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Websites accessibility assessment of voivodeship cities in Poland

Ocena dostępności stron internetowych miast wojewódzkich w Polsce

Kacper Czajka*, Maria Skublewska-Paszkowska

Department of Computer Science, Lublin University of Technology, Nadbystrzycka 36B, 20-618 Lublin, Poland

Abstract

The aim of this study is to assess the accessibility of the websites of provincial capitals in Poland. The experiment consisted of an automated survey using five tools and an eye-tracking experiment with 15 participants. Analysis of the results showed that sites with elements without contrast errors are easier to locate, which translates into shorter time to first fixation, and the lowest time to first fixation was obtained by sites with tiled menus. In contrast, it is not possible to identify the best site from the results obtained. Each of the automatic tools evaluates the site according to its own established criteria. In contrast, the eye-tracking experiment carried out examined a small proportion of entire websites. Creating websites that comply with accessibility standards is key.

Keywords: accessibility; eye tracker; websites; voivodeship cities

Streszczenie

Celem badań jest ocena dostępności stron internetowych miast wojewódzkich w Polsce. Eksperyment składał się z badania automatycznego przeprowadzonego przy użyciu pięciu narzędzi oraz eksperymentu eyetrackingowego z udziałem 15 osób. Analiza wyników wykazała, że witryny z elementami bez błędów kontrastu są łatwiejsze do zlokalizowania co przekłada się na krótszy czas do pierwszej fiksacji, a najniższe czasy do pierwszej fiksacji uzyskiwały strony z menu kafelkowym. Natomiast z uzyskanych wyników nie jest możliwe wskazanie najlepszej strony. Każde z narzędzi automatycznych ocenia witrynę pod względem własnych ustalonych kryteriów. Z kolei przeprowadzony eksperyment eyetrackingowy zbadał nieznaczną część całych serwisów. Kluczowe jest tworzenie stron zgodnych z standardami dostępności.

Słowa kluczowe: dostępność; okulograf; strony internetowe; miasta wojewódzkie

*Corresponding author

Email address: **s95378@pollub.edu.pl** (K. Czajka)

1. Introduction

Significant technological developments have made the Internet an important part of people's lives today, and access to information is easier and more accessible. News portals are largely based on modern technologies that enable the efficient exchange of information between owners and users. Examples of such websites include news services and the websites of public or state administrative bodies. Provincial capitals, as the administrative centres of provinces, play an important role in disseminating information to a wide audience. Therefore, the accessibility of their websites is crucial and can have a real impact on the effectiveness of public services.

Statistical study conducted in 2024 by the Central Statistical Office showed that 95.9% of households in Poland have access to the Internet. Meanwhile, 61% of the population aged 16-74 used public administration services via the Internet [1]. The results of the research indicate that it is necessary to guarantee all users free access to information. The needs of people with different types and degrees of disability should also be taken into account. Data from 2023 from the Central Statistical Office indicate that 4,006,400 people had a valid disability certificate [2]. In turn, according to estimates, every third person with a disability uses the Internet [3]. This indicates limited access to the Internet for this target group. An additional problem is that many websites and applications do not take into account the specific needs of people with disabilities, which makes it difficult for them to participate in digital life.

The role of website accessibility is to provide equal opportunities for all people, including those with disabilities, to use the content available on the Internet. Polish and European Union law contains relevant legal acts that regulate and ensure digital accessibility for people with special needs [4-6]. In addition, the WCAG (Web Content Accessibility Guidelines) document is an important aid in the design of websites and applications, helping to ensure accessibility for the widest possible range of users, including people with various disabilities [7].

The aim of this study is to assess the accessibility of the websites of provincial cities in Poland. The study used automated tools to verify compliance with the guidelines of the WCAG standard and conducted an experiment using eye-tracking technology analysing contrast, the chosen universal design principle and types of navigation on the pages. The present study was conducted on the basis of the following hypotheses:

H1. Elements on a page characterised by contrast errors are more difficult to locate than elements without such errors.

H2. In the eye-tracking study, times to first fixation are longer if the number of fixations is higher.

H3. The tiled menus of provincial city websites are more intuitive and easier for users to navigate compared to navigation in the form of linked text or drop-down menus

on websites, making the average time to first fixation shorter.

2. Related works

The accessibility of websites is the subject of numerous scientific studies. In their works, authors have conducted analyses using available tools or explained the legal regulations governing accessibility.

In the article [8] Małgorzata Szeroczyńska analyses the regulation of the law on digital accessibility of applications and websites of public entities. The author presents information on digital accessibility regulations in a clear and transparent manner, explaining rather complex legal acts. The author also presents a procedure that allows people with various disabilities to report a website that does not meet accessibility requirements. To report an inaccessible website, a request must be submitted to the relevant public entity asking for digital accessibility to be ensured, specifying the specific website, mobile application or part thereof.

In the article [9], the authors investigated the accessibility of the five most visited government e-service websites in Ecuador in terms of compliance with local regulations and the guidelines of the WCAG document. The study was performed using the WAVE tool and Cynthia Says. Analysis of the results showed that no site met the minimum requirements of WCAG 2.0, with the most common errors being the lack of alternative text for images, blank links and buttons. The authors emphasise that automated tools are helpful, but not sufficient, and point to conducting expert evaluations and user testing.

The authors of article [10] assessed the accessibility of 190 websites of municipal offices in the Lublin Province. The accessibility assessment was divided into two stages: automatic and expert analysis. Three validators were used in the automatic analysis to assess accessibility: Utilitia [11], Tingun Page Checker and Google PageSpeed Insights. In the expert study, the authors selected eight key criteria and conducted their analysis based on these criteria. For both analyses, thresholds were adopted on the basis of which a given website was considered accessible or not. The threshold was set at 80% for the automatic study and 50% for the expert study. Of the results obtained, only 33 out of 190 websites exceeded both thresholds. The authors point out that there is much to be done in the area of accessibility of municipal offices in the Lublin Province, and the results obtained indicate specific areas requiring improvement.

The authors of this article [12] studied the accessibility of portals and websites of the Ministries of Cyprus according to the WCAG 2.1 guidelines. The WAVE tool and Total Validator Pro were used in the study. From the results, the authors found that none of the evaluated sites were free of errors. Only one homepage met the full requirements of WCAG 2.1, and only 15.71% of all sites had no errors.

In the article An Eye-Tracking study of website complexity from cognitive load perspective, the authors focused on the impact of website complexity and how it affects user attention during task completion [13]. The experiment using eye-tracking technology was conducted with 42 students who had to perform simple and complex tasks on websites with three levels of complexity: low, medium, and high. The authors put forward a total of six research hypotheses, taking into account the division into simple and complex tasks. The results confirmed two of the three hypotheses for simple tasks, stating that the greater the complexity of the website, the greater the number and duration of fixations. In the case of complex tasks, all three hypotheses were confirmed. Pages of medium complexity proved to be the most demanding for the subjects, with the largest and longest fixations. The article points to the need to maintain a balance between visual diversity and the intensity of the content presented, while adapting these elements to the needs of users and the specific nature of the tasks performed.

The authors of the article [14] conducted a study on the usability of three news websites using, among other things, an eye-tracking technique. Forty-three respondents took part in the study. The authors noted that users used repetitive information search strategies, regardless of which portal they were dealing with. The study also confirmed that the way information is arranged on the pages has a direct impact on user interest. It was observed that the lower the content was located, the lower the user's interest in it declined. The authors emphasise that the eye-tracking technique provides valuable insights for web designers, and that web design should be informed by intuitive structure and content placement.

In the paper Analysis of the Usability and Accessibility of Websites in View of Their Universal Design Principles, the main objective was to analyse the usability and accessibility of websites in terms of universal design principles [15]. The authors decided to use three methods for the assessment: the LUT checklist, analysis with the WAVE tool for compliance with WCAG guidelines, and an experiment using eye-tracking technology. The research focused on four websites, two of which were compliant with universal design principles, while the other two were non-compliant. The research group consisted of 20 people, who were computer science students from the Lublin University of Technology. The results confirmed the hypotheses put forward by the authors at the beginning of the study. Namely, the average time to first fixation and the number of fixations in the eye-tracking study were lower for websites designed in accordance with universal design principles. In turn, the usability results obtained using the LUT list showed that the average results were 80% and 137% higher for websites compliant with universal design principles. In turn, analysis using the WAVE tool showed that the ratio of detected errors is lower on websites that take universal design guidelines into account.

3. Materials and Method

The research method was divided into two parts. The first stage involved conducting an accessibility survey using a selection of five automated tools. The second stage, on the other hand, involved conducting a survey using an eye-tracker.

3.1. Research objects

The accessibility analysis was conducted on the official websites of provincial capitals in Poland. Table 1 lists the names of cities along with their website addresses.

Table 1: Cities and their website addresses involved in the study

Cities	Website address
Białystok	https://www.bialystok.pl/
Bydgoszcz	https://www.bydgoszcz.pl/
Gdańsk	https://www.gdansk.pl
Gorzów Wielkopolski	https://um.gorzow.pl/
Katowice	https://www.katowice.eu/
Kielce	https://www.kielce.eu
Kraków	https://www.krakow.pl/
Lublin	https://lublin.eu/
Łódź	https://uml.lodz.pl/
Olsztyn	https://olsztyn.eu/o-olsztynie.html
Opole	http://www.opole.pl/dla-mieszkanca
Poznań	https://www.poznan.pl/
Rzeszów	https://www.erzeszow.pl/
Szczecin	https://szczecin.eu/pl
Toruń	https://torun.pl/pl
Warszawa	https://um.warszawa.pl/
Wrocław	https://www.wroclaw.pl/
Zielona Góra	https://www.zielona-gora.pl/

3.2. Accessibility studies

The first step in selecting accessibility testing tools was to establish the criteria on which the selection would be based:

- conducting the test free of charge,
- obtaining a result in numerical or percentage form on a scale of 0-10 or 0-100,
- diversification of validators in terms of the functions and elements analysed.

Finally, five tools were selected to conduct the accessibility test, namely: Accessibility Checker [16], Accessible Web Helper [17], MAUVE++ [18], and Utilitia. In addition, the accessibility study also used the WAVE tool, which allowed for the collection of information about possible contrast errors in the elements of provincial city websites, in the context of eye-tracking studies [19].

3.3. Research stand

The research stand prepared for the experiment using an eye tracker was equipped with an Acer Nitro 5 laptop and a Gazepoint GP3 HD eye tracker. The necessary Gazepoint Control and iMontions software was installed on the laptop. The task of the Gazepoint Control programme was to record eye movements [20]. The iMontions programme, on the other hand, displayed the prepared questions along with the stimuli assigned to them [21]. The eye tracker was placed directly below the laptop screen in such a way that it did not obscure the displayed content.

3.4. Research group

The research group consisted of 15 people aged between 23 and 25 years who were randomly selected from among second-cycle students of Computer Science at the Lublin University of Technology. Men accounted for 80% of the research group, while women accounted for 20%. An important feature of the research group was their good knowledge of computer use and website navigation.

3.5. Eye-tracking study

Before starting the study, the subjects were briefed on the experimental procedure. This was followed by the calibration of the equipment on the test bench, and then the actual part of the experiment began. The experiment consisted of 54 tasks concerning 18 websites of provincial cities in Poland. Three questions were prepared for each website in the study. The first focused on examining the elements on the pages in terms of contrast, the second concerned one of the principles of universal design, which is noticeable information. The last question aimed to compare the menu structure between the sites.

4. Results

4.1. Results of the automatic test

The tools listed in subsection 3.2 were used to test the accessibility of the test objects. The validators checked the compliance of the websites with the WCAG guidelines. Figure 1 shows the average accessibility score obtained using five automatic tools.

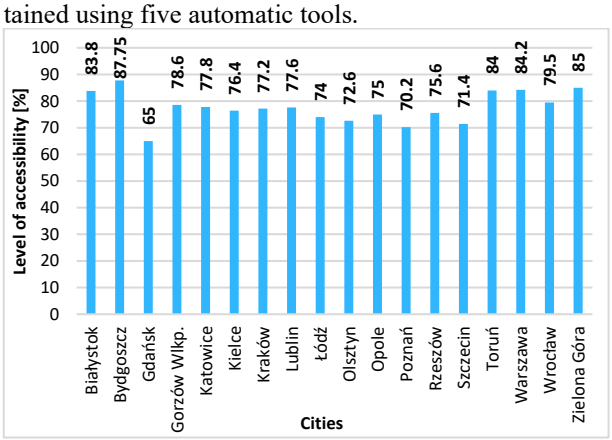

Figure 1: Average accessibility rating conducted using 5 automated tools.

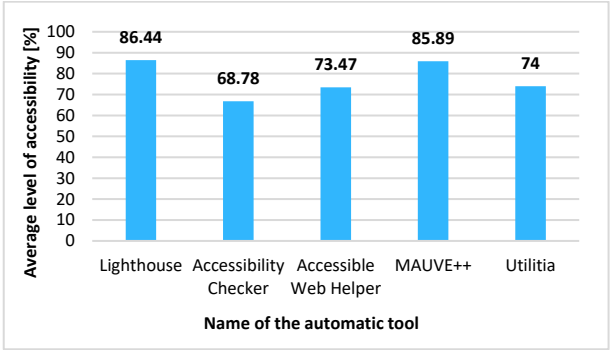

Figure 2: Average accessibility level of all sites for a given tool.

The highest average score was achieved by the website of the city of Bydgoszcz, which achieved an accessibility level of 87.75% (Fig. 1). The lowest score, at the level of 65%, was achieved by the website of the city of Gdańsk.

Considering the results obtained by provincial capital websites using individual tools, Figure 2 shows that, on average, the best ratings were given by the Lighthouse validator, at 86.44%. In contrast, the worst average results, 68.78%, were obtained by websites tested using the Accessibility Checker tool. Figure 3 shows the distribution of pages based on the presence or absence of contrast errors for the areas of interest sought in contrast analysis tasks in the eye-tracking experiment.

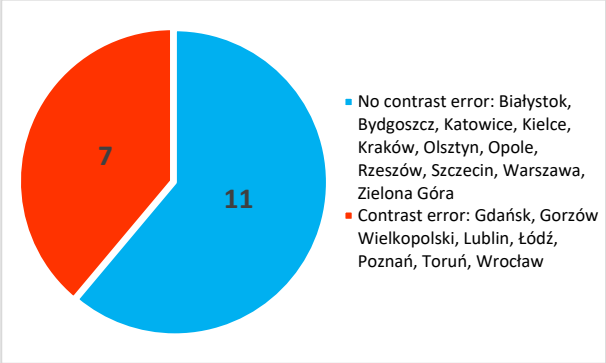

Figure 3: Distribution of provincial capital city websites in terms of detected contrast errors.

4.2. Results of the eye-tracking study

After the experiment was completed, the results were exported using the iMotions programme. A total of 918 results were obtained from the tasks performed by the test subjects. The data included both individual results for each respondent and aggregated results for the entire research group. The first step after obtaining the results was to verify the correctness of the tasks performed. The correctness of task performance was verified by analysing the scan paths obtained. Based on the results of the correctness of the tasks performed, 632 tasks were completed correctly and 163 were completed incorrectly. Figures 4 and 5 show the correctness of the subjects' execution of each task number. It was also decided that incorrectly performed tasks would not be considered in further analysis. Provincial capitals, as the administrative centres of provinces, play an important role in disseminating in-formation to a wide audience.

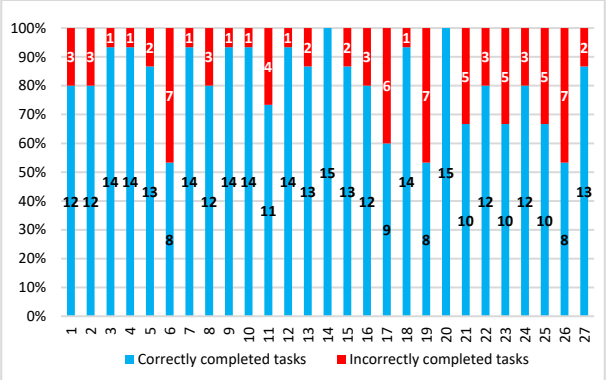

Figure 4: Correctness of tasks numbered 1-27.

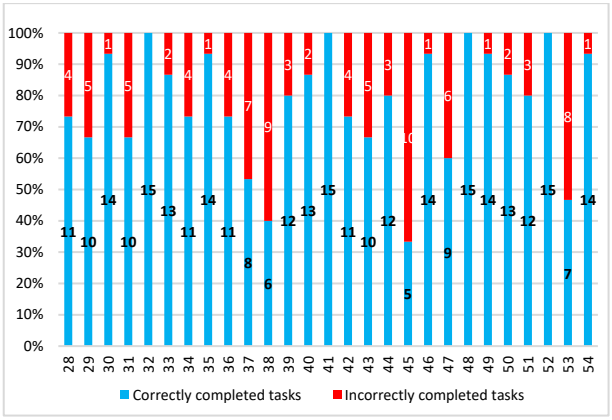

Figure 5: Correctness of tasks numbered 28-54.

Figures 6 and 7 below show examples of scanning paths in the case of correct identification of the area of interest (AOI) as well as incorrect task performance.

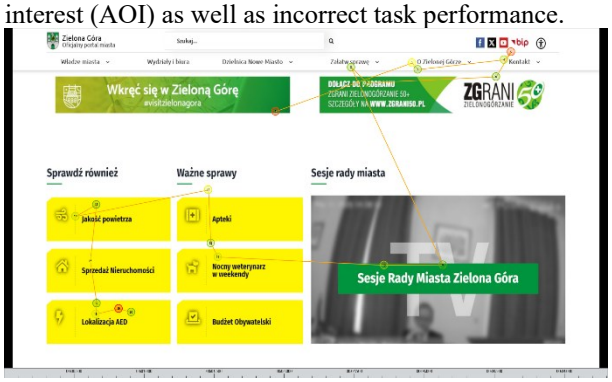

Figure 6: Scanning path for task 52 - finding the AOI correctly.

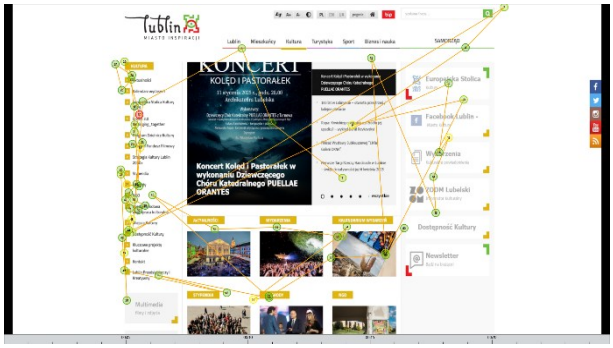

Figure 7: Scanning path for task 22 – AOI not found correctly.

4.3. Measurement of times to first fixation (TTFF)

The analysis of subsequent results concerns the times to first fixation from the eye-tracking experiment tasks. The results obtained were divided according to the type of questions discussed in subsection 3.5. In addition to the times obtained for the first fixation, additional calculations were also performed to obtain a more accurate analysis of the data.

Due to the analysis previously conducted using the WAVE tool presented in Figure 8, a division was obtained into tasks that had contrast errors and those that did not. Figure 8 provides us with information that the average time to first fixation is lower for tasks in which the area of interest under investigation does not have contrast errors by 0.79 seconds.

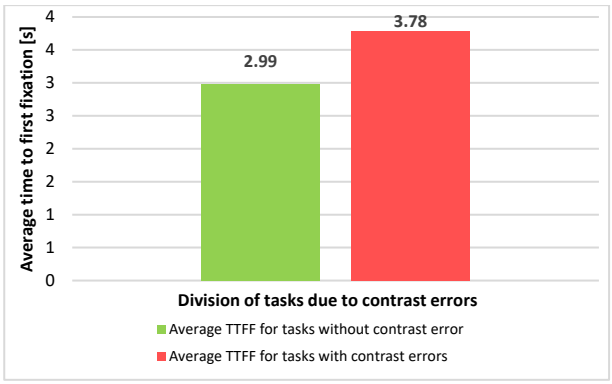

Figure 8: Average TTFF for contrast-related tasks.

The second type of tasks in the eye-tracking study was devoted to the universal design principle of noticeable information. The average completion time for all tasks was 4.47 seconds. The average completion time for task number 53, concerning the website of the city of Zielona Góra, was 0.85 seconds, making it the fastest task completed by participants. In contrast, respondents spent the most time on the website of the city of Łódź, where the average task completion time was 12.27 seconds. The graph shown in Figure 9 shows all average times to first fixation for this type of task.

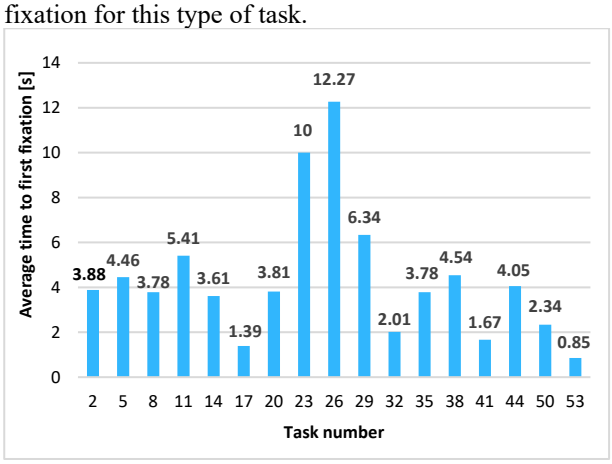

Figure 9: Average TTFF for tasks involving noticeable information.

The final task in the eye-tracking study focused on comparing menus on provincial city websites. Analysis of the websites' navigation systems allowed us to identify three main types: navigation based on linked text, tile menus, and drop-down menus. The final task in the eye-tracking study focused on comparing menus on provincial city websites. The participants were asked to locate for relevant links to subpages, which allowed for an assessment of the effectiveness of different types of navigation. An analysis of the websites' navigation systems allowed us to distinguish three main types: navigation based on linked text, tile menus, and drop-down menus. The participants performed best with tile-based navigation, achieving an average task completion time of 2.84 seconds. Using a linked text menu was slightly slower, with an average task completion time of 4.15 seconds. The longest task completion time was recorded for websites using drop-down menus, with an average of 5.47 seconds. These results are presented in Figure 10.

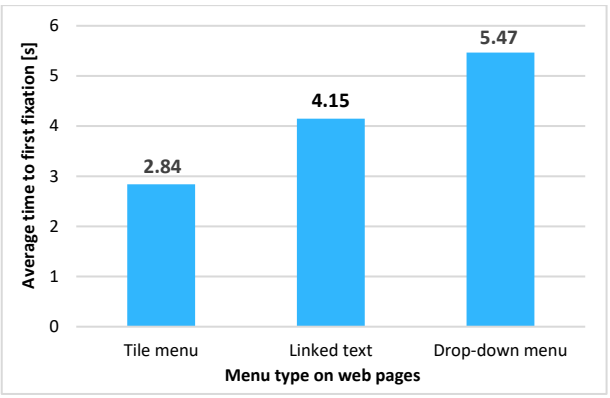

Figure 10: Average TTFF according to menu type on websites.

The last graph, presented in Figure 11, illustrates the cumulative average times to first fixation for all three questions included in the eye-tracking experiment, covering the websites of all provincial cities. Analysis of the graph shows that the fastest time to first fixation for all tasks was achieved by participants when completing the tasks from the Kielce city site, with a total average result of 2.08 seconds. On the other hand, respondents needed the longest average time, 8.61 seconds, to complete all tasks on the city of Łódź website.

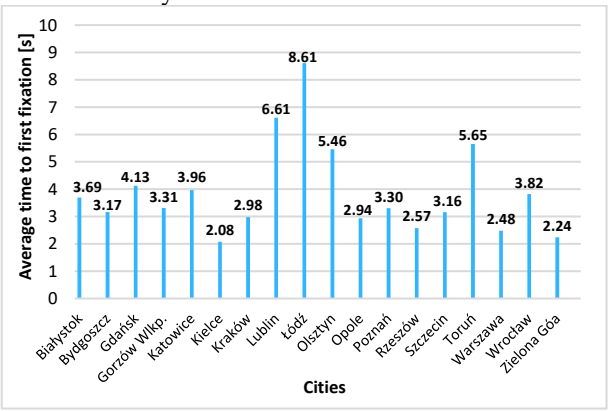

Figure 11: Average TTFF for all tasks from the eye-tracking experiment.

4.4. Measurement of the fixation count

The rest of the analysis focuses on the number of fixations. This number determines how many times the test subject focused their gaze on a specific area of a given stimulus. A low number of fixations indicates that the area of interest was easy to locate. On the other hand, a high number of fixations may indicate difficulty in locating it. Similar to the first fixation times, these data were also divided according to the types of tasks in the eye-tracking experiment. Charts were created to illustrate how many fixations the test subjects needed for each task.

The analysis of the results of the tasks concerning the evaluation of the contrast of elements on the websites showed significant differences in the number of fixations. The details of these differences are illustrated in Figure 12. The highest number of fixations, as many as 96, was recorded by one of the participants in task number 28, which concerned the website of the city of Olsztyn. On the other hand, in task number 16, which referred to the

website of the city of Kielce, one of the respondents identified the area of interest already at the first fixation, which was the lowest recorded result in this part of the study.

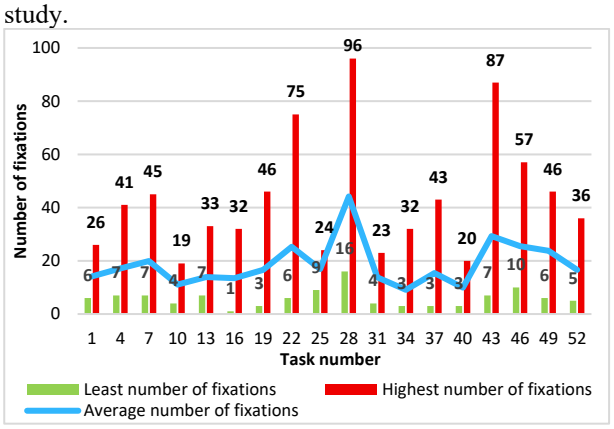

Figure 12: Analysis of the number of fixations for contrast tasks.

Next, tasks related to the visibility of information on websites were analysed, as illustrated in Figure 13. Tasks numbered 20, 29 and 50 stood out with the lowest number of fixations in this group, amounting to 3 fixations to correctly locate the area of interest. These tasks concerned the websites of the cities of Krakow, Olsztyn and Wrocław. In contrast, a record high number of 136 fixations was recorded for one of the respondents in task number 14 on the Katowice website.

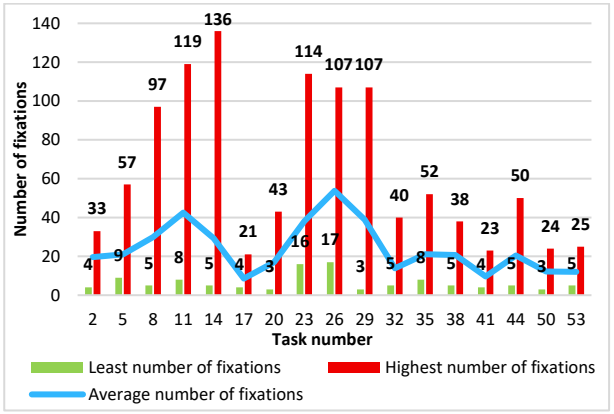

Figure 13: Analysis of the number of fixations for noticeable information tasks.

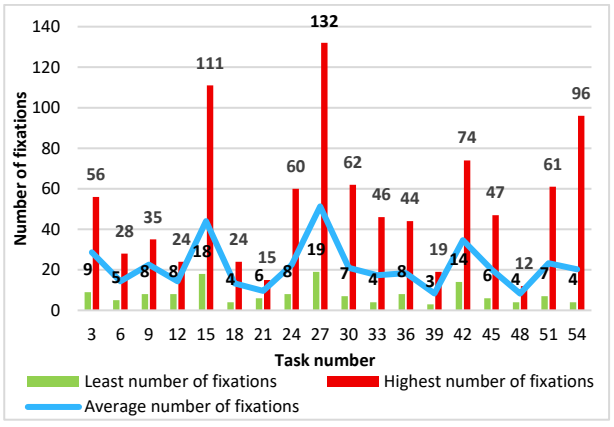

Figure 14: Analysis of the number of fixations for page navigation comparison tasks.

The last chart summarizing the number of fixations concerns tasks related to testing various navigation systems on websites, as shown in Figure 14. The highest number of fixations, as many as 132, was recorded for task number 27 on the Łódź website, which used linked text navigation. The fewest, only 3 fixations, were recorded in task number 39 on the Rzeszów website, which also used a linked text menu.

Based on the collected data on the average time to first fixation and the number of fixations, the authors investigated whether there is a relationship between these measures. In the first step, the normality of the obtained data was tested using the Shapiro-Wilk test. Due to the lack of normal distribution of the data, Spearman's rank correlation was used. The result confirmed a very strong positive correlation ($\rho = 0.87$, $p < 0.001$) between the average time to first fixation and the average number of fixations. This means that the greater the number of fixations required by the participants in the eye-tracking study, the more time it took them to locate the area of interest (AOI). This correlation is illustrated in Figure 15.

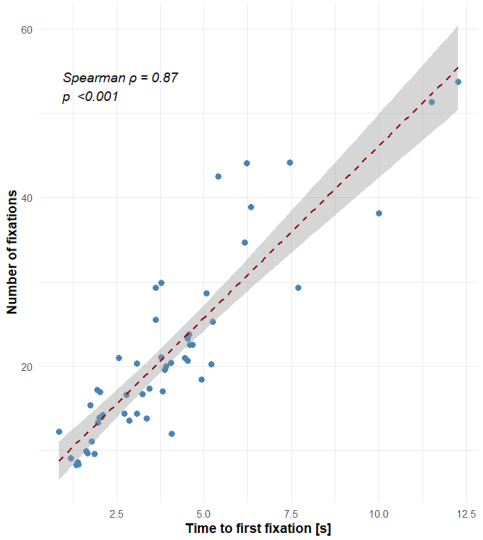

Figure 15: Correlation between time to first fixation and number of fixations.

5. Discussion

The study was conducted to confirm hypotheses H1-H3. The results provided extensive data, which was subjected to detailed analysis. Data obtained from automated testing allowed for verification of the extent to which provincial capital city websites comply with WCAG guidelines and provided information on the locations of contrast errors. In turn, the data obtained due to the experiment conducted with the use of an eye tracker was obtained not only in numerical form, but also in graphic form. The analysis of the research results helped to verify the research hypotheses set at the beginning of the work.

Hypothesis H1 assumed that elements on provincial capital city websites that have contrast errors are more difficult to find in an eye-tracking study than those that are free of such errors. The results confirm the validity of hypothesis H1. The average time to first fixation was lower in tasks where the elements in the area of interest

(AOI) did not contain contrast errors, compared to those where such errors occurred. The difference in these times was 0.79 seconds. In the paper [22] the authors also confirmed the importance of graphic contrast by examining its impact on the visibility of elements and the speed of attracting users' attention. Their findings showed that study participants located high-contrast elements on average twice as fast.

Hypothesis H2 was that in an eye-tracking study, the times to first fixation are longer when the number of fixations is higher. The Spearman's rank correlation analysis presented in Figure 15 showed a strong positive correlation, and the p-value confirmed statistical significance. This means that the more fixations the participants in the eye-tracking study needed, the more time it took them to find the area of interest (AOI), which confirms the validity of hypothesis H2. In turn, the authors of the paper [23] investigated whether the parameters obtained from the eye-tracking study allow for effective prediction of consumer decisions regarding the purchase of a given product. Based on the results obtained, the hypothesis that the number of fixations and the total fixation time effectively predict consumer choices was confirmed, and what is more, there is a clear correlation between them.

On average, the lowest times to first fixation were obtained by sites where the navigation was in the form of a tiled menu, and the average time to correctly locate the area of interest was 2.84 seconds, ahead of navigations in the form of linked text by 1.31 seconds and drop-down menus by 2.63 seconds. Figure 10 visualises these data, confirming the validity of hypothesis H3. In the study [24] the authors emphasise that there is a lack of clear, research-based evidence that indicates optimal menu positions from a usability perspective. The study focused on task completion times, error rates, click-through rates and user satisfaction. During the experiment, four variants of the online shop page were used with different positions of the navigation bar. Fifty-six participants took part in the study, and each had six product search tasks to complete on the site. From the results, the best menu positions were the top of the page (horizontally) and the left side (vertically). The authors suggest the need for further research with other menu types and task complexity.

The results collected and analysed in the paper above confirmed all the hypotheses H1-H3 posed at the beginning of the paper.

6. Conclusions

The accessibility of the websites of voivodship cities in Poland is of great importance, because, as administrative sites, they must meet the designated accessibility standards described in the WCAG standard. From the results obtained, it is not possible to conclude unequivocally that a given city fully meets these requirements, and a high accessibility score obtained in an automated survey does not always translate into faster service when using the website.

The analysis of the survey results in accordance with the previously established research methodology has shown the validity of the hypotheses adopted.

It should be noted that this study also has some limitations. The number of people taking part in the experiment was a relatively small group. In addition, the eye-tracker experiment should have examined a larger number of functionalities and page elements and should therefore have been split into several separate studies. Therefore, the study should be continued, involving a larger and more diverse group of participants. Such an approach will allow us to collect more representative data and contribute to a deeper understanding of the factors influencing the accessibility of websites of voivodeship cities in Poland.

The results and conclusions presented can be useful to improve accessibility and usability on the websites of provincial cities. Further research is also needed to deepen and verify the observations made. This is particularly important in the context of websites of voivodeship capitals, where the content changes dynamically.

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