Tailoring Automatic Text Simplification Output for Deaf and Hard of Hearing Adults

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Abstract

This paper presents a research proposal into tuning the outputs of an Automatic Text Simplification (ATS) system to the needs of the deaf and hard-of-hearing (DHH) community. There is an overview of simplification methods, and studies on ATS where it relates to the DHH community. It then presents an experimental design where research participants are presented with simplified text from an established method of ATS, and simplified text which has been post-processed to move the sentence topic to initial position - a common feature of sign languages. Each simplification method is also evaluated by automatic metrics.

Keywords

accessibility, natural language processing, sign language, text simplification

1. Introduction

Automatic Text Simplification (ATS) [1] is a valuable application of natural language processing (NLP) aiding both the performance of other NLP tasks by using simplified and clarified training data as inputs, and as a reading assistance tool for many populations. The general public may require simplified text to make highly specialised subject matter more accessible, while other populations include: Children at varying stages of development and literacy, L2+ language learners, or people with a clinical pathology including dyslexia, autism spectrum disorders, aphasia, or people in the deaf or hard-of-hearing (DHH) community.

The preferred method of communication for DHH individuals is sign language [2]. However, the DHH community may also predominantly include L2 users of their region's ambient spoken language. For example, a signer in the Republic of Ireland typically has Irish Sign Language as their native language (or L1), and English as their L2 - oftentimes with English being the only language available for public service information such as in healthcare. Variable and lower literacy rates within the DHH community with regard to the local ambient language [3] create barriers of access to information. According to the CNSE[1], more than 1 million people in Spain (2.3%) have hearing loss of some kind. Being DHH has adverse effects on an individuals' opportunities: One study on deaf Dutch students showed that reading literacy consistently lags

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behind their hearing peers throughout childhood [4], which prevents access to further education and employment opportunities. In the United Kingdom, 17% of hearing children progress to top-level universities, compared to 9% of their deaf peers[2]. Across the European Union the unemployment rate is much higher among the DHH community, tracking with employment figures for anyone with a disability [3][4].

This reality is not inevitable. It is suggested that empowering people with disabilities including deafness will not only promote equality of opportunities, but also costs less in terms of providing unemployment benefits[5]. With good quality ATS alongside the nascent area of sign language (machine) translation [5], providing a large amount of adequate materials for DHH people will become more practical and reliable.

The idea of providing ATS technology for reading assistance has been established [6, 7] as beneficial in improving access to information for DHH people. Recent work has also evaluated methods of ATS for reading assistance from a human-computer interaction standpoint [8], and the ability of evaluative metrics to measure text complexity for DHH people [3, 9]. This study aims to progress the current research by tuning methods of ATS to the needs of DHH people. It will adapt the output of an ATS system based on preferences of the DHH community from current literature, and propose some novel methods based on typologically common features of sign language.

In Section 2.1, an outline of ATS is drawn followed by a more in-depth discussion of research in the field related to DHH people in Section 2.2. Section 2.3 explores how knowledge of sign language grammar may interact with ATS research. The proposed methodology based on the research questions in Section 3 is described in Section 4. Finally, other considerations surrounding the study are located at the end of the paper in Section 5.

1.1. SignON

This work is being carried out in conjunction with the SignON[6] European Union project [10]. Its goal is to create a translation service between signed and spoken languages in Europe. This initiative is community-led, with input and leadership from the DHH community at every level. It is possible that using simplified text during the training of its machine translation system would be beneficial as a pre-processing step [11].

2. Related Work

2.1. Text simplification strategies

There are three main strategies for ATS: Lexical, syntactic, and a hybrid approach encompassing both. Lexical simplification falls into two main tasks [1], finding synonyms as word-replacement candidates and word sense disambiguation (WSD). To find synonyms, it is possible to use a

[2]https://www.independent.co.uk/news/education/education-news/deaf-students-russell-group-universities-level-results-access-national-deaf-childrens-society-a8463301.html

[3]https://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=7482

[4]Exact figures are not available, as 'disability' does not have an exact definition across EU states and institutions

[5]https://www.eud.eu/news/deaf-and-employment-crisis/ (European Union of the Deaf)

[6]https://signon-project.eu/

Table 1
Examples from different text simplifications paradigms

Type	Sentence
Original	Shippea Hill is a request stop halt, seven miles in an easterly bearing from Ely, Cambridgeshire
Lexical	Shippea Hill is a request stop **station**, seven miles in an easterly **direction** from Ely, Cambridgeshire
Syntactic	Shippea Hill is a request stop, seven miles from Ely, Cambridgeshire
Hybrid	Shippea Hill is a railway **station**, seven miles **east** of Ely, Cambridgeshire

lexical database such as WordNet [12] or more recently word2vec [13] which also contains syntactic information. Context-sensitive lexical simplification [11] ensures that replacement synonyms remain grammatical, and do not alter the intended meaning. WSD has multiple strategies which interpret the idea of word complexity differently. Some approaches rely solely on word frequency, while others incorporate word length [1].

Syntactic, or sentence-level, simplification relies on the transformation of linguistic structures which boost readability, i.e. require lower decoding and linguistic abilities [4] for the reader. For example, an utterance may be more readable if the argument structure and word order are more canonical for a given language, or through paraphrase - shortening the length and removing additional qualifiers and subordinate clauses from an utterance. Strategies for syntactic ATS have developed over the years from a hand-crafted rule-based approach [14, 15], into leveraging state-of-the-art neural machine translation models [16]. Table 2.1 shows an example of each text simplification strategy.

It has been alluded to that large databases and corpora are required to perform ATS. For English and Spanish, the proposed languages for this work, there are many resources specifically designed for this task. Simple English Wikipedia[7] is a central resource spawning corpora such as the large Parallel Wikipedia Simplification (PWKP) dataset [17] and Wikilarge [18]. However, caution must be used as Simple English Wikipedia is not a parellel corpus - rather a spontaneously written new language for the encyclopaedia. In fact, up to half of the PWKP corpus are not simplifications [1, 19].

Without a simple Spanish Wikipedia-type resource, there are corpora for parallel Spanish/simplified Spanish text. As an example, Simplext [20] contains 200 utterance pairs. There are also tools to create novel simplifications for a monolingual corpus. Candidate ranking [1] and context-aware algorithms like CASSA [21] can do Ngram-based lexical simplification. Text alignment [22] as part of a pipeline, and recent deep learning methods [11, 16] may also be used to create sentence-level simplification.

2.2. Text simplification and DHH accessibility

For around 20 years [6], there has been work into both lexical and syntactic simplification for readability focused on DHH readers. Inui and colleagues also highlighted the need for multiple degrees of reading aptitude in the output, as literacy levels are highly variable across

[7] https://simple.wikipedia.org/wiki/Main_Page

the community [3, 7, 9] and a 'one size fits all' approach is likely to be off-putting for DHH readers [8]. Following on from the goal of SignON [10], it is crucial to design outputs and systems based entirely on the needs and preferences of the target community for accessibility.

As a starting point, it would be useful to follow an established accessibility framework. The EASIER tool [23] was built around the Web Content Accessibility Guidelines [8], which are designed to make text content on the web available to everyone. In addition, Alonzo and colleagues studied preferences of the DHH community on the visualisation of a prototype lexical simplification system [8]. They state that it should be imperative to provide community tailored ATS output in their preferred display format, with a degree of autonomy in accessing the simplifications for themselves. It has been successful in other populations [23, 24], and ATS as reading assistance is argued to have an objective benefit to the DHH community [6].

In addition, evaluating ATS systems in the DHH communities has mostly been achieved through subjective, manual methods [9]. As automatic metrics for evaluating ATS exist (e.g. SARI [25]), it would be beneficial to incorporate these into a study alongside the opinions of target users. A logical next step is therefore to implement a syntactic or hybrid ATS system with post-processing and visualisation steps informed by the preferences of DHH readers.

2.3. Sign language interface

It is important to consider the language which most DHH people use in their daily lives, sign language. Unfortunately, datasets which could be used to create widely-available NLP-based technology are few and far between for sign languages [5, 26]. Widening accessibility may currently be achieved by simplifying text in the ambient language. By incorporating features of sign language grammar into the simplified ambient language text as far as remains grammatical, the information structure may be more accessible to DHH readers.

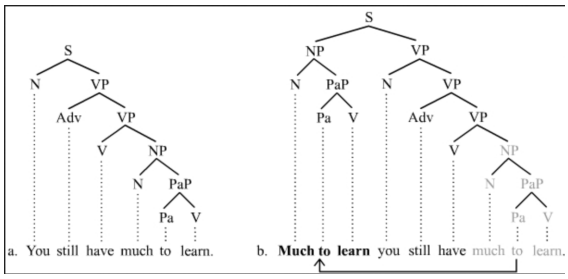

Figure 1: An example of topicalisation in English

There are some typologically-common grammatical features between sign languages, including those which are not closely related. In the paradigm of word order classification for spoken languages, e.g. SOV (Subject-Verb-Object), sign languages are flexible on word order. Instead sign languages tend to topicalise information [27], move discourse-prominent information to the first position in an utterance. An example of topicalisation is shown in Figure 1. In NLP, there

[8] https://www.w3.org/WAI/standards-guidelines/wcag

exist methods to extract the topic of an utterance. For example, the Latent Dirichlet Allocation algorithm can be used to pick out topic words from word distributions in a probabilistic manner [28]. If the topic noun phrase (NP) of a sentence could be fronted, this could be a method of making simplified utterance more accessible to DHH readers.

Many more linguistic features are shared by typologically-distant Sign Languages. Sign Languages tent to be productive in terms of derivational morphology, so compounding to reflect functions like negation or locative constructions is common [27, 29]. Another syntactic feature is the compulsory subject [30], usually in first position [29] in contrast to pro-drop being possible and frequent among the world's spoken languages. Modelling these features is another interesting and feasible question with current NLP tools. However, the present investigation focuses entirely on topic modelling.

3. Research questions

The proposed study will focus on the following questions:

- Which ATS system strategies are preferred by DHH readers?
- Do topic-focused simplified sentences benefit readability for DHH people compared to a baseline of lexically simplified sentences?
- Do automatic metrics for ATS correlate with the preferences of DHH readers?
- Does ATS system design cater for DHH readers at varying levels of reading literacy?

4. Proposed methodology

This section describes some possible techniques and experimental settings which may be effective in answering the primary research questions outlines so far. It discusses some methods of evaluating the experimental results, and how conclusions may be drawn from them. Predictions about the results are also made. Section 5 tackles challenges in conducting this research and other contextual factors it may be necessary to consider.

The key idea in the experiment settings is to compare a baseline of simplified sentences with the same simplified sentences which have been post-processed to 1) Find the topic words in an utterance, 2) Move the topic NPs to the start of the utterance, and 3) Ensure the utterance remains grammatical. The original, 'complex' sentences will also be used in comparative evaluation by the participants. Figure 2 illustrates the outline of the experimental design, showing the three different output types which will be shown to the participants. It is envisaged that both extant corpora for the input sentences, and an extant ATS tool for generating baseline simplified sentences, will be used.

4.1. Experimental setup

This study will be participant-based, and recruitment could take place through the SignON project and within the associated participating DHH communities, pending ethical and feasibility approval. The target ambient language communities are English and Spanish, with signers coming from the British Sign Language (BSL), Irish Sign Language (ISL), and Lengua de Señas

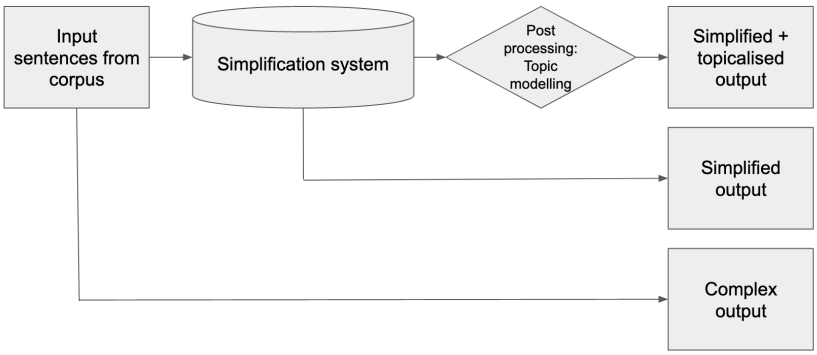

Figure 2: Experimental design, the three output types presented to participants

Española[9] (LSE) communities. Research participants will be invited to self identify as 'deaf', 'hard-of-hearing', and other identities covering the great diversity found in the DHH community [26]. In order to best analyse how reading literacy compares to the evaluation of an ATS system, it may also be necessary to evaluate the reading literacy of the participants. This could either be done through a short assessment (*c.f.* [8]), or by additional demographic questions about - for example - highest educational level achieved. In terms of avoiding bias in the results of the study, it would be beneficial to recruit at least twelve participants who have a range of reading literacy ability and vary in terms of their self-defined identity.

The research participants will be presented with three types of sentences:

- Complex sentences from a corpus
- Simplified sentences drawn from the complex sentences from an extant ATS tool
- Simplified, topic-focused sentences after pre-processing the simplified sentences

These sentences will be taken from a public domain parallel English-Spanish corpus, such as the OPUS[10] repository of corpora. Larger corpora are preferred, because there will be a greater number of sentences where sentence transformation with topic-prominence is possible. It is therefore possible to control for domain and parallel content shown to the research participants across language communities. The simplification tool used should be near to state-of-the-art, but could be either lexical (e.g. [11]), or hybrid (e.g. [15]) to provide a baseline of simplified sentences.

It is crucial to present participants grammatical and realistic utterances which have undergone topic-fronting. The most effective method to avoid transformation errors and ungrammaticality is to manually identify, extract, and move topic-prominent noun phrases to sentence-initial position. However, manual processing may be unfeasible or very time consuming with a large corpus. One possible way of automating this process could be to identify an utterance's topic by means of Latent Dirichlet Allocation [28]. The noun phrase containing the identified topic may

[9] Spanish Sign Language
[10] https://opus.nlpl.eu/

then be extracted through its branches on a dependency parse tree, such as those automatically generated in the spaCy[11] library. The resulting noun phrase can then be moved to the start of the sentence. This process automates the one depicted in Figure 1.

The displaying of example sentences to research participants will follow pre-established DHH community visual preferences [8] and more general accessibility guidelines for ATS [23]. Experimental instructions at every stage will be in plain language, in a large font, and without any distractions on-screen. The user interface will be interactive as possible to provide autonomy to participants.

4.2. Empirical evaluation

During the experiment, the participants will be invited to rate a given output sentence or text from one of the three output types defined in Figure 2. Their opinion-based scores could be presented on a Likert-type rating scale where $1 =$'*This is impossible to understand*' and $5 =$'*This is very easy to understand*'. Alternatively, pairs of output type sentences could be presented as an ABX test where the participants choose which sentence is more *readable* out of the pair. This method is thorough and provides a direct comparison between each output type for every sentence, but will ultimately mean subjecting participants to duplicate sentences. It is also important to gather a qualitative analysis from the participants. Participant comments about system design, and their preferences on system process and output have been invaluable in previous studies [8, 24, 26].

More indirect participant evaluation can be undertaken. As described in [9], measurements of reading speed and possibly eye gaze can be taken to judge the complexity and readability of a given utterance. Finally, automatic metrics evaluating the two simplified outputs against the complex output will complement the participant-based study - and make the results of the planned study comparable to other works in the field. The SARI metric [25] is an industry-standard in ATS which compares input and output sentences, as well as a *gold-standard* reference simplification. SacreBLEU [31], taken from machine translation research, is another useful metric which allows cross-study evaluation.

4.3. Predictions

In terms of answering the proposed research questions, it is likely from previous studies that DHH readers at all literacy levels will find simplified sentences more readable. As for sentences with topic focus, it is unclear how these sentences will be evaluated by DHH people as they are often a non-canonical construction in written English and Spanish. Automatic metrics are likely to disfavour them, while it is hoped post-processing in this manner will accommodate the argument structure which is familiar to sign language users.

5. Further considerations

This work is in its beginning stages of the design process, and sets out to provide more clarity on text simplification's role for the DHH community. It plans to objectively evaluate the outputs

[11] https://spacy.io/

of ATS systems for DHH people specifically, and compare these with the subjective analyses - an open area of research [9]. In the absence of on-demand sign language translation in the near future [5, 8], improving the quality of ATS in what is commonly the L2 of DHH people is crucial for their access to information. It offers a methodology which tailors the linguistic output of a baseline ATS system based on one syntactic feature typologically common in sign languages. In order to mitigate other syntactic effects, perhaps lexical simplification would be the best system to use to create the simplified outputs for the experiments.

Further experiments could explore incorporating more linguistic features which are prominent in sign languages, or even incorporate pictographic elements in the on-screen output as a step towards on-demand sign transformation. It is hoped that the participant-based elements of this research will take place as soon as possible, and that the work will be complete within the lifetime of the SignON project[12].

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[12] The project runs from January 2021-December 2023, with a timeline available at https://signon-project.eu/about-signon/workplan/

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