

A Tool Suite for Cognitive Accessibility Leveraging Easy-to-Read Resources and Simplification Strategies

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Abstract

In an increasingly information-driven world, ensuring equitable access to this information is a right, particularly for individuals with cognitive impairments, intellectual disabilities, older adults, those with low literacy levels, and non-native language speakers. The HULAT research group has addressed this need by developing a suite of tools and resources aimed at content simplification, thereby facilitating understanding and access to critical information in areas such as e-government, health, and education. This article introduces two main tools: EASIER, focused on lexical simplification, and Access2meet, an accessible videoconferencing solution, alongside the EASIER corpus, which has been enriched through annotation and validation by experts and individuals with intellectual disabilities. These technologies incorporate Natural Language Processing (NLP) and Artificial Intelligence (AI) approaches and specific datasets in easy reading, highlighting the importance of direct participation by disabled individuals in the development of accessible technologies.

Keywords

Accessibility, easy-to-read, text simplification, subtitling

1. Introduction

In today's world, where information drives much of our daily interactions and access to services, equitable access to this data must be accessible for all. This need transcends the general population, touching the lives of those individuals with cognitive impairments, intellectual disabilities, the ageing population, those with limited literacy skills, and non-native speakers. The rapid proliferation of digital content, coupled with the complexities of navigating the Internet, often presents significant barriers to these groups, limiting their ability to participate fully in society.

Addressing these challenges requires more than just incremental improvements in existing technologies; it necessitates a fundamental rethinking of how we design and disseminate information. The HULAT¹ research group, knowing this need, has developed tools and resources dedicated to simplifying complex content. Their work focuses on ensuring that critical information, especially in essential domains such as e-government, health, and education, becomes accessible to everyone, irrespective of their cognitive or linguistic capabilities.

The paper introduces the results of their research: the EASIER and Access2meet tools alongside the EASIER corpus. EASIER is a tool that zeroes in on the lexical simplification of texts, incorporating resources in easy reading and plain language to make content more understandable. Access2meet, on the other hand, offers an accessible videoconferencing solution that bridges the gap in digital communication, ensuring that meetings and content are accessible to all. Complementing these tools is the EASIER corpus, a resource enriched through annotation and validation by experts and individuals with intellectual disabilities, as well as resources in easy reading and plain language, highlighting the importance of creating content that is comprehensible for all, including those with disabilities.

The integration of Natural Language Processing (NLP) and Artificial Intelligence (AI) in these technologies, coupled with the utilization of specific datasets tailored for easy reading, underscores a commitment to innovative problem-solving. Moreover, the emphasis on direct participation by disabled individuals in the development process highlights a shift towards more inclusive technology design philosophies.

This comprehensive approach not only seeks to address the immediate challenges faced by individuals with cognitive and learning disabilities but also paves the way for a more inclusive digital future. Through the detailed exploration of the EASIER and Access2meet tools and the EASIER corpus, this paper aims to shine a light on the critical work being done at the intersection of accessibility, technology, and social inclusion.

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¹<https://hulat.inf.uc3m.es/>



Figure 1: User Interface of the EASIER Tool.

2. EASIER: Lexical simplification tool for Intellectual Disability

The Easier system²³ provides a specialized tool designed to enhance the understanding and readability of text content for individuals with intellectual disabilities. This approach combines methods from the disciplines of Artificial Intelligence (AI) and Human-Computer Interaction to generate accessible interfaces with simplified texts. Specifically, the system employs Natural Language Processing (NLP) techniques and resources from the domains of Easy Reading and Plain Language to assess and classify words in Spanish texts as complex or straightforward.

The process begins when a user inputs Spanish text into a textbox. The Easier system identifies complex words within the text, highlighting them for easy recognition (see Figure 1). Upon hovering over these highlighted words, the system displays a tooltip that suggests a simpler replacement or synonym, effectively aiding the user in improving their reading and comprehension skills. To further assist, the system provides a variety of resources

for each identified complex word, including synonyms, definitions, and pictograms tailored to the word's context. These invaluable resources are consolidated into a Glossary facility specifically aimed at supporting people with intellectual disabilities.

The foundation of the Easier system is a robust machine learning model that has been extensively trained using a wide array of texts annotated by experts in Spanish Easy Reading and Plain Language and validation with individuals with disabilities [1] as well as the use of the EASIER corpus that is described in section 3.

To ensure the generation and selection of contextually appropriate synonyms, a comprehensive suite of tools, including dictionaries, semantic similarity techniques, and paraphrasing resources, was developed. Additionally, for the critical task of providing accurate definitions for complex words within their specific contexts, a disambiguation process using the BERT (Bidirectional Encoder Representations from Transformers) word embedding model was employed [2].

The Easier system draws its definitions from authoritative sources such as the "Diccionario Fácil"⁴ (Easy Dictionary) for Easy Reading definitions and the Royal Spanish

²<http://easier.hulat.uc3m.es/>

³<https://github.com/LURMORENO/easier>

⁴<https://www.diccionariofacil.org/>

Academy (RAE) dictionaries⁵. For the visual representation of concepts, pictograms supplied by ARASAAC⁶ are utilized, further enhancing the system's accessibility.

In designing the Easier user interface, Web Content Accessibility Guidelines (WCAG) and the guidelines established by the "Cognitive and Learning Disabilities Accessibility Task Force (W3C-COGA)" were followed [3]. Additionally, specific Design Patterns were employed to optimize the system's design for cognitive accessibility, ensuring that it meets the highest standards of accessibility and usability [4]. The web user interface of the Easier system boasts a responsive design, making it accessible on a wide range of devices, from desktop computers to mobile devices. Moreover, to extend the system's utility, extensions for Chrome and Mozilla browsers have been developed.

The EASIER system was evaluated by individuals with intellectual disabilities and older people. Fifty participants were recruited in partnership with an organization serving people with intellectual disabilities. The evaluation indicated that the chosen texts were more challenging for those with intellectual disabilities than for older adults, suggesting the proposal was more beneficial for the intellectually disabled group [5].

3. EASIER corpus: A resource for people with cognitive impairments

The proliferation of accessible information presents challenges for individuals with ageing-related or intellectual disabilities, as well as for non-native speakers who encounter difficulties in reading comprehension. To address these challenges, text simplification emerges as a crucial tool for improving information accessibility. The application of Natural Language Processing (NLP) techniques, often involving machine learning, requires resources such as corpora for the development and validation of lexical simplification methods. Motivated by this need, the EASIER Corpus⁷ has been developed as a resource aimed at fostering lexical simplification strategies for Spanish texts without being confined to any specific domain [6]. This corpus, resulting from the collaboration of three expert Spanish-speaking annotators from Plena Inclusión Madrid⁸ and Grupo Amas Fácil⁹, comprises 260 diverse news articles from the "60 y más" magazine¹⁰. These articles span a broad array of topics and maintain domain

⁵<https://www.rae.es/>

⁶<https://arasaac.org/>

⁷https://github.com/LURMORENO/EASIER_CORPUS

⁸<https://plenainclusionmadrid.org/>

⁹<https://amasfacil.org/>

¹⁰<https://imsero.es/el-imsero/documentacion/publicaciones/publicaciones-periodicas/60-mas>

independence, with an average of 15 sentences per document, rendering the EASIER corpus a highly adaptable resource. It includes 260 documents with 8,155 complex words and 5,130 words associated with context-aware synonyms, all annotated in accordance with easy-to-read standards.

To facilitate the annotation process, sixteen guidelines were established to differentiate between complex and simple words, thereby enhancing the corpus's utility and supporting subsequent annotations. The criteria for identifying complex words encompass uncommon vocabulary, syllable complexity, technical jargon, and abstract terms. Utilizing their extensive experience in converting conventional texts into formats that are easier to read, the annotators manually adapted the texts through a methodology that actively involved individuals with intellectual disabilities throughout the process.

The validity of the corpus was verified through an inter-annotator agreement test, resulting in a Fleiss Kappa coefficient of 0.641, which signifies a moderate level of agreement among annotators. Furthermore, a qualitative evaluation with 45 users, including those with intellectual disabilities and older adults, demonstrated moderate effectiveness in complex word identification and considerable approval for the suggested synonyms.

4. Access2meet: Patient-Centered Videoconference Tool

Since the COVID-19 pandemic began, video conferencing tools have become deeply embedded in our daily routines, emphasizing their role as vital conduits for social inclusion. Research by Transparency Market Research forecasts that the value of the video conferencing market is set almost to double its 2019 figure, reaching an estimated \$11.56 billion by 2027. However, concerns have arisen regarding the accessibility of these tools for people with disabilities. Studies highlight a significant gap in accessibility for these individuals [7] [8] [9]. These technologies involve interaction with people through user interfaces, and this implies designing accessible user interfaces that ensure access and management of systems and their contents for all people regardless of their visual, auditory, cognitive, or motor abilities. Videoconferencing systems should be designed following accessibility standards and User Experience (UX) requirements to ensure access to people with disabilities. Intuitive user interfaces, text simplification, and summarization services, and subtitling are essential accessibility requirements that must be met.

ACCESS2MEET is a project focused on the application of accessibility techniques in designing interactive video conferencing systems for all users, including those with disabilities. This interdisciplinary research draws on Nat-

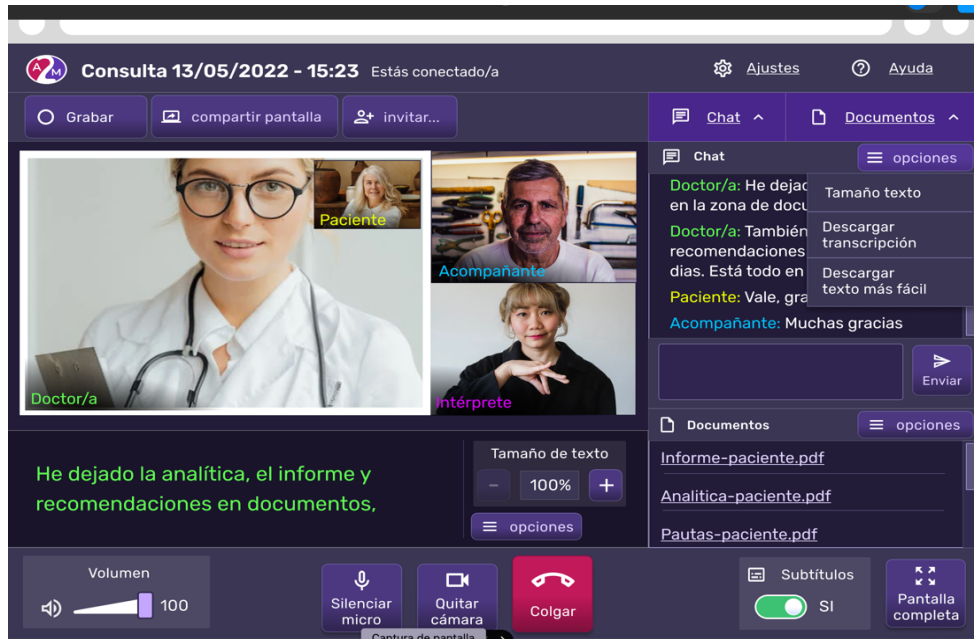


Figure 2: User Interface of the Access2Meet Tool with Multiple Features Deployed.

ural Language Processing (NLP) and Human-Computer Interaction (HCI), particularly addressing the complexity of medical texts for patients. To design the user interface of a videoconferencing system, first, an exhaustive review of accessibility requirements was carried out following standards, and based on these requirements, design patterns were defined [10]. From the author's prior research, the platform was designed to comply with standards such as WCAG, UAAG, and EN 301549 [11], with essential requirements including:

- An accessible interface for magnifiers for individuals with low vision, screen readers for the blind, and device-independent input access for people with physical-motor disabilities.
- Subtitling services for those with hearing impairments, with the option for sign language interpreter participation.
- An interface that is intuitive and cognitively accessible for people with cognitive challenges. Also, it was required that the content and information exchanged during meetings be accessible. To address this:
 - The text content must be simplified into plain language.
 - Give the possibility of providing summaries as a meeting outcome.
 - Provide the possibility of simplifying the chat messages to plain language.

These requirements and their design patterns have resulted in the development of the Access2meet accessible videoconferencing tool, tailored for medical consultations within the Spanish healthcare domain, which is showcased in this demonstration (see Figure 2 and Figure 3).

In this demonstration, we will focus on describing aspects of the real-time subtitling service that can be activated during a medical appointment involving the doctor, nurse, patient, family member, and, if necessary, a sign language interpreter, as well as the text simplification services to facilitate the readability and understanding of health information.

Access2meet is an innovative platform architected for accessibility that integrates technology with user-centered design to deliver an accessible videoconferencing experience. Its backend is powered by Express.js and enriched by WebRTC for real-time video interactions, along with socket.io for instantaneous data exchange. Python APIs facilitated by the Django Rest Framework are employed for AI features. The platform distinguishes itself by offering integrated automatic subtitling, utilizing AI-driven speech-to-text conversion, and a text simplification service that processes complex medical documents through AI and NLP techniques. The frontend, crafted with React, ensures barrier-free user engagement thanks to the accessible components developed in the project. It features real-time subtitle displays during video calls and user interfaces that facilitate interaction with simplified

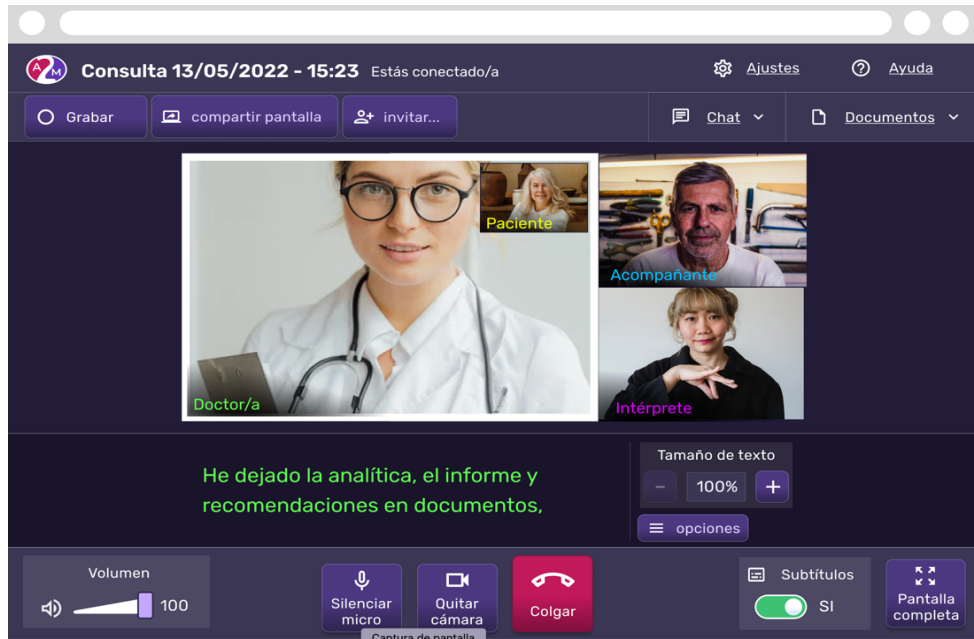


Figure 3: User Interface of the Access2Meet Tool with Some Features Not Deployed.

texts. Users have access to a straightforward toggle option for subtitles and can effortlessly upload documents for simplification. Smooth data flow is paramount, with Socket.io ensuring prompt backend-to-frontend communication for subtitle and text updates. Regarding the subtitling and simplification services:

- **Simplification module:** This module is in charge of translating a medical note elaborated by the doctor into a clearer and simpler one, following plain language and easy-to-read guidelines. It is based on current transformer architectures, particularly decoder-based models. There are not any Spanish generative models, and consequently, we have adopted a multilingual Llama2 open-source, [12] from Huggingface (Llama-2-7b-hf). Llama2 has shown considerable potential when performing difficult processing tasks requiring specialized knowledge in a variety of domains, including generating text from commands and instructions. Apart from fine-tuning with a collection of clinical cases and its easy-to-read simplifications, several prompts have been tested to translate text input to simplified content. These approaches have been described in [13].
- **Subtitling module:** The integration of real-time transcription and captioning functionalities addresses the needs of people with hearing impairments, ensuring access to spoken content dur-

ing videoconference. By providing synchronized text-based representations of verbal communication, this feature enhances comprehension and retention for patients. The system has been developed using Node.js and boasts a comprehensive API comprising REST and Web Sockets endpoints. The Web Sockets API serves a critical role in providing live transcriptions for the incoming audio of sessions in real-time, leveraging the streaming recognition functionality of Google Cloud Speech API. Consequently, each audio stream has a dedicated streaming recognizer and a corresponding Web Socket to facilitate seamless data transmission and reception. Before transmitting the transcriptions, the output from the Speech API undergoes further processing through an in-house trained Transformers model, thereby automating the punctuation of the transcribed text. This step is of paramount importance, given that the Speech API's punctuation functionality yields limited results for the Spanish language. To include punctuation in transcriptions, we experimented [14] with various encoder-based pre-trained models using Spanish-only models, particularly RoBERTa-bne-base [15] that has been trained with corpora from the Spanish National Library at the Barcelona Supercomputer Center.

5. Ongoing Work

As the next step, we are developing an advanced tool built on the integrated services of the EASIER system aimed at helping professionals who specialize in adapting texts to Easy-to-Read and Plain Language standards. This tool will provide a comprehensive suite of lexical resources and support functionalities designed to streamline the text adaptation process.

Moreover, we are testing the Access2meet tool with users, including those with cognitive impairments and other disabilities, healthcare professionals, and relatives, to assess its real-world efficacy and inform further development. Simultaneously, we're enhancing the platform to create easy summaries from subtitle transcriptions and to simplify chat interactions with plain language and emojis, thereby improving digital communication accessibility for all users.

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References

- [1] R. Alarcon, L. Moreno, P. Martínez, Lexical simplification system to improve web accessibility, *IEEE Access* 9 (2021) 58755–58767.
- [2] R. Alarcon, L. Moreno, P. Martínez, Word-sense disambiguation system for text readability, in: *Proceedings of the 9th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion*, 2020, pp. 147–152.
- [3] W3C, W3c web accessibility initiative (wai), 2019. URL: <https://www.w3.org/WAI/>.
- [4] L. Moreno, H. Petrie, P. Martínez, R. Alarcon, Designing user interfaces for content simplification aimed at people with cognitive impairments, *Universal Access in the Information Society* (2023) 1–19.
- [5] R. Alarcon, L. Moreno, P. Martínez, J. A. Macías, Easier system. evaluating a spanish lexical simplification proposal with people with cognitive impairments, *International Journal of Human-Computer Interaction* 40 (2024) 1195–1209.
- [6] R. Alarcon, L. Moreno, P. Martínez, Easier corpus: A lexical simplification resource for people with cognitive impairments, *Plos one* 18 (2023) e0283622.
- [7] L. Moreno, A. Diaz-Redondo, P. Martínez, H. Ochoa, Assessing standards-driven accessibility in top video conferencing platforms. universal access in the information society (in press) (2024).
- [8] M. Hersh, B. Leporini, M. Buzzi, et al., Accessibility evaluation of video conferencing tools to support disabled people in distance teaching, meetings and other activities, in: *Future Perspectives of AT, eAccessibility and eInclusion*, ICCHP, 2020, pp. 133–139.
- [9] J. Boland, S. Banks, R. Krabbe, S. Lawrence, T. Murray, T. Henning, M. Vandenberg, A covid-19-era rapid review: using zoom and skype for qualitative group research., *Public Health Research & Practice* 32 (2022).
- [10] L. Moreno, P. Martínez, R. Alarcon, Requirements and design patterns for an accessible video conferencing tool, in: *Proceedings of the XXII International Conference on Human Computer Interaction*, 2022, pp. 1–9.
- [11] CEN, CENELEC, ETSI, Accessibility requirements for ict products and services, 2021. URL: https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf.
- [12] H. Touvron, L. Martin, K. Stone, P. Albert, A. Almahairi, Y. Babaei, N. Bashlykov, S. Batra, P. Bhargava, S. Bhosale, et al., Llama 2: Open foundation and fine-tuned chat models, *arXiv preprint arXiv:2307.09288* (2023).
- [13] P. Martínez, A. Ramos, L. Moreno, Exploring large language models to generate easy-to-read content. artificial intelligence and digital accessibility (submitted), *Frontiers in Computer Science* (2024).
- [14] M. Perez-Enriquez, J. Masiello-Ruiz, J. Lopez-Cuadrado, P. M. I. Gonzalez-Carrasco, B. Ruiz-Mezcua, Automatic punctuation model for spanish live transcriptions, *LREC-COLING 2024* (2024).
- [15] A. Gutiérrez-Fandiño, J. Armengol-Estapé, M. Pàmies, J. Llop-Palao, J. Silveira-Ocampo, C. P. Carrino, A. Gonzalez-Agirre, C. Armentano-Oller, C. Rodriguez-Penagos, M. Villegas, Maria: Spanish language models, *arXiv preprint arXiv:2107.07253* (2021).