Language and Cognition (2025), 17, e87, 1–27
doi:10.1017/langcog.2025.10042

ARTICLE

Visual support in easy language: The impact of images on comprehension, perceived difficulty and eye movements

Mariona González-Sordé[1], Olga Soler-Vilageliu[2], Krzysztof Krejtz[3] and Izabela Krejtz[3]

[1]Department of Translation, Interpreting and East Asian Studies, Autonomous University of Barcelona, Barcelona, Spain; [2]Department of Basic, Developmental and Educational Psychology, Autonomous University of Barcelona, Barcelona, Spain and [3]Faculty of Psychology, SWPS University, Warsaw, Poland
Corresponding author: Mariona González-Sordé; Email: mariona.gonzalezs@autonoma.cat

(Received 01 April 2024; Revised 16 October 2025; Accepted 28 October 2025)

Abstract
Easy Language (EL) presents information in a simplified way and benefits people who have difficulty understanding standard language. The present study evaluates the effects of visual support inclusion, as it is a recurring recommendation in EL guidelines. We examined 52 adults (23 men and 29 women; mean age of 39.9; 26 with intellectual disabilities [ID], 26 neurotypical) in a mixed design study. They read EL texts that presented either no visual support, photographs or illustrations. Their eye movements were recorded, and they answered comprehension, text difficulty and style preference questions. The inclusion of visual support had no effect on comprehension, nor did the type of visual support (photographs/illustrations). The group (ID/neurotypical) and the type of visual support also showed no effects on the perceived difficulty of the text. Neurotypical participants showed a preference for illustrations. Photographs may be more difficult to interpret than illustrations due to longer fixations and shorter saccades in both groups. The group with an ID showed more and longer fixations, especially on text and whitespace, while the neurotypical group tended to explore the image more. Results prompt a discussion on the potential improvements of EL guidelines and highlight the need for similar empirical studies in the area.

Keywords: comprehension; Easy Language; eye tracking; intellectual disability; visual support

1. Introduction

Working toward accessible communication means aiming for information to be available to everyone in a way that it is 'accurate, clear, direct, precise and easy to understand' (Perego, 2020, 21). Everyone can benefit from making standard communication more accessible. In that regard, one could opt to use Plain Language

© The Author(s), 2025. Published by Cambridge University Press. This is an Open Access article, distributed under the terms of the Creative Commons Attribution-ShareAlike licence (http://creativecommons.org/licenses/by-sa/4.0), which permits re-use, distribution, and reproduction in any medium, provided the same Creative Commons licence is used to distribute the re-used or adapted article and the original article is properly cited.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

(less-simplified variant of easy-to-understand languages) or Easy Language (more-simplified) (Matamala, 2022) to convey information in a clearer way.

Easy Language (EL) is a 'language variety in which a set of recommendations regarding wording, structure, design and evaluation are applied to make information accessible to people with reading comprehension difficulties for any reason' as stated in the ISO standard dedicated to it (ISO, 2023, 2). If the standardized recommendations are followed and applied, the resulting EL text should deviate from standard use with linguistic elements related to content, vocabulary and structure (Bernabé, 2020; Lindholm & Vanhatalo, 2021; Nomura et al., 2010) and with graphic elements, such as visual support, design or layout (Nomura et al., 2010).

The present study, as outlined in Section 2, investigates the effects of incorporating visual support in texts, in line with what is recommended in Easy Language guidelines. First, the theoretical foundations and previous research on which this study builds will be reviewed (Sections 1.1–1.3). We then provide a detailed explanation of the study itself, including its objectives (Section 2) and methodology (Section 3). The findings are presented in Section 4, followed by a discussion in Section 5. Finally, the paper concludes with a summary of the main results and a reflection on its limitations.

1.1. The use of images with text

1.1.1. The multimedia principle

Cognitive psychology has shown that mental imagery, concreteness and verbal association play an important role in supporting learning across different domains (Clark & Paivio, 1991). Building on that foundation, Cognitive Load Theory (CLT) (Sweller et al., 1998) argues that working memory has a limited capacity and operates through partially independent systems for processing verbal/auditory information and visual/spatial material, whereas long-term memory is essentially unlimited and stores structured knowledge that can become increasingly automated.

Mayer's Cognitive Theory of Multimedia Learning (CTML) (2014) integrates these perspectives, proposing that learners gain more from words and pictures presented together than from words alone. CTML is based on three assumptions: (1) visual and auditory information are processed through separate channels (drawing on dual-coding theory), (2) each channel has limited capacity (consistent with CLT) and (3) learning is an active process of selecting, organizing and integrating new information with prior knowledge. The theory also outlines twelve design principles, including the multimedia principle itself, which emphasizes the use of both verbal (text or narration) and visual (images, animations or video) representations to promote deeper understanding by engaging multiple processing channels.

Based on this theory, empirical research has demonstrated that combining text with images generally leads to more effective learning than relying on text alone or pictures alone, a phenomenon often referred to as the multimedia principle (Anglin et al., 2004; Butcher, 2014; Mayer, 2014). However, not all images are equally beneficial. Research shows that while relevant visuals can significantly enhance comprehension, decorative or tangential images may have little effect or even hinder learning. For instance, Sung and Mayer (2012) found that graphics often increased learners' enjoyment of online lessons but did not consistently improve understanding, highlighting the potentially seductive effect of irrelevant visuals. Similar findings

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

are reported in Levie and Lentz (1982), Guo et al. (2020) and Beymer et al. (2007). A more detailed discussion of empirical studies in this area will be presented in Section 1.2.

1.1.2. Visual support in Easy Language texts

Visual support is mentioned in some way and has a prominent position in all 23 reviewed Easy Language guidelines in González-Sordé and Matamala (2023). Photographs, illustrations and symbols may accompany text 'so that if a reader encounters an unknown word, the visual representation can be used to bootstrap understanding of the text, allowing the reader to obtain the intended meaning' (Rivero-Contreras et al., 2023, 2). Nevertheless, while EL guidelines widely promote the use of images, there is not a unanimous guidance on how to put this into practice. In fact, recommendations from different guidelines can be contradictory. For example, guidelines by The Department of Health in the UK (2010) state that images should be placed on the left of the text, while the Social Care Institute for Excellence's Accessibility Guidelines (2005) defend that they should appear on the right. Since both were published in the UK, differences cannot be linked to cultural preferences.

It is also unclear which type of visual support is best to use. For example, in García-Muñoz (2012, 74), it is advised to 'explore if the public prefers drawings [or] photography […] and keep the same style in all the text' Nevertheless, these guidelines do not explain how to determine what the public prefers. On this, Sutherland and Isherwood (2016, 308) determined that 'aside from the simplified written text, it is not clear from the current paucity of experimental research whether other aspects of [EL] such as symbols, pictures (line drawings), or photographs necessarily enhance understanding […]. Overall, there is little supporting evidence in the literature for the recommendations contained in many [EL] design guidelines'.

Although literature reviews show that there has been a rise of empirical studies on EL (Chinn & Homeyard, 2017, 1190; González-Sordé & Matamala, 2023; Lindholm & Vanhatalo, 2021, 15; Rivero-Contreras & Saldaña, 2020; Sutherland & Isherwood, 2016, 297–298), it is observably necessary to foster research that evaluates the effectiveness of certain aspects of this language variety. In the following section, we will explore some findings that the present study premises on.

1.2. Research background

Studies collected through the review of recent literature in the area will be presented according to their results: (1) the inclusion of visual support showed positive effects, (2) negative effects or no effects.

Rivero-Contreras et al. (2021, 2023) showed that visual support facilitated sentence processing for adults with and without dyslexia (2021) and with different levels of education (2023). In Schatz et al. (2017), neurotypical participants performed better when the EL version was accompanied by simple illustrations than when it was not. Jones et al. (2007) found that comprehension scores of participants with mild or borderline learning disabilities were significantly higher for the symbolized texts than the non-symbolized ones. Hibbing and Rankin-Erikson (2003) found that the addition of illustrations to text could enhance struggling middle-school readers' comprehension. Levie and Lentz (1982) reviewed 55 experimental studies and found that meaningful, well-integrated visuals consistently improve comprehension and

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

recall compared to text found alone, and that they are especially beneficial to poorer readers. When it comes to studies on people with intellectual disabilities (ID), Wadihah and Fauzi (2021) found that the use of images accompanying text improved reading comprehension for intellectually disabled students. Buell (2017) tested adults with an ID and found evidence to demonstrate that images decreased cognitive effort.

Hurtado et al. (2014) and Saletta et al. (2019), on the other hand, found negative and uncertain effects of visual support when it comes to reading comprehension. Saletta et al. (2019) found that adding images in EL texts did not improve reading comprehension for young adults with intellectual or developmental disabilities. They tested three types of images (photographs, line drawings and control images), all with the same outcome. And Hurtado et al. (2014) demonstrated that under certain conditions, photographs can even increase cognitive effort for readers with an ID. Additionally, this last study found no significant differences in comprehension (which was assessed through a questionnaire) between participants when showed a 'picture only' and when showed an EL text with a picture.

Likewise, Dye et al. (2004) observed that the inclusion of photographs in the questionnaire did not affect the ability of adults with learning disabilities to complete it. Yaneva et al. (2016) also found no effects in comprehension after showing neurotypical adults and participants with autism EL texts both with and without pictures (photographs and icons). Finally, Poncelas and Murphy (2007) declare that the participants with an ID did not understand any of the versions (text-based and symbol-based) of the simplified manifesto they showed them.

All said, extensive research confirms that adding relevant visuals to text improves learning (Sung & Mayer, 2012) and comprehension (Beymer et al., 2007; Guo et al., 2020; Levie & Lentz, 1982), whereas decorative images provide little benefit and can even distract readers (Guo et al., 2020; Levie & Lentz, 1982).

As shown, there are not enough studies performed in the area to be able to have conclusive findings regarding what type of images to use, or whether visual support should be considered an essential feature of Easy Language. As stated in Hurtado et al., 'the generalised use of text and picture formats for all people with an ID in spite of the scant evidence supporting its effectiveness is concerning' (Hurtado et al., 2014, 822). The use of eye tracking in EL research is growing (Borghardt et al., 2021; Deilen & Schiffl, 2020), but it has still not been used to its full potential.

1.3. Monitoring eye movements

Eye tracking measures eye position, eye movement and pupil size to detect zones in which the user has a particular interest at a specific time (González-Sánchez et al., 2017). One of the basic output measures of interest is fixations, which are eye movements that stabilize the retina over a stationary object of interest and indicate that the participant focused their attention on it (Duchowski, 2007, 46). For instance, when looking at text, the fixation position indicates which part of the sentence is currently being processed to a certain extent (Borghardt et al., 2021). In that regard, eye movements have been shown to be directly influenced by textual variables (e.g., 'increased linguistic complexity leads to increased fixation duration and decreased saccade length' [Borghardt et al., 2021, 4]) and provide information on different cognitive processes (e.g., Rayner, 1998; White et al., 2022) (see Section 3.5). Nevertheless, eye movements alone do not provide the complete picture of text processing

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

and reading comprehension that we aim to build (Boland, 2004). For that reason, it is advised to combine eye-tracking data with other data (Van Gog et al., 2005), as has been done in the present study with comprehension, perceived difficulty and preference questions.

For years, researchers have been using eye tracking to explore the processing of information in text and images or the integration of information in both elements, with a recurrent focus on education and learning. For example, Hannus and Hyönä (1999) determined that children (10-year-olds of high and low intellectual ability) inspected the illustrations in science textbooks minimally and that learning was mainly driven by the text. Zhao et al. (2014) later found that, although text (rather than a picture) is more likely used to construct mental models in initial coherence-formation processing of text and picture, secondary students seemed to also rely on the picture to answer the question after having had a first contact with the material. Additionally, Krejtz et al. (2016) showed that interactive elements are optimal to spur reading, leading to a more complete visual inspection of the material, rather than static illustrations.

Eye tracking has also already been used to study EL (Rivero-Contreras et al., 2023; Rivero-Contreras et al., 2021; Denzen et al., 2012; Yaneva et al., 2016), as the tracking of eye movements is a non-invasive method to assess online cognitive skills and processes involved in reading (Mézière et al., 2023; Rayner et al., 2006; Rayner et al., 2011). The German research group 'Simply complex – Easy Language' stands out in the use of this technology in EL research (Deilen, 2020; Schiffl, 2020). The findings of Rivero-Contreras et al. (2021) and Yaneva et al. (2016), which examine visual support through eye-tracking methods, have already been discussed in Section 1.2.

It is important to bear in mind that opting for this technology for a study on EL can also present some challenges. Participants with an ID are among the primary users of EL and require researchers to carefully consider necessary adaptations in the experiment's design and implementation, as well as the associated ethical constraints (Borghardt et al., 2021; Csákvári & Gyori, 2015; Deilen & Schiffl, 2020). Listed below are some challenges researchers may face when performing eye-tracking tests on users with an ID, compiled by Deilen and Schiffl (2020); with comments from the authors on how these were acknowledged or resolved in the present study:

(1) Participants with an ID may not be able to communicate their desires or comprehend given information as easily as neurotypical participants (Csakvari and Gyori, 2015; Deilen & Schiffl, 2020). For this reason, we provided all written information in EL (including all data collection information and consents) and frequently asked the participant if they wanted to carry on with the test or if they had any doubts.
(2) Participants with an ID may find it hard to limit their movement throughout the experiment due to memory or executive control deficits (Deilen & Schiffl, 2020). In our study, we identified that the participants with an ID often turned their heads when the researcher started talking. For this reason, we had to frequently remind them to stay still and later review the gaze plots[1] in search

[1]Gaze plots are a way of reviewing the participant's eye movements after the recording has stopped. Gaze plots show the location, order and time spent looking at locations on the stimulus, which in our study was a page including text and an image or text only.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

of any issues that might invalidate the recording of eye movements. This led to the rejection of 2 recordings.

(3) Participants with an ID are more prone to present problems of vision or wear thick glasses that interfere with an optimal calibration[2] process (Warburg, 2001; Csakvari and Gyori, 2015), an issue that still has no general solution (Deilen & Schiffl, 2020). In our study, we identified that 2 participants with an ID wore thick glasses that deformed their eyes, and another user with an ID squinted their eyes while reading. For this reason, we asked participants if they had any problems of vision we should acknowledge at the beginning of the test (3 users with an ID said they did), and we searched for any issues in the gaze plots once the test was finished. This issue led to the rejection of 2 additional recordings.

2. Aims of the study

As argued in the previous section, the limited research on the impact of visual support on EL comprehension does not help determine whether visual support is beneficial for a user facing reading or comprehension barriers. In fact, many of the reviewed studies showed no beneficial effects of visual support for the reader (e.g., Dye et al., 2004; Poncelas & Murphy, 2007; Yaneva et al., 2016), as did two studies that resembled the present one in terms of aims and method (Hurtado et al., 2014; Saletta et al., 2019).

The contribution of the present paper is threefold. First, we examine how the type of visual support used (illustrations, photographs, or no image) affects content comprehension, perceived difficulty and preference. Second, we monitor the reading behavior with the means of eye tracking. Finally, we study the effects of visual support in EL comprehension both on a group of people with ID and on a group of neurotypical participants. Our hypotheses areas follows :

H1. *Visual support of any type has significant effects on text comprehension for readers with intellectual disabilities.* Easy Language guidelines (García-Muñoz, 2012; ISO, 2023; Nomura et al., 2010; UNE, 2018) suggest that appropriate visual support facilitates text comprehension. As per previous research (Section 1.2), a significant difference is expected for individuals with ID (Buell, 2017; Wadihah & Fauzi, 2021).

H2. *People with and without intellectual disabilities explore the page differently.* Authors expect the group with an ID to make more and longer fixations; thus, also a longer fixation time. This group is also expected to perform shorter saccades (see Section 3.5 for a discussion on eye-tracking metrics and how they can reveal how readers engage with and process textual information).

Finally, a part of our study is exploratory due to the lack of previous consistent findings. For this reason, we also formulate two open research questions:

Q1. *How does the presence and type of visual support influence perceived level of text difficulty?*

[2]Calibration is the process by which the characteristics of a participant's eyes are estimated as the basis for a fully customised and accurate calculation of the gaze points (where the participant is looking). The participant is presented with targets, and the tracker collects data about the participant's eyes and their gaze to that target.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Q2. *How does the presence and type of visual support influence the way readers explore the page?*

3. Method

We designed an eye-tracking study combined with three questionnaires on comprehension, perceived difficulty and preference of visual support. This is a mixed design study which presents an independent variable with 3 levels: (1) no visual support, (2) illustration and (3) photograph; and the two groups of participants (ID/neurotypical) as the between-subjects factor.

Previous to the study, we performed a pilot test with 6 participants (medium age of 28.5; 5 women and 1 man). These participants had no cognitive disabilities or reading difficulties and followed the full procedure of the test. This experience allowed the researchers to perform slight changes to the design based on their observations and the analysis of the results. We will now expose in detail the final test design and method.

3.1. Participants

Initially, we aimed for a total of 60 participants, 30 in each group, but some of the users with an ID had to be discarded due to eye-tracking calibration or data collection problems (see Section 1.3). The final sample includes 52 participants (23 men and 29 women; mean age of 39.9 [SD = 14.5]). 26 of them had ID, and 26 did not. Participants with an ID (12 men and 14 women; mean age of 44.4 [SD = 13.2]) were recruited by contacting two local non-profit organizations that work on watching over the quality of life and giving jobs to people with intellectual or developmental disabilities (Som – Fundació, Taller Jeroni de Moragas). Neurotypical participants (11 men and 15 women; mean age of 34.8 [SD = 11.5]) were recruited through word-of-mouth promotion. In all cases, participation was strictly voluntary, and no participant was reimbursed.

All participants were native speakers of Catalan with normal or corrected vision (the recordings of 2 out of the 3 participants who declared having eye problems had to be discarded). Participants were not asked to provide a formal diagnosis of ID. Since having an ID was already a requirement to receive support from the collaborating foundations, this was considered sufficient to meet the diagnostic criterion. To ensure consistency within the group, two screening tests were administered, confirming that none of the participants showed intelligence levels or reading comprehension skills that differed significantly from the rest. Refer to Section 4.1 for the participants' results on the screening tests on (1) reading comprehension and (2) intelligence and abstract reasoning.

3.2. Materials

3.2.1. Evaluation instruments

We used two **screening tests**, one that assessed reading comprehension (*Test de lectura comprensiva* [TLC]) (Comes, 1990) and one that evaluated intelligence and abstract reasoning (Raven's Progressive Matrices [RPM]) (Raven, 1998), to collect data on these aspects for each participant and group. TLC has been proven to be a

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

fully valid initial assessment of text comprehension skills in readers with varying proficiency levels (Baez-Naghelli et al., 2015; Del Cueto et al., 2019; Ferreres et al., 2009). Similarly, RPM has demonstrated strong validity and reliability and is widely regarded as an appropriate measure of nonverbal and general intelligence (Kazem et al., 2007; Queiroz-Garcia et al., 2021).

Screening tests were conducted prior to the eye-tracking assessment and took approximately one hour per participant. The TLC and RPM tests were administered in group sessions, where participants completed the assessments individually and autonomously, all within the same room. Responses were recorded on paper, and participants could request assistance from the researcher if needed. In contrast, questions assessing comprehension, perceived difficulty and preference were administered on a separate day during individual one-on-one sessions with the researcher, held in the eye-tracker room. During these sessions, participants provided their responses orally.

All **comprehension questions** were of a similar low difficulty and asked on explicit information in the text (Fajardo et al., 2014) and on elements that appeared or were related to the image. See an example:

Què envolta el poble de Rupit?
A) Un pantà. B) Una riera. C) Salts d'aigua.

What is the town of Rupit surrounded by?
A) A swamp. B) A stream. C) Waterfalls.

Perceived difficulty was assessed through a Likert scale (Yaneva et al., 2016) after each page, which presented options from 1 to 4 to avoid a neutral answer. This measure reflects the subjective impressions of the participants on text difficulty.

Has trobat aquest text difícil de llegir?

1	2	3	4
Gens, ha estat fàcil.	*No gaire.*	*M'ha costat una mica.*	*M'ha costat molt.*

Did you find the text difficult to read?

1) Not at all, it was easy.	2) Not very.	3) It was a little difficult.	4) It was very difficult.

Finally, at the end of the experiment, participants were asked an open question on their **preference** in terms of visual support ('would you rather read plain text, a text with a photograph or a text with an illustration?').

3.2.2. Stimuli

Stimuli shown in the experiment were based on an EL brochure-style publication on tourist attractions of the Catalan towns of Rupit and Pruit (Vidal, 2021). The texts were in EL, included no low-frequency words and had low text complexity. Researchers chose this brochure due to its adequacy for the purpose of the test: images in it share the same representative function (Carney & Levin, 2002), which facilitated the task of formulating adequate and homogeneous comprehension questions. The content in the original brochure was complemented with other

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

information about the described locations from different tourist guides, and it was slightly adapted so all the pages shown (6 in total) (1) had the same layout, (2) had about the same length (between 65 and 70 words) and (3) presented a similar number of ideas. The Fernández Huerta readability index[3] for all 6 texts was between 90.12 and 102.70, in which results over 90 are labelled as 'very easy' for adult readers. Sentences were presented in black 14-point Arial font on a white background, and paragraphs were double-spaced.

Each of the 6 texts had 3 different presentations, corresponding to the 3 levels of the independent variable: no visual support, photograph and illustration. All participants read the same six texts in the same order, but with different conditions regarding visual support. This was achieved through a Latin square array. For the sake of minimizing the possible influence of extraneous factors, a set of stimuli was arbitrarily assigned to each participant with only one criterion: making sure that in the end, the same number of participants would have read through each set of stimuli.

When it comes to images, stimuli presented (1) the original photographs used in the brochure and (2) illustration-style copies of them, created with digital illustration tools. All images were representational (Carney & Levin, 2002) and relevant to the content in the text. Pages had a size of 1230 × 819. On the pages with visual support, a 520 × 390 (4:3) image appeared in the top left corner, as this is their usual placement in Spanish and Catalan EL texts (Plena Inclusión, 2021). Photographs and illustrations were in color and of high resolution. The right half of the page showed the text, which, as stated before, was always between 65 and 70 words in length and was presented in 10 lines. On pages where no visual support was provided, the text was centered on the screen. See Table 1 for an example.

It is important to consider that a group of people belonging to the EL target group validated both the original text and the supporting images and considered them adequate for an EL adaptation before publication. Validation with the target group is strongly recommended to publish under the 'Easy Language' category. At Plena Inclusión, an advocacy movement that fights for the rights of people with intellectual and developmental disabilities in Spain, they validate images by asking the participants 'what do you see in the image?' and 'how does the image relate to the text?'. If an issue arises, they ask the follow-up questions 'how should the image be to explain this topic well?' and 'what do we do to ensure the image is properly related to the text?' (Plena Inclusión, 2021).

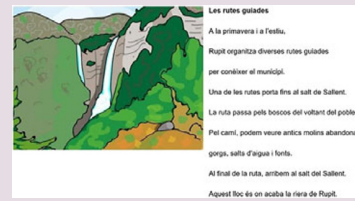
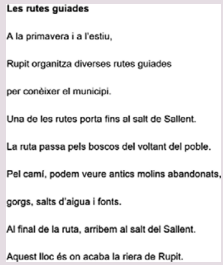
3.3. Apparatus

Eye movements were recorded with a Tobii T60 (sampling rate of 60 Hz) in a desk monitor setup. Head movements were not restrained, although participants were given instructions to stay still while performing the test (as discussed in Section 1.3, this was hard for some participants with an ID). Viewing was binocular, and the movements of both eyes were recorded. Participants were seated approximately 60 cm away from the 43 cm display size monitor with a screen resolution of 1280 × 1024 pixels. The Tobii T60 eye tracker and the stimuli were controlled through a laptop. A different laptop was used to record the participant's answers and comments in a digital document.

[3]Adaptation of the Flesch–Kincaid test to assess Spanish texts; also used for Catalan in the absence of a specific index.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Table 1. Different versions of a stimulus

1) 	2) 
3) 	*Direct translation:* **Guided routes** In spring and summer, Rupit organizes several guided tours for people to get to know the town. One of the routes leads to the Sallent jump. The route passes through the woods around the village. Along the way, we can see old, abandoned mills, gorges, waterfalls and fountains. At the end of the route, we arrive at the Sallent jump. This place is where the Rupit stream ends.

3.4. Procedure

Participants first signed the written informed consent and demographics form. They then performed the TLC and RPM tests in a group session. Later, they proceeded with the eye-tracking experiment in a separate room, with the only company of the observing researcher. For participants with an ID, the two sessions were conducted on different days to reduce the risk of fatigue (Deilen & Schiffl, 2020) and to allow extra time for explanation and assistance. In contrast, the sessions for neurotypical participants were conducted on the same day. The eye-tracking test lasted around 40 minutes and for each participant we retrieved a maximum of 25 minutes of recorded eye movements (around 4 minutes per page of stimuli). The recording was paused while the participants answered the comprehension, perceived difficulty and preference questions, which explains the difference in these times.

The researcher always explained the procedure and calibrated the eye tracker before starting this last test. Then the participant read the first page of stimuli describing a tourist attraction on Rupit and Pruit and answered two multiple-answer comprehension questions orally (see the stimuli explained in Section 3.2.2). The researcher switched to the next screen once the participant told them they had finished reading. They could read the text again if they needed to, once the questions were asked, since the aim was not to measure short-term memory or recall. As mentioned, the eye tracker only recorded eye movements performed while the participants were reading the text prior to the posing of the question. Participants were also asked about their perceived difficulty of the text, which they also answered orally. This process was repeated until readers had read through all 6 pages of the stimuli.

The study protocol (CEEAH CA40) was approved by the Research Ethics Committee of the Universitat Autònoma de Barcelona in February 2022.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

3.5. Eye-tracking measures

Eye-tracking measures can be categorized as local or global. Global measures are aggregated over broader regions, such as sentences or multiple sentences, and provide information on overall reading behavior, including individual differences between groups with varying reading skills (Mézière et al., 2023, 428). For example, Rayner et al. (2006) showed that reading more difficult texts results in longer average fixation durations. Similarly, Reichle et al. (2013) and Blythe and Joseph (2012) found that less skilled readers tend to make more and longer fixations than skilled readers, with longer fixations reflecting prolonged processing times or processing difficulties.

Recent studies have also demonstrated that global eye-tracking measures can predict reading comprehension. Southwell et al. (2020) had participants read long passages silently and then answer multiple-choice questions. They found that eye movements predicted comprehension scores with correlations ranging from 0.35 to 0.40, with more fixations and shorter fixation durations being associated with better performance. D'Mello et al. (2020) reported similar findings, further highlighting the predictive value of global measures.

In contrast, local measures provide more detailed insights into the specific cognitive processes affected by reading ability (Mézière et al., 2023). However, because most research has emphasized global measures, it remains unclear whether local eye movements can reliably predict reading comprehension accuracy.

Given this background, the present study will focus on the global measures listed below, as they have been more consistently linked to reading comprehension outcomes and offer a robust starting point for examining individual differences in reading behavior.

1. Fixation count: the sum of the number of fixations (defined in Section 1.3) in an area (Clifton et al., 2007; Duchowski, 2007).

Fixation count is an indicator of visual processing of that area or stimuli (e.g., the image, the text) (Krejtz et al., 2016). More (and shorter) fixations may reflect attentive reading (Faber et al., 2018; Southwell et al., 2020) as the number of fixations tends to increase when the text is difficult (Rayner et al., 2006) and more fixations are shown to be linked to help memory performance (Fehlmann et al., 2020). Orduna-Hospital et al. (2023) showed that people with an ID tended to exhibit a higher number of fixations.

2. Average fixation duration: the average duration of a single fixation (White et al., 2022).

Longer fixations are associated with reading difficulty, and poor readers tend to exhibit them (Rayner et al., 2006) while shorter fixations are associated with better comprehension (Copeland & Gedeon, 2013; Southwell et al., 2020). The slower the cognitive processing, the longer the fixation (He et al., 2015). Studies suggest that unskilled readers (such as readers with an ID or learning disabilities) will have longer fixation duration (Everatt & Underwood, 1994; Rivero-Contreras, 2023).

3. Total fixation time: the sum of all single fixations on a certain area (Clifton et al., 2007; Duchowski, 2007).

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

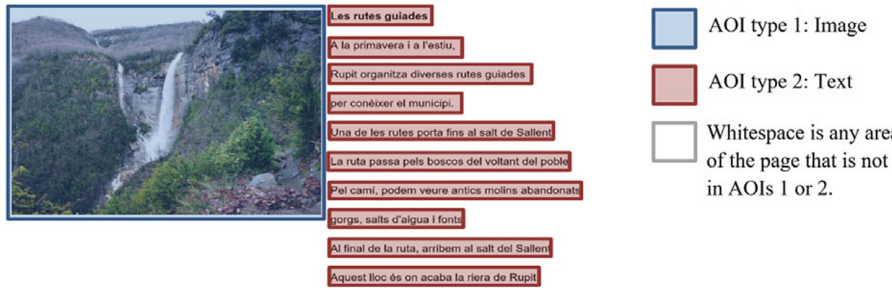


Image 1. Groups of AOIs in a page of stimuli.

It reflects encoding processes (Child et al., 2020) and is an indicator of lexical access and integration (Inhoff & Rayner, 1986; Morton, 1969; Whaley, 1978). A longer total fixation time is considered an indicator of a deeper and more effortful processing of visual information (Just & Carpenter, 1980; Krejtz et al., 2016).

4. Average saccade amplitude: the average distance travelled by the eye between two fixation points (Paeye & Madelain, 2011, 149).

A pattern of long saccades indicates greater exploration (Wang & Sparks, 2016). Poor readers tend to exhibit shorter saccades (Rayner et al., 2006). Orduna-Hospital et al. (2023) showed that people with an ID exhibited a higher number of saccades. Subjects without ID showed faster saccades and with a higher amplitude than those with ID.

Finally, areas of interest (AOIs) are an analytical tool that allows for calculating these measures and receiving quantitative, relevant metrics. Put simply, AOIs are the boundaries drawn around an area of each page of stimuli that fall into different categories. In the present study, researchers determined three types of AOIs: image, text and whitespace (see Image 1).

4. Results

To examine differences in the screening tests, comprehension, perceived difficulty and style preference, we have run an analogous 3-way analysis of variance and a series of independent t-tests. These results, as well as the ones from the participant's eye movements, will be presented in this section. We used R for the statistical analysis. Results will be discussed in Section 5.

4.1. Screening tests: TLC and RPM

There were no intra-group outliers in the results from the screening tests. Participants with an ID got on average 33.7% of the answers correct in the TLC test on reading comprehension (SE = 0.829), whereas the neurotypical group scored 85.8% (SE = 0.443). The difference was significant, $t(52) = 17.198$, $p < .001$.

In regard to the RPM test on abstract reasoning and intelligence, the ID group got 62.9% of the questions right (SE = 1.604), whereas the neurotypical group obtained 95.1% of accurate answers (SE = 0.374). The difference was also significant ($t(52) = 6.54$, $p < .001$) (Tables 2 and 3).

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Table 2. T-Test results from the screening tests

	T-Test scores (between group with an ID and neurotypical)
TLC (reading comprehension)	($t(52) = -17{,}198$, $p < .001$)
RPM (intelligence and abstract reasoning)	($t(52) = -6{,}54$, $p < .001$)

Table 3. Accuracy results from the screening tests

	TLC score (reading comprehension)	RPM score (intelligence and abstract reasoning)
ID	33.7%	62.9%
Neurotypical	85.8%	95.1%

4.2. Comprehension, perceived difficulty and preference questions

We performed basic percentage and statistical calculus from the participants' answers to the comprehension, perceived difficulty and preference questions and a Mann–Whitney U test to compare the tendencies for both groups. Both the comprehension and perceived difficulty questions showed relevant between-group differences. The question on the page layout preference, on the other hand, showed no between-group relevance (Table 4).

Regarding the perceived difficulty of the texts, interestingly, the group with an ID gave a mean of 1.69 out of 4 on difficulty for all 3 types of visual support, showing their rating was independent of the variable. The neurotypical group rated 1.23 out of 4 in difficulty for those texts accompanied by photographs ($p = .002$) or illustrations ($p < .001$), and a slightly lower rate of 1.07 on average for those with no visual support ($p = .002$) and showing a relevant difference between groups for all three types of visual support ($p < .001$) (Table 5).

Finally, when analyzing the answers to the comprehension questions, we can see a relevant between-group difference and a non-relevant within-group difference among participants. The inclusion of visual support is non-relevant for any of the

Table 4. T-Test results from the comprehension, perceived difficulty and preference questions

	T-Test scores (between group with an ID and neurotypical)
Comprehension questions	($t(624) = -12{,}967$, $p < .001$)
Perceived difficulty	($t(312) = 6{,}16$, $p < .001$)
Layout preference	($t(48) = 0$, $p = 1$)

Table 5. Perceived difficulty out of 4

	ID		Neurotypical	
	Mean	Median	Mean	Median
Photograph	1.69	1	1.23	1
Illustration	1.69	1	1.23	1
No visual support	1.69	1	1.07	1

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Table 6. Correct answers to comprehension questions out of 104

	ID		Neurotypical	
	Correct answers	% in group	Correct answers	% in group
Photograph	58	55.7	98	94.2
Illustration	59	56.7	100	96.1
No visual support	56	53.8	99	95.1

Table 7. Visual support preference

	ID		Neurotypical	
	Participants	% of group	Participants	% of group
Photograph	9	34.6	7	26.9
Illustration	1	3.8	5	19.2
No visual support	1	3.8	1	3.8
No preference	15	57.6	13	50

groups (ID: $p = .34$; neurotypical: $p = 1$). Neither does the type of visual support show effects in the accuracy of the participants (ID: $p = 1$; neurotypical: $p = .48$), while the between-group difference is shown to be relevant ($p < .001$). The participants with an ID answered on average 55.4% of the questions correctly, against the 95.1% of the neurotypical group. These results are portrayed in Table 6.

Finally, most participants (53.8%) showed no clear preference when it came to the type of visual support in the text. Among those who did show a preference, the majority of participants preferred the use of pictures (34.6% of ID, 26.9% of neurotypical). While the preference of no visual support is anecdotal and very low for both groups (only one participant and 3.8% in both groups), the between-group difference is only bigger when it comes to the preference of illustrations: only one participant (3.8%) chose this typology in the group with an ID, versus the 19.2% of participants in the neurotypical group. Nevertheless, between-group differences show no relevance ($p = 1$). These results are displayed in Table 7.

4.3. Differences in eye movement characteristics

To verify whether there were differences in reading depending on the characteristics of the stimuli and the participant groups, as per our initial hypotheses, we ran a 3-way mixed design ANOVA with group (neurotypical versus ID) as the between-subjects variable, areas of the page (whitespace versus image versus text) and experimental condition (photograph versus illustration) as within-subjects independent variables.

Before conducting statistical tests, outlying fixations in terms of duration were identified using the standard ±1.58 IQR/sqrt(n) criterion (Chambers et al., 1983). Fixations exceeding 1032 ms were classified as outliers, accounting for 11.79% of cases. Prior to analysis, these outliers were replaced with the largest non-outlying fixation duration (1031 ms), following a procedure known as winterization (Kuwak & Kim, 2017). A similar approach was applied to outliers in saccadic amplitude (11.17%).

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

4.3.1. Fixation count

The analysis on the fixation count yielded a significant difference between groups; individuals with an ID exhibited a higher number of fixations (M = 10.82, SE = .956) than the cognitively neurotypical (M = 5.63, SE = .996), (F (1, 46) < .001, p < .001, eta^2 = .105).

The difference in the number of fixations for different types of images was not significant (F (1, 46) = .2, p = .660, eta2 < .001), nor was the interaction between group and type of image (F (1, 46) = .07, p = .793, eta^2 < .001), showing that both groups had a similar number of fixations on the two types of images (illustrations and photographs).

The analysis also revealed significant differences in fixation count between areas of the page, (F (1.23, 56.54) = 27.32, p < .001, eta^2 = .213), see Figure 1. Post hoc comparisons indicated that both groups had the highest number of fixations on whitespace (M = 12.89, SE = 1.65), followed by text (M = 8.51, SE = .59) and image (M = 3.25, SE = .231).

Interestingly, the interaction effect between participant group and areas of the page was significant, (F (1.23, 56.54) = .007, p = .007, eta^2 = .065), see Figure 1. Post hoc comparisons indicated that participants with an ID had a significantly higher number of fixations on whitespace (M = 18.17, SE = 2.286) than the neurotypical participants (M = 7.62, SE = 2.383), (t(46) = 3.195, p < .001). They also looked significantly more at text (M = 10.55, SE = .827) than the neurotypical group (M = 6.48, SE = .862), (t(46) = 3.413, p = .001). The difference between groups was smallest for the image, yet still significant (t(46) = 2.050, p = .046). Participants with an ID exhibited more fixations (M = 3.73, SE = .319) than the neurotypical participants (M = 2.78, SE = .333).

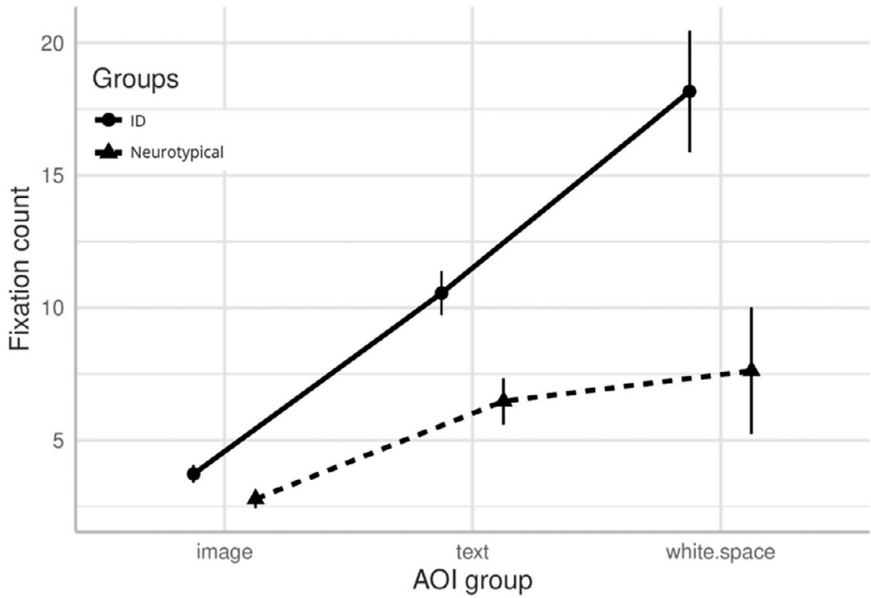


Figure 1. The interaction between participant group and AOI group on fixation count.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

4.3.2. Average fixation duration

Participants with an ID also showed significantly longer average fixations (M = 308, SE = 11.3) than the users in the neurotypical group (M = 266, 11.8), (F (1, 46) = .006, p = .012, eta^2 = .066).

The analysis revealed a significant interaction effect between the group and the area of the page (F (1.44, 66.24) < .001, p < .001), see Figure 2. Post hoc comparisons suggested that the longest fixations of the group with an ID were on the text (M = 358, SE = 14.4), while their fixations on whitespace (M = 293, SE = 15.1) and the image (M = 274, SE = 12.7) were much shorter. Interestingly, neurotypical users show the longest fixations on images (M = 291, SE = 13.2), while their fixations on text (M = 261, SE = 15.1) and white space (M = 245, SE = 15.8) are shorter (F (1.44, 66.24) < .001, p < .001). Interestingly, the relevance of differences on average fixation duration between areas of the page for one group is opposed to the other: for the group with an ID, we only see a relevant difference between image and text (p < .001) and image and whitespace (p < .001), but not between image and whitespace (p = .5). On the contrary, the neurotypical group only show relevant differences in their average fixation duration between image and whitespace

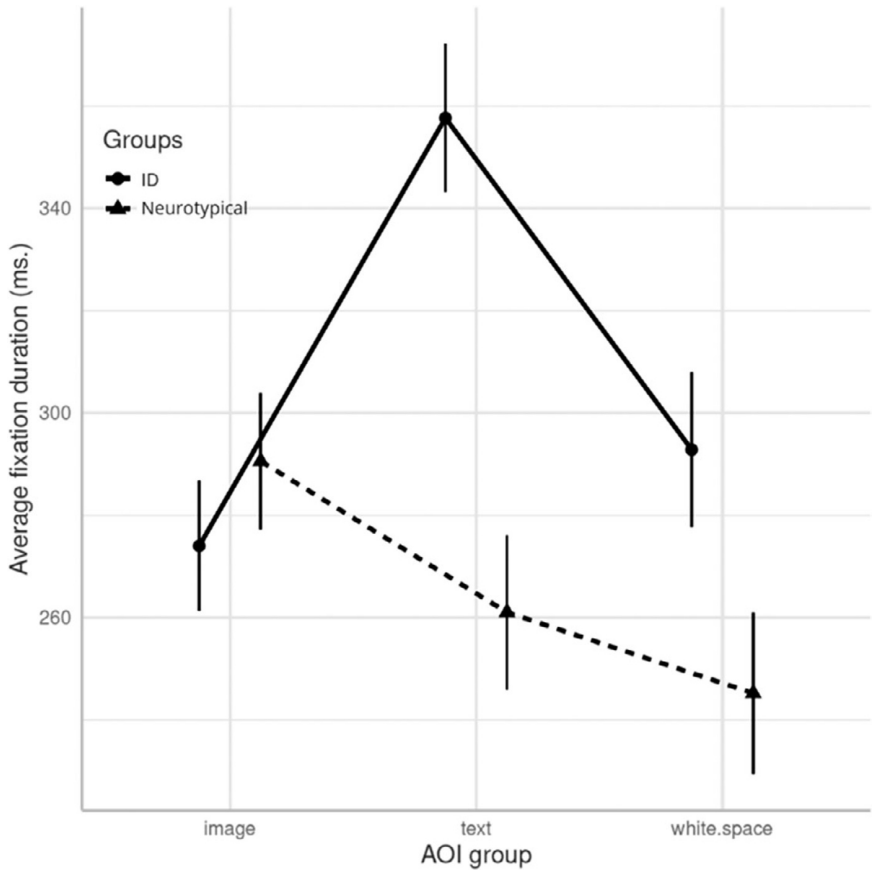


Figure 2. The interaction between participant group and AOI group on average fixation duration.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

(p = .02), but not for the other two pairs of AOIs (image-text (p = .2), text-whitespace (p = .22)).

With this, there is a highly significant difference between the duration of the fixations on the text ($t(46)$ = 4.635, p < .001) and on whitespace ($t(46)$ = 2.181, p = .034) between the two groups, being much higher in both cases for the participants with an ID. This difference is not observed for images ($t(46)$ = −.905, p = .37).

There was also a significant interaction between type of image and page area, (F (1.66, 76.42) = .039, p = .031), see Figure 3. Both groups performed longer fixations on the image when it was a photograph (M = 303, SE = 12.1) than when it was an illustration (M = 261, SE = 10.8), ($t(46)$ = 3.035, p = .039), whereas type of image did not affect the average fixation durations on text ($t(46)$ = 1.215, p = .231) and white space ($t(46)$ = .262, p = .795).

4.3.3. Total fixation time

The difference in the total fixation time (tft) depending on the image type was not significant ($F(1, 46)$ = .15, p = .696, eta^2 = < .001). However, we observed a significant

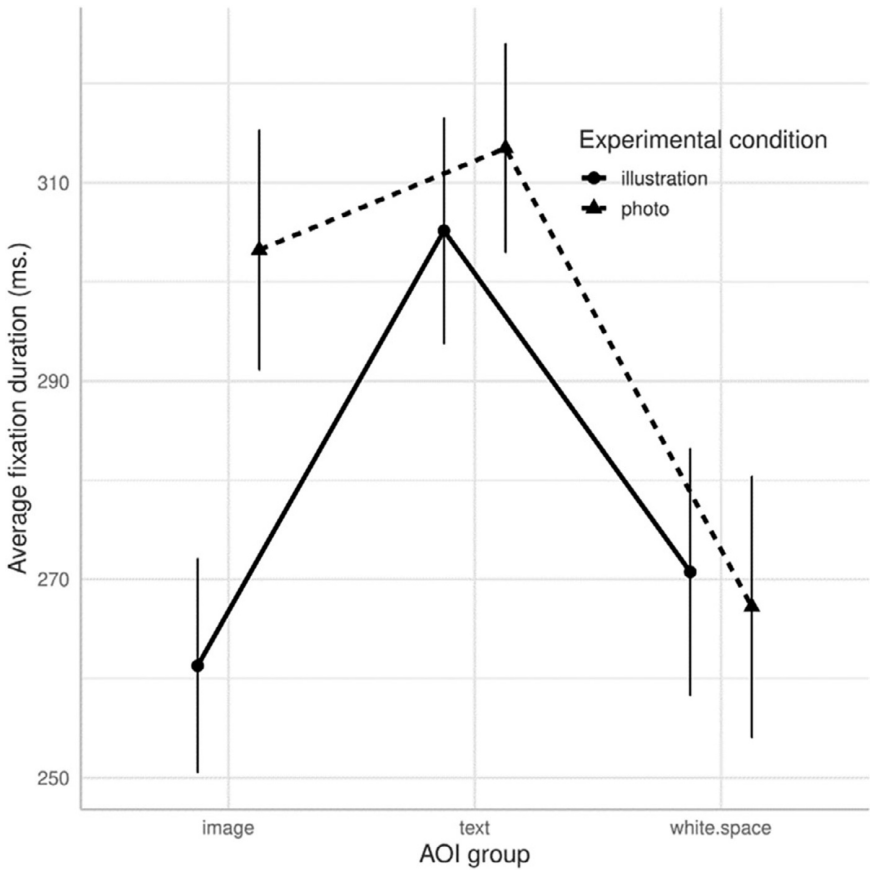


Figure 3. The interaction between experimental condition and AOI group on average fixation duration.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

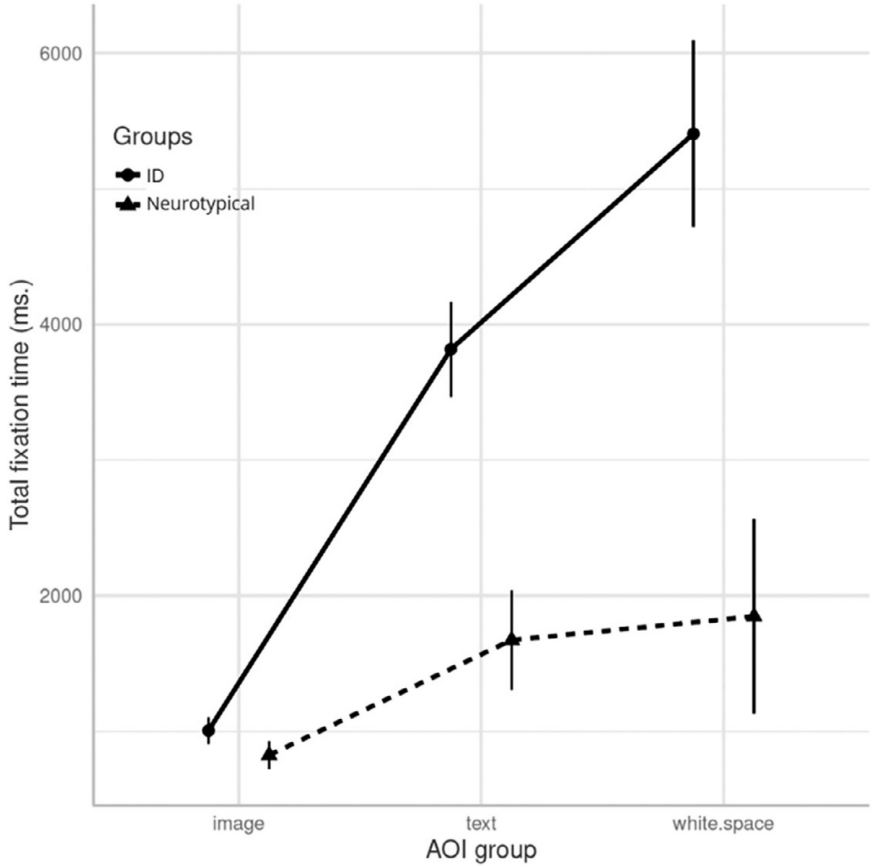


Figure 4. The interaction between participant group and AOI group on total fixation time.

main effect of the page areas. Both groups showed a significantly higher tft on whitespace (M = 3626, SE = 496) and text (M = 2745, SE = 253) than on images (M = 914, SE = 70), (F (1.44, 66.31) < .001, p < .001, eta^2 = .189) (see Figure 4).

The participants with an ID fixated on whitespace for longer (M = 5406, SE = 686) than the neurotypical group (M = 1847, SE = 715), (t(46) = 3.592, p < .001). The same happens with text, where the group with an ID fixated for more time (M = 3818, SE = 350) than the neurotypical group (M = 1673, SE = 365), (t(46) = 4.243, p < .001). However, there was not a significant effect on total fixation time of the interaction between image type and participant group (F (1, 46) = .04, p = .846, eta^2 < .001), and the two groups did not differ significantly in the time they looked at the images (t(46) = 1.292, p = .203).

4.3.4. Saccadic amplitude

Regarding saccadic amplitude, we observed a significant interaction effect between group and page area, (F(1.29, 59.35) = .04, p = .022, eta^2 = .044). We see a significant between-group difference in the saccadic amplitude on image, with smaller saccades

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

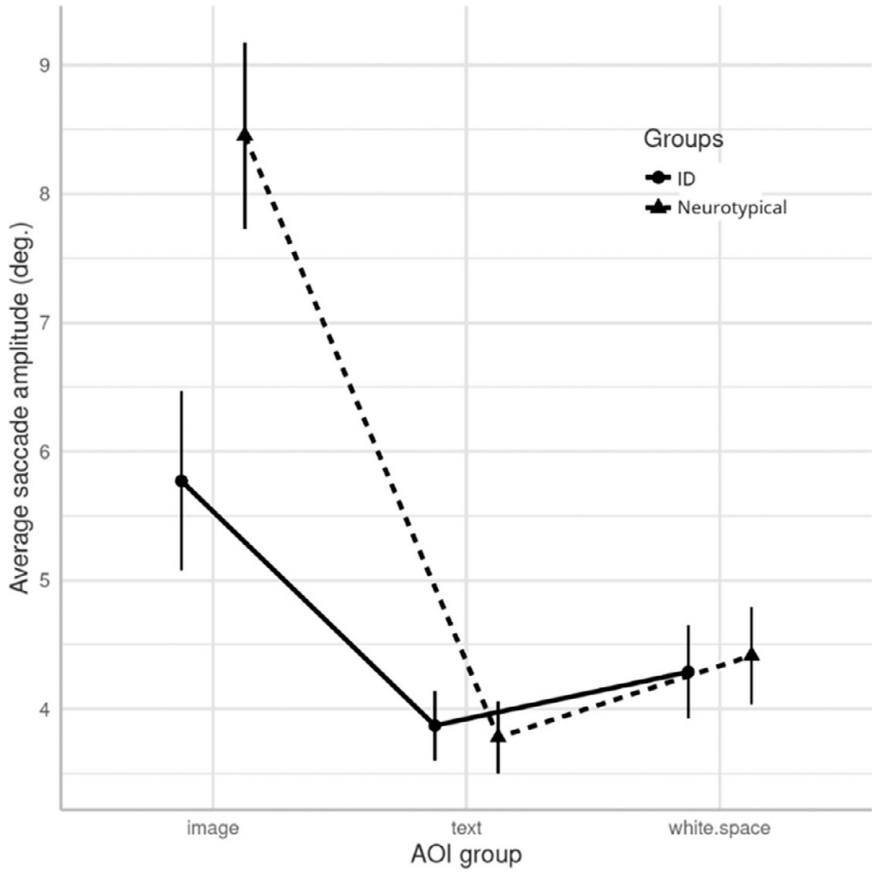


Figure 5. The interaction between participant group and AOI group on average saccade amplitude.

for the group with an ID (M = 5.77, SE = .692) than for the neurotypical group (M = 8.45, SE = .722), ($t(46)$ = 2.680, p = .01, see Figure 5).

Analogous comparisons for text ($t(46)$ = .239, p = .8121) and white space ($t(46)$ = −.243, p = .8089) were not significant. In addition, participants performed smaller saccades on the photographs (M = 4.72, SE = .244) than on the illustrations (M = 5.48, SE = .244), ($F(1, 46)$ = 6.47, p = .014, eta^2 = .016). This effect of image type was quantified by group ($F(1, 46)$ = .372, p = .06, eta^2 = .016). The neurotypical group showed significantly bigger saccades for illustrations (M = 6.22, SE = .353) than photographs (M = 4.88, SE = .353), ($t(46)$ = 3.100, p = .003), whereas the group with an ID showed small saccades for both types of images, with non-relevant differences ($t(46)$ = .444, p = .6591). These results also show a significant between-group difference in saccadic amplitude for illustrations, with the neurotypical participants performing significantly bigger saccades (M = 6.22, SE = .353) than the participants with an ID (M = 4.74, SE = .338), ($t(46)$ = 3.030, p = .004). This difference was not significant for saccades on photographs, which were small for both groups ($t(46)$ = .5) (see Figure 6).

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

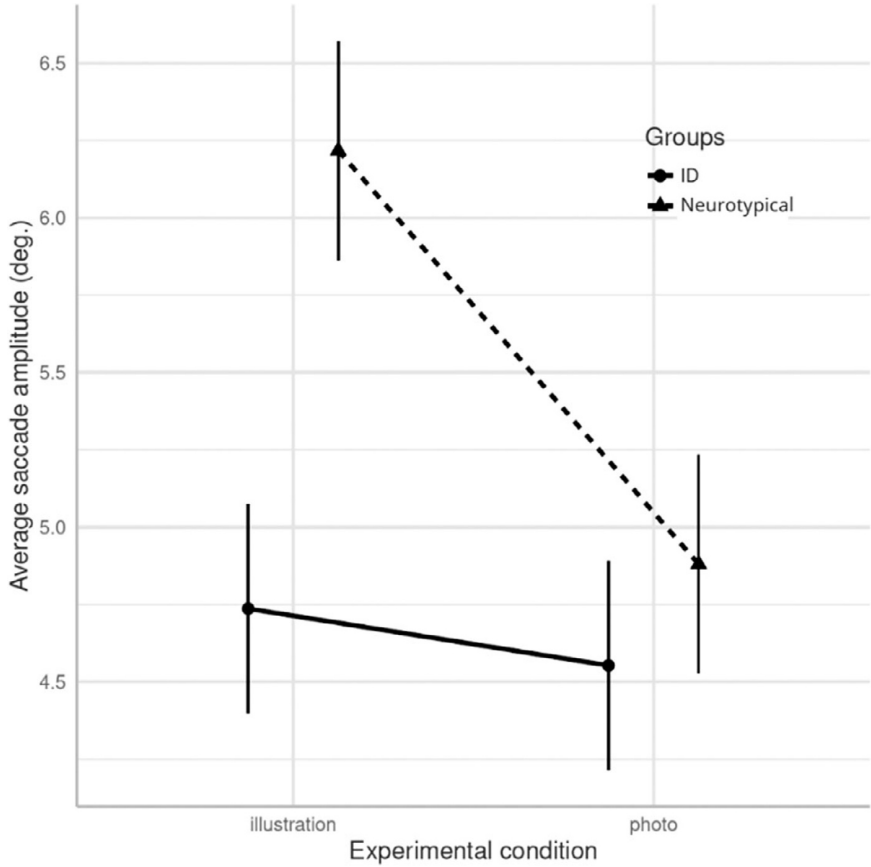


Figure 6. The interaction between participant group and experimental condition on average saccade amplitude.

5. Discussion

We will first review the hypotheses and contrast them with the results of our study (findings reject H1 and confirm H2). We will also answer the exploratory research questions Q1 and Q2. Later on, we will discuss other interesting findings outside the scope of our initial hypotheses.

H1. *Visual support of any type has significant effects on text comprehension for readers with intellectual disabilities.* Visual support inclusion was not related to accuracy in comprehension questions in any of the groups of participants. The type of visual support also showed no effects on reading comprehension. Therefore, we found no evidence of differential influence of photographs or illustrations helping in the comprehension of the text that they accompany.

H2. *People with and without intellectual disabilities explore the page differently.* The group with an ID was expected to make more and longer fixations, show a longer fixation time and perform shorter saccades. The total fixation time of the participants with an ID on the text was also higher than those in the neurotypical group, probably indicating a

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

higher difficulty to decode the text or interpret its content (Rayner, 1998). The same happens with the average fixation duration: the group with an ID shows much longer fixations on text and whitespace, indicating a higher cognitive effort when reading (Southwell et al., 2020). Differently, the neurotypical group shows shorter fixations overall, with their longest ones being on the image (opposite to the results of the group with an ID), arguably because they may find more interest in exploring that area.

Regarding saccades, the neurotypical participants performed longer ones on the image area, possibly due to them searching for items or details in the scene. Saccades were also longer when the image was an illustration, showing extensive eye movements around the abstract picture. The overall smaller saccades of the group with an ID show that they were focusing on areas of interest on the page with more and longer fixations, rather than scanning and exploring around it.

Q1. *How does the presence and type of visual support influence perceived level of text difficulty?* There were no significant differences on the perceived difficulty of the text that could be linked to the inclusion or type of visual support.

Q2. *How does the presence and type of visual support influence the readers' eye movements?* We found that saccades were longer on illustrations than on photographs, a difference that was especially significant in the neurotypical group. This group showed extensive eye movements around the abstract picture.

Having assessed the initially posed hypotheses and questions, it is also very interesting to see that the participants, especially those on the group with an ID, had the highest number of fixations and average total fixation time on whitespace. We suggest that this may have occurred because the texts shown lengthened between 65 and 70 words rather than being of sentence-length, and the participants might have needed to rest their gaze on the whitespace briefly; although it may also reflect a difference in how the two groups scan the scene and integrate the different areas of the page (Skversky-Blocq et al., 2022).

Other aspects worth discussing would be the between-group difference on the answers on perceived difficulty, style preference and comprehension questions. There were no relevant differences on the perceived difficulty of the text that could be linked to the participant groups. Regarding preference on the inclusion and type of visual support in the page, most participants showed no preference or would rather not communicate it. Photographs were the preferred style for both groups, but it is very interesting to discuss the number of participants that chose illustrations, which is much higher in the neurotypical group (19.2%) than in the group with an ID (3.8%). This may possibly be due to participants with an ID being more aware and averse to infantile styles of visual support, as some participants in the group communicated to the researcher. Lastly, results make it clear that the comprehension questions were easy for the neurotypical group (95.1% of correct answers) and quite difficult to answer for the participants with an ID (55.4% of accuracy). It is hard to determine whether these results are fully due to the participants with an ID being unable to comprehend the needed information in the text, but it probably indicates a difference in the reading comprehension capacities of each group.

6. Conclusions

We were able to assess our initial hypotheses and shed light on the more exploratory aspects analyzed. On the one hand, contrary to H1, visual support was not related to

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

accuracy in comprehension questions. This questions whether this should be such an established aspect of EL texts. On the other hand, H2 was confirmed, indicating that global eye-tracking measures are a good tool to predict the cognitive effort of processing different types of texts and that, although participants with an ID might need some adaptations in the test design and setting, it is possible and advisable to use this methodology with EL primary groups.

Additionally, there was no effect of the group or visual support on how difficult the participants perceived the text. In this regard, the way participants with an ID perceive the text in terms of difficulty does not match their lower results on comprehension, showing a misperception of their reading abilities or a reluctance to verbalize their struggles. Notably, neurotypical participants showed a higher preference for illustrations than that of participants with an ID, possibly reflecting a desire of the latter for less infantilizing support.

On this basis, the present study makes a meaningful contribution to the limited empirical evidence directly examining EL recommendations and offers valuable insights into the relationship among visual support, eye-tracking measures and reading comprehension. Nevertheless, it is important to acknowledge its limitations and suggest directions for future research.

6.1. Limitations and future research directions

First, regarding the eye-tracking measures used in the present study, global measures are not very informative about the specific cognitive processes affected by reading ability (Mézière et al., 2023, 428). For example, we do not know whether the differences between groups in processing times are due to linguistic (e.g., lexical access) or non-linguistic (e.g., working memory) processes. Therefore, it would be valuable for future studies to assess local measures (although since most studies have focused on global measures, it remains uncertain whether local eye movements can also predict reading comprehension accuracy). Second, it would be valuable to examine within-group differences in comprehension by presenting participants with the same information in both standard language and EL, incorporating this as a within-group variable. Third, while we aimed for a larger sample, our final participant pool included 52 individuals (26 per group). Given the limited research involving adults with an ID in this area, we encourage future studies to replicate our findings or conduct similar investigations with larger samples.

We also observed unexpected results outside our original hypotheses that merit further study. For instance, the group with an ID reacted negatively to illustrations, while these were much more appreciated by the neurotypical group. In addition, many linguistic and graphical aspects of EL remain unexplored and should be addressed in future work. Validating EL adaptations empirically is key to ensuring their effectiveness and improving accessible communication.

Our study made a significant contribution to the limited empirical evidence directly assessing EL recommendations, although it is essential that future research continues to evaluate their validity and applicability.

Data availability statement. The data and analysis scripts related to the reported results are available on OSF: https://osf.io/ecwkx/?view_only=ba4285b1ccb44fb19ceb2c0f7bcc9ede

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Acknowledgements. The authors thank the organizations SOM Fundació (Barcelona) and Taller Jeroni de Moragas (Valldoreix) for their collaboration in the study by facilitating contact with participants and providing a space to perform the experiment.

Funding statement. This work is part of Mariona González-Sordé's PhD in Translation and Intercultural Studies at the Department of Translation and Interpreting and East Asia Studies of the Universitat Autònoma de Barcelona. The publication is partially based upon work performed within the COST Action LEAD-ME (CA19142), supported by COST (European Cooperation in Science and Technology) and within the EU-funded Innovation Action (IA) MediaVerse project (H2020-EU.2.1.1 programme). MediaVerse has received funding from the Horizon 2020 Research and Innovation Programme of the European Union, under grant agreement number 957252.

Competing interests. González-Sordé and Soler-Vilageliu are members of TransMedia Catalonia, a research group funded by the Catalan Ministry of Research and Universities (2021 SGR 00077).

References

Anglin, G. J., Vaez, H., & Cunningham, K. L. (2004). Visual representations and learning: The role of static and animated graphics. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (pp. 865–916). Lawrence Erlbaum Associates Publishers.

Asociación Española de Normalización. (2018). *UNE* 153101:2018 *EX: Lectura fácil. Pautas y recomendaciones para la elaboración de documentos.*

Baez-Naghelli, C., Águila, L., Nieves, D., Grande, M., & Mena, T. (2015). *Test leer Para Comprender: Evaluación de la comprensión lectora en educación primaria*. Ediciones Paidós.

Bernabé, R. (2020). New taxonomy of easy-to-understand access services. *Monografías de Traducción e Interpretación*, 12, 345–380. https://doi.org/10.6035/MonTI.2020.12.12.

Beymer, D., Orton, P. Z., & Russell, D. M. (2007). An eye tracking study of how pictures influence online reading. In C. Baranauskas, P. Palanque, J. Abascal, & S. D. J. Barbosa (Eds.), Human-computer interaction – INTERACT *2007* (pp. 3–7). Springer. https://doi.org/10.1007/978-3-540-74800-7_41

Blythe, H. I., & Joseph, H. S. S. L. (2012). Children's eye movements during reading. In S. P. Liversedge, I. Gilchrist, & S. Everling (Eds.), *The Oxford handbook of eye movements* (pp. 644–662). Oxford University Press.

Boland, J. (2004). Linking eye movements to sentence comprehension in reading and listening. In M. Carreiras & C. Clifton (Eds.), *The on-line study of sentence comprehension: Eyetracking, ERP, & beyond*. Psychology Press.

Borghardt, L., Deilen, S., Fuchs, J., Gros, A., Hansen-Schirra, S., Nagels, A., Schiffl, L., & Sommer, J. (2021). Neuroscientific research on the processing of easy language. *Frontiers in Communication*, 6. https://doi.org/10.3389/fcomm.2021.698044.

Buell, S. (2017). *Health-based information for people with intellectual disabilities: An investigation into the linguistic properties of "easy read" literature and its contribution to the construction of meaning: The Easy Read Project* [Doctoral thesis]. University of East Anglia. https://ueaeprints.uea.ac.uk/id/eprint/65618

Butcher, K. R. (2014). The multimedia principle. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 174–205). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.010

Carney, R. N., & Levin, J. R. (2002). Pictorial illustrations still improve students' learning from text. *Educational Psychology Review* 14(1), 5–26. http://www.jstor.org/stable/23363486

Chambers, J. M., Cleveland, W. S., Kleiner, B., & Tukey, P. A. (1983). *Graphical methods for data analysis*. Wadsworth & Brooks/Cole Statistics.

Child, S., Oakhill, J., & Garnham, A. (2020). Tracking your emotions: An eye-tracking study on reader's engagement with perspective during text comprehension. *Quarterly Journal of Experimental Psychology*, 73(6), 929–940. https://doi.org/10.1177/1747021820905561.

Chinn, D., & Homeyard, C. (2017). Easy read and accessible information for people with intellectual disabilities: Is it worth it? A meta-narrative literature review. *Health Expectations*, 20(6), 1189–1200. https://doi.org/10.1111/hex.12520.

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, 3, 149–210. https://doi.org/10.1007/BF01320076.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Clifton, C., Jr., Staub, A., & Rayner, K. (2007). Eye movements in reading words and sentences. In R. P. G. van Gompel, M. H. Fischer, W. S. Murray, & R. L. Hill (Eds.), *Eye movements: A window on mind and brain* (pp. 341–371). Elsevier. https://doi.org/10.1016/B978-008044980-7/50017-3

Comes, A. (1990). *TLC: Test de lectura comprensiva*. TEA.

Copeland, L., & Gedeon, T. (2013). Measuring reading comprehension using eye movements. In *4th IEEE international conference on cognitive infocommunications (CogInfoCom 2013) – Proceedings* (pp. 791–796). https://doi.org/10.1109/CogInfoCom.2013.6719207.

Csákvári, J., & Gyori, M. (2015). Applicability of standard eye-tracking technique in people with intellectual disability: Methodological conclusions from a series of studies. *Studies in Health Technology and Informatics*, 217, 63–70. https://pubmed.ncbi.nlm.nih.gov/26294454/

Deilen, S. (2020). Visual segmentation of compounds in easy language: Eye movement studies on the effects of visual, morphological, and semantic factors on the processing of German noun-noun compounds. In S. Hansen-Schirra & C. Maaß (Eds.), *Easy language research: Text and user perspectives* (pp. 241–256). Frank & Timme.

Deilen, S., & Schiffl, L. (2020). Using eye-tracking to evaluate language processing in the easy language target group. In S. Hansen-Schirra & C. Maaß (Eds.), *Easy language research: Text and user perspectives* (pp. 273–281). Frank & Timme.

Del Cueto, J., Conte, N. B., Parellada, C., & Roldan, L. A. (2019). Validación de un screening académico Para evaluar la comprensión lectora: Estudio piloto. In *XI Congreso Internacional de Investigación y Práctica Profesional en Psicología*. https://www.aacademica.org/000-111/120

Denzen, E. M., Santibáñez, M. E., Moore, H., Foley, A., Gersten, I. D., Gurgol, C., Majhail, N. S., Spellecy, R., Horowitz, M. M., & Murphy, E. A. (2012). Easy-to-read informed consent forms for hematopoietic cell transplantation clinical trials. *Biology of Blood and Marrow Transplantation*, 18(2), 183–189. https://doi.org/10.1016/j.bbmt.2011.07.022.

Department of Health. (2010). *Making written information easier to understand for people with learning disabilities: Guidance for people who commission or produce easy read information.*

D'Mello, S. K., Southwell, R., & Gregg, J. (2020). Machine-learned computational models can enhance the study of text and discourse: A case study using eye tracking to model reading comprehension. *Discourse Processes*, 57(5–6), 420–440. https://doi.org/10.1080/0163853X.2020.1739600.

Duchowski, A. T. (2007). *Eye tracking methodology: Theory and practice*. Springer.

Dye, L., Hare, D. J., & Hendy, S. (2004). Capacity to consent to participate in research: A reconceptualisation. *British Journal of Learning Disabilities*, 31(1), 1–7. https://doi.org/10.1111/j.1468-3156.2004.00262.x.

Everatt, J., & Underwood, G. (1994). Individual differences in reading subprocesses: Relationships between reading ability, lexical access, and eye movement control. *Language and Speech*, 37(3), 283–297. https://doi.org/10.1177/002383099403700305.

Faber, M., Bixler, R., & D'Mello, S. K. (2018). An automated behavioral measure of mind wandering during computerized reading. *Behavior Research Methods*, 50(1), 134–150. https://doi.org/10.3758/s13428-017-0857-y.

Fajardo, I., Ávila, V., Ferrer, A., Tavares, G., Gómez, M., & Hernández, A. (2014). Easy-to-read texts for students with intellectual disability: Linguistic factors affecting comprehension. *Journal of Applied Research in Intellectual Disabilities*, 27(3), 212–225. https://doi.org/10.1111/jar.12065.

Fehlmann, B., Coynel, D., Schicktanz, N., Milnik, A., Gschwind, L., Hofmann, P., Papassotiropoulos, A., & de Quervain, D. J. (2020). Visual exploration at higher fixation frequency increases subsequent memory recall. *Cerebral Cortex Communications*, 21(1). https://doi.org/10.1093/texcom/tgaa032.

Ferreres, A., Abusamra, V., Casajús, A., Cartoceti, R., Squillace, M., & Sampedro, B. (2009). Pruebas de screening Para la evaluación de la comprensión de textos. *Neuropsicología Latinoamericana*, 1(1), 41–56.

García Muñoz, Ó. (2012). *Lectura fácil: Métodos de redacción y evaluación*. Real Patronato sobre Discapacidad.

Gonzalez-Sanchez, J., Baydogan, M., Chavez-Echeagaray, M. E., Atkinson, R., & Burleson, W. (2017). Affect measurement: A roadmap through approaches, technologies, and data analysis. In M. Jeon (Ed.), *Emotions and affect in human factors and human-computer interaction* (pp. 255–288). Elsevier. https://doi.org/10.1016/B978-0-12-801851-4.00011-2

González-Sordé, M., & Matamala, A. (2023). *Empirical evaluation of easy language recommendations: A systematic literature review from journal research in Catalan, English, and Spanish*. Universal Access in the Information Society. https://doi.org/10.1007/s10209-023-00975-2.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Guo, D., McTigue, E. M., Matthews, S. D., & Zimmer, W. (2020). The impact of visual displays on learning across the disciplines: A systematic review. *Educational Psychology Review*, 32, 627–656. https://doi.org/10.1007/s10648-020-09523-3.

Hannus, M., & Hyönä, J. (1999). Utilization of illustrations during learning of science textbook passages among low- and high-ability children. *Contemporary Educational Psychology*, 24(2), 95–123. https://doi.org/10.1006/ceps.1998.0987.

He, W., Garrido, M. I., Sowman, P. F., Brock, J., & Johnson, B. W. (2015). Development of effective connectivity in the core network for face perception. *Human Brain Mapping*, 36(6), 2161–2173. https://doi.org/10.1002/hbm.22762.

Hibbing, A. N., & Rankin-Erickson, J. L. (2003). A picture is worth a thousand words: Using visual images to improve comprehension for middle school struggling readers. *The Reading Teacher*, 56 758–770.

Hurtado, B., Jones, L., & Burniston, F. (2014). Is easy read information really easier to read? *Journal of Intellectual Disability Research*, 58(9), 822–829. https://doi.org/10.1111/jir.12097.

Inhoff, A. W., & Rayner, K. (1986). Parafoveal word processing during eye fixations in reading: Effects of word frequency. *Perception & Psychophysics*, 40(6), 431–439. https://doi.org/10.3758/BF03208203.

International Organization for Standardization. (2023). *ISO/IEC DIS 23859:2023: Information technology—User interfaces—Requirements and recommendations on making written text easy to read and understand*. ISO.

Jones, F. W., Long, K., & Finlay, W. M. L. (2007). Symbols can improve the reading comprehension of adults with learning disabilities. *Journal of Intellectual Disability Research*, 51(7), 545–550. https://doi.org/10.1111/j.1365-2788.2006.00926.x.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, 87(4), 329–354. https://doi.org/10.1037/0033-295X.87.4.329.

Kazem, A. M., Alzubiadi, A. S., Yousif, Y. H., Aljamali, F. A., Al-Mashhdany, S. I., Alkharusi, H. A., Al-Busaidi, O. B., Alsarmi, A. M., Al-Bulushi, S. S., Al-Bahrani, W. A., & Al-Fori, S. M. (2007). Psychometric properties of Raven's Colored progressive matrices for Omani children aged 5 through 11 years. *Social Behavior and Personality*, 35(10), 1385–1398. https://doi.org/10.2224/sbp.2007.35.10.1385.

Krejtz, K., Duchowski, A. T., Krejtz, I., Kopacz, A., & Chrząstowski-Wachtel, P. (2016). Gaze transitions when learning with multimedia. *Journal of Eye Movement Research*, 9(1). https://doi.org/10.16910/jemr.9.1.5.

Kwak, S. K., & Kim, J. H. (2017). Statistical data preparation: Management of missing values and outliers. *Korean Journal of Anesthesiology*, 70(4), 407–411. https://doi.org/10.4097/kjae.2017.70.4.407.

Levie, W. H., & Lentz, R. (1982). Effects of text illustrations: A review of research. *Educational Technology Research and Development*, 30, 195–232. https://doi.org/10.1007/BF02765184.

Lindholm, C., & Vanhatalo, U. (2021). *Handbook of easy languages in Europe*. Frank & Timme.

Matamala, A. (2022). Easy-to-understand language in audiovisual translation and accessibility: State of the art and future challenges. *XLinguae*, 15(2), 130–144. https://doi.org/10.18355/XL.2022.15.02.10.

Mayer, R. E. (2014). *The Cambridge handbook of multimedia learning*. (2nd ed.). Cambridge University Press.

Mézière, D. C., Yu, L., Reichle, E. D., der Malsburg, T., & McArthur, G. (2023). Using eye-tracking measures to predict reading comprehension. *Reading Research Quarterly*, 58, 425–449. https://doi.org/10.1002/rrq.498.

Morton, J. (1969). Interaction of information in word recognition. *Psychological Review*, 76(2), 165–178. https://doi.org/10.1037/h0027366.

Nomura, M., Nielsen, G., & Tronbacke, B. (2010). *Guidelines for easy-to-read materials*. International Federation of Library Associations and Institutions (IFLA).

Orduna-Hospital, E., Hernández-Aranda, D., & Sanchez-Cano, A. (2023). Ocular motility patterns in intellectual disability: Insights from the developmental eye movement test. *Life*, 13(12). https://doi.org/10.3390/life13122360.

Paeye, C., & Madelain, L. (2011). Reinforcing saccadic amplitude variability. *Journal of the Experimental Analysis of Behavior*, 95(2), 149–162. https://doi.org/10.1901/jeab.2011.95-149.

Perego, E. (2020). *Accessible communication: A cross-country journey*. Frank & Timme.

Plena Inclusión. (2021). ¿Cómo usamos las imágenes en la lectura fácil? https://www.plenainclusion.org/noticias/como-usamos-las-imagenes-en-la-lectura-facil/

Poncelas, A., & Murphy, G. (2007). Accessible information for people with intellectual disabilities: Do symbols really help? *Journal of Applied Research in Intellectual Disabilities*, 20(5), 466–474. https://doi.org/10.1111/j.1468-3148.2006.00334.x.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Queiroz-Garcia, I., Espirito Santo, H., & Pires, C. (2021). Propriedades psicométricas da forma geral das Matrizes Progressivas de Raven numa amostra Portuguesa. *Revista Portuguesa de Investigação Comportamental e Social*, 7(1), 84–101. https://doi.org/10.31211/rpics.2021.7.1.210.

Raven, J. C. (1998). *Raven's progressive matrices*. Pearson Clinical.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124(3), 372–422. https://doi.org/10.1037/0033-2909.124.3.372.

Rayner, K., Chace, K. H., Slattery, T. J., & Ashby, J. (2006). Eye movements as reflections of comprehension processes in reading. *Scientific Studies of Reading*, 10(3), 241–255. https://doi.org/10.1207/s1532799xssr1003_3.

Rayner, K., Pollatsek, A., Ashby, J., & Clifton, C. (2011). *Psychology of reading*. Psychology Press.

Reichle, E. D., Liversedge, S. P., Drieghe, D., Blythe, H. I., Joseph, H. S., White, S. J., & Rayner, K. (2013). Using EZ reader to examine the concurrent development of eye-movement control and reading skill. *Developmental review*, 33(2), 110–149. https://doi.org/10.1016/j.dr.2013.03.001

Rivero Contreras, M., Engelhardt, P. E., & Saldaña Sage, D. (2023). Do easy-to-read adaptations really facilitate sentence processing for adults with a lower level of education? An experimental eye-tracking study. *Learning and Instruction*, 84. https://doi.org/10.1016/j.learninstruc.2022.101731.

Rivero-Contreras, M., Engelhardt, P. E., & Saldaña, D. (2021). An experimental eye-tracking study of text adaptation for readers with dyslexia: Effects of visual support and word frequency. *Annals of Dyslexia*, 71, 170–187. https://doi.org/10.1007/s11881-021-00217-1.

Rivero-Contreras, M., & Saldaña, D. (2020). ¿Legibilidad es sinónimo de comprensión en Lectura Fácil? Una revisión de estudios sobre comprensión lectora en textos adaptados o simplificados y su calidad metodológica. In A. E. Díez Mediavilla & R. Gutiérrez Fresneda (Coords.), *Lectura y dificultades lectoras en el siglo XXI* (pp. 714–728). Octaedro.

Saletta, M., Kaldenberg, E., Rivera, K., & Wood, A. (2019). Do illustrations promote reading comprehension in adults with intellectual or developmental disabilities? *Education and Training in Autism and Developmental Disabilities* 54(3), 225–236. https://www.jstor.org/stable/26780623

Schatz, T., Haberstroh, J., Bindel, K., Oswald, P., Pantel, J., Paulitsch, M., Konopik, N., & Knopf, M. (2017). Improving comprehension in written medical informed consent procedures. *GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry*, 30(3), 97–108. https://doi.org/10.1024/1662-9647/a000169.

Schiffl, L. (2020). Easy language research: Text and user perspectives. In S. Hansen-Schirra & C. Maaß (Eds.), *Easy language research: Text and user perspectives* (pp. 227–239). Frank & Timme.

Skversky-Blocq, Y., Shmuel, S., Cohen, O., & Shechner, T. (2022). Looking fear in the face: Adults but not adolescents gaze at social threat during observational learning. *International Journal of Psychophysiology*, 182, 240–247. https://doi.org/10.1016/j.ijpsycho.2022.11.004.

Social Care Institute for Excellence. (2005). *How to produce information in an accessible way (social care accessibility guidelines)*. NHS England

Southwell, R., Gregg, J., Bixler, R., & D'Mello, S. K. (2020). What eye movements reveal about later comprehension of long connected texts. *Cognitive Science*, 44(10), 1–24. https://doi.org/10.1111/cogs.12905.

Sung, E., & Mayer, R. E. (2012). When graphics improve liking but not learning from online lessons. *Computers in Human Behavior*, 28(5), 1618–1625. https://doi.org/10.1016/j.chb.2012.03.026.

Sutherland, R. T., & Isherwood, T. (2016). The evidence for easy-read for people with intellectual disabilities: A systematic literature review. *Journal of Policy and Practice in Intellectual Disabilities*, 12(4), 297–310. https://doi.org/10.1111/jppi.12201.

Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10, 251–296. https://doi.org/10.1023/A:1022193728205.

Van Gog, T., Ericsson, K. A., & Rikers, R. M. J. P. (2005). Instructional design for advanced learners: Establishing connections between the theoretical frameworks of cognitive load and deliberate practice. *Educational Technology Research and Developmen*, 53, 73–81. https://doi.org/10.1007/BF02504799.

Vidal, L. (2021). *La Mirada Tàctil. Versió LF: Llocs d'interès de Rupit i Pruit*. Oficina de Patrimoni Cultural, Diputació de Barcelona, Ajuntament de Rupit i Pruit.

Wadihah, H., & Fauzi, A. (2021). Using image media on reading text to improve reading comprehension of students with intellectual disabilities. *Jurnal Asesmen dan Intervensi Anak Berkebutuhan Khusus*, 21(1).

Wang, Y., & Sparks, B. A. (2016). An eye-tracking study of tourism photo stimuli: Image characteristics and ethnicity. *Journal of Travel Research*, 55(5), 588–602. https://doi.org/10.1177/0047287514564598.

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press

Warburg, M. (2001). Visual impairment in adult people with intellectual disability: Literature review. *Journal of Intellectual Disability Research*, 45(5), 424–438. https://doi.org/10.1046/j.1365-2788.2001.00348.x.

Whaley, C. P. (1978). Word-nonword classification time. *Journal of Verbal Learning and Verbal Behavior*, 17(2), 143–154. https://doi.org/10.1016/S0022-5371(78)90110-X.

White, H., Heck, A., Jubran, R., Chroust, A., & Bhatt, R. S. (2022). Average fixation duration in infancy: Stability and predictive utility. *Infancy: The Official Journal of the International Society on Infant Studies*, 27(5), 866–886. https://doi.org/10.1111/infa.12483.

Yaneva, V., Temnikova, I., & Mitkov, R. (2016). Accessible texts for autism: An eye-tracking study. In *ASSETS 2015, the 17th international ACM SIGACCESS conference on computers and accessibility* (pp. 49–57). https://doi.org/10.1145/2700648.2809852

Zhao, F., Schnotz, W., Wagner, I., & Gaschler, R. (2014). Eye-tracking indicators of reading approaches in text-picture comprehension. *Frontline Learning Research*, 2(5), 46–66. https://doi.org/10.14786/flr.v2i4.98.

Cite this article: González-Sordé, M., Soler-Vilageliu, O., Krejtz, K., & Krejtz, I. (2025). Visual support in easy language: The impact of images on comprehension, perceived difficulty and eye movements, *Language and Cognition*, 17, e87, 1–27. https://doi.org/10.1017/langcog.2025.10042

https://doi.org/10.1017/langcog.2025.10042 Published online by Cambridge University Press