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CRITERIA FOR ACCESSIBILITY OF PUBLICATIONS FOR READERS WITH VISUAL IMPAIRMENTS: A REVIEW

R. H. Zatserkovnyi, V. Z. Maik

Ukrainian Academy of Printing,
19, Pid Holoskom St., Lviv, 79020, Ukraine

The definition of "visual impairment" is considered; the criteria for classifying different types of visual impairments as well as the main symptoms that adversely affect a reader's ability to print and electronic publications are reviewed. A number of requirements and recommendations for accessible print publications are reviewed. Finally, the need to develop our own set of standards for such print publications is emphasized.

Keywords: *visual impairment, accessible publishing, visual acuity, field of vision, requirements for accessible publications.*

Problem statement. People with visual impairments are one of the main users of accessible print publications, and meeting their needs is one of the top priorities when ensuring a publication is fully accessible. *Visual impairment* refers to any reduction in a person's ability to see caused by a medical condition affecting vision. This reduction must be significant enough to interfere with a person's daily life or professional activity, and severe enough that it cannot be corrected with glasses, contact lenses, surgery, etc.

Visual impairment can be caused by a wide range of diseases, and oftentimes people with severe low vision have several conditions at once (for example, due to old age or an eye injury). These diseases cause a number of symptoms that can interfere with the user's ability to experience web pages, electronic and printed publications. Conventional print publications often do not consider these factors in their design process, and therefore publications intended for visually impaired readers must be adapted before publications. Such adaptation is one of the main priorities of inclusive design in the publishing field.

Unlike the problem of web accessibility, where numerous international standards for accessible content – such as the Web Content Accessibility Guidelines (WCAG) – have been developed, few formalized standards for adapting print publications exist. However, by combining recommendations and suggestions from several different sources – such as of people with visual impairments, or publishers involved in adapting publications to readers with low vision –our own formalized set of criteria can be developed that determines whether a publication is sufficiently well-adapted for the end user.

Review of the latest research and papers – in recent years, adapting content to the needs of people with visual impairments has been of considerable interest to researchers. A number of authors – B. Gibson; S. Kurt; A. Hurst and C. Kearney-Volpe – analyze and investigate the suitability of electronic publications and websites for readers with visual

impairments. Although publications on this subject often concern electronic content like e-books and websites, some studies cover traditional print publications. For example, G. Kouroupetroglou covers the creation of textbooks on physics and other natural sciences for all educational levels with the help of OCR (optical text recognition), encoding formulae in the MathML markup language, and converting graphics & diagrams into a clearer format. M. I. Laitano proposes a methodology that can be applied to all forms of accessible design, focusing on identifying stakeholders who both produce and consume content for people with visual impairments with a focus on the latter category. However, compared to web or e-book accessibility, papers related to adapting print textbooks are relatively uncommon.

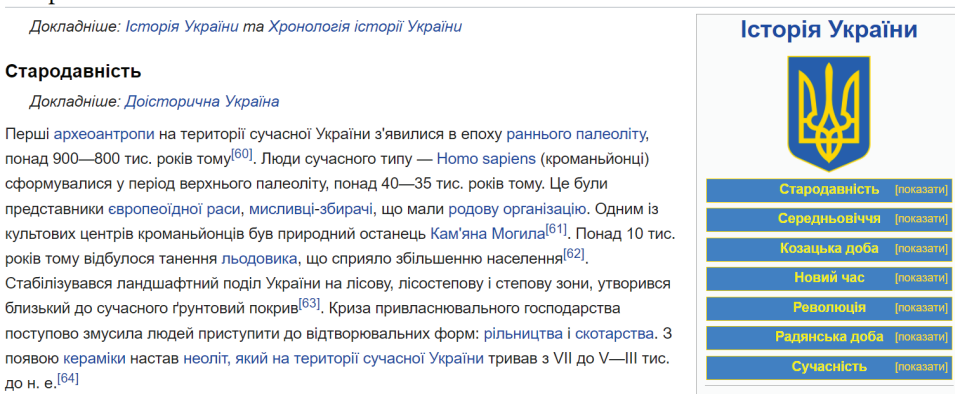
Goal of the study – to review the concept of visual impairment and the main types of visual impairments that affect the accessibility of print publications for people with visual impairment; analyze requirements and recommendations for accessible print publications.

Main research material. The World Health Organization classifies visual impairments based on two main parameters: visual acuity and field of vision. Visual acuity determines the ability of the eye to clearly distinguish small details, whereas field of vision refers to the area within which the eye can clearly distinguish such minute details. In addition to these two parameters, there are several other types of visual impairments that relate to the perception of web publications:

- **Photosensitivity (photophobia)** – painful sensitivity of the eye to sources of bright light which would normally not cause pain. A person with pronounced photosensitivity may feel discomfort – pain in the eyes, tearing, headache, fatigue and so forth – from both natural and artificial light sources.
- **Low contrast sensitivity** – some conditions may deteriorate a person's ability to distinguish between bright and dim areas of the image. A person with low contrast sensitivity may clearly see high-contrast objects, but will have difficulty distinguishing between two objects with a small difference in contrast.
- **Low color perception** – besides visual acuity and field of vision, a group of conditions known as color blindness negatively affects a person's ability to distinguish the colors of different objects in their field of vision. Some people with color blindness cannot distinguish certain combinations of red, blue and green – this is caused by illnesses related to cone cells, which are responsible for an eye's perception of color. Others cannot perceive any colors at all.

Visual impairments can have varying levels of severity. In many countries, particularly serious types of visual impairment are classified as so-called "legal blindness". This level of vision loss means that a person is unable to carry out most types of daily activities and is entitled to disability assistance, participation in rehabilitation programs, exemption from certain categories of taxes, etc. – however, it does not necessarily mean that a person has full vision loss. The International Classification of Diseases ICD-10 (ICD-10) defines three main categories of visual impairment – mild amblyopia, severe amblyopia and blindness. In this system of classification, blindness also refers to sufficiently severe vision impairment, and not just the absence of any and all vision.

Visual impairment can be caused by a number of diseases; often people with severe low vision have several conditions at the same time (for example, due to old age or an eye injury). These diseases cause a number of symptoms that can interfere with the user's experience while viewing web pages and publications, both electronic and printed One of the most frequently encountered symptoms of visual impairment is blurred vision, which makes a person's eyesight becomes less accurate at close range, causing difficulties when trying to distinguish minute details. Blurred vision can be caused by both mundane symptoms like ordinary fatigue and a number of serious vision disorders.


Історія

Докладніше: Історія України та Хронологія історії України

Стародавність

Докладніше: Доісторична Україна

Перші археоантропи на території сучасної України з'явилися в епоху раннього палеоліту, понад 900—800 тис. років тому[60]. Люди сучасного типу — Homo sapiens (кроманьйонці) сформувалися у період верхнього палеоліту, понад 40—35 тис. років тому. Це були представники європеоїдної раси, мисливці-збирачі, що мали родову організацію. Одним із культових центрів кроманьйонців був природний останець Кам'яна Могила[61]. Понад 10 тис. років тому відбулося танення льодовика, що сприяло збільшенню населення[62]. Стабілізувався ландшафтний поділ України на лісову, лісостепову і степову зони, утворився близький до сучасного ґрунтовий покрив[63]. Криза привласнювального господарства поступово змусила людей приступити до відтворювальних форм: рільництва і скотарства. З появою кераміки настав неоліт, який на території сучасної України тривав з VII до V—III тис. до н. е.[64]

Історія України

Стародавність [показати]
Середньовіччя [показати]
Козацька доба [показати]
Новий час [показати]
Революція [показати]
Радянська доба [показати]
Сучасність [показати]

Fig. 1. A webpage in the eyes of a person without any significant vision loss (source: Ukrainian Wikipedia, "Ukraine" article)

Fig. 2. A webpage in the eyes of a person with blurred vision

Another common, and previously mentioned, symptom of visual impairment is color blindness. This symptom concerns a person's ability to distinguish colors: people with it often lose the ability to distinguish certain combinations of colors, seeing the world in an unusual color spectrum. "Full color blindness", when a person sees the world only in shades of gray, is a rather rare phenomenon. Instead, less severe types of color blindness affecting the ability to see one or two types of colors are much more common.

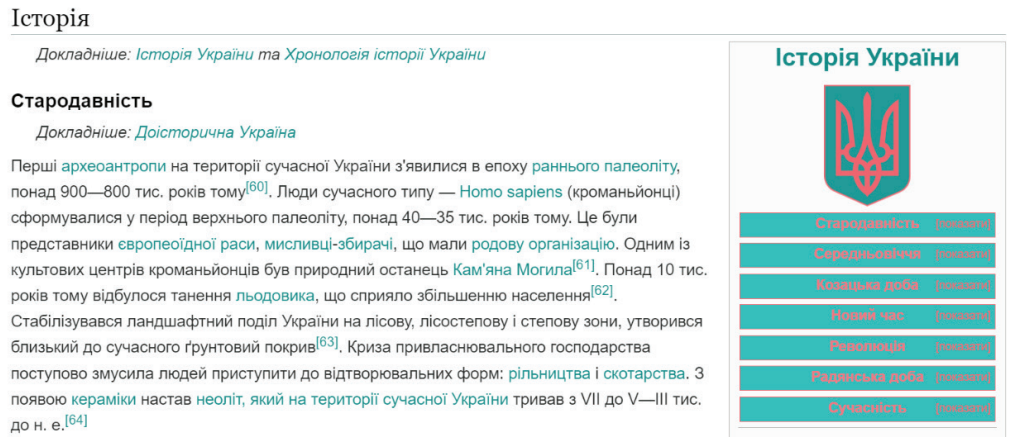


Fig. 3. A webpage through the eyes of a person with tritanopia, a form of partial color blindness

Certain diseases affect the field of vision rather than visual acuity. Tunnel vision is a symptom characterized by the loss of lateral vision; a person with this condition can see an object only when looking directly at it. Other diseases such as glaucoma can cause the opposite issue - the appearance of blurry, and eventually completely darkened spots in the middle of a person's field of vision, which may increase over time without proper treatment.

Fig. 4. A webpage through the eyes of a person with tunnel vision

To develop our own recommendations for accessible print publications, we have analyzed a number of existing guidelines and requirements. Unlike the field of web accessibility, where several commonly accepted international standards have been developed – for example, the Web Content Accessibility Guidelines (WCAG) – there is no such standard for printed publications. However, by combining recommendations from several different sources we may develop our own comprehensive series of requirements.

"Methodological recommendations for the preparation and printing of textbooks and manuals for children with visual impairments" is a series of guidelines on developing textbooks for children with both partial and full loss of vision. We focus on the latter series of requirements, which are presented as follows:

- The size of the main body of text should be 50-60% relative to that of the page; the rest of the page should be reserved for margins. A large number of clear, high-contrast illustrations is recommended.
- The font size should be at least 18-20 points, spacing between words should be no less than the chosen size of the font, and the distance between individual characters should be about 20-30% of their width.
- The authors of the guidelines highlight a number of forbidden parameters, which are related both to the design and layout of the text and physical characteristics of the print publication:
  - Fonts with narrow strokes as well as inverted text (light words on a black background) are strictly prohibited.
  - Placing text on multiple columns is not recommended, especially for children of preschool and elementary school age.
  - The background of the main body of text, as well as areas of workbooks intended for writing, cannot be a color other than white.
  - Glossy paper, which can cause unwanted glare, should not be used.
- To adapt a textbook for colorblind readers, combinations of red and green as well as blue and green colors should be avoided. If this is not possible (for example, in pictures of flowers or other natural phenomena), the textbook should use high-contrast colors and separate them with a clear outline.
- Each illustration should be somewhat stylized and simplified, clearly highlighting the features of the subject that are considered the most essential: for example, a chair should have 4 legs, and a bird should have 2 legs and visible wings. Details that are less important for understanding the essence of the subject can be ignored.
- Illustrations should have the following set of recommended characteristics:
  - Lines – clear, high-contrast (80-100%), at least 1mm in width;
  - Images – between 10x10 and 15x20 cm in size;
  - Lowest acceptable size of individual elements in an illustration – 3 to 15 mm; ideally 7 to 10 mm.
- Requirements for tables are defined as follows:
  - Light gray or light beige background;
  - Light reflectance value coefficient at least 60%;
  - At most 3-5 columns;
  - Height of individual letters – no less than 10mm;
  - Height of individual numbers – no less than 12mm.
- Illustrated graphics should contain no more than 5 elements that are clearly different from each other. To indicate the direction between one element and another, solid arrows should be used, differences between them being determined by their thickness

and color. Individual elements of this graphics should be at least 4-5 times larger than the main font size.
- The weight of the textbook should not exceed 600 g.
- Textbooks for children with visual impairments should be designed for only one year of study, textbooks combining several study programs are not allowed.

Best Practices and Guidelines for Large Print Documents used by the Low Vision Community is a list of recommendations from the American Council of the Blind. This document was developed as a result of the work of an ad hoc committee to identify, analyze, and evaluate the various adapted publications available in the United States.
- The font size for the main body of text should be at least 18 pt (ideally, 20 pt). A monospaced, semi-bold, sans-serif font should be used – fonts that meet this set of criteria include Verdana, Helvetica, Thoma, Arial, Futura Light Bold and Gotham Rounded.
- Line spacing should be set to at least 1.5 – this will help reduce visual strain and ensure the text is easier to process.
- Headings should have a size larger than that of main text; they should use both lowercase and uppercase letters rather than all-capitals.
- Both the main text of the publications and its headings must be left-aligned rather than justified. Paragraph spacing should be doubled.
- Large, dark markers should be used to indicate list items. Elements of a list (as well as paragraphs) must be separated by double spacing.
- Hanging lines at the beginning or the end of a paragraph should be avoided.
- Page numbering is mandatory. The style and size of these numbers must match the rest of the text in a document. In single-sided publications without binding, they should be placed in the upper right corner; in regular publications, at the bottom right or the bottom left.
- The minimum size of margins is set to 0.75 inches, or about 1.9 cm.
- The paper used for print publications must have a color that reduces the negative effects of glare; for example, an “eggshell” color (very light beige).
- Colored text or italics should not be used to highlight individual words – instead, the use of bold text, dashes, asterisks or underlines is acceptable.
- If related information is horizontally separated on a page – for instance, section titles and page numbers in the table of contents – it needs to be connected with dots rather than spaces. Furthermore, clearly recognizable horizontal and vertical lines should be used in tables.
- For adapted publications printed on conventional printers, staplers or spiral binding should be used. A full-fledged binding requires a larger margin size. In addition, during the printing process, the “page stretching” functionality available in some printers should not be used – instead, the document should be adapted in a word processor and then printed normally.
- Images, graphics and charts should be placed on a separate page with an associated explanatory caption.

– High visual contrast is important to many people with visual impairments; high contrast between the background and the text, as well as within individual illustrations, should be ensured.

EBU Clear Print Guidelines is a set of recommendations developed by the European Union of the Blind (EBU). This organization represents over 30 million people with visual impairments living in Europe. Its recommendations aim to help publishers, companies and other organizations improve the accessibility and usability of their publications.

– **Text contrast** is considered one of the main factors affecting the ability of people with visual impairments to perceive text, sometimes even more important than its size and font style. Therefore, both electronic and print publications should use the best possible contrast levels, with low background brightness and high text brightness. Specific examples of acceptable color combinations are black or blue text on a white background (a light-yellow background is even more preferred, as it reduces the effects of glare). To further reduce glare, the opposite color structure – light, high-contrast text on a dark background – should be considered.
– **Font size and font style.** For the main text body, sans-serif fonts with clearly distinguished uppercase and lowercase characters should be used; some examples of acceptable fonts are Arial, Helvetica and Verdana. Serif fonts such as Times New Roman, as well as decorative and handwritten fonts, should be avoided. The font weight should be average; fonts with very thin (Ultra Light, Thin, Light) or thicker than normal (Bold, Heavy, Black) strokes should be avoided. The recommended font size is 14 pt to 18 pt when using Arial, although it may differ for other font.
– **Text highlighting**. Furthermore, italics, underlining or capital letters should not be used to highlight certain parts of the text – bold fonts can be used instead. Quotes, rather than italics, should be used to highlight quotes and citations (for extra convenience, the entire citation may be enclosed in parentheses).
– **Inter-letter spacing.** The EBU recommends the use of monospaced fonts. In such fonts, the distance between all letters is the same, while the distance between words is slightly larger. Monospaced fonts include, for example, the sans-serif font Arial. Spacing should be 25-30% of the font size - this will help readers with shifting focus from one line of text to another.
– **Alignment, margins and columns.** Text should be left-aligned. Using justified alignment is strongly discouraged - it can create large gaps between words, making them much harder for people with visual impairments to follow. Wide margins should be used, and spiral binding is ideal. Text can be placed in both one and two columns; the latter will make the text easier to read because it requires less eye movement. However, this is acceptable only for relatively large page formats – for example, A4 with Arial 14pt. Two columns should not be used for brochures and other small publications.
– **Text structure.** Headings should be clearly visible so that they can be easily recognized. The best way to make headings stand out is to use bold fonts and a font size slightly larger than the main text. It is also possible to use another high-contrast color – in this case, it must be surrounded by a colored rectangle or another form

of highlighting. Page numbering is mandatory; numbers must be in the same place for all pages. Like headings, page numbers should ideally be displayed on a colored background. The publication must contain a table of contents; in electronic editions, this should consist of links to the relevant pages of the text.

– **Tables and illustrations.** Tables should have clearly visible bold lines, with a sufficient distance between the text and the lines. Illustrations should also consist of high-contrast elements and use thick lines. If possible, they should be placed either next to the text they relate to or on a separate page immediately after the corresponding text. The text should not overlap with the image - instead, in both print and electronic publications, a caption should be added next to it. In electronic publications, "alt text" – a text description that is shown to people who, due to visual impairment or for other reasons, cannot fully perceive the illustration – should be added to every image.
– **Printing technology.** The paper used for print publications should have matte finish. Glossy coating should be avoided, as it can lead to excessive glare, which is uncomfortable for people with impaired vision. For the same reason, entirely white paper should be avoided – instead, "off-white" (bright light gray) colors are recommended.

Conclusion. Based on the results of our research, the following series of conclusions can be drawn:

– Visual impairment is caused by a wide range of conditions that in one way or another affect the reader's ability to perceive a publication. Some of these conditions adversely affect visual acuity, while others impact the field of view or color perception. However, most people with visual impairment retain some level of vision – with the proper adaptations, they can still make use of paper publications.
– Currently, there are a number of requirements and recommendations for ensuring the accessibility of paper publications. Their recommendations include requirements for text size, font styling, tables, illustrations, paper quality, etc. However, none of them are formalized standards that prioritize one particular set of requirements over another.

On the basis of the recommendations that have been reviewed, the authors will develop a mathematical model that will allow them to formally determine the level of a publication's accessibility, as well as determine the importance of different accessibility criteria.

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ОГЛЯД КРИТЕРІЇВ ДОСТУПНОСТІ ВИДАНЬ ДЛЯ ЧИТАЧІВ З ПОРУШЕННЯМИ ЗОРУ

Р. Г. Зацерковний, В. З. Маїк

Українська академія друкарства,
вул. Під Голоском, 19, Львів, 79020, Україна
zatserkovnyi.rostyslav@gmail.com

Люди з порушеннями зору є одними з основних користувачів адаптованих друкованих видань, і задоволення їхніх потреб є важливим в процесі адаптації видання для якомога ширшого кола читачів. Порушеннями зору є будь-які зниження здатності людини бачити, які є достатньо значними, щоб завадити їй в повсякденному житті або під час роботи; такі симптоми не можуть бути виправлені за допомогою окулярів, контактних лінз або простих хірургічних операцій. Порушення зору можуть бути спричинені широким спектром захворювань, а також старінням. Існує чимало симптомів, які суттєво впливають на здатність читача сприймати друковане видання – найпоширенішими з них є втрата гостроти зору, колірна сліпота (або дальтонізм) і обмежене поле зору.

Звичайні друковані видання часто не враховують читачів із порушеннями зору в процесі дизайну, і тому їх необхідно певним чином адаптувати, перш ніж можна вважати доступними для всіх категорій читачів. На сьогодні розроблено низку вимог та рекомендацій для адаптування доступних видань – вони регламентують розмір тексту, стиль шрифту, таблиць, ілюстрацій, якість паперу, що використовується для друку тощо.

У цій роботі ми розглядаємо поняття «порушення зору» та низку видів порушень зору, що впливають на читабельність друкованих видань; при цьому надаючи ілюстровані приклади web-сторінки очима читачів з різними порушеннями зору. Ми аналізуємо низку рекомендацій щодо адаптації друкованих видань і детально описуємо вимоги та рекомендації з різних джерел, в тому числі видавництв та спілок для людей з порушеннями зору. Зрештою, ми обґрунтовуємо необхідність розробки власного набору стандартів для адаптованих друкованих видань; в тому числі математичну модель, яка враховуватиме пріоритети для кожного критерію доступності видання, а також забезпечуватиме автоматичне оцінювання рівня читабельності адаптованого видання.

Ключові слова: *порушення зору, доступні видання, гострота зору, поле зору, вимоги для видань.*

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