3 Focus Order (Level A), and 2.4.7 Focus Visible (Level AA), were introduced in detail in chapter 2. As mentioned earlier, violations to these criteria hamper the operability and navigability of the website.

Website and date	Error number	Error description	Severity 1 - high 2 - medium 3 - low	WCAG criteria
zalando.fi 21.7.2023	zalando-E1	The focus is not indicated when browsing the items on the sort order ("Lajittele") filter.	2	2.4.7 Focus visible (Level AA)
	zalando-E2	In the search bar of the brand ("Merkki") filter the "X" button does not do anything. However, this is a general bug because the button does not work for mouse users either. Users can erase the text with backspace.	1	-
	zalando-E3	The filter dropdowns are not automatically closed when the focus moves forward.	2	-
	zalando-E4	The focus jumps to an unexpected place – the browser address bar – after the last dropdown filter item if no items are selected.	2	2.4.3 Focus order (Level A)
	zalando-E5	By continuously pressing the tab key on an open dropdown menu, the focus unexpectedly jumps to the address bar instead of continuing to the next element (zalando-E4). If the user continues pressing tab from the address bar wishing to get back to the filter dropdowns, the main menu opens under the already open dropdown menu. The main menu stays open even if focus gets to the elements under it preventing the user from seeing which element is in focus.	1	2.4.7 Focus visible (Level AA)
	zalando-E6	The focus is not indicated when it is on the remove selections ("Poista valinnat") button of filter dropdowns.	2	2.4.7 Focus visible (Level AA)
hm.com 21.7.2023	hm-E1	The sort order ("Lajittelu") filter dropdown options are inaccessible by keyboard.	1	2.1.1 Keyboard (Level A)
	hm-E2	Each list item with a checkbox has two focus areas instead of one which causes unnecessary clicks for a keyboard user.	2	-
	hm-E3	When multiple filters are selected, some of the selections are hidden inside an accordion element. There is a button to open the accordion, but the focus reaches the button only after going through the whole list of selected filters. This causes the focus to be invisible while going through the list of selected filters.	2	2.4.3 Focus order (Level A), 2.4.7 Focus visible (Level AA)

Table 5. Accessibility errors of the product filters of zalando.fi and hm.com fashion e-commerce websites with severity rating and the WCAG criteria that the error violates.

Website and date	Error number	Error description	Severity 1 - high 2 - medium 3 - low	WCAG criteria
boozt.com 13.8.2023	boozt-E1	The filter dropdown menus cannot be scrolled down with a keyboard while they are open. Thus, only the first items of the list are visible even though the focus goes down the list. It is impossible to know which element is in focus when the current focus is not visible. This problem is evident in the brands ("Brändit") filter as the list of brands is long.	1	2.1.1 Keyboard (Level A), 2.4.7 Focus visible (Level AA)
	boozt-E2	The color ("Väri") dropdown options are inaccessible by keyboard.	1	2.1.1 Keyboard (Level A)
uniqlo.com 24.7.2023	uniqlo-E1	The focus is not indicated on the filters.	2	2.4.7 Focus visible (Level AA)
stockmann.com 24.7.2023	stockmann-E1	Users can not access any other filter except the category filter that is open by default. The focus moves right to the product listing after passing the category filter. The focus never gets to the other filters.	1	2.1.1 Keyboard (Level A)
	stockmann-E2	The focus is not indicated on the sort order filter.	2	2.4.7 Focus visible (Level AA)
ellos.fi 7.8.2023	ellos-E1	When pressing the filter opening button, filters appear before the filter opening button, category selection and the breadcrumbs of the page. The navigation order gets unintuitive and the user must understand navigating backwards to get to the filters.	2	2.4.3 Focus order (Level A)
	ellos-E2	The focus is not indicated when it is on the filters.	2	2.4.7 Focus visible (Level AA)
	ellos-E3	The focus is not indicated on the filter options of size ("Koko") and material ("Materiaali") filters.	2	2.4.7 Focus visible (Level AA)
	ellos-E4	The focus never gets to the prize slider by keyboard.	1	2.1.1 Keyboard (Level A)
	ellos-E5	The last elements of size ("Koko"), material ("Materiaali") and brands ("Merkit") filters are invisible even if focus is on them.	1	2.1.1 Keyboard (Level A)

Table 6. Accessibility errors of the product filters of boozt.com, uniqlo.com, stockmann.com and ellos.fi fashion e-commerce websites with severity rating and the WCAG criteria that the error violates.

Website and date	Error number	Error description	Severity 1 - high 2 - medium 3 - low	WCAG criteria
shein.com 7.8.2023	shein-E1	The focus is not indicated when it is on the filters.	2	2.4.7 Focus visible (Level AA)
	shein-E2	None of the filters work for keyboard users because the filter options cannot be selected by keyboard.	1	2.1.1 Keyboard (Level A)
	shein-E3	The sort order dropdown menu is inaccessible by keyboard. It seems that the focus never gets to the element but this cannot be confirmed because the focus is not indicated (shein-E1).	1	2.1.1 Keyboard (Level A)
aboutyou.fi 7.8.2023	aboutyou-E1	The focus never gets to the view type selection ("Näytä") filter dropdown options.	1	2.1.1 Keyboard (Level A)
	aboutyou-E2	The focus never gets to the sort order ("Järjestä") filter dropdown options.	1	2.1.1 Keyboard (Level A)
	aboutyou-E3	The focus is not indicated on size ("Koko"), color ("Väri"), brand ("Tuotemerkki"), special sizes ("Erikoiskoot"), material ("Materiaali"), pattern ("Kuvio"), responsibility ("Vastuullisuus"), sleeve length ("Hihan pituus"), neck ("Pääntie"), package ("Pakkaus"), and length ("Pituus") filters.	2	2.4.7 Focus visible (Level AA)
	aboutyou-E4	By default, some of the filters are hidden and the show more filters button is placed after the hidden filters. The focus is lost in the hidden elements while the user navigates to the button.	2	2.4.3 Focus order (Level A), 2.4.7 Focus visible (Level AA)
	aboutyou-E5	The filter and product listing element gets misaligned when hidden filters are browsed or opened before clicking the show more filters button.	3	-
	aboutyou-E6	Focus is not indicated when it is on the show more filters button.	2	2.4.7 Focus visible (Level AA)

Table 7. Accessibility errors of the product filters of shein.com and aboutyou.fi fashion e-commerce websites with severity rating and the WCAG criteria that the error violates.

Website and date	Error number	Error description	Severity 1 - high 2 - medium 3 - low	WCAG criteria
xxl.fi 7.8.2023	xxl-E1	Each option in product category ("Tuoteryhmä"), size ("Koko"), color ("Väri"), fit ("Istuvuus"), usage ("Käyttö"), brand ("Tuotemerkki"), and quality ("Laatu") filters has two focus areas instead of one which causes unnecessary clicks for a keyboard user.	2	-
	xxl-E2	The focus is not indicated when it is on the empty all filters ("Tyhjennä") button.	2	2.4.7 Focus visible (Level AA)
	xxl-E3	The focus never gets to the availability selection radio buttons.	1	2.1.1 Keyboard (Level A)
sokos.fi 13.8.2023	sokos-E1	The focus is not indicated on the items of the sort filter ("Järjestä").	2	2.4.7 Focus visible (Level AA)
	sokos-E2	The focus never gets to the filters for brand ("Brändi"), color ("Väri") and size ("Koko").	1	2.1.1 Keyboard (Level A)

Table 8. Accessibility errors of the product filters of xxl.fi and sokos.fi fashion e-commerce websites with severity rating and the WCAG criteria that the error violates.

Table 9 which presents a more detailed categorization of highly severe accessibility errors. Severe accessibility errors prevent the user from using the feature that the issue affects.

From Table 9 we can see that the most common sub-category among the severe accessibility errors is that the element is unreachable. This means that the element is skipped altogether and the focus never gets to it when the user navigates on the page with keyboard. Thus, all the errors in this sub-category violate the WCAG criterion "2.1.1 Keyboard (Level A)". From the screenshots in appendices listed in Table 9, we can see that there is a large variety of skipped elements – accordion menus, sliders, dropdown menus, and radio buttons – and all of them in these implementations are totally inoperable by keyboard. It is quite alarming that over half of the websites included in this research had at least one accessibility error in this category.

The second largest sub-category of the severe accessibility errors is inoperable options as we can see from Table 9. Inoperable options mean that the focus gets to the elements but no

selections can be done using the keyboard. The screenshots in appendices demonstrate that errors of this subcategory can be found from radio buttons and checkboxes of product filters. As with unreachable elements, also all the errors in this sub-category violate the WCAG criterion “2.1.1 Keyboard (Level A)”.

The third sub-category of highly severe accessibility errors in Table 9 is unscrollable elements. From screenshots in respective appendices we can see that this error concerns dropdowns as well as accordions. The whole set of options cannot be viewed by using only a keyboard and therefore, the user never sees all the available options. The focus gets lost in the hidden elements and the user must guess where the focus is. Errors in this category violate criteria “2.1.1 Keyboard (Level A)” and “2.4.7 Focus visible (Level AA)”.

Category of accessibility errors	Error number	WCAG criteria	Screenshot
Unreachable element	stockmann-E1	2.1.1 Keyboard (Level A)	Appendix 5, Figure 22
	ellos-E4	2.1.1 Keyboard (Level A)	Appendix 6, Figure 28
	shein-E3	2.1.1 Keyboard (Level A)	Appendix 7, Figure 33
	aboutyou-E1	2.1.1 Keyboard (Level A)	Appendix 8, Figure 35
	aboutyou-E2	2.1.1 Keyboard (Level A)	Appendix 8, Figure 36
	xxl-E3	2.1.1 Keyboard (Level A)	Appendix 9, Figure 44
	sokos-E2	2.1.1 Keyboard (Level A)	Appendix 10, Figure 47
Inoperable options	hm-E1	2.1.1 Keyboard (Level A)	Appendix 2, Figure 11
	boozt-E2	2.1.1 Keyboard (Level A)	Appendix 3, Figure 17
	shein-E2	2.1.1 Keyboard (Level A)	Appendix 7, Figure 32
Unscrollable elements	boozt-E1	2.1.1 Keyboard (Level A), 2.4.7 Focus visible (Level AA)	Appendix 3, Figure 16
	ellos-E5	2.1.1 Keyboard (Level A)	Appendix 6, Figures 29 and 30
Non-functional button	zalando-E2	-	Appendix 1, Figure 4
Stacking elements	zalando-E5	2.4.7 Focus visible (Level AA)	Appendix 1, Figure 7

Table 9. Detailed categorization of highly severe (severity: 1 - high) accessibility errors of the product filters of ten fashion e-commerce websites.

The two remaining sub-categories in Table 9 each contain only one error. First of these categories is the non-functional button. In one of the product filters of zalando.fi, there is a search bar with an erase button (Appendix 1, Figure 4) that does not do anything. However, as already said in the error description, this is a general bug because the button does not work for mouse users either and users can erase the text with backspace. But regardless of these notices, the button is still non-functional and does not serve the function it is created for.

The last category of highly severe errors in Table 9 is about stacking elements. When elements are stacked on top of each other, not only the stacked elements are unusable but also elements under them because the focus gets lost under the opened elements and the user cannot know where the focus is. The unfortunate situation is well described by Figure 7 in Appendix 1 where a filter dropdown and main menu are blocking the view while the focus indicator is somewhere under the opened elements. This situation violates the criterion “2.4.7 Focus visible (Level AA)”.

When looking back on Tables 5–8, we can see that the majority of errors are in the severity category medium. They cause inconvenience and hindrance to the user and prevent the optimal usage of the feature without totally blocking the usage. Table 10 contains a more fine-grained categorization of these errors.

As can be seen from Table 10, the largest sub-category of medium-level accessibility errors is the category of missing focus indicators. All the errors in this sub-category violate the WCAG criterion “2.4.7 Focus visible (Level AA)”. Keyboard focus indicator is an outline or other clearly visible visual indicator at the element in focus and it follows the current place of focus as the user navigates on the page. Focus indicator is an essential feature for a keyboard user as it is often the only way to know where the focus is without randomly clicking interactive elements on the site to get a hint of the location of the focus. In total, eight of the ten inspected websites had at least one error in this sub-category so this can be considered as a common accessibility issue among the observed websites.

The second sub-category in Table 10 is unintuitive navigation order. In some cases, the focus jumps to an unexpected and illogical place (zalando-E4), while in other cases the user must navigate through an invisible list of items before getting to an element that should have

been next in order according to the visual user interface (hm-E3, aboutyou-E4). Also new elements are added before the current element and the user is expected to navigate backwards to the newly appeared element (ellos-E1). In all of these cases navigation becomes unintuitive. All of them violate the WCAG criteria “2.4.3 Focus order (Level A)” and in addition to that in two of the errors focus is temporarily lost in hidden elements so they violate “2.4.7 Focus visible (Level AA)”.

Category of accessibility errors	Error number	WCAG criteria	Screenshot
No focus indicator	zalando-E1	2.4.7 Focus visible (Level AA)	Appendix 1, Figure 3
	zalando-E6	2.4.7 Focus visible (Level AA)	Appendix 1, Figure 8
	uniqlo-E1	2.4.7 Focus visible (Level AA)	Appendix 4, Figure 20
	stockmann-E2	2.4.7 Focus visible (Level AA)	Appendix 5, Figure 23
	ellos-E2	2.4.7 Focus visible (Level AA)	Appendix 6, Figure 26
	ellos-E3	2.4.7 Focus visible (Level AA)	Appendix 6, Figure 27
	shein-E1	2.4.7 Focus visible (Level AA)	Appendix 7, Figure 32
	aboutyou-E3	2.4.7 Focus visible (Level AA)	Appendix 8, Figure 37
	aboutyou-E6	2.4.7 Focus visible (Level AA)	Appendix 8, Figure 40
	xxl-E2	2.4.7 Focus visible (Level AA)	Appendix 9, Figure 43
	sokos-E1	2.4.7 Focus visible (Level AA)	Appendix 10, Figure 46
Unintuitive navigation order	zalando-E4	2.4.3 Focus order (Level A)	Appendix 1, Figure 6
	hm-E3	2.4.3 Focus order (Level A), 2.4.7 Focus visible (Level AA)	Appendix 2, Figure 12
	ellos-E1	2.4.3 Focus order (Level A)	Appendix 6, Figure 25
	aboutyou-E4	2.4.3 Focus order (Level A), 2.4.7 Focus visible (Level AA)	Appendix 8, Figure 38
Unnecessary clicks	zalando-E3	-	Appendix 1, Figure 5
	hm-E2	-	Appendix 2, Figure 12
	xxl-E1	-	Appendix 9, Figure 42

Table 10. Detailed categorization of accessibility errors with medium severity (severity: 2 - medium) of the product filters of ten fashion e-commerce websites.

The last category of errors of medium severity in Table 10 is unnecessary clicks. As can be read from the error descriptions in Tables 5 and 8 and seen from the respective appendices, unnecessary clicks are caused by dropdowns that do not close when the focus leaves them (zalando-E3) and filter option lists where each option has more than one focus area from which only the latter is activatable (hm-E2, xxi-E1).

Unnecessary clicks are a common hindrance and a source of annoyance for keyboard users even though there is no WCAG criteria for that. The group of accessibility errors in this research does not properly indicate the prevalence of this issue, because already during the data gathering there were numerous unnecessary clicks caused by main menus with no “skip to the main content” options as well as the product listings with an excessive amount of clicks per product. But optimizing the amount of clicks for keyboard users is a topic for another research.

Only one error got a low severity rating. It does not block the feature completely from a keyboard user nor does it cause unbearable discomfort when using the feature. However, it does give an unfinished impression of the site and reveals that keyboard accessibility is not fully taken into account in design and implementation. The error in this category is about misaligned elements (aboutyou-E5, Appendix 8, Figure 39) and it could be given a category “broken styles”. No WCAG criteria could be identified to concern this type of error.

4.2. Accessibility errors affect the usage of common product filters

Regardless of the product, there are usually a few commonly relevant filters in every e-commerce website [Baymard Institute 2021, 2020]. Among the ten fashion e-commerce websites included in this research, five common filters could be identified. They are category selection, sort order, brand, size, and color.

For simplicity, the sort order is called a filter in this inspection even though technically it is not that. Sorting just arranges the product listing into an order that is relevant to the customer. This is a crucial feature especially if the list of products is long, as it is a tedious process to browse through all the products manually [Baymard Institute 2021]. Filtering,

unlike sorting, means that items are extracted from the product listing according to the filter setting.

Almost all of the fashion e-commerce websites had these five common filters, as can be seen from Table 11. Uniqlo.com and shein.com had excluded the brand filter but otherwise they are found from every site.

In Table 11, the error code in parenthesis indicates which accessibility error is blocking or hindering the usage of the filter. Some errors are severe and they block the usage of the filter completely, as discussed earlier. Shein.com performs the worst, as none of the common filters is usable by keyboard. Even the category selection is unusable by keyboard in shein.com, when in every other website it is accessible and usable.

The second worst position in this comparison is shared between stockmann.com and sokos.fi. In both of these websites, product categories can be selected without problems and sort order can be set regardless of some inconvenience, but products cannot be filtered by brand, size or color because all of these filters are inaccessible by keyboard.

Four of the studied websites do quite well with the common product filters. As can be seen from Table 11, zalando.fi, uniqlo.com, ellos.fi, and xxl.fi each have some level of keyboard accessibility in all of the common filters implemented. None of the accessibility issues in those filters does block the usage of the filter completely even though the issues might hinder the usage with keyboard and leave an unfinished impression on the website.

The color filters have the greatest amount of severe accessibility errors as Table 11 indicates. Four of the ten websites have inaccessible color filters while sort order, brand, and size filters are inaccessible only on three websites. Category selection is the most accessible filter among the websites as it is inaccessible only in one website.

Website	Category selection	Sort order	Brand	Size	Color
zalando.fi	yes	yes (zalando-E1)	yes (zalando-E2)	yes	yes
hm.com	yes	no (hm-E1)	yes (hm-E2)	yes (hm-E2)	yes (hm-E2)
boozt.com	yes	yes	no (boozt-E1)	yes	no (boozt-E2)
uniqlo.com	yes	yes (uniqlo-E1)	-	yes (uniqlo-E1)	yes (uniqlo-E1)
stockmann.com	yes	yes (stockmann-E2)	no (stockmann-E1)	no (stockmann-E1)	no (stockmann-E1)
ellos.fi	yes	yes (ellos-E2)	yes (ellos-E2, ellos-E5)	yes (ellos-E2, ellos-E3, ellos-E5)	yes (ellos-E2)
shein.com	no (shein-E2)	no (shein-E3)	-	no (shein-E1, shein-E2)	no (shein-E1, shein-E2)
aboutyou.fi	yes	no (aboutyou-E2)	yes (aboutyou-E3)	yes (aboutyou-E3)	yes (aboutyou-E3)
xxl.fi	yes	yes	yes (xxl-E1)	yes (xxl-E1)	yes (xxl-E1)
sokos.fi	yes	yes (sokos-E1)	no (sokos-E2)	no (sokos-E2)	no (sokos-E2)

Table 11. Keyboard accessibility of common product filters of ten fashion e-commerce websites. “Yes” means that the filter is accessible and usable by keyboard. “No” means that the filter is unaccessible and inoperable with the keyboard. The error code related to the feature is in parenthesis. Empty cells indicate that the filter is not implemented on the website.

5. Product filters need further development for accessibility

The product filtering pages of the studied e-commerce websites have three key parts: list of categories, filters, and the product listing. This thesis focuses on the filters and the list of categories, which is basically a filter. The layout of the product filtering page varies from site to site.

As examples of different layouts, for example, on [zalando.fi](#) (Appendix 1, Figure 2) and [boozt.com](#) (Appendix 3, Figure 15) the filters are positioned horizontally over the product listing while on [hm.com](#) (Appendix 2, Figure 10) and on [uniqlo.com](#) (Appendix 4, Figure 19), the filters are opened to the side as a modal view. Most often the product categories are displayed on the left side of the page, like on [hm.fi](#) (Appendix 2, Figure 9) and [aboutyou.fi](#) (Appendix 8, Figure 34), but on some sites, like [sokos.fi](#) (Appendix 10, Figure 45), they are listed horizontally.

The filters on all websites are implemented as dropdowns or accordions containing lists of selectable options, checkboxes, radio buttons, and sliders. Regardless of some differences in layout and implementation, the accessibility of product filters could still be evaluated and the results of evaluation could be categorized and compared.

Drawing from the findings, categorizations and comparisons of the accessibility errors presented in the previous chapters, we can conclude that there are a large number of critical and medium accessibility errors in the ten leading fashion e-commerce websites in Finland. Many of the accessibility errors violate the lowest level – level A – WCAG success criteria.

As the level A sets only the minimum level of accessibility, it is alarming that multiple violations to that level could be found even in these small fragments of the sites. All websites except [uniqlo.com](#) had at least one level A success criteria violation on their product filters so a broad accessibility on those sites is not even closely achieved. In addition, all websites had at least one level AA success criteria violation which indicates that even if the product filters were accessible to some users, they are still not accessible for users in a variety of contexts.

It must be kept in mind that the number of found errors is not a sensible way to make conclusions on the accessibility of product filters on a certain website. The sites had

different amounts of filters and the severity of the errors varied. For example, on stockmann.com almost all of the filters were totally inaccessible and thus a fewer number of errors were reported than from sites where more of the filters could be tested. Also, having a bit of misaligned text or extra keystrokes are not as severe errors as a totally inaccessible filter.

Furthermore, not all accessibility errors violate any WCAG criteria directly, but they are still considered as accessibility issues because they cause problems and confusion for keyboard users. Even compliance with WCAG does not fully guarantee accessibility [W3C 2016a].

The improvement to the keyboard accessibility depends on the accessibility error. As a practical benefit of this thesis, the accessibility errors with their respective screenshots in Appendices 1–10 can be converted to backlog tasks for the development teams with just some further refinement.

On a high level, the improvements are quite straightforward. Table 9 presented the detailed categorization of highly severe accessibility errors. Every error concerning unreachable elements could be improved by making the keyboard focus stop in all interactive elements. The focus should also stop on every option of the filter which would solve errors in category inoperable options. Elements should be scrollable by keyboard when they are scrollable with mouse and buttons should have the same functionality for mouse and keyboard users. Finally, if the focus is lost under the stacked elements, it should be confirmed that the previous elements are always closed before opening new ones and that the focus is always on the topmost element.

The errors in the medium severity category were presented in Table 10. Improvements to these errors can also be listed in a straightforward way. For every error about unindicated focus, the improvement would be to make the focus clearly indicated. A common practice is to have a blue outline around the element in focus. The navigation should follow intuitive order and the order presented in the graphical user interface to avoid confusion and loss of focus. Unnecessary clicks can be eliminated by paying attention to the amount of activatable fields in every element during implementation. And finally, the only error with low severity rating which concerned the broken styles (aboutyou-E5, Appendix 8, Figure 39) could be

improved by making the style sheet of the page take into account the situation causing the misalignment of the elements.

All these accessibility errors can have a severe impact on user experience of individuals who rely on keyboard accessibility. Poorly accessible or totally inaccessible product filters can cause a lot of frustration and disappointment among the users who want to effectively browse the products in fashion e-commerce websites.

Due to the abundance of options in e-commerce, users are quick to abandon the site in case they cannot effectively find what they are looking for [Baymard Institute 2023, 2015b]. In previous research, it has been confirmed that accessibility violations have a significant effect on user experience. Emotions are a large part of user experience and accessibility issues make users frustrated and reduce engagement [Sauer et al. 2020, 1209; Patvardhan et al. 2022, 1]. From the results of this thesis, it can be concluded that product filters of the fashion e-commerce websites need further development for accessibility to ensure a good user experience.

6. Conclusion

The continuously growing popularity of e-commerce websites has raised discussion on their accessibility. Web accessibility is particularly important for the inclusivity of users with disabilities. However, when the accessibility guidelines are followed, the web content is more usable to all users.

Even though WCAG guidelines have been in existence for over twenty years, they are not widely conformed by private sector actors. The guidelines are not restrictive and accessibility is not set as a high priority in web development projects. This had led to neglecting the accessibility. However, in the EU, legislation concerning accessibility of private sector actors' websites will become in force in 2025 and with the peremptory nature of the law, the accessibility situation will be improved during the following years.

Among the users with disabilities, the keyboard is a widely supported input method. In addition to that, fashion is the largest business-to-consumer e-commerce category and product filters play a significant part in an online shopping experience. For these reasons, the status of keyboard accessibility of product filters on the leading fashion e-commerce websites in Finland was chosen as the research question for this thesis.

By identifying and analyzing the keyboard accessibility errors in the product filters on ten leading fashion e-commerce websites, the research question and the supporting minor research questions could be answered. The results show that in total, over 30 accessibility errors could be identified by manual expert evaluation. The accessibility violations were categorized by severity and sub-categorized by the type of the error. Also the violated WCAG guidelines were identified and discussed and some instructions for improving the accessibility were given.

The accessibility errors were classified to three levels of severity: high, medium, and low. Majority of the errors are medium in their severity which means that they do not block the feature completely from a keyboard user nor do they cause unbearable discomfort when using the feature. The second largest category was severe accessibility errors which prevent the user from using the feature that the issue affects. Only one error of low severity was found.

Almost all of the severe errors violated the lowest level – level A – WCAG success criteria while most of the medium level errors violated the level AA WCAG success criteria. The violated WCAG criteria were 2.1.1 Keyboard (Level A), 2.4.3 Focus order (Level A), and 2.4.7 Focus visible (Level AA).

Accessibility errors were also noticed to affect largely the usage of common product filters. From these findings, a conclusion can be drawn that the status of keyboard accessibility of product filters on the leading fashion e-commerce websites in Finland needs urgent attention.

Improvements to the accessibility errors were suggested. There is a need, for example, to make the keyboard focus to stop on all interactive elements because at the moment some of the elements are totally skipped. Options of filters should be selectable and elements should be scrollable as they are for mouse users. Focus indicator must be in place to indicate the keyboard user the place of the current focus. Also navigation should be made intuitive and unnecessary clicks should be avoided. Styles of the page should be made so that they do not break when navigating the site by keyboard.

The identified accessibility errors were considered so dominant that they might affect the user experience. More research on user experience is needed, but in the meantime, the product filters of the fashion e-commerce websites need further development for accessibility and that also helps to ensure a good user experience.

6.1. Limitations

The selected scope of this study, the evaluation methods and the special characteristics of software products compared to physical products pose some limitations for the analysis and results. As said before, the data was collected during July and August 2023. Therefore, the results of this research can only be seen as an evaluation of the state of the examined product filters at that point in time. One of the core qualities of software products compared to physical products is easy updateability which means that some updates to accessibility issues highlighted in this research might already have been addressed when this thesis is published.

Other limitations of this research rose from the selected method. The accessibility evaluation was done purely as a manual expert evaluation without automatic tools or user testing with real end users. The findings also represent only accessibility errors that have a direct impact on keyboard users. Due to the selected research method, the answers to the last research question concerning the possible effects on user experience only had to stay at a hypothetical level. To get reliable insight on user experience, user-based methods are required.

6.2. Further research topics

This thesis focused on providing an overview of the keyboard accessibility of the product filters on fashion e-commerce websites. However, it was challenging at times to keep the focus solely on the selected elements. To get a more comprehensive understanding about the level of accessibility, a general accessibility audit of fashion e-commerce websites for keyboard users would be a natural continuum for this research. If user testing was included in the accessibility audit, the last research question of this thesis could be reformulated to *“How do accessibility violations impact the user experience for individuals who rely on keyboard accessibility?”* for new research.

The selected method for this thesis was manual expert evaluation. However, an advanced automated tool for evaluating the keyboard accessibility is developed [Chiou et al. 2021], and accessibility testing combining automated tools, expert evaluation and user testing for fashion e-commerce would be in place for getting a more comprehensive view of the state of accessibility of these websites.

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Appendix 1. Screenshots of zalando.fi

The screenshot displays the Zalando.fi website interface for men's clothing. At the top, the navigation bar includes the Zalando logo, user account icons, and a search bar. Below the navigation bar, the breadcrumb trail shows 'Miehet > Vaatteet'. The main heading is 'Miesten vaatteet'. A sidebar on the left lists various clothing categories such as 'T-paidat & pikeet', 'Kauluspaidat', 'Collegeet & hupparit', 'Housut', 'Farkut', 'Shortsit', 'Takit', 'Neuleet', 'Urheiluvaatteet', 'Verryttelypuvut', 'Räätälöinti', 'Päälystakit', 'Alusasut & sukat', 'Uima-asut', and 'Oloasut & yöpuvut'. The main content area features a grid of product filters: 'Lajittele', 'Koko', 'Merkki', 'Uutuudet', 'Kestävä kehitys', 'Hinta', 'Väri', 'Pintamateriaali', 'Istuvuus', 'Monipakkaus', 'Lisää kokoja', and 'Kaikki filterit'. Below the filters, the number of products is shown as '114 939 tuotetta'. The product grid displays three items: 1. 'Multiply Apparel Verryttelyhousut - black soda washed' (54,90 €), 2. 'Pier One 2 PACK - T-paita - black/black' (19,95 €), and 3. 'Multiply Apparel OVERSIZE TEMPEL - Huppari - black stri...' (49,90 €). Each product card includes a 'Sponsoroitu' label, a heart icon, and a 'Pitkän matkan toimitus' icon.

Figure 2. Zalando.fi product filters on 21.7.2023.

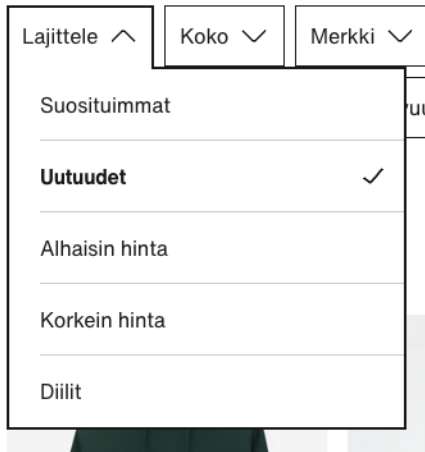


Figure 3. Accessibility error zalando-E1: The focus is not indicated when browsing the items on the sort order ("Lajittelu") filter.



Figure 4. Accessibility error zalando-E2: In the search bar of the brand ("Merkki") filter the "X" button does not do anything. However, this is a general bug because the button does not work for mouse users either. Users can erase the text with backspace.

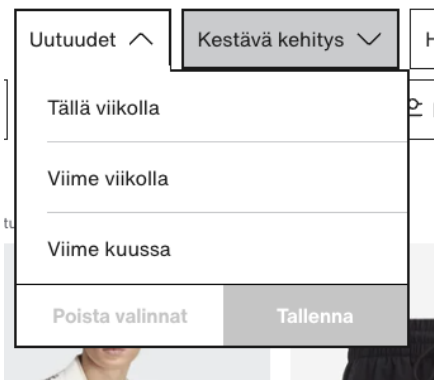


Figure 5. Accessibility error zalando-E3: The filter dropdowns are not automatically closed when the focus moves forward.

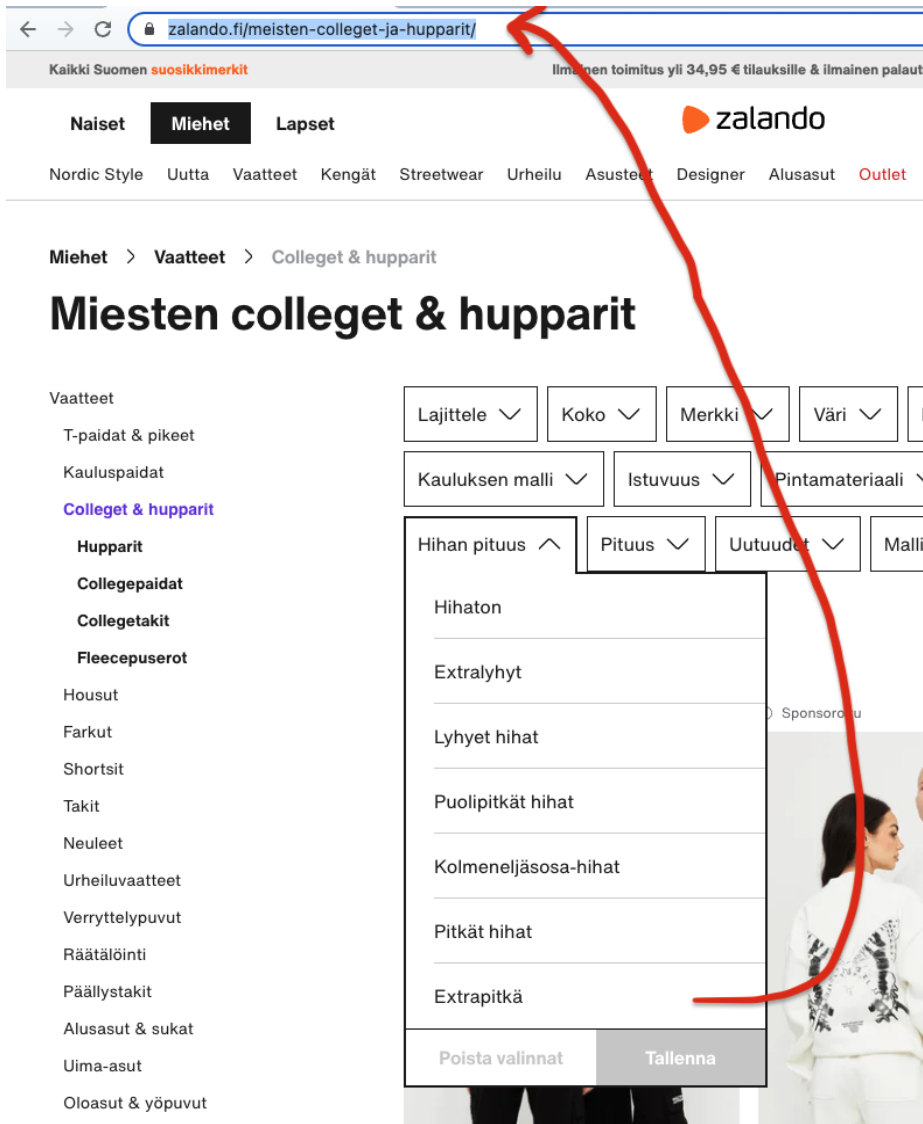


Figure 6. Accessibility error zalando-E4: The focus jumps to an unexpected place – the browser address bar – after the last dropdown filter item if no items are selected.

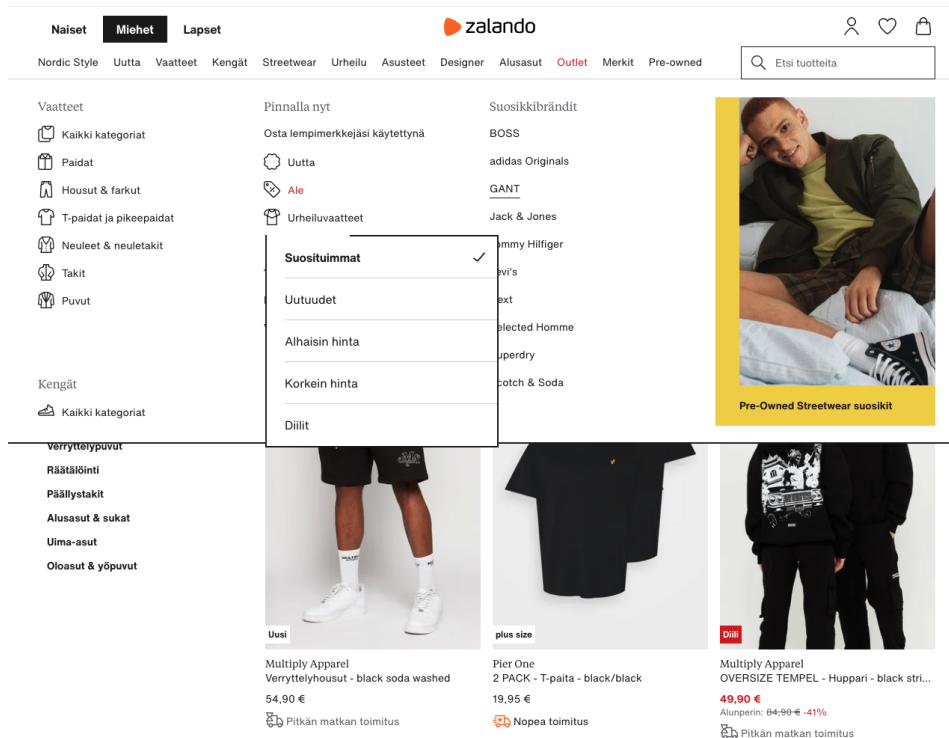


Figure 7. Accessibility error zalando-E5: By continuously pressing the tab key on an open dropdown menu, the focus unexpectedly jumps to the address bar instead of continuing to the next element (zalando-E4). If the user continues pressing tab from the address bar wishing to get back to the filter dropdowns, the main menu opens under the already open dropdown menu. The main menu stays open even if focus gets to the elements under it preventing the user from seeing which element is in focus.

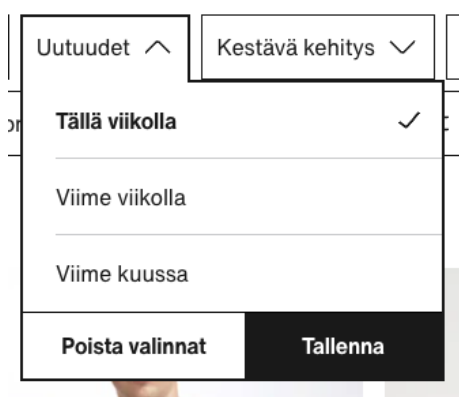


Figure 8. Accessibility error zalando-E6: The focus is not indicated when it is on the remove selections ("Poista valinnat") button of filter dropdowns.

Appendix 2. Screenshots of hm.com

The screenshot shows the H&M website interface. At the top, there is a navigation bar with the H&M logo, user account options (Kirjautu sisään, Suosikit, Ostoskori (0)), and a search bar (Hae tuotteita). Below the navigation bar, there are category tabs: Naiset, Miehet, Divided, Vauvat, Lapset, H&M HOME, Beauty, Urheilu, Ale, &Brands. A red banner for 'Final sale jopa -70%' is prominently displayed, with buttons for various categories: Naiset, Miehet, Divided, Vauvat, Lapset, H&M HOME, Urheilu, &Brands. Below the banner, the section is titled 'MIESTEN KAULUSPAIDAT' (Men's Shirts). A paragraph of text describes the collection, mentioning styles like slim-fit, regular fit, and various fabrics like flannel and poplin. Below the text, there is a grid of product images. The first row shows four shirts: a beige Oxford shirt (Regular Fit, 19,99 €), a white Oxford shirt (Relaxed Fit, 19,99 €), a dark navy poplin shirt (Relaxed Fit, 19,99 €), and a beige Lyosellipäälyspaita (Regular Fit, 39,99 €). The second row shows four more shirts: a white Oxford shirt (Regular Fit, 19,99 €), a light blue Oxford shirt (Relaxed Fit, 19,99 €), a dark blue patterned shirt (Regular Fit, 19,99 €), and a white Lyosellipäälyspaita (Regular Fit, 39,99 €). A left sidebar contains a 'Osta tuotteen mukaan' (Shop by product) menu with various categories like T-paidat, Paidat, Pitkähihaiset paidat, etc. The URL at the bottom is https://www2.hm.com/fi/fi/productpage.1036739002.html.

Figure 9. Hm.com category selection on 21.7.2023.

www2.hm.com/fi_fi/miesten/osta-tuotteen-mukaan/paidat.html

Asiakaspalvelu Uutiskirje Löydä myymälä

Naiset Miehet Divided Vauvat Lapset H&M HOME Vastuullisuus Beauty

ETUSIVU/Miehet/Paidat

Uutuudet
 Katso kaikki
 Vaatteet
 Kengät ja asusteet
 Urheiluvaatteet & Brands

Sesongin trendit
 Rääteltyä lookit
 Pellavavaatteet
 Kesätyylit
 Festivaali

Osta tuotteen mukaan
 T-paidat ja aluspaidat
 Paidat
 Pitkähihaiset paidat
 Rennot paidat
 Kauluspaidat
 Farkkupaikat
 Lyhythihainen
 Flanellipaidat
 Pellavapaidat
 Paitatakit
 Shortsit
 Uima- & ranta-asut
 Hupparit & colleget
 Hausut
 Farkut
 Bleiserit ja puvut
 Kengät
 Asusteet
 Laukut
 Urheiluvaatteet
 Takit
 Miesten sukat
 Alusvaatteet
 Yö- & oloasut
 Neuleet
 Neuletakit & neuleet
 Premium Selection
 Haitatuotteet
 Alennetut hinnat
 Katso kaikki

Final sale jopa
 Aiemmin koskaan ylläkköksi tuotteita niin kauan kuin niitä on jäljellä. Hm.comin ja myymälöissämme.

Naiset Miehet Divided Vauvat Lapset

MIESTEN KAULUSPAIDAT
 Päivitä arkilookiasi tyylikkääksi valikoimamme miesten kauluspaidoilla. Meiltä löydät mielialaagular fit -paidat, kuten klassiset vaarinpaidat ja kauluspaidat sekä ajattomat farkkupaikat. Trenditietoinen? Tutustu tyylikkäisiin paitatakkeihin, jotka ratkaisevat pukeutumisongelmat. Yhdistä uuteen lempipaasi farkut, ja olet valmis.

Lajittelu

Oxford-paita Regular Fit 19,99 €

Oxford-paita Relaxed Fit 19,99 €

Popliini 19,99 €

351 tuotetta

Tyhjennä kaikki Valmis

Suodata

Tuotemerkki →

Hihan pituus →

Koko →

Väri →

Kuosi →

Istuvuus →

Tyyli →

Tilanne →

Kaulus →

Laatu →

Materiaali →

Ominaisuus →

Figure 10. Hm.com product filters on 21.7.2023.

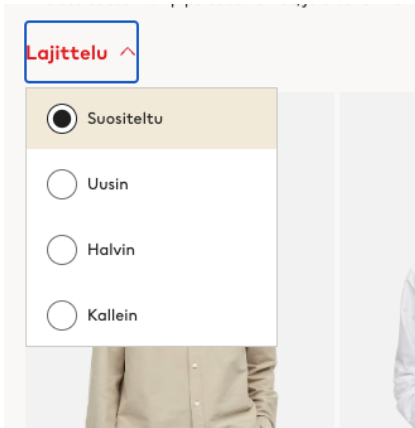


Figure 11. Accessibility error hm-E1: The sort order ("Lajittelu") filter dropdown options are inaccessible by keyboard.

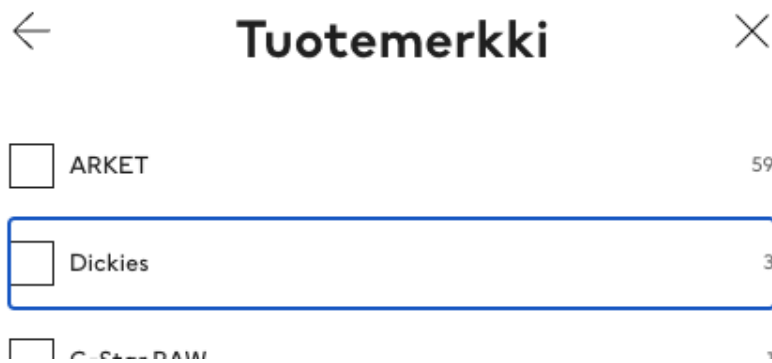


Figure 12. Accessibility error hm-E2: Each list item with a checkbox has two focus areas instead of one which causes unnecessary clicks for a keyboard user.



Figure 13. Accessibility error hm-E2: Each list item with a checkbox has two focus areas instead of one which causes unnecessary clicks for a keyboard user.



Figure 14. Accessibility error hm-E3: When multiple filters are selected, some of the selections are hidden inside an accordion element. There is a button to open the accordion, but the focus reaches the button only after going through the whole list of selected filters. This causes the focus to be invisible while going through the list of selected filters.

Appendix 3. Screenshots of boozt.com

The screenshot shows the Boozt.com website interface for men's clothing. The top navigation bar includes categories like 'Naiset', 'Miehet', 'Lapset', 'Urheilu', 'Kosmetiikka', and 'Koti'. The main content area features a grid of product cards, each with a discount tag (EXTRA25) and a 'BUYERS' PICK' label. The filters section includes 'Brändit', 'Koko', 'Väri', 'Hinta', 'Materiaali', and 'Lajittelu'. The product cards display items from brands like Polo Ralph Lauren, BLS Hafnia, GANT, and Les Deux, with prices and size options.

Navigation and Search:

- Country: Suomi
- Language: Suomi
- Search: Hae tuotteita tai brändejä
- Account, Wishlist, and Cart icons

Product Grid:

Brand	Discount	Price	Size Range
Polo Ralph Lauren	35%	92.14 € (122.85 € - 189 €)	S M L XL
BLS Hafnia	20%	57 € (76 € - 95 €)	S M L XXL
GANT	50%	52.46 € (69.95 € - 139.90 €)	S M L XL XL/XXL
Les Deux	40%	54 € (72 € - 120 €)	XS S M L XXL

Filters:

- Brändit
- Koko
- Väri
- Hinta
- Materiaali
- Lajittelu

Product Categories (Left Sidebar):

- Vaatteet: 14 733
- Ulkovaatteet: 2 112
- T-paidat: 2 358
- Svetarit: 2 164
- Kauluspaidat: 1 924
- Uimavaatteet: 286
- Pikeepaidat: 725
- Paitatakit: 518
- Farkut: 1 203
- Housut: 1 040
- Shortsit: 728
- Neuleet: 1 026
- Puvut & bleiserit: 490
- Collegehousut: 415
- Sadetakit: 254
- Osta tyylin mukaan: 1 372

Additional Information:

- ALE - Aktivoit tarjouskoodin:** Osta vähintään 2 tuotetta vähintään 69 € :lla! Voimassa 2023-07-31 23:59 asti | Säännöt ja ehdot
- Viimeksi katsotut tuotteet:** Sinulla ei ole viimeksi katsottuja tuotteita. Kun aloitat selaamisen, katsomasi tuotteet näkyvät täällä.
- Suosikit:** Sinulla ei ole tallennettuja suosikkeja. Klikkaa sydäntä tuotteen vieressä tallentaaksesi tuotteen suosikkeihin.

Figure 15. Boozt.com product filters on 13.8.2023.

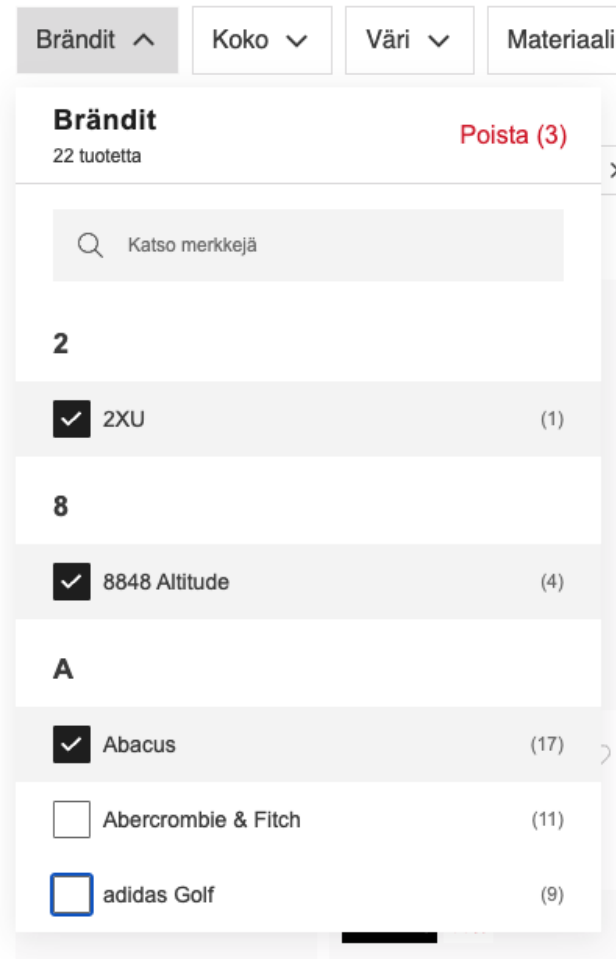


Figure 16. Accessibility error boozt-E1: The filter dropdown menus cannot be scrolled down with a keyboard while they are open. Thus, only the first items of the list are visible even though the focus goes down the list. It is impossible to know which element is in focus when the current focus is not visible. This problem is evident in the brands ("Brändit") filter as the list of brands is long.

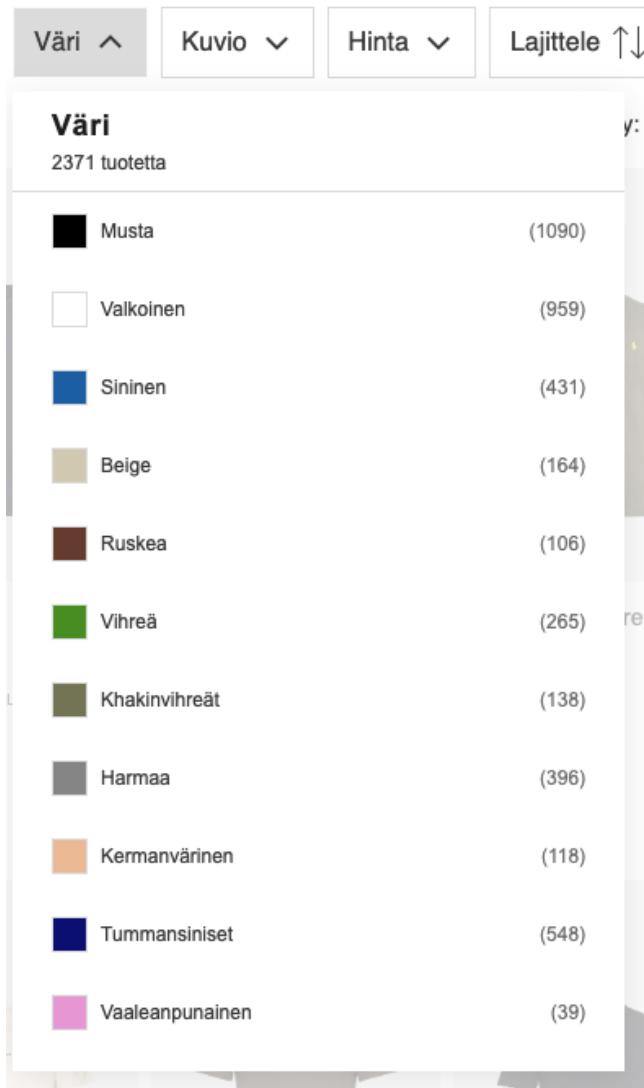


Figure 17. Accessibility error boozt-E2: The color ("Väri") dropdown options are inaccessible by keyboard.

Appendix 4. Screenshots of uniqlo.com

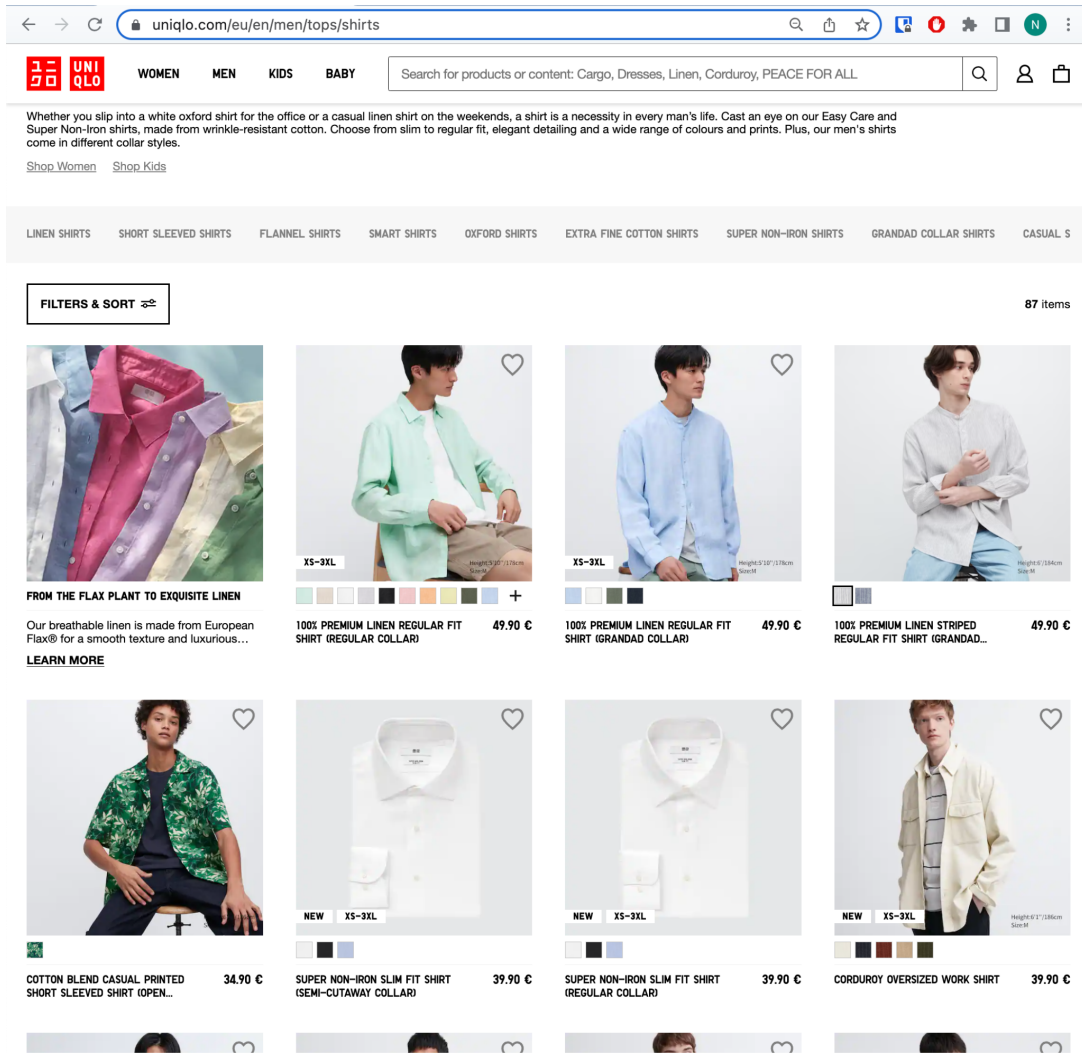


Figure 18. Uniqlo.com closed product filters on 24.7.2023.

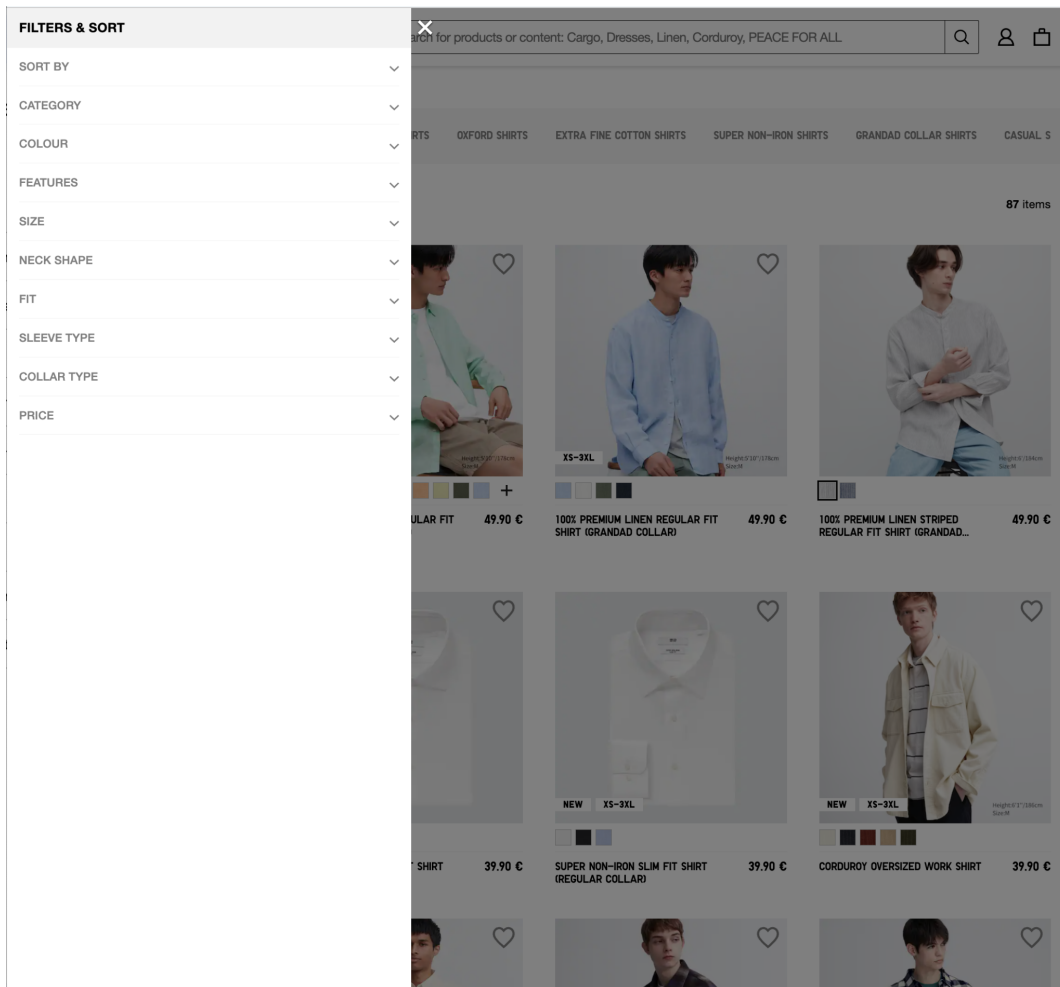


Figure 19. Uniqlo.com product filters open on 24.7.2023.

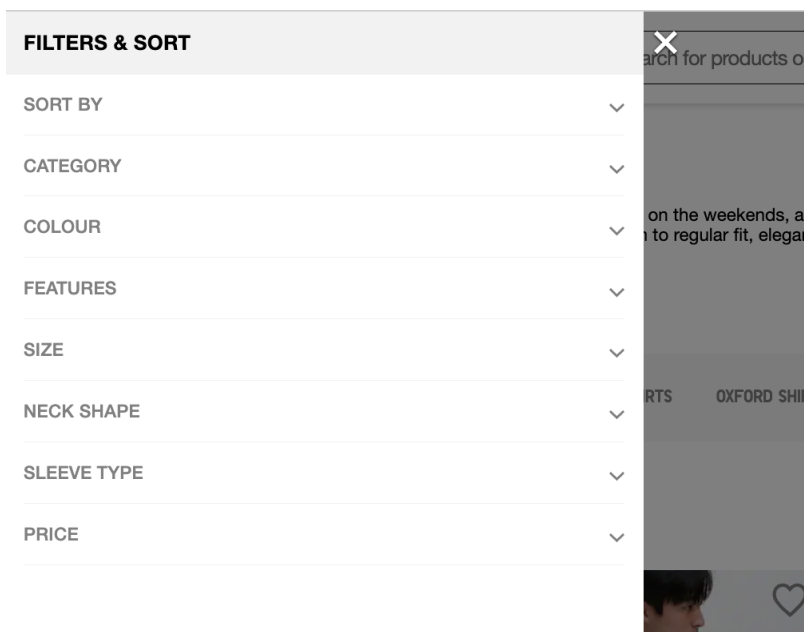


Figure 20. Accessibility error uniqlo-E1: The focus is not indicated on the filters.

Appendix 5. Screenshots of stockmann.com

The screenshot displays the Stockmann.com website interface for men's clothing. The browser address bar shows the URL `stockmann.com/muoti/miehet/vaatteet?store=ecomm`. The navigation bar includes categories like **NAISET**, **MIEHET**, **LAPSET**, **KOTI**, **KOSMETIIKKA**, **UUTUUDET**, **EDUT & IDEAT**, **LAHJAIDEAT**, and **ALE**. The main content area is titled **MIEHET / Vaatteet** and shows a grid of men's clothing items. On the left, there is a sidebar with filters for **MYYMÄLÄSAATAVUUS**, **EDUT**, **KATEGORIA**, **Alusasut**, **Bleiserit**, **Farkut**, **Housut**, **Neuleet**, **Paidat**, **Puvut**, **Pyjamat & kylpytakit**, **Takit**, **Uimahousut**, and **Naiset**. The product grid includes:

- MONCLER** Felpa Con Cappuccio -huppari, 515,00 €
- MARIMEKKO** Runoja Unikko -huppari, 210,00 €
- TIGER OF SWEDEN** Lawson-nahkatakki, 499,00 €
- ACNE STUDIOS** 1996 Vintage-farkut, 300,00 €
- TURO** Bilbao Houston -puku, 120,80 € (379,00 €)

A large red promotional banner in the center of the grid reads: **-60% NYT LISÄÄLE -20% KAIKKI ALETUOTTEET NYT**. The top right of the grid has a dropdown menu labeled **SUOSITUIMMAT**. The bottom right corner features an upward-pointing arrow icon.

Figure 21. Stockmann.com product filters on 24.7.2023.

MYYMÄLÄSAATAVUUS	+
EDUT	+
KATEGORIA	-
Kosmetiikka Koti Lapset Miehet Asusteet Kengät Laukut & lompakot Urheilu Vaatteet Alusasut Bleiserit Farkut Housut Neuleet Paidat Hupparit & collegepaidat Kauluspaidat Pikepaidat T-paidat Puvut Pyjamat & kylpytakit Takit Uimahousut <input type="text" value="Naiset"/>	
KOKO	+
VÄRI	+
BRÄNDI	+
HINTA	+
PÄÄMATERIAALI	+
TUOTEKONSEPTI	+

Figure 22. Accessibility error stockmann-E1: Users can not access any other filter except the category filter that is open by default. The focus moves right to the product listing after passing the category filter. The focus never gets to the other filters.



Figure 23. Accessibility error stockmann-E2: The focus is not indicated on the sort order filter.

Appendix 6. Screenshots of ellos.fi

The screenshot shows the Ellos.fi website interface. At the top, there are navigation links and a search bar. The main content area is titled "T-paidat & puserot" and features several filters: "Hihattomat", "Pitkähihaiset puserot", and "T-paidat". A "Lajittele" button is present, and the page indicates "612 osumaa. Lajittele. Myydymmit". Below the filters, there is a grid of t-shirt products. Each product is displayed with a model wearing the t-shirt, a heart icon for favoriting, and a price tag. The products are:

- Ellos ON OUR TERMS T-paita Miles**: 13 EUR (original price 17,99 EUR, -25% discount). The t-shirt is dark blue with "ORIGINALS" and "LEANS WEAR CO." printed on it.
- Ellos ON OUR TERMS T-paita Miles**: 13 EUR (original price 17,99 EUR, -25% discount). The t-shirt is black with a graphic print.
- Ellos ON OUR TERMS T-paita Miles**: 11 EUR (original price 17,99 EUR, -35% discount). The t-shirt is dark blue with "CALIFORNIA" printed on it.
- Ellos ON OUR TERMS T-paita Miles**: 13 EUR (original price 17,99 EUR, -25% discount). The t-shirt is olive green with "NYC" printed on it.
- Ellos ON OUR TERMS T-paita Miles**: 13 EUR (original price 17,99 EUR, -25% discount). The t-shirt is blue with "LOS ANGELES California" printed on it.
- Ellos ON OUR TERMS T-paita Miles**: 13 EUR (original price 17,99 EUR, -25% discount). The t-shirt is black with a graphic print.

Figure 24. Ellos.fi product filters on 7.8.2023.

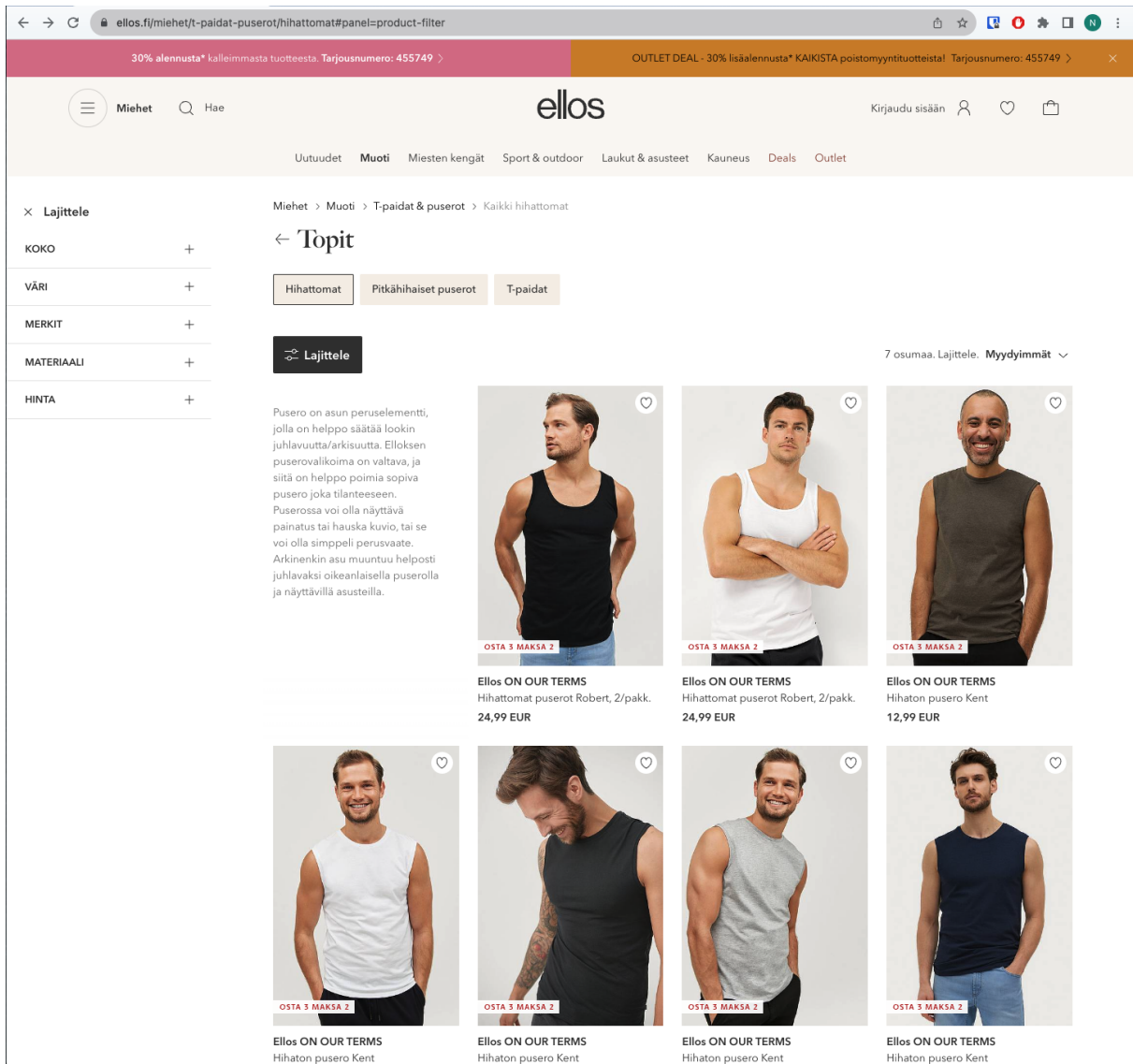


Figure 25. Accessibility error ellos-E1: When pressing the filter opening button, filters appear before the filter opening button, category selection and the breadcrumbs of the page. The navigation order gets unintuitive and the user must understand navigating backwards to get to the filters.

× Lajittele

KOKO	+
VÄRI	+
MERKIT	+
MATERIAALI	+
HINTA	+

Figure 26. Accessibility error ellos-E2: The focus is not indicated when it is on the filters.

× Lajittele

KOKO		—
6XL	S	
M	L	
XL	2XL	
3XL	4XL	
5XL		

Figure 27. Accessibility error ellos-E3: The focus is not indicated on the filter options of size ("Koko") and material ("Materiaali") filters.

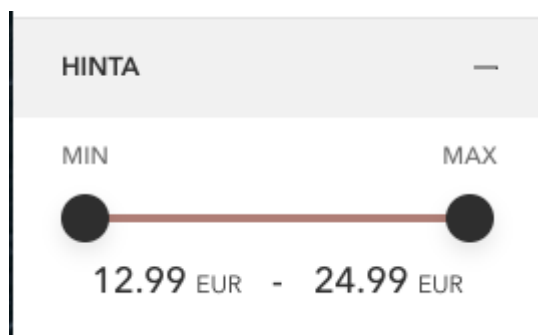


Figure 28. Accessibility error ellos-E4: The focus never gets to the prize slider by keyboard.

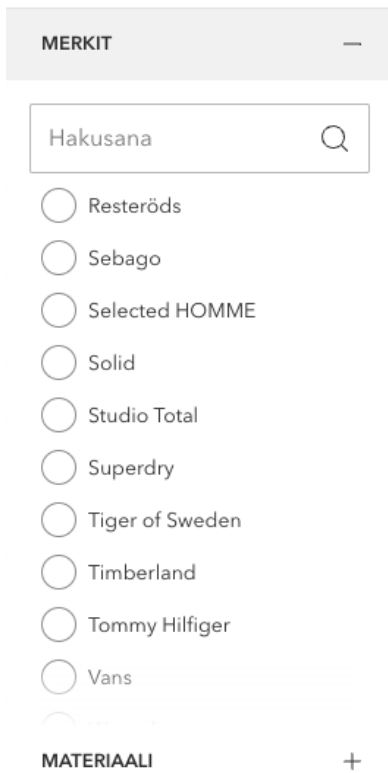


Figure 29. Accessibility error ellos-E5: The last elements of size ("Koko"), material ("Materiaali") and brands ("Merkit") filters are invisible even if focus is on them.

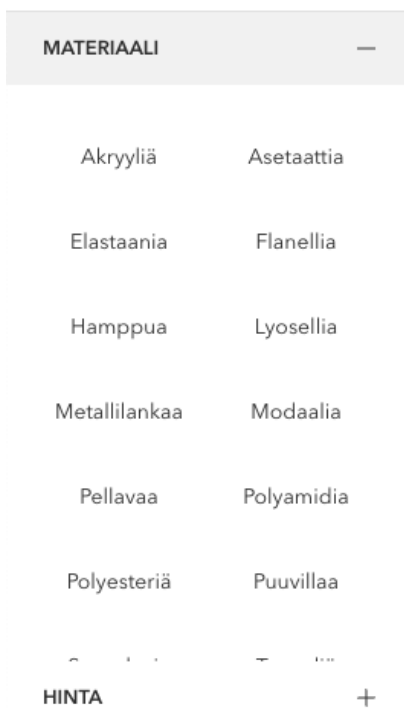


Figure 30. Accessibility error ellos-E5: The last elements of size ("Koko"), material ("Materiaali") and brands ("Merkit") filters are invisible even if focus is on them.

Appendix 7. Screenshots of shein.com

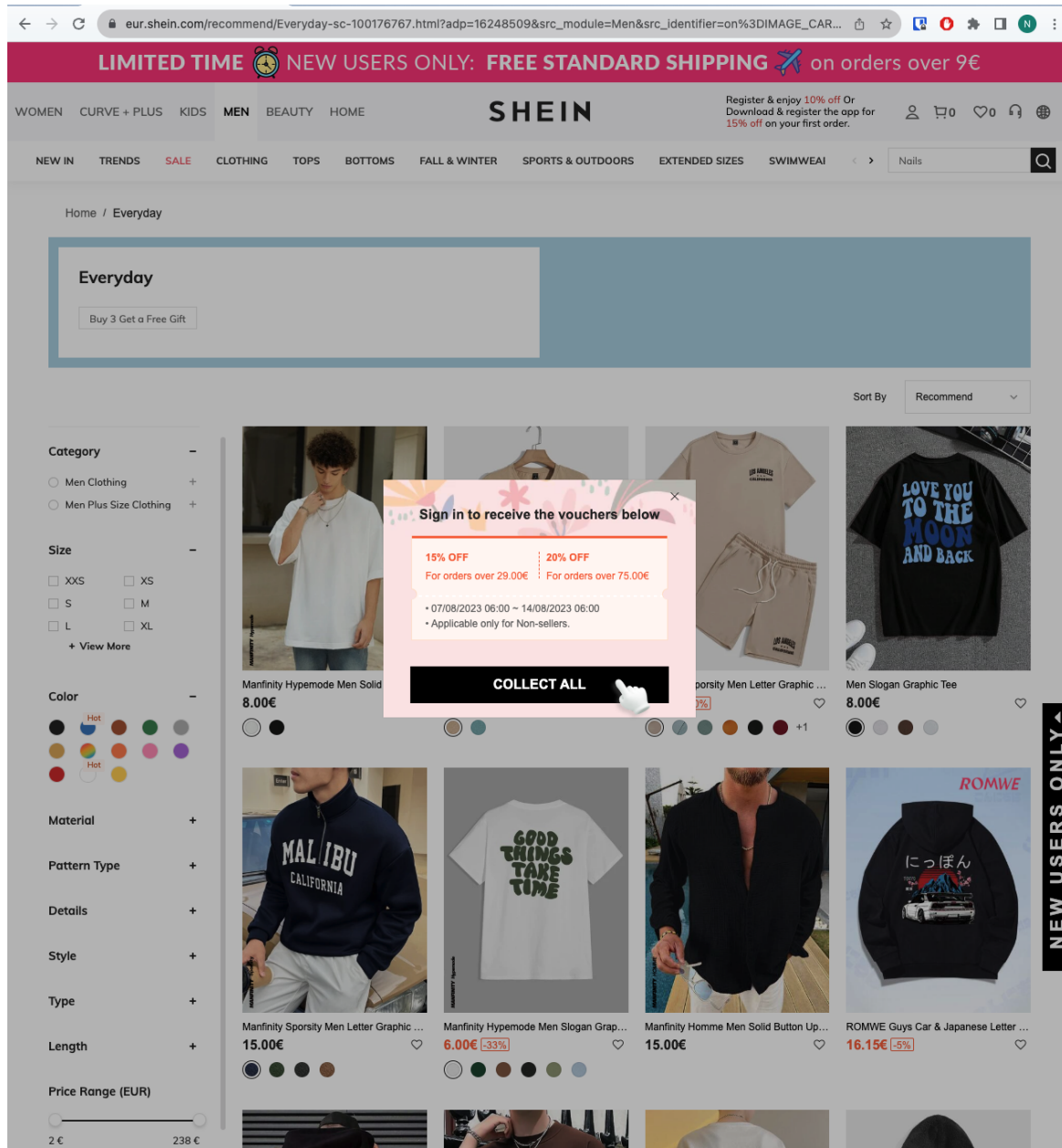


Figure 31. Shein.com product filters on 7.8.2023.

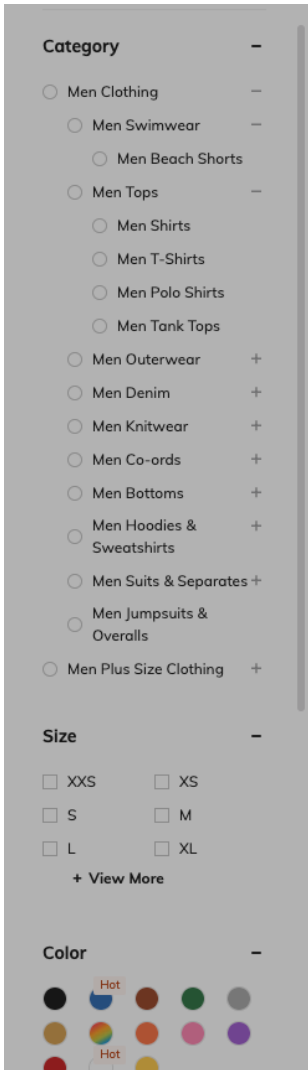


Figure 32. Accessibility error shein-E1: The focus is not indicated when it is on the filters. Accessibility error shein-E2: None of the filters work for keyboard users because the filter options cannot be selected by keyboard.

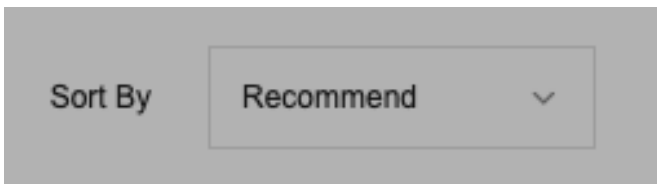


Figure 33. Accessibility error shein-E3: The sort order dropdown menu is inaccessible by keyboard. It seems that the focus never gets to the element but this cannot be confirmed because the focus is not indicated (shein-E1).

Appendix 8. Screenshots of aboutyou.fi

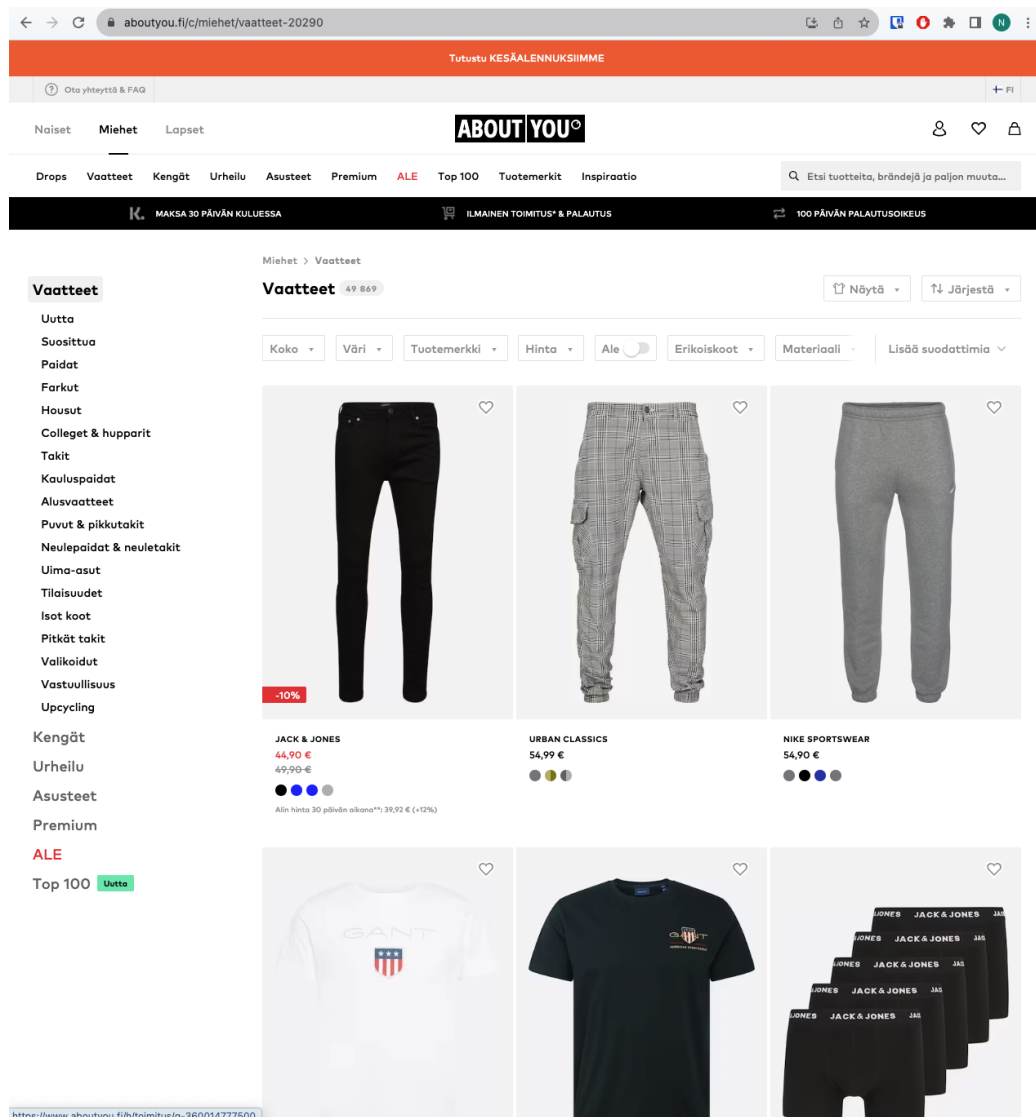


Figure 34. Aboutyou.fi product filters on 7.8.2023.

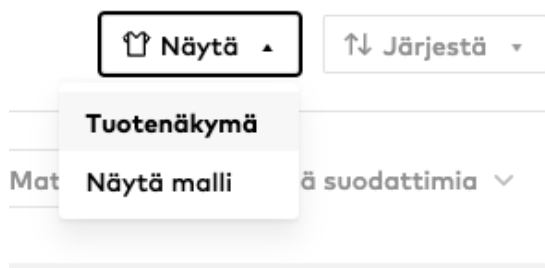


Figure 35. Accessibility error aboutyou-E1: The focus never gets to the view type selection ("Näytä") filter dropdown options.

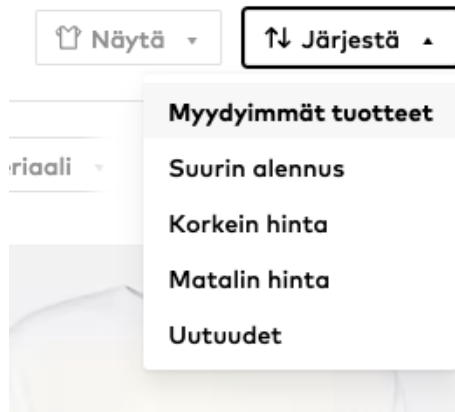


Figure 36. Accessibility error aboutyou-E2: The focus never gets to the sort order ("Järjestä") filter dropdown options.

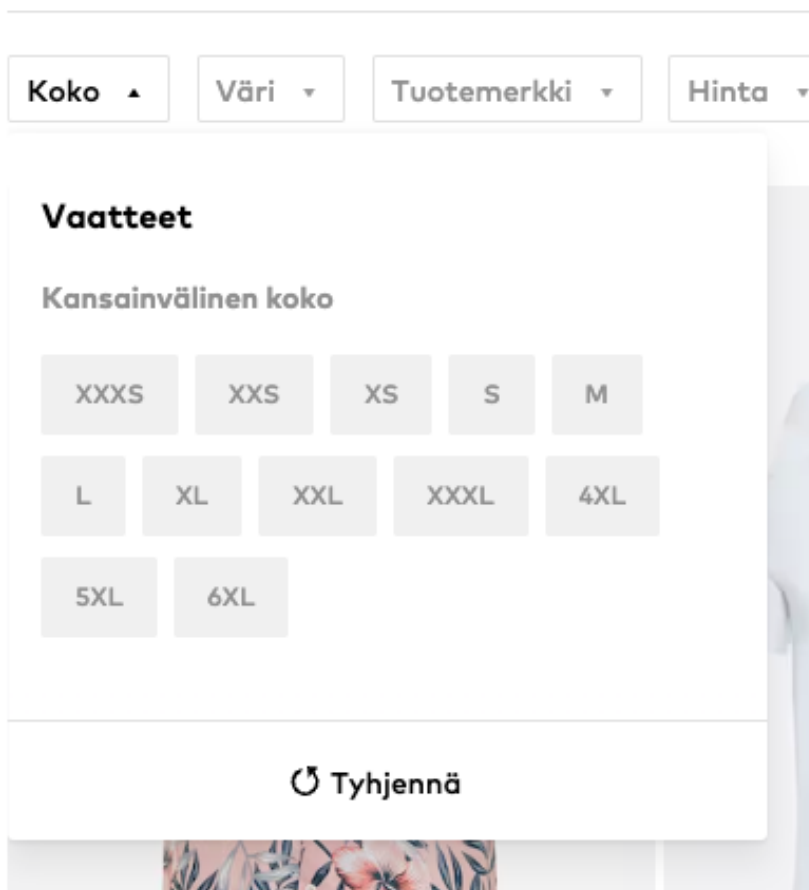


Figure 37. Accessibility error aboutyou-E3: The focus is not indicated on size ("Koko"), color ("Väri"), brand ("Tuotemerkki"), special sizes ("Erikoiskoot"), material ("Materiaali"), pattern ("Kuvio"), responsibility ("Vastuullisuus"), sleeve length ("Hihan pituus"), neck ("Pääntie"), package ("Pakkaus"), and length ("Pituus") filters.



Figure 38. Accessibility error aboutyou-E4: By default, some of the filters are hidden and the show more filters button is placed after the hidden filters. The focus is lost in the hidden elements while the user navigates to the button.

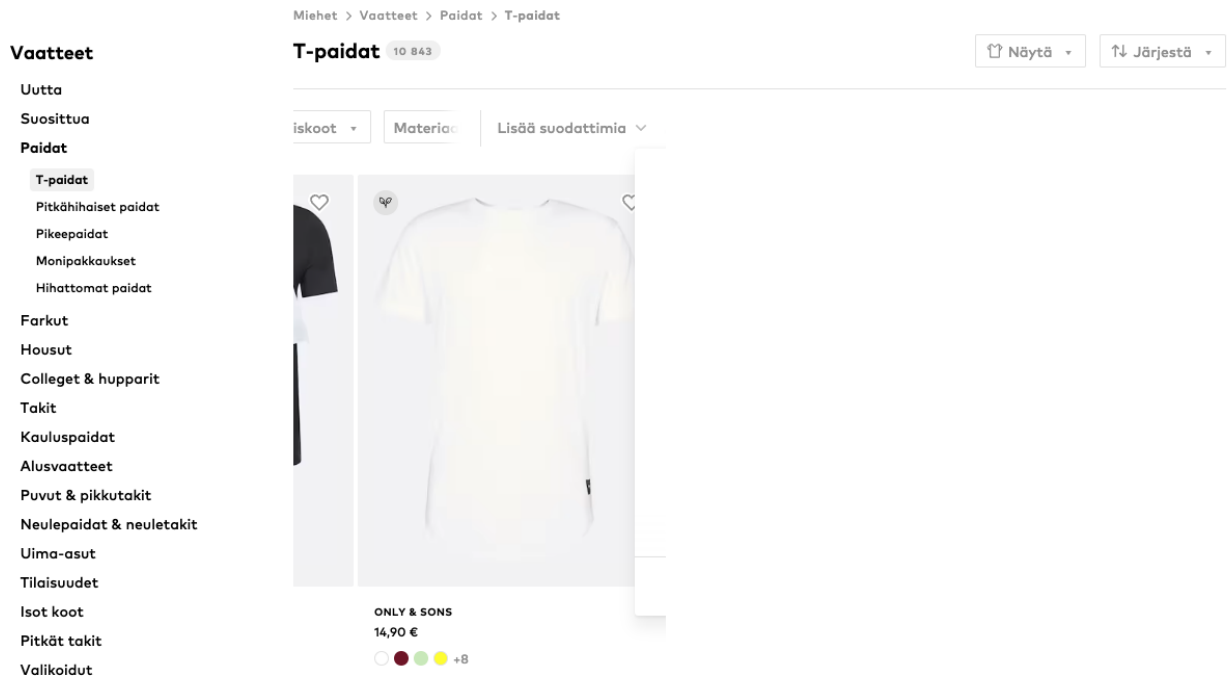


Figure 39. Accessibility error aboutyou-E5: The filter and product listing element gets misaligned when hidden filters are browsed or opened before clicking the show more filters button.

Lisää suodattimia ▾

Figure 40. Accessibility error aboutyou-E6: Focus is not indicated when it is on the show more filters button.

Appendix 9. Screenshots of xxl.fi

The screenshot shows the XXL.fi website interface for a search query "miesten t-paita". The page features a navigation bar with the XXL logo and search bar. Below the navigation bar, there are several promotional banners. The main content area is titled "Hakusi miesten t-paita" and displays a list of 130 products. The products are filtered by availability (Saatavilla verkkokaupasta and Saatavilla tavaratalosta) and sorted by "Järjestä Suosituin". The filters on the left include "Suodatin" (Tuoteryhmä, Koko, Käyttäjä, Tuotemerkki), "Hinta" (7.99 - 119), and "Väri" (Harmaa, Keltainen, Monivärinen, Musta, Oranssi, Punainen). The product listings show three items in the top row: Adidas Essentials Colorblock T-Shirt (29,99), Line One Basic Tee (7,99), and Line One Basic Tee (7,99). The bottom row shows three more items: a white Adidas t-shirt, a blue Oakley t-shirt, and a black Adidas t-shirt. A chat icon is visible in the bottom right corner.

Figure 41. XXL.fi product filters on 7.8.2023.

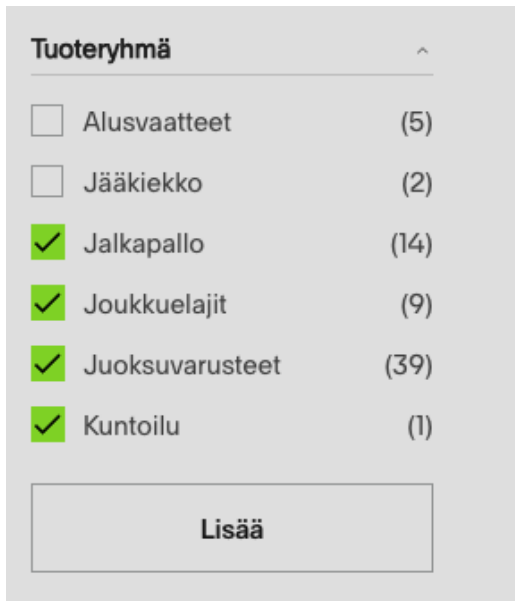


Figure 42. Accessibility error *xxl-E1*: Each option in product category ("Tuoteryhmä"), size ("Koko"), color ("Väri"), fit ("Istuvuus"), usage ("Käyttö"), brand ("Tuotemerkki"), and quality ("Laatu") filters has two focus areas instead of one which causes unnecessary clicks for a keyboard user.

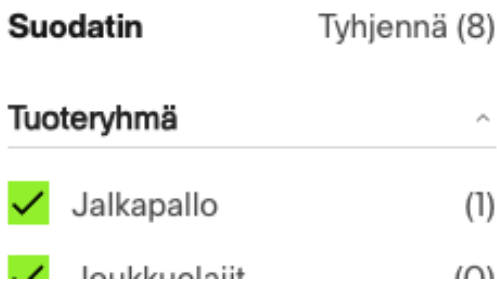


Figure 43. Accessibility error *xxl-E2*: The focus is not indicated when it is on the empty all filters ("Tyhjennä") button.

Tuotteet (14)

Saatavilla verkkokaupasta
 Saatavilla tavaratalosta

Figure 44. Accessibility error *xxl-E3*: The focus never gets to the availability selection radio buttons.

Appendix 10. Screenshots of sokos.fi

sokos.fi/kategoria/muoti

Brändit Inspiroidu

SOKOS

Kosmetiikka **Muoti** Koti Hyvinvointi Ajankohtaista

Etusivu > Muoti

Muoti

Muodin valikoimasta löydät trendikästä, klassista ja mukavaa arki- ja juhlapukeutumista naisille sekä miehille. Katso ajankohtaiset uutuudet brändeiltä kuten Tommy Hilfiger, Mos Mosh, Adidas, Levi's ja Makia, ja löydä tyylisi tuhansien vaihtoehtojen joukosta! Tutustu lisää brändeihin.

SUOSITTELEMME NAISET MIEHET ASUSTEET LAPSET

VAATEHUOLTO

Kaikki tuotteet

8392 tuotetta

Suodata Brändi Väri Koko

Järjestä Myydyimmät

Saatavilla verkosta

Tarvitsetko apua?

Figure 45. Sokos.fi product filters on 13.8.2023.

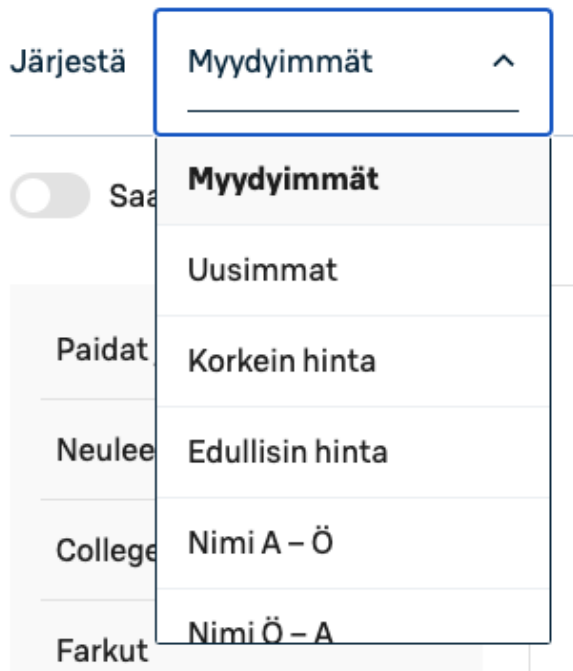


Figure 46. Accessibility error sokos-E1: The focus is not indicated on the items of the sort filter ("Järjestä").



Figure 47. Accessibility error sokos-E2: The focus never gets to the filters for brand ("Brändi"), color ("Väri") and size ("Koko").