Parallèles

Null and overt pronouns and subordinate clauses in Catalan Easy Language: An eye-tracking study on adults with and without intellectual disabilities

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Abstract

Easy Language guidelines discourage the use of full overt pronouns and subordinate clauses. This study examines how manipulating these linguistic elements influences perceived reading difficulty, reader preference, and the cognitive effort involved in text processing. We also assessed the effects of null and overt pronouns on content comprehension. 26 adults with intellectual disabilities and 26 neurotypical adults participated in a mixed-design experiment involving two reading tasks. For both tasks, we recorded participants' eye movements while they rated the perceived difficulty and reported their preference. Additionally, Task 1 included open-ended comprehension questions. The linguistic elements only had significant effects on fixation patterns and focal attention. Crucially, they did not significantly alter perceived text difficulty. These findings suggest that including subordinate clauses does not significantly hinder comprehension. However, further research is essential to guide the future development of Easy Language, as evidence is still limited regarding its additional linguistic and graphic features and the needs of different target groups.

Keywords

Easy Language, eye tracking, intellectual disability, pronouns, subordinate clauses, accessibility

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1. Introduction

Usability and accessibility in communication depend heavily on how understandable the content is, and this can be markedly improved through text simplification methods (Saggion et al., 2011; Perego, 2020). Historically, cognitive barriers have received less scholarly attention than physical or sensorial ones (Alarcon et al., 2019). However, the field is evolving, with growing interest in cognitive accessibility among researchers and policymakers, leading to new developments and practices in the field.

To contribute to this expanding area of research, this article details the research undertaken to address this topic. We will begin by outlining key concepts related to this study and the research performed in the area. Next, we will review relevant prior research, followed by the presentation of our hypotheses, study design, and methodology. Finally, we will present the results, discuss their implications, and conclusions.

2. Related work

This section reviews the main literature relevant to the present study. It first introduces the concept of Easy Language. Then, it focuses on specific linguistic features that are central to this research (null and overt pronouns, and subordinate clauses), describing how they are used in Catalan and how they are addressed in Easy Language recommendations. Finally, the section outlines the research background that informs this study, identifying areas where further investigation is needed.

2.1. Easy Language

Easy Language (EL) is a language variety that adapts texts at both the linguistic and graphic levels to make information accessible to people who may have trouble reading and understanding standard language (ISO, 2021, p. 2).

In the Catalan context, we can refer to the Inclusion Europe (Inclusion Europe, 1998) or International Federation of Library Associations and Institutions (IFLA, 2012) guidelines. The Spanish Association for Standardisation published a standard (UNE, 2018) that is the main guide for EL practice in Spain, and which is also used as a guide for practice in Catalonia. Although Catalonia and Spain are relatively advanced in terms of EL literature for practitioners, these guidelines have notable shortcomings. For example, the existing literature primarily relies on intuition about text accessibility (Maaß, 2020) and findings from previous studies focused on isolated linguistic elements (Hansen-Schirra et al., 2020). This content therefore often lacks grounding in empirical studies that measure the effects of complexity reduction on cognitive processing in EL texts.

Empirical evidence is therefore needed to determine which adaptations should be recommended in the guidelines (Lindholm & Vanhatalo, 2021, p. 15; Sutherland & Isherwood, 2016, pp. 297-298). The IFLA guidelines for EL in Catalan state: “more scientific research is needed on reading difficulties and the concept of Easy Language” (IFLA, 2012, p. 41). In essence, although research in this field has grown in the past years, it is still not sufficient, as recent literature reviews have suggested (Sutherland & Isherwood, 2016; González-Sordé & Matamala, 2023) and as shown in §2.2.2.

2.1.1. Ellipses and co-reference through null and overt pronouns

Catalan is a null-subject language or pro-drop language (Pérez & Mestre, 2022; Mayol & Clark, 2010). Subjects are omitted more often than objects in several typologically diverse languages (Allen, 2000; Serratrice et al., 2004). In Catalan, it is common to find the subject of the sentence being omitted once it is considered that it can be easily inferred, as exemplified in Table 1. This

occurrence is called "null subject" (Mayol & Clark, 2010). In a broader sense, when a pronoun (subject or not) is omitted for the same reason, it is a "null pronoun" (Mayol & Clark, 2010).

Coherent discourse often includes the repetition of certain concepts. One example of this are anaphors, which are "referential expressions that co-refer with an antecedent found earlier in the same discourse" (Ducrot & Todorov, 2003, p. 323). As it can be observed in Table 1, Catalan regularly uses pronouns as co-referents for different elements of the sentence (IEC, 2022). Some high-frequency overt pronouns are subject pronouns ("*ell, ella, ells, elles*"), direct object pronouns ("*el, la, els, les*"), as well as "*li*" (singular indirect object pronoun), "*en*" and "*hi*" (unstressed or weak pronouns, called "*pronoms febles*" in Catalan).

Null pronoun *The omission of the null pronoun (in this case, a null subject) is marked with [NULL] in the position where an overt subject would normally appear.*	**Overt pronoun** *The position of the overt pronoun in Catalan is marked as [OVERT] in the English translation, since the pronoun used in the example ("li") has no direct equivalent in English.*
[Catalan] La Laura va al mercat cada matí. Avui, [**NULL**] ha comprat taronges. [English] Laura goes to the market every morning. Today, [**NULL**] bought oranges.	[Catalan] La Laura ha comprat taronges. **Li** agraden molt. [English] Laura bought oranges. [**OVERT**] likes them very much.

Table 1. Examples of null and overt pronouns

2.1.2. Subordinate clauses

A subordinate clause does not form a simple sentence by itself and is connected to the main clause of a sentence (Merriam-Webster Dictionary, 2024). Substantive clauses and relative clauses are types of subordinate clauses. As Table 2 illustrates, substantive clauses perform one of the syntactic functions typically associated with a noun phrase, while relative clauses modify the preceding noun or noun phrase (IEC, 2022).

Substantive clause	**Relative clause**
[Catalan] M'ha dit **que vindrà a la tarda**. [English] NULL told me **that NULL will come in the afternoon**.	[Catalan] L'home **que venia cada tarda a la biblioteca** fa molts dies que no ve. [English] The man **that came to the library every afternoon** has not come for a few days.

Table 2. Examples of subordinate clauses

2.1.3. Ellipses, co-reference and subordinate clauses in Easy Language guidelines

The linguistic elements presented (null and overt pronouns, subordinate clauses) are frequent features of standard Catalan, yet their use is discouraged in EL guidelines. To exemplify this, Table 3 presents extracts from the UNE standard on EL (UNE, 2018), as these are the guidelines relevant in both Spanish and Catalan contexts. Nevertheless, the same suggestions are phrased differently in the ISO standard (ISO, 2021).

Recommendations in the UNE standard	**Discouraged linguistic aspects**
"Elliptical constructions should not be used. The reader should not have to make inferences. In any case, omissions should be minimal, and referential identification should be guaranteed. (INCORRECT) Juan bought 2 balls. One for himself and another for his nephew. (CORRECT) Juan bought 2 balls. One **ball** is for himself, and the other is for his nephew." (UNE, 2018, p. 23)	Null and overt pronouns
"The reader should not have to make inferences to understand the text." (UNE, 2018, p. 24)	Null and overt pronouns
"The same word must be used throughout the text to refer to the same object or referent." (UNE, 2018, p. 20)	Overt pronouns
"Simple sentences should be used, and complex sentences should be avoided. If in some cases they cannot be avoided, it is advisable to separate the ideas into different lines. […] NOTE 2: Subordinate clauses can be used, but with moderation and linked with conjunctions commonly used in spoken language." (UNE, 2018, p. 22)	Subordinate clauses

Table 3. Recommendations that refer to the linguistic elements assessed in the study

In summary, EL recommendations advise against co-referencing and using ellipses, elements that force the reader to make inferences. Subordinate clauses and other complex sentences should also be kept to a minimum, in favour of simple sentences.

2.2. Research background

Since only a small number of studies have addressed EL directly (González-Sordé & Matamala, 2023), most research on the linguistic elements and measures relevant to our work come from other contexts. Moreover, no studies have focused on Catalan EL to date.

2.2.1. Relevant linguistic research

Given the lack of research on the linguistic features of EL on readers with intellectual disabilities, empirical studies are essential. A study by Fajardo et al. (2014) assessed linguistic aspects of EL, including the effect of co-referential and inferential information, on students with intellectual disabilities (ID). Participants, aged between 16 and 22 (M = 18.9, SD = 1.84), read EL texts and then performed a reading comprehension test. The study found that the only linguistic feature that was a good predictor of inferential comprehension was the number of sentences. The higher the sentence density, the lower the ability of students with an ID to find relationships between sentences (Fajardo et al., 2014, p. 221). This finding may reflect the reduced ability of students with an ID to effectively store and retrieve information from memory (Wolman, 1991). Other linguistic aspects analysed, such as word frequency and word length, showed no significant effect on comprehension. The authors argue that these results could question the validity of some EL recommendations, such as that of "augmenting word frequency" (Fajardo et al., 2014, p. 212).

While Fajardo et al. focus on word frequency and word length, other research has considered pronominal structures, particularly in pro-drop languages, although they are mostly performed on children (Grinstead et al., 2018; Dickinson et al., 2023; Mazzagio & Shield, 2020). Gristead et al. (2018) argued that the presence of null subjects reflects the challenges Spanish-speaking children with specific language impairments face in acquiring discourse-sensitive constructions. More recently, Dickinson et al. (2023) reported that Spanish children with developmental language disorders use overt subject pronouns less frequently than their typically developing peers in switch-reference contexts, that is, when the subject of the prior finite verb differs from the subject of the current clause. In related work, Mazzagio and Shield (2020) observed that Italian children with autism spectrum disorder (ASD) showed lower accuracy than typically developing children in producing first-, second-, and third-person singular pronouns. These children often substituted nouns or proper names for pronouns, and in marked contexts they displayed a preference for overt pronouns over null pronouns.

On a different note, Loureda et al. (2024) performed an eye-tracking study on neurotypical adults and found that reading times were higher when the co-referent was an overt pronoun than when the element was repeated. For those elements that can be omitted, they found that null pronouns showed lower reading times than overt pronouns (Loureda et al., 2024; Gelormini & Almor, 2011). This could suggest that the presence of null pronouns facilitates reading. Nevertheless, their participant pool did not include the EL target audience, and reading time was shown to be an inconsistent predictor of text comprehension (Wallot et al., 2014).

Finally, few studies have focused on the processing of subordinate clauses. In this regard, studies on neurotypical English-speaking adults showed that working memory plays a significant role in relative clause processing difficulty through reading tasks in which eye movements (Staub, 2010) and comprehension (Roland et al., 2021) were measured. The frequency of the relative embedded clause[1] also affects relative clause processing, as argued in a corpus analysis by Reali and Christiansen (2007).

2.2.2. Empirical research on EL and the case of German Easy Language

Research on EL remains generally limited, with the notable exception of German EL. González-Sordé and Matamala (2023) highlight that while some empirical studies exist, overall, the field lacks sufficient publications and broadly applicable results. Still, several studies in different contexts shed light on how EL adaptations can influence comprehension.

Frondén and Kaakinen (2023) used eye-tracking to study how adults with ID read Swedish EL texts. They found that short, frequent words were read more quickly, while long, infrequent words caused difficulties. However, the small sample size and lack of comparison with neurotypical readers limit the generalisability of these results. In the Spanish context, Fajardo et al. (2013) showed that simplified news texts supported students with mild ID, particularly for literal comprehension. Interestingly, reducing coreferences improved performance, while denser texts hindered inferential comprehension.

Other studies extend the scope beyond the group of users with an ID. Rivero-Contreras et al. (2021) tested visual support and lexical simplification with young adults with and without dyslexia. Both adaptations aided sentence processing, especially for those with lower print exposure and smaller vocabularies. Similarly, Schmutz et al. (2019) examined EL on web usability on neurotypical users. Despite enhanced content recognition, the EL versions were associated with longer reading times, reduced preference ratings, and a decreased likelihood of revisiting

[1] Subordinate clause provides additional information about a noun and is integrated into the main sentence, often modifying a specific element within it.

the webpage, highlighting that improvements for certain users may impose disadvantages on others. Finally, Buell et al. (2020) explored health information comprehension among adults with IDs, focusing on simplified language and mediation. Although neither factor alone improved understanding, combining both produced better results. Their findings suggest that comprehension relies not only on textual form but also on individual language-processing capacities.

In contrast, and as mentioned earlier, EL in Germany has a well-established research tradition and strong legal support. Under German law (BITV 2.0, 2011), German EL is the preferred means of providing accessible written information. Since 2010, it has been the subject of extensive scientific investigation, particularly by the research group Simply Complex – Easy Language, which has applied methods such as eye-tracking and functional MRI to evaluate and refine EL guidelines. Unlike in other variants, German EL is not only guided by practical recommendations but also by rulebooks validated through interdisciplinary research at the University of Hildesheim, where the Research Centre for Easy Language was founded in 2014.

Several studies have offered important insights. Pappert and Bock (2020) confirmed that segmenting compound nouns improved reading performance for adults with ID. Schiffl (2020) compared readers with cognitive impairments to neurotypical readers and found no significant differences in how word frequency, length, and repetition influenced comprehension, suggesting that such factors affect both groups in similar ways.

Despite these advances, studies with individuals with cognitive or sensory impairments remain difficult due to ethical concerns and informed consent requirements. For this reason, most research has relied on eye-tracking (e.g., Gutermuth, 2020), though even this method poses challenges when working with participants with an ID (Deilen & Schiffl, 2020). As these participants often struggle with instructions or communication, their participation requires careful adjustments in study design and implementation, along with sensitivity to ethical issues (Deilen & Schiffl, 2020; Borghardt et al., 2021; Csákvári & Gyori, 2015).

3. Hypotheses

Drawing on the reviewed literature and related work in the field, the present study examines how specific linguistic features of Catalan that are unadvised in EL guidelines, namely null and overt pronouns and subordinate clauses, influence reading comprehension, perceived difficulty, preference, and cognitive effort among adults with and without ID. The following hypotheses are proposed:

H1. The presence of null and overt pronouns makes the text harder to understand for people with an ID.

H2a. People with an ID perceive texts with null and overt pronouns as more difficult to understand and prefer texts without these elements.

H2b. People with an ID perceive texts with subordinate clauses as more difficult to understand and prefer texts without these elements.

H3a. The presence of null and overt pronouns affects the cognitive effort required for text processing.

H3b. The presence of subordinate clauses affects the cognitive effort required for text processing.

4. Study design

We tested these hypotheses across two reading tasks performed in one session. Task 1 focused on null and overt pronouns while Task 2 focused on the presence of subordinate clauses. We

designed a mixed-design experimental study in which we manipulated independent variables within subjects (absence/presence of the linguistic element). The grouping of participants (ID/neurotypical) was a second main independent variable.

Both tasks measured (1) the cognitive effort of text processing (through eye-tracking), (2) perceived text difficulty (through self-reported questions answered through Likert-type scales), and (3) text preference (through open-ended questions). Task 1 assessed one additional measure: the comprehension of the content through open-ended questions. In Task 2, this type of question was not included because the texts used in this experiment were significantly shorter, making it more difficult to assess content comprehension through such questions. Additionally, this decision was made to reduce the risk of participant fatigue, particularly among those in the group with an ID (Deilen & Schiffl, 2020).

It is worth mentioning that we performed a pilot test beforehand with 6 neurotypical participants (average age of 28.5; 5 women and 1 man) which allowed us to make minor adjustments to the stimuli and questions.

5. Method

The study protocol (CEEAH CA40) was approved by Universitat Autònoma de Barcelona in February 2022. The following section outlines the methodological framework, detailing the procedures and tasks included in the study.

5.1. Participants

We initially aimed for 30 participants in each group, however, four users in the group with an ID had to be excluded due to issues with eye-tracking calibration or data collection (a common issue, as presented in Deilen & Schiffl, 2020). The final sample consists of 52 participants (23 men and 29 women; mean age 39.9, *SD* = 14.5), of which 26 have an ID and 26 are neurotypical. The participants with an ID (12 men and 14 women; mean age 44.4, *SD* = 13.2) were recruited through two local non-profit organisations (Som — Fundació, Taller Jeroni de Moragas). The neurotypical participants (11 men and 15 women; mean age 34.8, *SD* = 11.5) were recruited via word-of-mouth. The two groups did not differ significantly in terms of age ($t(25) = 1.276$, $p = 0.213$). Participation was voluntary and unpaid, all participants were Catalan speakers with normal or corrected-to-normal vision, and their identifying data remains confidential.

The formal diagnosis of ID was not requested from the participants. Having an ID was a requirement to be a beneficiary of the collaborating foundations, and this condition was considered sufficient to fulfil the diagnostic criteria. It was verified that none of them had an intelligence level or reading comprehension that significantly deviated from the group using two screening tests (see the results in section 6.1).

5.2. Procedure

Participants first provided written informed consent and completed a demographics form, after which they were encouraged to ask questions or express any concerns. Next, they took part in the reading comprehension screening test (TLC) (Comes, 1990) and the abstract reasoning screening test (Raven's Progressive Matrices [RPM]) (Raven, 1998) in a small group setting. Subsequently, participants completed reading Tasks 1 and 2 in a separate room, accompanied only by the observing researcher. For participants with ID, these two sessions were held on separate days to minimise fatigue (Deilen & Schiffl, 2020) and allow additional time for clarification and support. In contrast, neurotypical participants completed both sessions on the same day.

For Tasks 1 and 2, participants were seated in front of a computer screen and asked to focus on various points on the screen to calibrate the eye-tracker. After each page of stimuli, participants answered either open-ended comprehension questions (for Task 1) or questions about perceived text difficulty (for both Tasks 1 and 2) orally. To reduce memory bias and because the goal was not to assess memory or retrieval, participants were allowed to re-read the text before answering the questions. At the end of each task, participants were asked about their preferred text style.

Task 1 lasted around 15 minutes and for each participant we retrieved a maximum of 13 minutes of recorded eye movements (around 3 minutes per page of stimuli). Task 2 lasted around 20 minutes and for each participant we retrieved a maximum of 17 minutes of recorded eye movements (around 2 or 3 minutes per page of stimuli). The recording of eye movements was paused while the participants answered the perceived difficulty, preference, and comprehension questions and the researcher registered the oral answers in their computer.

Eye-tracking raw data were pre-processed using the vendor's software to identify fixations and saccades. Prior to the main analyses, we examined individual fixation durations and saccadic amplitudes for outliers, using the criterion $\pm 1.58 \times IQR / \sqrt{n}$, where IQR denotes the interquartile range (Chambers, 1983). All outlying values (both fixation durations and saccadic amplitudes) were replaced with the nearest non-outlying value (i.e., the respective maximum or minimum; Wickham et al., 2025). Data cleaning and statistical analyses were conducted in R (R Core Team, 2025).

5.3. Materials

5.3.1. Stimuli

The stimuli in Task 1 included 4 short Brothers Grimm tales taken from a published Catalan EL adaptation (Grimm & Grimm, 2018) that had been validated by the target group of EL, and the texts used did not contain low-frequency words. All the pages shown (four to each participant) had a similar text length (between 75 and 100 words; and between 9 and 12 lines). For Task 1, all texts scored between 87 and 99 (mean = 93.5) on the Fernández Huerta readability index, indicating that they are "easy" (80-89) or "very easy" (90-99) and that they could be suitable for neurotypical children aged 9 to 11. Notably, texts with and without pronouns scored almost identically in terms of readability.

In Task 2, we showed participants 6 short texts on health recommendations for people living in Barcelona, taken from a published booklet in Catalan EL (Agència de Salut Pública, 2023) validated by the target group of EL. The texts also contained no low-frequency words. All the pages shown (six to each participant) had a similar text length (between 35 and 45 words; and between 4 and 7 lines). For Task 2, all texts scored between 73 and 99 on the Fernández Huerta readability index (M = 85.75), suggesting they range from "somewhat easy" (70-79) to "easy" (80-89) and "very easy" (90-99). These texts are considered appropriate for neurotypical children aged 9 to 12. Interestingly, texts with and without subordinate clauses had very similar readability scores, with those containing subordinate clauses scoring slightly higher.

The pages shown in both tasks presented a similar structure and they all appeared in the centre of the screen. Sentences were presented in black 14-point Arial font on a white background, with double-spaced paragraphs.

We created a different version of the tale for each level of the independent variable: one version had null and object pronouns (in Task 1) or subordinate clauses (in Task 2). In the second version, all subjects were explicit and each referent was identified through one word (in Task 1) or the text only consisted of simple sentences (in Task 2), as per EL recommendations.

All participants read the texts in the same order but with differences in terms of the inclusion of the linguistic aspects assessed. Participants saw the same number of pages of each level of the independent variable (2 of each in Task 1, making a total of 4 pages; 3 of each in Task 2, making a total of 6 pages). This was achieved by creating two sets of stimuli for each reading task through a Latin square array.

5.3.2. Evaluation instruments

First, participants signed the consent form, which was written in EL and read aloud by the researcher, if requested by the participant. Then, they filled out the demographics form, where they reported their age, gender, whether they had any non-corrected vision problems, and whether they knew about EL. After that, we used a reading comprehension screening test (TLC) (Comes, 1990) and an intelligence and abstract reasoning screening test (Raven's Progressive Matrices [RPM]) (Raven, 1998) to collect data on these aspects for each participant. Both screening tests took about one hour per participant in total and were performed prior to the experiment. TLC and RPM were applied in group sessions, with the users answering the questions autonomously and individually. Participants answered in silence by circling the response on their piece of paper (both screening tests followed an "a, b, c" choice structure). All participants knew how to read autonomously, and they were always allowed to ask the researcher for assistance.

Task 1 assessed text comprehension using 12 low-difficulty, open-ended questions (three per page across four pages). These questions required participants to recall information directly from the text (Fajardo et al., 2014), specifically referents, subjects or objects. Participants completed the task individually, accompanied by the researcher, and answered the questions orally. An example is provided below.

Text A *Explicit referent; no null or overt pronouns.*	**Text B** *Null and overt pronouns.*
[Catalan] (...) Aleshores, una pagesa va passar pel carrer i va cridar: "venc melmelada!" El sastre va convidar **la pagesa** a pujar a casa. [English] (...) Then a peasant woman passed by on the street and shouted: "I'm selling jam!" The tailor invited **the peasant woman** up to the house.	[Catalan] (...) Aleshores, una pagesa va passar pel carrer i va cridar: "venc melmelada!" El sastre **la** va convidar a pujar a casa. [English] (...) Then a peasant woman passed by on the street and shouted: "I'm selling jam!" The tailor invited **her** up to the house.
Question: Who entered the tailor's house?	

Table 4. Extract from Task 1 stimuli and example of a comprehension question

Perceived difficulty was assessed in both tasks through a Likert scale (Yaneva et al., 2016), which presented options from 1 to 4 to avoid a neutral answer. Again, the participants answered these questions individually and orally:

> Did you find the text difficult to read?
>
> 1) Not at all, it was easy. 2) Not very. 3) I struggled a little bit. 4) I struggled a lot.

Finally, participants were asked an open question on their preference at the end of both tasks

after being shown (1) a short text with null and full pronouns (Task 1) or with subordinate clauses (Task 2) and (2) another without those elements. Participants answered individually and orally to the question "which one of these pages do you prefer?"

5.3.3. 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 instructed to stay still while completing the test. Viewing was binocular, and the movements of both eyes were recorded. Participants were seated approximately 60 cm away from the 43 cm diagonal display size monitor with a screen resolution of 1280 x 1024 pixels. The Tobii T60 eye tracker was controlled by a laptop computer, and another laptop computer was used to record the participant's answers in a digital document.

5.4. Eye movements and eye-tracking measures

Eye movements are directly influenced by different text elements, like linguistic complexity, which "leads to increased fixation duration and decreased saccade length" (Borghardt et al., 2021, p. 4). Eye movements can be a useful indicator of the reader's cognitive processes (e.g., Rayner, 1998), although they cannot be the only measure used when assessing text processing and reading comprehension (Boland, 2004) and should be combined with data retrieved through different methods (Van Gog et al., 2005). In our study, eye-tracking data is complemented with the results from the perceived difficulty and preference questions. Additionally, for the task on null and overt pronouns, it is complemented with results from comprehension questions.

Eye-tracking measures are categorised as either global or local, each serving distinct analytical purposes. While local measures (e.g., first-fixation duration) reveal detailed cognitive processes influenced by reading ability over small segments, global measures summarise reading behaviour over larger text segments like sentences and capture overall patterns, including differences between readers of varying skill levels (Mézière et al., 2023). Since global measures also predict reading comprehension (Southwell et al., 2020; D'Mello et al., 2020) and local measures have uncertain predictive value, our study focused on global measures. We analysed fixation count and average fixation duration, widely used indicators of cognitive processing effort (see, for example, Just et al., 1982), along with the *K* coefficient to assess the ambient and focal attention.

- Ambient/focal attention captured by the second-order metric; *K* coefficient of ambient-focal attention measures the dynamics of visual attention. A K below 0 indicates ambient processing, and one above 0 indicates focal processing (Krejtz et al., 2016; Krejtz et al., 2014). Ambient attention relates to awareness of the peripheral visual field, while focal attention allows individuals to perceive fine details in the central visual field. Focal processing reflects deeper attention and active information processing (Trevarthen, 1968; Eisenberg & Zacks, 2016). Research indicates that longer fixation durations and shorter saccade amplitudes are characteristic of focal vision (Helmert et al., 2005; Krejtz et al. 2012), which may indicate greater linguistic complexity (Borghardt et al., 2021, p. 4).
- Number of fixations refers to the total number of fixations in one area (Clifton et al., 2007; Duchowski, 2007) and a greater number of fixations indicates a need for more time to process text (Rodríguez et al., 2025). In the present study, we calculated the number of fixations for the whole text.
- Average fixation duration (in milliseconds) is the duration of a single fixation, on average (White et al., 2022; Duchowski, 2007). Slower cognitive processing tends to show longer

fixations (He et al., 2015; Borghardt et al., 2021). Rare or unfamiliar words, which lack stored entries in our mental lexicon, are processed through the slower sublexical route. This involves step-by-step decoding via grapheme-phoneme rules, making it more time-consuming than direct lexical access. As a result, long and uncommon words tend to produce the longest gaze times as they are harder to process (Tiffin-Richards & Schroeder, 2015).

We determined distinct areas of interest (AOIs) across the different pages of our stimuli (see Image 1). As pictured in the example in Image 1, our AOIs were drawn around each sentence. Working with texts in EL allowed us to make the AOIs also consist of one line of text, as the texts were structured with one unit of meaning or sentence per line, as recommended in the guidelines and standards (ISO, 2021; UNE, 2018). Everything outside of the AOIs was considered "whitespace", as our stimuli only consisted of text.

The area designated as "whitespace" was included to track participants' eye movements and gaze behaviour across the page (Bruckmaier et al., 2019). Other studies have included whitespace as part of the areas analysed to assess attention patterns (Kim et al., 2012; Wei et al., 2018). Previous research have used the gaze on whitespace as an indicator of cognitive effort (Ferreira et al., 2008; Renkewitz & Jahn, 2010; Scholz et al., 2018; Johansson et al., 2022). This is based on the idea that shifting one's gaze away from the material aids in retrieving information held in short-term memory.

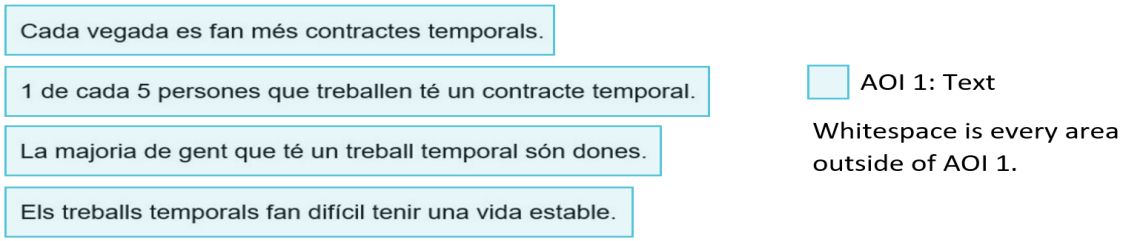

Image 1. Areas of interest in a page of stimuli from Task 2

6. Results

After reporting the results of the screening tests, results of Task 1 and Task 2 will be presented separately.

6.1. Screening tests

Screening tests confirmed that there were no intra-group outliers in the resulting data. Performance on the TLC reading comprehension test showed a significant difference: Participants with an ID achieved an average of 33.7% correct answers (*SE* = 0.829), while the neurotypical group scored 85.8% (*SE* = 0.443). This difference was significant, $t(52) = 17.198$, $p < 0.001$.

The ID group answered 62.9% of the questions correctly on the RPM test on abstract reasoning and intelligence (*SE* = 1.604), whereas the neurotypical group obtained 95.1% on the RPM (*SE* = 0.374). Again, the difference was statistically significant ($t(52) = 6.54$, $p < 0.001$).

6.2. Task 1: null and overt pronouns

First, we will present the results of the comprehension, perceived difficulty, and preference questions. Then, we will move on to the results of the eye-tracking metrics. The analysis of comprehension, perceived difficulty, and preference employed the two-way mixed-design (2 x

2 x 2) analysis of variance (ANOVA) followed by pairwise comparisons with Turkey's range test (HSD) correction for multiple comparisons if necessary.

The ANOVA on comprehension questions proved statistically significant for the main effects of the group ($F(1, 620) = 106.323$, $p < 0.001$, $\eta^2 = 0.145$), while neither the main effect of the presence of pronouns ($F(1, 620) = 0.102$, $p = 0.337$, $\eta^2 = 0.001$) nor the interaction term of both variables was statistically significant ($F(1, 620) = 1.437$, $p = 0.230$, $\eta^2 = 0.001$). When there were full and overt pronouns in the text, the group with an ID scored the lowest ($M = 67.94\%$, $SE = 0.025$).

The results on perceived text difficulty revealed that the group variable showed a significant effect ($F(1, 204) = 69.221$, $p < 0.001$, $\eta^2 = 0.248$), while the presence of pronouns ($F(1, 204) = 2.433$, $p = 0.120$, $\eta^2 = 0.008$) and the interaction of both of the variables ($F(1, 204) = 2.433$, $p = 0.120$, $\eta^2 = 0.008$) showed no significant effect on perceived difficulty. In general, the group with an ID perceived the texts as more difficult ($M = 1.94$, $SE = 0.109$) than the neurotypical group ($M = 1.03$, $SE = 0.018$).

Finally, the results of the preference questions showed no significant intra-group difference ($F(1, 150) = .266$, $p = 0.109$, $\eta^2 = 0.05$). Most participants in both groups (ID = 80.7%, neurotypical = 65.3%) showed no clear preference between a text with null and overt pronouns and without these elements.

6.2.1. Eye movements

A 2 (group: ID vs typical) x 2 (pronouns: included vs omitted) x 2 (AOI type: text vs whitespace) mixed design ANOVA was employed to analyse the eye-movement metrics (*K* coefficient, number of fixations, and average fixation duration).

Regarding differences in ambient and focal attention, there was a significant effect of group ($F(1, 50) = 9.05$, $p = 0.004$, $\eta^2 = 0.112$). The attention of the group with an ID was less ambient ($M = -0.039$, $SE = 0.065$) than the neurotypical group ($M = -0.328$, $SE = 0.07$). There was a significant effect of AOI type, ($F(1, 50) = 31.05$, $p < 0.001$, $\eta^2 = 0.020$). Not surprisingly, both groups were, on average, less ambient while reading text ($M = -0.078$, $SE = 0.05$) than when looking at whitespace ($M = -0.289$, $SE = 0.053$).

The interaction effect between the group and AOI type was also statistically significant ($F(1, 50) = 9.34$, $p = 0.004$, $\eta^2 = 0.020$) (see Figure 1). When reading text AOI, the group with an ID was significantly more focal ($M = .124$, $SE = 0.068$) than the neurotypical group ($M = -0.280$, $SE = 0.073$), ($t(50) = 4.03$, $p < 0.001$). The group with an ID showed ambient processing on whitespace ($M = -.203$, $SE = .072$) and focal processing on text ($M = .124$, $SE = .068$).

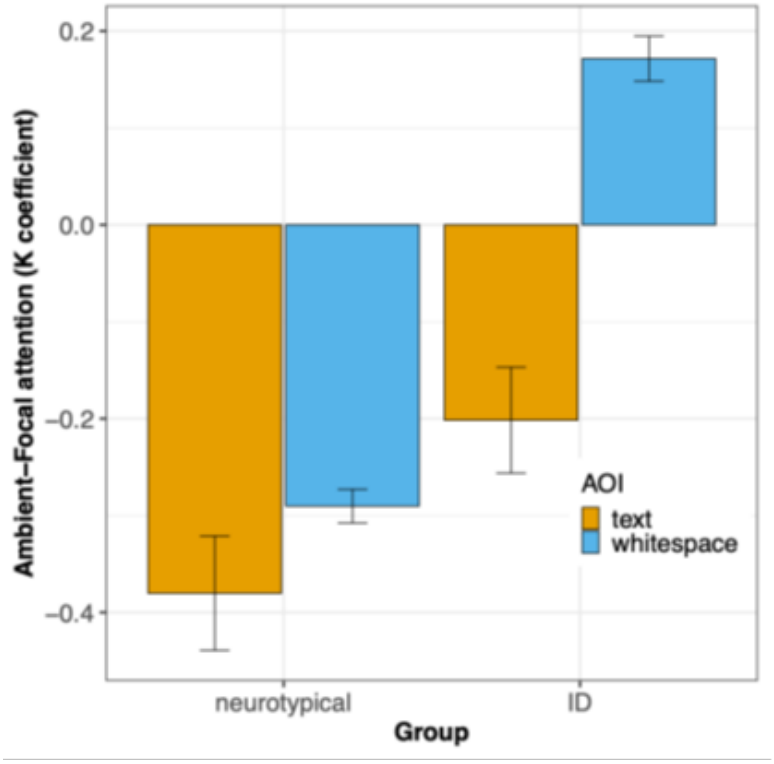

Figure 1. Ambient and focal attention (K coefficient) depending on group and AOI type in Task 1. Bar heights represent mean values of K coefficient; whiskers indicate the 95% confidence intervals for the means.

The ANOVA for the number of fixations as a dependent variable showed a significant effect of group ($F(1, 50) = 6.21$, $p = 0.016$, $\eta^2 = 0.062$). The group with an ID performed more fixations ($M = 17.40$, $SE = 2.02$) than the neurotypical group ($M = 10.00$, $SE = 2.19$). The analysis also revealed a significant main effect of AOI type ($F(1, 50) = 28.82$, $p < 0.001$, $\eta^2 = 0.057$). Both groups, on average, exhibited significantly more fixations on whitespace ($M = 18.44$, $SE = 2.67$) than on text ($M = 8.99$, $SE = 0.62$).

Also, we observed a significant interaction between the inclusion of pronouns and AOI type, ($F(1, 50) = 4.94$, $p = 0.031$, $\eta^2 = 0.005$), as illustrated in Figure 2. The pairwise comparisons decomposing this interaction term revealed a significant difference in the number of fixations in the text depending on the inclusion of null and overt pronouns with a significantly higher number of fixations on texts without these elements ($M = 9.39$, $SE = 0.641$) than those that included them ($M = 8.58$, $SE = 0.631$), ($t(50) = 3.18$, $p = 0.002$). Both groups also demonstrated a statistical tendency for a higher number of fixations on whitespace when the text had null and overt pronouns ($M = 20.03$, $SE = 3.07$) than when it did not ($M = 16.84$, $SE = 2.54$) ($t(50) = 1.75$, $p = 0.085$). These results may denote effort in visual processing (Rodríguez et al., 2025) of texts without pronouns.

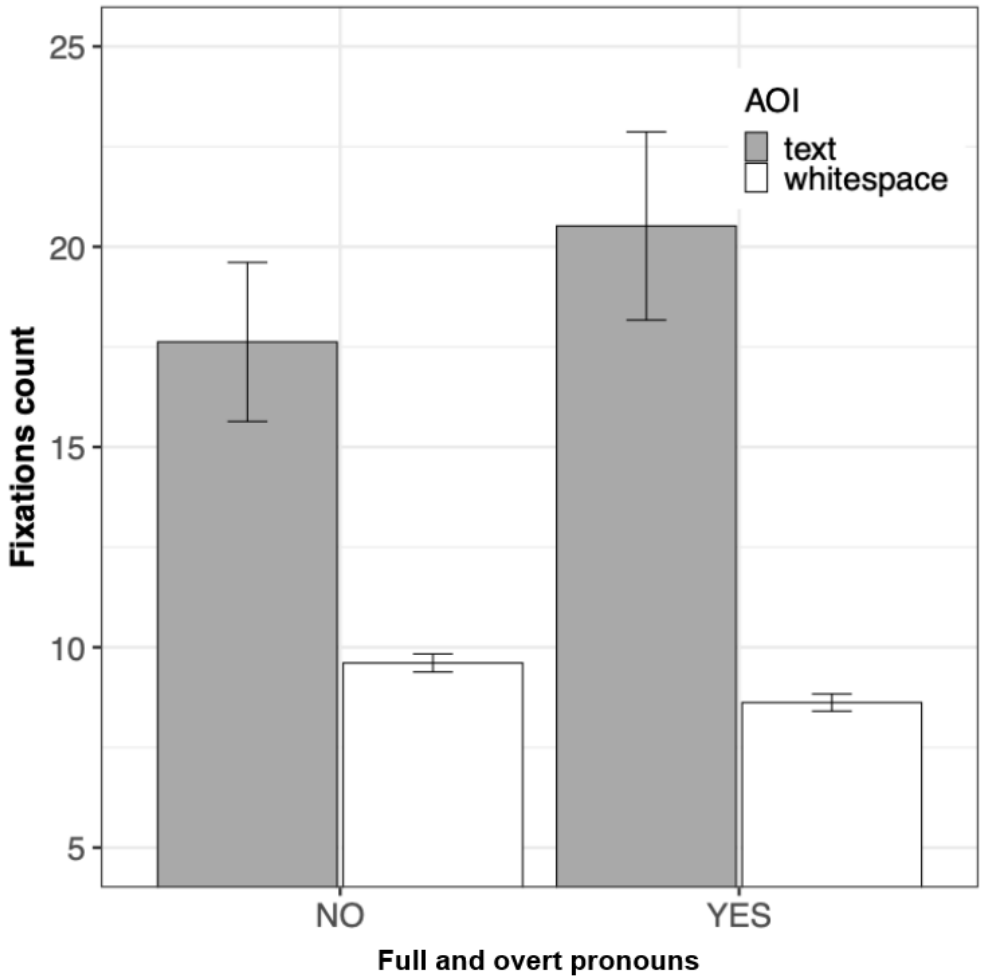

Figure 2. Number of fixations depending on AOI type and inclusion of pronouns in Task 1. Bar heights represent mean values of fixation count; whiskers indicate the 95% confidence intervals for the means.

The analysis for average fixation duration as a dependent variable revealed a significant main effect of the group ($F(1,50) = 18.43$, $p < .001$, $\eta^2 = .219$), with longer average fixation duration in the group with an ID (M = 327ms. SE = 12.70) than in the neurotypical group (M = 247ms., SE = 13.70). There was also a statistically significant main effect of AOI ($F(1,50) = 28.82$, $p <.001$, $\eta^2 = .057$), with longer average fixation durations for text (M = 306ms. SE = 10.50) than for white space (M = 269ms., SE = 9.43). Finally, the interaction effect of the group and AOI was obtained only on the marginally significant level, $F(1,50) = 3.97$, $p = .052$, $\eta^2 = .008$). Pairwise comparison for this effect revealed slightly larger differences in average fixation duration on text (M = 353ms., SE = 14.30) and white space (M = 302ms., SE = 12.80) in the group with an ID than a difference in average fixation duration on text (M = 259ms., SE = 15.40) and white space (M = 235ms., SE = 13.80) in the neurotypical group, as illustrated in Figure 3.

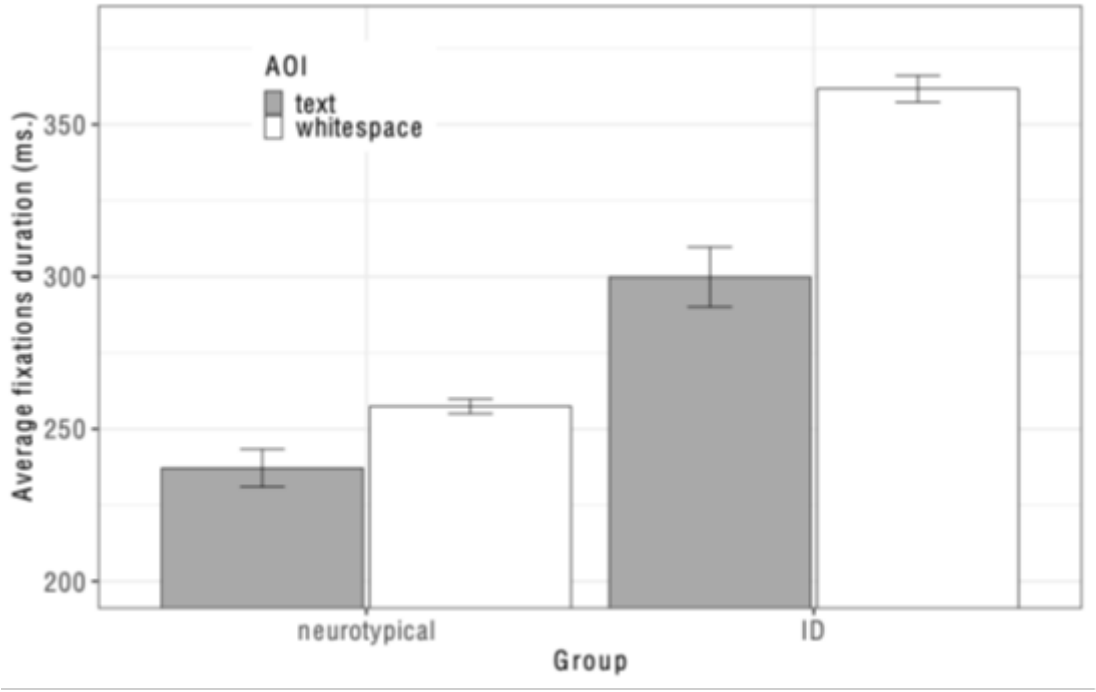

Figure 3. Average fixation duration depending on AOI type and group in Task 1.
Bar heights represent means; whiskers indicate the 95% confidence intervals for the means.

In summary, the group and AOI type (text vs. whitespace) showed meaningful differences in the number of fixations, and visual attention mode: ambient vs focal. The analysis of ambient and focal attention indicated that when reading text, the group with an ID showed more focal attention than the neurotypical group. This effect was independent of the type of text (inclusion of pronouns). We observed that the inclusion of null and overt pronouns yields more fixations on whitespace, which is one of the indicators of cognitive load.

We demonstrated that participants in the ID group in general exhibited significantly more and longer fixations which might be an indicator of deeper cognitive involvement in task completion in this group. That is especially visible in the analysis of eye movements located on the text.

6.3. Task 2: subordinate clauses

The results will be reported following the same structure as for Task 1. Data on the perceived text difficulty was analysed through a two-way ANOVA, with group and text type (with or without subordinate clauses) as independent variables. The group showed a significant effect ($F(1, 308) = 34.977$, $p < 0.001$, $\eta^2 = 0.101$). In general, the ID group perceived the texts as more difficult ($M = 1.67$, $SE = 0.77$) than the neurotypical group ($M = 1.17$, $SE = 0.35$). The presence of subordinate clauses, on the other hand, showed no significant effect ($F(1, 308) = .274$, $p = 0.600$, $\eta^2 = 0.008$); nor did the interaction of both variables ($F(1, 308) = .005$, $p = .940$, $\eta^2 < 0.001$).

The participants' preference (between texts with or without subordinate clauses) showed a significant intra-group difference ($F(1, 150) = 73.529$, $p < 0.001$, $\eta^2 = 0.100$). All 26 neurotypical participants and most participants with an ID (65.4%) expressed no preference.

6.3.1. Eye movements

A series of 2 (group: ID vs typical) x 2 (subordinate: included vs omitted) x 2 (AOI type: text vs white space) mixed-design ANOVA was conducted with eye-movement related metrics as dependent variables (*K* coefficient, number of fixations, and average fixation duration).

Regarding ambient and focal attention, it yielded a significant effect of the group ($F(1, 47) = 27.48$, $p < .001$, $\eta^2 = .256$). The ID group was less ambient ($M = -0.197$, $SE = 0.079$) than the neurotypical group ($M = -0.799$, $SE = 0.084$). There was also a significant main effect of AOI ($F(1, 47) = 36.14$, $p < .001$, $\eta^2 = 0.133$). Both groups were less ambient while reading text ($M = -0.296$, $SE = 0.053$) than when looking at a whitespace ($M = -0.698$, $SE = 0.078$). The results corroborate those from the first task. Interestingly, the analyses revealed marginally significant 3-way interaction of group, AOI and subordinate clauses ($F(1, 47) = 3.30$, $p = .076$, $\eta^2 = 0.008$). The pairwise comparisons showed that the neurotypical group exhibited a significantly higher *K* coefficient ($M = -0.474$, $SE = 0.079$) when reading text with clauses than text without clauses ($M = -0.631$, $SE = 0.084$). The effect is shown on Figure 4.

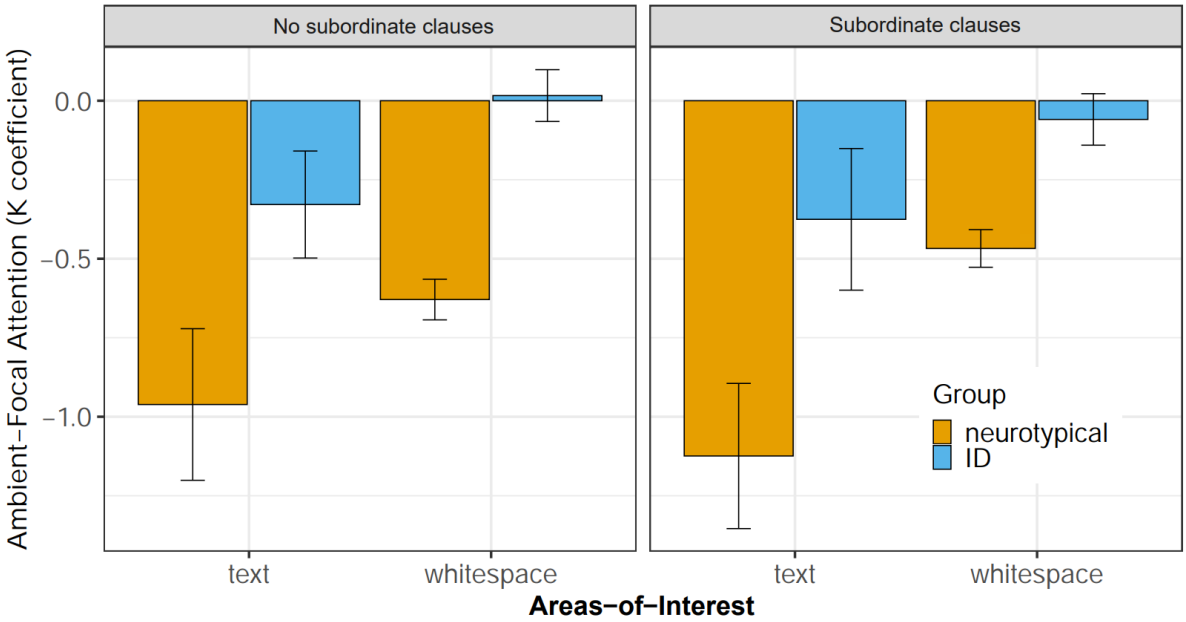

Figure 4. Ambient-Focal attention in both groups while reading text or looking at whitespace. Bar heights represent mean values of K coefficient; whiskers indicate the 95% confidence intervals for the means.

Next, we analysed the differences in the number of fixations. The analysis revealed that the group with an ID had more fixations ($M = 217.50$, $SE = 22.50$) than the neurotypical group ($M = 83.20$, $SE = 24.0$), ($F(1, 47) = 16.66$, $p < 0.001$, $\eta^2 = 0.171$).

The group with an ID also had a longer average duration of fixations ($M = 442$, $SE = 20.00$) than the neurotypical group ($M = 294$, $SE = 21.3$), ($F(1, 47) = 25.50$, $p < 0.001$, $\eta^2 = .278$). The interaction between AOI type and group indicates that participants with an ID had much longer fixations on the text ($M = 499$, $SE = 24.8$) than on whitespace ($M = 384$, $SE = 19.8$), $t(47) = 5.64$, $p < 0.001$. This difference was not statistically significant for neurotypical participants, ($t(47) = 1.50$, $p = 0.139$) (see Fig. 5).

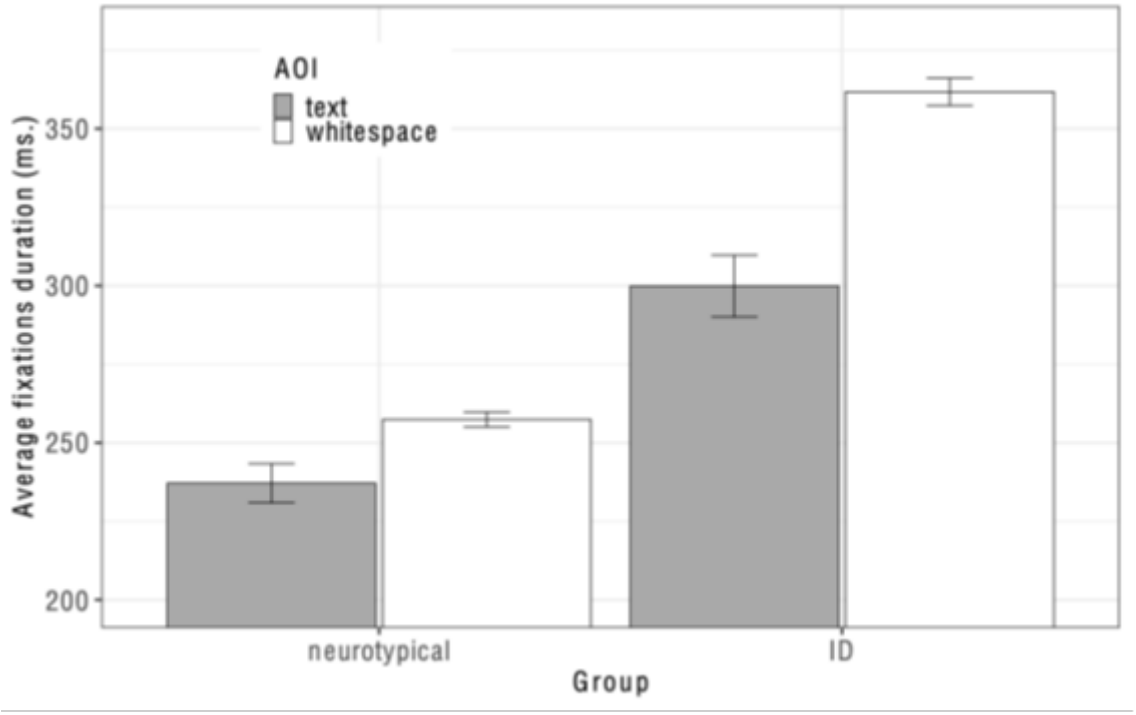

Figure 5. Average fixation duration results of Task 2.
Bar heights represent mean values of average fixation duration;
whiskers indicate the 95% confidence intervals for the means.

In summary, we found systematic differences between participants with an ID and their neurotypical counterparts. The group with an ID was less ambient and had more frequent and longer fixations while reading the text than the neurotypical group. We did not observe any significant differences due to the presence or absence of subordinate clauses.

7. Discussion and conclusions

This study examined linguistic elements often discouraged by EL guidelines. There is ongoing expert debate regarding the effectiveness of these adaptations, as most guidelines are primarily rooted in practice and intuition rather than empirical evidence. The study aims to help bridge this gap. In the following section, we address our hypotheses based on the empirical results of the present study.

H1. The presence of null and overt pronouns makes the text harder to understand for people with an ID.

In Task 1, comprehension was assessed through open-ended questions. The results showed that H1 was not supported, as there was no significant effect of null or overt pronouns on comprehension in either the group with an ID or the neurotypical group ($F(1, 620) = 0.102$, $p = 0.337$, $\eta^2 = 0.001$). Therefore, we cannot conclude that these elements are either detrimental or beneficial for content comprehension in either group. This finding calls into question whether such pronouns could, in fact, be used in Catalan EL texts without impairing comprehension.

H2a. People with an ID perceive texts with null and overt pronouns as more difficult to understand and prefer texts without those elements.

H2b. People with an ID perceive texts with subordinate clauses as more difficult to understand and prefer texts without those elements.

These aspects were assessed using a Likert scale for perceived difficulty, along with direct preference questions. Hypothesis H2a was not supported: 80.7% of the group with an ID showed no preference regarding the inclusion or omission of null and overt pronouns and no significant differences were observed in either group's perception of text difficulty based on the inclusion of these elements ($F(1, 204) = 2.433$, $p = 0.120$, $\eta^2 = 0.008$). H2b is also false, as 65.4% of the group with an ID showed no preference and the inclusion of subordinate clauses did not significantly affect perceived difficulty in either group ($F(1, 308) = .274$, $p = 0.600$, $\eta^2 = 0.008$).

H3a. The presence of null and overt pronouns affects the cognitive effort required for text processing.

H3b. The presence of subordinate clauses affects the cognitive effort required for text processing.

These aspects were evaluated using eye-tracking data, which supported hypothesis H3a by revealing significant differences related to the inclusion of null and overt pronouns. For both groups, texts containing null and overt pronouns elicited more fixations on whitespace ($M = 20.03$, $SE = 3.07$) than texts without these elements ($M = 16.84$, $SE = 2.54$), ($t(50) = 1.75$, $p = 0.085$). Conversely, texts without null or overt pronouns prompted more fixations on the text itself ($M = 9.39$, $SE = 0.641$) compared to texts that included them ($M = 8.58$, $SE = 0.631$), ($t(50) = 3.18$, $p = 0.002$). This indicates that texts without null or overt pronouns require greater cognitive effort to process (Rodríguez et al., 2025), which contradicts the recommendations outlined in EL guidelines. On the other hand, H3b was not supported because the presence of subordinate clauses had no significant effect on eye movements. Additionally, there were no significant interactions between the linguistic elements and the group.

The study has also provided some relevant findings outside of the scope of our initial hypotheses. To begin with, the group (ID/neurotypical) is the only variable that consistently showed a significant effect on almost all measures, as expected. Regarding ambient-focal attention, while the neurotypical group showed ambient attention in all cases, the group with an ID was always more focused on the text. Overall, the group with an ID also showed both a greater number of fixations and longer fixations durations.

The study's findings indicate no discernible differences regarding the use of subordinate clauses in EL across the variables analysed. In contrast, the results offer some support for the use of pronouns, aligning with and complementing Loureda et al. (2024), who suggested that the presence of null pronouns facilitates reading for neurotypical adults. The present findings contradict established EL guidelines (see section 2.1.3). Specifically, the inclusion of simple sentences had no measurable effect on any variable. Furthermore, the omission of null and overt pronouns was shown to hinder reading in both groups, as evidenced by more fixations on the text, indicating increased cognitive effort. However, this omission did not significantly affect either group's performance on comprehension questions.

Despite the contributions of the present study, several limitations should be acknowledged, that suggest avenues for future research. In Task 2, processing difficulty was measured exclusively through eye-tracking, preference ratings, and perceived difficulty questions, without including comprehension questions. While the choice for this approach is explained in section 4, adding comprehension measures could have further enriched the analysis. Another limitation is the relatively small sample size. Ethical constraints regarding participants with an ID, combined with the need for a controlled environment for eye-tracking, required careful planning and extended recruitment time, which limited the number of participants. Future studies should aim to replicate this work with a larger pool of participants. Furthermore, no previous study

was fully comparable to the present one, suggesting the need for replication studies both of prior research and of the current study itself. Future research could also explore additional eye-tracking measures and study other features or target users of EL. Comparing results across languages with frequent use of null and overt pronouns and subordinate clauses could provide additional insights. To control for order effects in future studies, the texts should be presented in a randomized text order, addressing a limitation of the current design.

Although we cannot yet draw definitive conclusions regarding specific EL guideline recommendations, the present study underscores the value of empirically testing EL and opens new avenues for research. No clear benefits were observed from following the EL recommendations concerning null and overt pronouns or the use of subordinate clauses. We hope these results inspire much-needed future studies with larger participant samples, examining additional linguistic or graphic elements of EL or different target groups.

Conflict of interests and data availability statement

Authors declare no financial or proprietary interests. The data and analysis scripts related to the reported results are available on OSF: https://osf.io/md6g7/overview?view_only=c90295d6d1cc44708abb3dc4aca762a0

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