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ALCOVE: An Accessible Comic Reader for People with Low Vision

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ABSTRACT

Low vision is a visual impairment that affects one's capacity to perform daily activities, among others, reading. Since difficulty to access printed materials is an obstacle to education, employment and social activities, adaptations of these material is often required, such as the usage of large print or audio transcriptions. The advent of digital documents, on computers and mobile devices, has enhanced the accessibility of text for people with low vision; however, there is still a lack of supply regarding accessible books for recreation reading. In this work, we study how an accessible reader can impact reader's engagement with comics, for both children and adults. We summarise the results of online surveys that have been conducted about the current usage of comics by reader with low vision and how professional attempt to provide them. This led to the design of ALCOVE, an accessible comic reader for people with low vision. We report the results of a user study with 11 participants with low vision, that examined both the usefulness of the proposed comic reader and the reading presentation mode. Results show that the participants found our application easy and very convenient to use.

CCS CONCEPTS

• CCS → Human-centered computing → Accessibility → Accessibility design and evaluation methods

KEYWORDS

Accessible comics, Low vision people, Page layout, Reading mode

ACM Reference format:

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1 INTRODUCTION

According to a recent survey [1], in 2015 there were globally around 253 million people with visually impairment (VI), of whom 36 million were blind. These numbers are less important than the World Health Organisation's numbers in 2010 (285 million people with VI, of whom 39 million were blind) [3]. This could be explained in some extent by the Organisation's current global action plan (2014-2019) regarding universal eye health for the prevention of blindness and visual impairment [2]. However, it remains that many people with VI face a lifetime of inequality, as they daily have to face barriers such as mobility, education, information, culture, etc.

Low vision (LV) is the term used to describe moderate or severe visual impairment, that cannot be corrected with glasses, contact lenses, medication or eye surgery. Reading difficulty is a major consequence of the visual impairment for people with LV. Indeed, an activity that should be effortless and enjoyable often requires a lot of preparation and adjustment for people with LV. In 1997, [8] reported that the main objective for 75% of their study's elderly participants with LV was to gain improvement in personal reading. Several LV aids for reading can be used such as handheld magnifiers, large print books, or audio recordings.

For digital reading, displays have provided many opportunities to enhance the accessibility of text for people with LV. The first barrier is the print size of the text that is usually too small by default. However, other text variables, such as spacing, contrast and font style also have an impact on the reading process [9]. In 2016, Legge G.E. [10] gave insights and guidelines on digital reading with LV. He later studied how people with LV achieved magnification in digital reading. He reported that the participants “*achieved desirable magnification primarily by enlarging physical character size and to a lesser extent by reducing viewing distance*”. An interesting observation was that “*people with a wide range of acuities are engaged in digital reading*”, on computers, smartphones and tablets.

In order to increase the engagement of people with LV into the reading activity, and especially children, we aimed to design a comic reader that allows them to have access to digital comics. Comics are a medium used to tell stories through the combination

of text and images. Recent studies have shown that comics are beneficial to children, allowing improvement in reading, writing, vocabulary comprehension, information retention, etc. [12]. Another emerging field that leverages the efficiency of comics is data comics [13], to tell stories and convey messages with data. Nevertheless, since by definition comics deliver messages through visual information, they are not accessible to people with VI. In 2017, Rayar [7] identified the few existing initiatives for printed versions and argued about the challenges and opportunities of making comics accessible for people with VI.

Over the recent years, techniques from Document Images Analysis have brought insights on the understanding and analysis of digital comics. More recently, the advent of Artificial Intelligence and Deep Learning has provided new cutting-edge methods to extract content from digital comics. These methods allow to extract comics elements such as panels, balloons, characters, text, etc. Performing the adaptation needed to make a comic accessible to people with LV is a manual, time-consuming and very tedious task. Hence, taking advantage of cutting-edge methods to automatically extract content could be a good opportunity to improve the accessibility of comics for people with LV, especially through assistive user interfaces.

In this paper, we first describe the outcome of two online surveys on the access of comics by readers with LV and how professionals attempt to provide them. Then, we describe the design and features of ALCOVE, an accessible comic reader for people with LV. Results of a user evaluation on 11 participants with LV are presented. Finally, we discuss the results that have been obtained, highlight some limitations of the current prototype and consider directions for future works.

2 RELATED WORK

2.1 Accessible digital comics

Accessibility of digital documents, such as web pages, Microsoft Word documents, PDF files, etc. is an issue that has been addressed by several studies in the past (e.g. [15]). Making accessible such complex documents that combine pictorial and textual elements presents many challenges, such as the reading mode, the order of presentation of the contents or the precision of images description. Therefore, it remains a challenging and not completely solved problem.

According to several interviews with transcribers, PDF is the most used format to provide digital comics to people with LV. For instance, in France, there is an exception to copyright in favour of people with disabilities since 2010. This exception allows non-profit organisations to freely and without prior authorization adapt and provide people with disabilities with books and comics. Hence, these organisations can have access to the original

electronic records of books and comics, that are provided by the editors, mostly in PDF format.

It is to be noted that efforts have been done to make eBooks accessible using the Epub format. Indeed, specification, guidelines and techniques are provided¹. More recently, initiatives to provide specifications in order to allow future web-published comics to be natively accessible are being conducted, notably through the W3C “*BD Comics Manga Community Group*”². However, these specifications will mainly be used for upcoming comics (e.g. such as webcomics, turbomedia, etc.) and will not provide any solutions about the accessibility of existing digital comics.

To the best of our knowledge, there is only one series of work related to digital comics accessibility in the literature. In 2009, Christophe Ponsard et al. [4][5] used screens to allow people with LV or motor-impairment to read comics. More specifically, they implemented a digital comics viewer, namely eComics, where a special attention was paid to navigation and magnification. To do so, they performed an automatic panel segmentation, followed by panels ordering. Later, an improvement has been proposed [6] to perform automatic recognition of bubble text, using an off-the-shelf OCR system. However, only a panel reading mode was proposed, and no user evaluation has been performed to assess the usability of the proposed comic viewer.

In this work, based on two surveys involving people with visual impairments and professionals of accessible documents, we designed and developed a digital comic reader accessible to people with LV. This reader encompasses past and current digital comics that do not integrate accessibility features, as well as future digital comics. Finally, we evaluated the usability of several reading modes, and assessed to what extent the pleasure of reading was restored.

2.2 Understanding digital comics

Comics have been extensively studied from a theoretical perspective (historical development of the medium, its fundamental linguistic aspects [16], its usage as an education [17] or communication tool [18], etc). In the last decades, the advent of Internet and digital content has shed light on comics as a subject of interest in the Document Analysis and Recognition research community. By considering a comic page as a digital image, early works used Pattern Recognition algorithms in order to automatically extract elements of interest [19]. These elements can be structural area of a comic page such as panel, speech balloon, onomatopoeia, characters, etc.

More recently, methods from machine learning have been used in order to perform enhanced content extraction along with other usage: sketch-based information retrieval, automatic colorization,

¹ <http://www.idpf.org/epub/a11y/>

² <https://www.w3.org/community/bdcomag/>

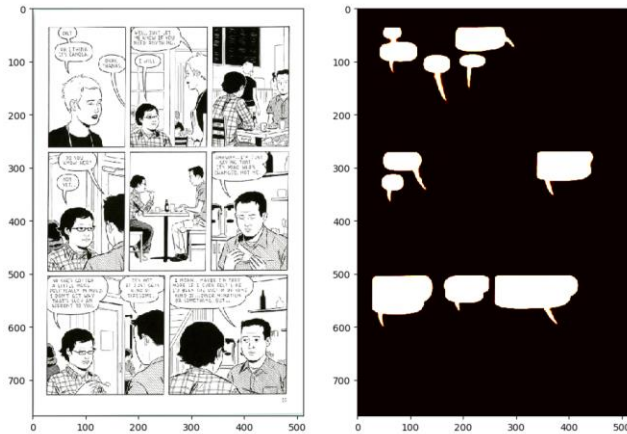


Figure 1. Deep CNN-based Speech Balloon Detection and Segmentation in a comic page. Illustration from [21].

storyline understanding, synthetic comic generation, reading behaviour study, etc. One can refer to [20] for a thorough survey of recent comic research in computer science. Such studies leverage the efficiency of current Deep Learning neural-network-based algorithms, aka. Artificial Intelligence (AI) technologies. Figure 1 illustrates an example where speech balloons are automatically extracted in a comic page with a pixel-wise precision, using a method based on a Deep Convolutional Neural Network (CNN). In 2016, Google Bubble Zoom³ presented a new way to read digital comics on phones and tablets, by exploiting the extraction of speech balloons. A one-tap-at-a-time allowed the user to expand the speech balloons, making them easier to read on small devices. Going a step further, one can use a neural-network approach to perform the extraction of multiple elements in a comic page. For instance, [22] uses an optimised multi-task learning to extract text, balloons, characters, etc. Figure 2 illustrates the network used to this end.

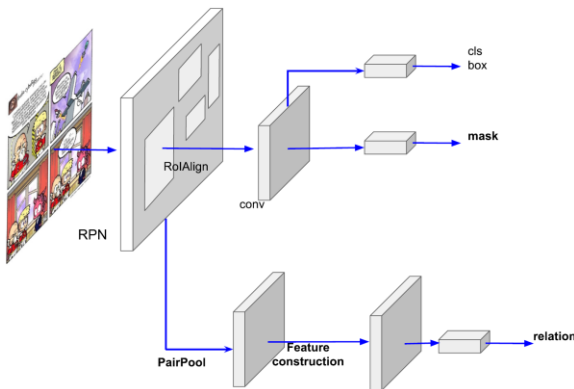


Figure 2. Multi-task learning model to extract several elements in a comic page. Illustration from [22].

This paper explores how these recent advances in comic analysis and understanding can be leveraged. More specifically, we rely on the results of such methods to propose different reading mode and enhanced functionalities, in order to improve the accessibility of digital comic books for people with LV.

3 FORMATIVE STUDY

3.1 Comics accessibility for people with VI

Prior to the design of ALCOVE, we have conducted an online questionnaire including people with VI (either blind or with LV). Three main points have been inquired: (i) on the usage of smartphone, tablets and computers, (ii) on the usage of printed and digital books and (iii) on the usage and interest of reading comics.

98 participants (55 males and 43 females) answered to the questionnaire: 62% were fully blind, 16% were people with LV that could not use their remaining vision to read and 22% were people with LV that can read with a technical aid. Among the latest category, the results show that: (i) the computer was used daily by all of them, unlike the smartphone (only 66%) and the tablets (only 42%), (ii) more than half of them read digital books (52%), and (iii) more than half of them has read at least a few comics in their life (52%) and 82% of them were interested in reading comics in the future if they were accessible.

3.2 Transcribing comics for people with VI

In parallel to the questionnaire for people with VI, we made another online questionnaire aimed at professional transcribers that are supposed to adapt books (and comics) for people with VI. 33 people answered (12 males and 21 females). More than half of them (55%) has already transcribed a comic for a people with VI, mostly for children (between 6 and 14 years old), and responding to demands from the children or their teachers. However, this supply of accessible comics for people with VI remains very low, mainly because it is a time-consuming task.

Personalised interviews with transcribers showed that the following steps are usually done to make a comic accessible to a person with LV: after retrieving the PDF file, they first perform a strip segmentation of each comic page. Then, if they have time, they manually create large speech balloons with custom background colour and text attributes (font, size, colour). Some of them also provide a description of each panel, in a separate textual document.

3.3 Design principles

According to the insights gained from both the online surveys and the interviews with the transcribers, we decided the following design principles for the accessible comic reader:

³ <https://www.blog.google/products/google-play/google-play-books-introduces-bubble-zoom/>

- It must mainly target usage on the computer. However, it would be appreciated if it works on smaller devices (smartphones and tablets) too.
- It could be used as a website, because most of the people with VI are familiar with online navigation.
- In order to include many people with different impairments, and hence a large spectrum of reading abilities, it should include several reading modes.
- Text must be customisable (font, size, colour, etc ...)

4 ALCOVE

4.1 Architecture

AI technologies currently compute the physical layout, in the sense that a comic page is divided in homogeneous areas, along with a logical layout analysis: the found regions are assigned to different semantic labels (e.g., character, text, etc.). In this work, we have enhanced the results of [22] by adding a logical layout (i.e. semantic relations between the extracted comic elements). To do so, we followed guidelines from the Digital Humanity community and used XML format for document modelling. The SVG format has been used for the physical structure description, and the Comic Book Markup Language (CBML) [28] for the logical structure description. Figure 3 illustrates an example of the SVG description obtained thanks to an AI analysis of a comic page.

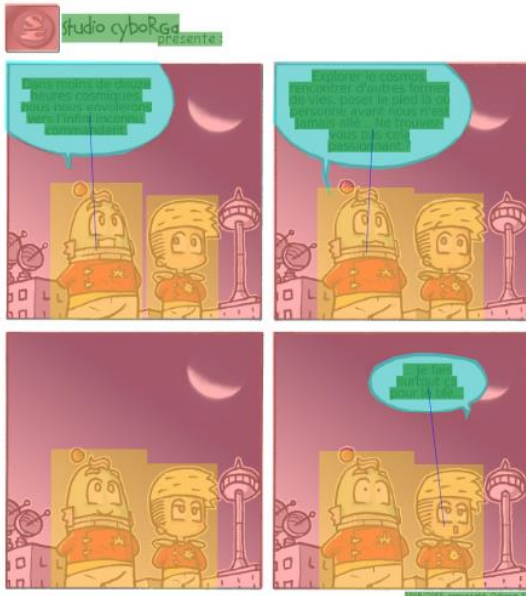


Figure 3. Sample of an SVG description of a comic page.

4.2 Web platform

Following the aforementioned principles, we designed ALCOVE, an accessible comic reader for people with LV. It is a web platform, designed to have an easy-to-learn and simple interface. In ALCOVE, several functionalities are provided to the reader, we details them below.

Reading mode. The user is provided with three main reading modes, namely Page (the whole comic page is displayed), Strip (horizontal sequence of panels) and Panel. It is possible to easily switch between the reading modes, thanks to large buttons on the left part of the interface. In each reading mode, the user can navigate either with previous/next buttons in the interface or left/right arrows of the keyboard. An audio notification is given whenever the user reaches the beginning or the end of a page.

Overview widget. When using either the Strip or the Panel reading mode, the user can display an overview widget that shows a thumbnail of the whole page, highlighting the strip/panel that is being read. The logical layout is preserved in order to allow the user to situate himself with a quick glimpse. This was motivated by observations during our interviews with transcribers, but also by the fact that it is a user concern reported in [23]: “*The people concerned would like to have better access to digital documents as well as a better overview over their structure and content*”. Figure 4 illustrates the three main reading modes, along with the overview widget.

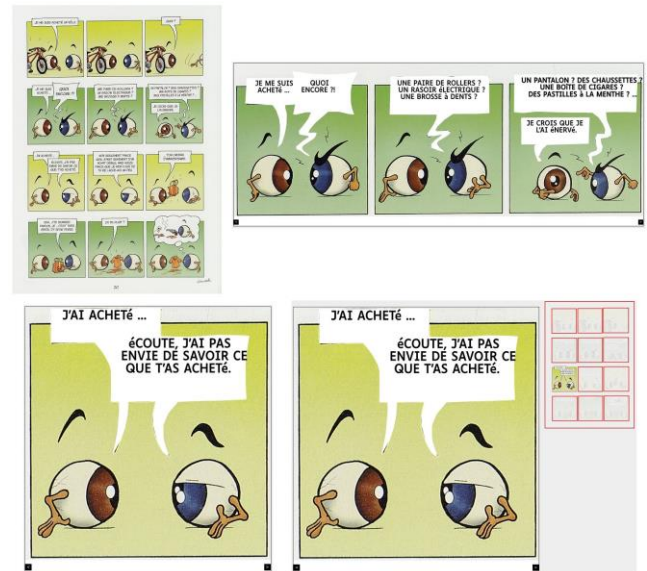


Figure 4. Reading modes. From left-top to bottom-right: Page, Strip, Panel and Hybrid. Navigation buttons are provided below to navigate. For the Hybrid mode, the overview widget is displayed on the right-top of the interface, with the current panel highlighted.

Comic element magnification. The user has the possibility to magnify several comic elements that have been extracted: panels, characters, speech balloons and text (within balloon or not). A simple click (or tap) on the element of interest triggers the magnification, and a second click/tap un-magnify the element. Sequential magnification of nested element is allowed. Finally, a reset button allows the reader to go back to the default view.

Autoplay mode. Since the sequential order of the panels is known, we have provided an autoplay mode. An animation is generated where the focus is set for each panel on the following order: first on the panel itself, on the first character, on his first speech balloon, on the second character, on his speech balloon, and so on. The pace for this automatic animation is customizable, and the user can also manually control this mode by using either buttons on the interface or left/right arrows of the keyboard.

Text to Speech. Since the textual content of the speech balloons is available, we included a Text to Speech (TTS) tool for audio augmentation of the comic. A single voice was used for all the texts, and a simple bip sound was provided to notify the end of a speech balloon.

Platform customisation. It is possible for the user to customise several features of the comic reader: the text font, size, colour, letter interspacing, the balloon colour, the autoplay delay between each animation and the TTS properties (the pitch, rate, and voice to use when the text is uttered).

5 USER EVALUATION

5.1 Research questions

We performed an evaluation to answer the three following research questions:

RQ1: Is ALCOVE a good tool to read comics for people with LV?

RQ2: Is there a preferred reading mode?

RQ3: Is the overview widget useful during the reading process?

5.2 Preliminary heuristic evaluation

Recruiting participants with VI is not an easy task and we aimed at having an application with a minimal amount of issues. To this end, we have performed a heuristic evaluation with 2 sighted persons (two males of 21 and 26 years old). They were wearing goggles that simulate a visual impairment (in this case a glaucoma and a cataract). The heuristic evaluation helped to identify usability problems in the user interface and hence to design a better version of the comic reader for the evaluation with people with LV.

5.3 Participants

We recruited 11 participants with LV: 3 females and 8 males, from three different institutes working with persons with VI. They all met the following inclusion criteria: using remaining vision and being able to read printed materials. They were aged from 15

to 52 years old, with an average age of 33 years (SD=14). Table 1 summarises the list of participants.

Table 1. List of participants

ID	Sex	Age	Pathology name	Disability
P1	male	46	Retinal detachment	severe
P2	male	28	Choroideremia	moderate
P3	male	32	Usher syndrom Type 2	moderate
P4	female	46	Congenital cataract	moderate
P5	male	52	Congenital cataract	moderate
P6	male	18	Congenital cataract	moderate
P7	male	15	Organic amblyopia	moderate
P8	male	18	Aniridia	moderate
P9	male	19	Myopia	moderate
P10	female	52	Bilateral amblyopia	severe
P11	female	32	Glaucoma	severe

5.4 Materials

The comics that have been used in the present study come from the eBDtheque data set [25]. This data set contains 100 pages from American, Japanese and French comic books. It is composed of 46 pages that were digitised from 14 albums and 54 web comics. Annotations about panels, characters, speech balloons and text lines are provided along with the comic pages in SVG format. In this experiment, we have selected a subset of 16 comic pages in French, with different dimensions (from 4 to 12 panels), and containing either handwriting or computer-generated text. Note that only short stories were used (i.e. standalone 1 page long comic).

We have conducted all the experimental sessions in the specialized institutes. The participants were sitting in front of a screen, with a mouse and keyboard. They were asked to get conformable for a reading session and could adjust the position and height of the screen. Either 22- or 24-inch screens were used during the study.

5.5 Experimental design

The study followed a within-participants design, with one independent variable: the reading mode. Four reading modes were used in the proposed comic reader: Page, Strip, Panel and Hybrid. The Hybrid reading mode consists in the Panel navigation along with the overview widget that is displayed. A control mode was also used: reading the PDF of the comic with Acrobat Reader. Existing standard tools for accessibility (e.g. the operating system's magnification lenses) were available to be used by the participants. The order of the 5 reading modes was counterbalanced across participants using a Williams design Latin square [24]. These squares allow to avoid first order carryover effects.

5.6 Procedure

The study included a single session per participant. First, participants were welcomed and a brief introduction about the

project and the evaluation was given. Then, the ALCOVE comic reader was presented. During the experiments, the TTS and the Autoplay mode were not available in order to focus the study on the usability of the reading modes. The use of Acrobat Reader was also presented (magnification and navigation, using either the mouse or the keyboard). Participants were free to read a comic page using ALCOVE during the familiarisation phase.

Second, the experiment consisted in reading 3 comic pages for each of the five modes. After the participant finished reading a page, three questions were asked about the content of the comic. These questions were either about the content of the speech balloon, the storyline, the characters or the background. Since the goal of the study was not to evaluate retrieval of information, however, participants were not allowed to see the comic while answering the questions. In total, the participants had to answer 5 (reading modes) \times 3 (comics) \times 3 (questions) = 45 questions.

Finally, the participants were asked to answer questionnaires:

- The Reading Flow Short (RFSS) [26]. It is a recent approach to assess the pleasure of reading. It consists in a 10 items questionnaire, where responses to individual statements are expressed with a 7-level Likert scale (-3 = I strongly disagree and +3 = I strongly agree). Table 2 presents the 10 items of the RFSS.
- The Abridged AttrakDiff [27] to evaluate the usability and the design of ALCOVE. For each reading mode, participants were asked to give a score between -3 and +3 for ten pairs of adjectives.
- Preferences questions: (1) “Do you prefer the ALCOVE or the PDF to read comics?” (2) “Please rank the 4 reading modes of ALCOVE by order of preference.” (3) “Have you used the overview widget in the Hybrid mode? In what situations do you think it could be useful?”
- Open-ended questions and discussion.

Table 2. RFSS items.

ID	Affirmation
Q1	I felt optimally challenged during reading.
Q2	I read this text smoothly and fluently.
Q3	I did not notice time passing during reading.
Q4	I had no problem to concentrate during reading.
Q5	My mind was totally clear during reading.
Q6	I was completely immersed in what I was reading.
Q7	Thoughts, emotions, and images emerged automatically and spontaneously, inspired by what I was reading.
Q8	I knew on every page that I was able to grasp the story.
Q9	I had the feeling that I understood everything during reading.
Q10	During reading I became so oblivious that I became completely unaware of myself.

6 RESULTS

The average duration of the evaluation was 69 minutes (SD=15), with an average reading session of 47 minutes (SD=14).

6.1 Questions about the comics content

On average the participants had 67.9% (SD=11.4) of correct answers. We observed that the lowest scores (53.3%) were corresponding to the participants that showed the lowest engagement in the reading session. Another observation is that the best score does not go over 85%. This was to be expected: some of the questions were indeed rather difficult to answer. Figure 5 illustrates two panels that were concerned by three of the questions with the lowest correct answers. On the left panel, questions were “what is Teckel Boy eating?” (difficult because two characters are eating something) and “what is the colour of Mouette Man and Teckel Boy friend’s glove?” (difficult because his name was never mentioned). On the right panel, the question was “did you see any text on the last panel?” (difficult to read the “Game Over” drawn within the background). On these questions, only 1 or 2 participants answered correctly among the 11 participants.

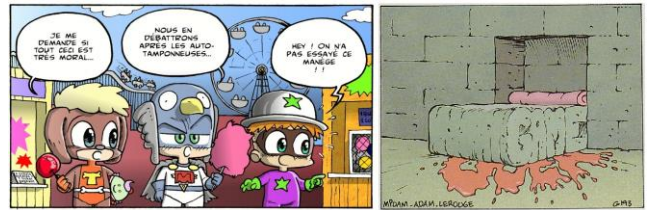


Figure 5. Examples of comic panels concerned by questions with the lowest scores.

Figure 6 illustrates the percentage of correct answers for each reading mode evaluated in the study. Panel is the reading mode that allowed our participants to achieve the best score (77.8%). The other reading modes allow an average accuracy between 64.6% and 66.6%. Hence, we cannot conclude with the current evaluation that the reading mode has an impact on the comprehension of the comics.

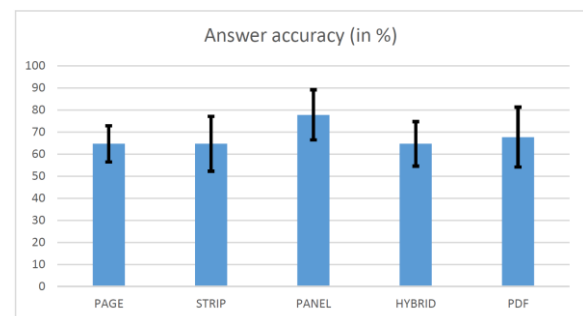


Figure 6. Percentage of correct answers per reading mode (in percentage).

6.2 RFSS

Table 3 presents the average scores obtained for the RFSS questionnaire and Figure 7 details the distribution of answers along the 7-level Likert scale.

Table 3. Average values and standard deviation obtained on the 10-items RFSS survey.

ID	M (SD)	ID	M (SD)
Q1	0.09 (2.26)	Q6	1.64 (1.86)
Q2	1.27 (1.85)	Q7	1.00 (1.73)
Q3	2.00 (1.90)	Q8	2.18 (1.47)
Q4	1.73(1.74)	Q9	1.82 (1.72)
Q5	2.18 (1.47)	Q10	0.55 (1.92)

Overall, results are positive, with an emphasis on the fact that the participants: (1) did not see time passing during the reading session, (2) had a clear mind during the session, and (3) had the feeling to grasp the story of each comic page.

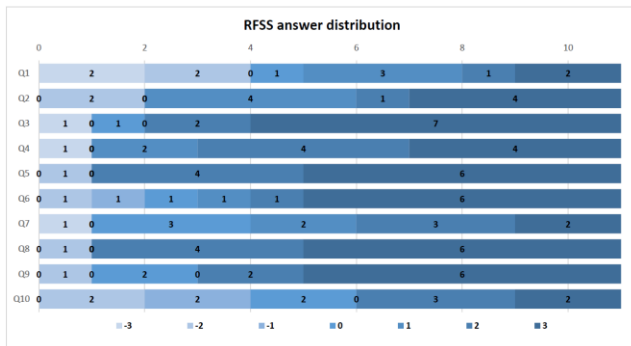


Figure 7. RFSS answer distribution. Most of the participants gave positive scores (between +1 and +3).

6.3 AttrakDiff

Figure 8 presents the average results obtained for the Abridged AttrakDiff questionnaire for each reading mode proposed in the evaluation: Page, Strip, Panel, Hybrid and PDF. We can highlight three observations:

- The 5 reading modes have been positively noted on average. Hence, we can observe that even with the “worst” layout, the possibility to read comic was worth the effort.
- The PDF is the least preferred reading mode in terms of usability and design, and is less well rated than all ALCOVE’s reading modes.
- The layout Page is the least preferred. There is no clear distinction between Hybrid, Panel and Strip.

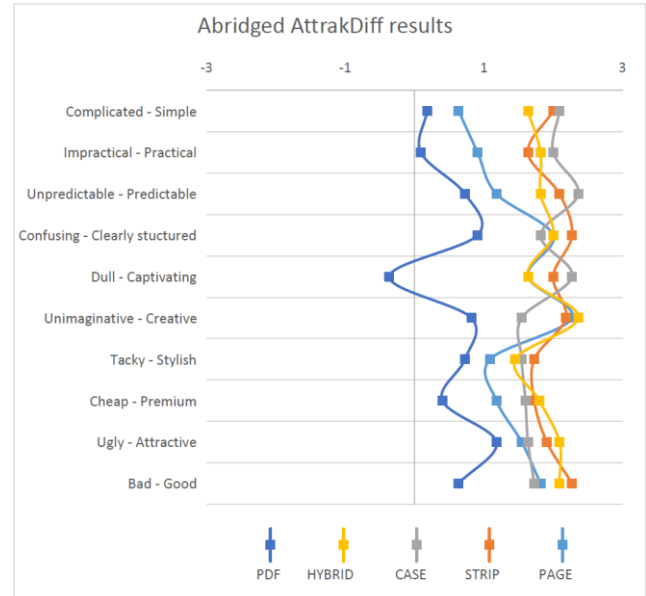


Figure 8. Abridged AttrakDiff results, for each reading mode.

6.4 Preferences questionnaire

To the question: “Do you prefer ALCOVE or the PDF to read comics?”, 10 participants out of 11 answered that they largely preferred our comic reader to read digital comics.

Figure 9 shows a visualisation of the reading mode preferential order given by the participants. For each reading mode, we have counted the occurrences it has been ranked either in the first, second, third or fourth position. The Strip reading mode appears as the best trade-off: 9 participants out of 11 ranked it either at the first or second position. Furthermore, Strip is the Condorcet winner⁴, because it wins again Page (9 vs. 2), Panel (6 vs. 5) and Hybrid (9 vs. 2).

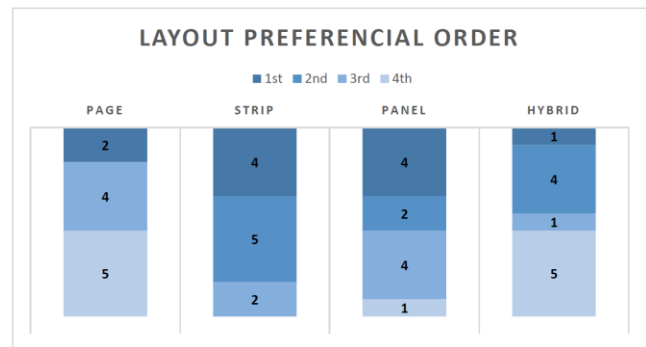


Figure 9. Reading mode preferential order.

⁴ The Condorcet method is an election method that elects the candidate that would win a majority of the vote in all of the head-to-head elections against each of the other candidates.

Finally, only 3 out of 11 participants actually used the overview widget when using the Hybrid reading mode. However, 7 out of 11, felt that it could sometimes be useful to have a glimpse on the whole page and situate ones in a large comic page.

7 DISCUSSION

7.1 Research questions

Overall, participants in this study were generally enthusiastic about ALCOVE. Most of them have clearly indicated that it is a good way to read comics with LV, answering our first research question (RQ1). For instance, one participant stated that *“the interface is very clear and easy to use”*, while another said that *“it is easy to get used to it”* about the navigation within the comic page. In contrast, several complaints were expressed regarding the PDF reading mode, such as: *“it takes too much to read, zoom and move”* within the comic, or more generally: *“PDF are not fun for us!”*.

As mentioned previously, Strip is the preferred reading mode, answering the second research question (RQ2). Reasons to explain the advantages of Strip are diverse. First, it can fill in the whole screen, and there is no spared space. Second, it allows to parse and read a comic page faster. Third, it preserves a sense of continuity during reading of the comic, instead of reading isolated panels. Last, it allowed the reader going back to check for a detail or take a quick look forward. Nevertheless, it is to be noted that the Page and Panel were ranked first by 2 and 4 participants respectively. Therefore, the possibility to easily switch between reading modes seems relevant in an accessible comic reader for people with LV.

Regarding the last research question (RQ3), we obtained mixed results. The overview widget has not been used much, although it was perceived as useful *“for others having a more severe visual impairment”* as one participant said. Hence, we suggest that this overview could be provided on demand, according to the complexity of the comic page layout and the user needs.

7.2 Lessons learnt

This study has brought to light a number of interesting findings:

Navigation vs. Exploration. Taking advantages of AI-based extraction of semantic element in comics seems relevant to enhance the accessibility of comics to people with LV. However, the magnification functionalities should not be completely tied to these elements. Hence, we argue that the logical structure (strips, panels, speech balloons) should be used to enhance the navigation during the reading session, while the possibility to explore each panel must be unconstrained. By unconstrained, we mean not only to allow the reader to magnify extracted comic element, but also zoom on any details of a given panel he wants to have a look at,

using for instance a drag interaction with the mouse or using the arrows keys.

Text with Images. By definition, comics takes advantage of the combination of text and images to convey messages or tell stories. We observed that by default, most of the participants were focusing their attention in the textual content of the panels (mostly the speech balloons), behaviour that can limit the pleasure of reading comics. One of the participants explicitly said that *“It is difficult to read comics, because we have to read the text, then watch the picture, then navigate within the panel or the comic page”*. Hence, we suggest that comics with no or a little amount of text must also be provided, to make them familiar with a reading behaviour of comics that can allow them to enjoy both the textual along with the surrounding drawings. In parallel, description of panels, at different level of precision, could also be provided to help the reader enjoy the drawing.

Pleasure to read. Comics are a powerful tool to convey messages that can be used in education, learning or other fields. Indeed, despite the cognitive load, most participants in this study were enthusiastic and engaged in the reading sessions, enjoying the comics and laughing at the jokes. One of the participant said: *“I wish it existed when I was little!”*. Another important remark is about the content: on the one hand, most participant had knowledge of old French-Belgian comics that they read and wish to read again. On the other hand, the youngest participants try to read recent Japanese manga. In both cases, the possibility to have access to various content using the proposed comic reader has been expressed by almost all the participants.

7.3 Limitations

There are a few limitations with our study, that must be addressed in the follow-up of this work. First, in the current implementation of ALCOVE, a TTS and an Autoplay mode were available (see Section 4.2), but were neither introduced to the participants, nor evaluated. It would be relevant to see in what extent such aids could help the reading task for people with LV. Second, the selected apparatus consisted in a classic computer, with a screen, a mouse and a keyboard. We argue that the possibility to read comics on tablets (or smartphones) could increase reading of comics by people with LV. Indeed, this will bring more flexibility when one wants to read a comic. Since ALCOVE is implemented with web-technologies, it is natively usable with tablets. Hence evaluating this aspect would be interesting. Third, in this study, only a few standalone 1-page long comics have been used. It would be relevant to evaluate the usage of ALCOVE during the reading of multipage comic stories, in several sessions. Finally, at this stage, we only performed an evaluation with 11 persons with LV. It would be interesting to use an open call for volunteers, to collect feedback from an evaluation performed directly online on Internet.

7.4 Generalisability

This work focused exclusively on people with LV that use remaining vision to read. As such, we cannot generalise the findings of this study to other groups of people. However, the design principles and functionalities of ALCOVE are not limited to a specific audience. Hence, we think that our comic reader could also be used by everyone (new reading behaviour, multi-lingual comics for language learner, etc.), including blind people (using the TTS and descriptions of the panels), people with motor impairments (using single interactions to navigate in the comic page/book), or people known as "prevented", i.e. meeting for various reasons great difficulties to read (using functionalities like read-aloud with words highlighting).

8 CONCLUSION

In this paper, we have presented ALCOVE, a web-based accessible comic reader for people with LV, that leverage AI-based extraction of comic elements. The design principles and functionalities of ALCOVE are motivated by the outcomes of a formative study with people with VI and transcribers that attempt to provide them accessible comics in a sporadic fashion. We evaluated the proposed comic reader with 11 participants with LV, showing that ALCOVE allows users to enjoy reading comics, by consulting both textual and visual content.

Directions of future work include improving the current version of the comic reader with enhanced functionalities. For further evaluation, we would have an open call for volunteers through an online evaluation, while making AI technologies converge with HCI, by providing more content.

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REFERENCES

- [1] R. A. Bourne, S. R. Flaxman, T. Braithwaite, M. V. Cicinelli, A. Das, J. B. Jonas, J. Keeffe, J. H. Kempner, J. Leasher, H. Limburg, K. Naidoo, K. Pesudovs, S. Resnikoff, A. Silvestre, G. Retchen A. Stevens, N. Tahhan, T. Y. Wong and H. R. Taylor and on behalf of the Vision Loss Expert Group. 2017. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. In *Lancet Glob Health* 5 (2017), e888–e897.
- [2] World Health Organization. 2017. Prevention of Blindness and Visual Impairment. <http://www.who.int/blindness/en/>.
- [3] D. Pascolini and S. P. Mariotti. 2012. Global estimates of visual impairment: 2010. In *British Journal of Ophthalmology* 96, 5, 614–618.
- [4] C. Ponsard. 2009. Enhancing the Accessibility for All of Digital Comic Books. In *e-Minds* 1, 5.
- [5] C. Ponsard and V. Fries. 2008. An Accessible Viewer for Digital Comic Books. In 11th International Conference on Computers Helping People with Special Needs. 569–577.
- [6] C. Ponsard, R. Ramdoyal, and D. Dziamski. 2012. An OCR-Enabled Digital Comic Books Viewer. In 13th International Conference on Computers Helping People with Special Needs. 471–478.
- [7] F. Rayar. 2017. Accessible Comics for Visually Impaired People: Challenges and Opportunities. In *IAPR International Conference on Document Analysis and Recognition*, Vol. 03. 9–14.
- [8] D. B. Elliott, M. Trukolo-Ilic, J.G. Strong, R. Pace, A. Plotkin and F. Bevers. 1997. Demographic characteristics of the vision-disabled elderly. In *Invest Ophthalmol Vis Sci.* 38(12). 2566–75.
- [9] American Council of the Blind. 2011. Best Practices and Guidelines for Large Print Documents Used by the Low Vision Community. (<http://www.acb.org/large-print-guidelines>)
- [10] G. E. Legge. 2016. Reading Digital with Low Vision. In *Visible language* vol. 50,2: 102–125.
- [11] C. Granquist, Y.H. Wu, R. Gage, M.D. Crossland and G.E. Legge. 2018. How People with Low Vision Achieve Magnification in Digital Reading. *Optometry and vision science: official publication of the American Academy of Optometry*, 95(9), 711–719.
- [12] M. Jaffe. 2014. Raising a Reader! 2014 Comic Book Legal Defense Fund.
- [13] B. Bach, N. H. Riche, S. Carpendale and H. Pfister, The Emerging Genre of Data Comics. 2017. In *IEEE Computer Graphics and Applications*, vol. 37, no. 3, pp. 6–13.
- [14] N-V. Nguyen, C. Rigaud and J-C Burie. 2019. Comic MTL: optimized multi-task learning for comic book image analysis. In *International Journal on Document Analysis and Recognition (IJDAR)*, Volume 22, Issue 3, pp 265–284.
- [15] Y. B. Issa, M. Mojahid, B. Oriola and N. Vigouroux, Accessibility for the blind: An automated audio/tactile description of pictures in digital documents. 2009 In *International Conference on Advances in Computational Tools for Engineering Applications*, pp. 591–594.
- [16] Scott McCloud. 1993. Understanding Comics: The Invisible Art
- [17] W. W. D. Sones. 1944. The Comics and Instructional Method. In the *Journal of Educational Sociology*, vol. 18, no. 4, pp. 232–240.
- [18] M. Spiegelman, C. Terwilliger and F. 1952. The Content of Comic Strips: A Study of a Mass Medium of Communication, *The Journal of Social Psychology*, 35:1, 37–57.
- [19] C. Rigaud, J-C. Burie. 2018. Computer Vision Applied to Comic Book Images. In *Empirical Comics Research. Digital, Multimodal, and Cognitive Methods*. Edited by A. Dunst, J. Laubrock and J. Wildfeuer.
- [20] O. Augereau, M. Iwata and K. Kise. 2018. A Survey of Comics Research in Computer Science. In *Journal of Imaging*, 4(7), 87.
- [21] D. Dubray, J. Laubrock. 2019. Deep CNN-based Speech Balloon Detection and Segmentation for Comic Books. *arXiv preprint. arXiv:1902.08137*
- [22] N-V. Nguyen, C. Rigaud and JC Burie 2019.. Comic MTL: optimized multi-task learning for comic book image analysis. In *International Journal of Document Analysis and Recognition*. 22: 265–284.
- [23] M. Dorigo, B. Harriehausen-Mühlbauer, I. Stengel and P.S. Dowland. 2011 Survey: Improving Document Accessibility from the Blind and Visually Impaired User's Point of View. In *Universal Access in Human-Computer Interaction. Applications and Services*. vol 6768.
- [24] E.J. Williams. 1949. Experimental designs balanced for the estimation of residual effects of treatments. In *Australian Journal of Scientific Research, Ser. A* 2, 149–168.
- [25] C. Guérin, C. Rigaud, A. Mercier, F. Ammar-Boudjelal, K. Bertet, A. Bouju JC. Burie, G. Louis, J.M. Ogier and A. Revel. 2013. Ebdtheque: a representative database of comics. In *International Conference on Document Analysis and Recognition*. pp. 1145–1149.
- [26] B.A.K. Thissen, W. Menninghaus and W. Schlotz. 2018. Measuring Optimal Reading Experiences: The Reading Flow Short Scale. *Front. Psychol.* 9:2542
- [27] M. Hassenzahl, M. Burmester and F. Koller. 2003. AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität. In: Ziegler, J., Szwillus, G. (eds.) *Mensch & Computer 2003. Interaktion in Bewegung*, pp. 187–196. B.G. Teubner, Stuttgart.
- [28] J. A. Walsh. 2012. Introduction and rationale for the development of Comic Book Markup Language. In *Digital Humanities Quarterly*. Volume 6 Number 1.