To simplify or not? Facilitating English L2 users' comprehension and processing of Open Educational Resources in English using text simplification

Abstract

Open Educational Resources (OER) aim to provide equal access to education. Yet, as the language level used in OER presents a barrier to many learners, there is a need to make these resources more comprehensible. This study combined eye-tracking methodology and comprehension assessment to explore the effect of text simplification on English second language (L2) users, while also accounting for text organisational structure, and individual predispositions. A total of 37 adult English L2 users took part in the study. They had to read either an authentic narrative, authentic expository OER, or their linguistically simplified versions. The analysis showed that simplification led to better text comprehension, and text narrativity facilitated text recall, particularly at lower English proficiency levels. Eye-tracking measures revealed that text simplification led to an increase in processing time during the initial reading of the text and a decrease in processing time during text re-inspection. These findings have strong practical applications for online teaching with OER.

Keywords: text simplification, online learning, eye-tracking, reading comprehension, text processing

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An important channel of learning is successful text comprehension, especially in academic contexts. However, a number of claims have been made that students graduating from high schools cannot comprehend easily the texts they encounter at university or as part of their continuing education (Williamson, 2006; Amendum, Conradi & Hiebert, 2018). Academic text comprehension creates even further vexing challenges to English second language (L2) users [1](Arfé, Mason & Fajardo, 2018; Shadiev, Wu & Huang, 2018). In recent years such claims have particularly been voiced in the context of Open Educational Resources (OER), where most academic materials offered online are in English, and most learners are English L2 users (e.g., Hatakka, 2009; Rets, Coughlan, Stickler & Astruc, 2020). The language level used in OER was found to be a barrier to many learners (e.g., Hatakka, 2009; Cobo, 2013; Papathoma et al., 2020; Rets et al., 2020).

One way to increase access to the learning content and accommodate learners' needs with difficult academic texts is to use text simplification. It is the process of modifying authentic texts, or texts written for the first language (L1) users of a given language, with the intent to reduce the language level of these texts and increase their accessibility for the L2 users of this language (Tickoo, 1993). Linguistically simplified materials have the potential to reduce the mismatch between the proficiency level of many English L2 users and the language difficulty of the online materials in English and allow them to learn more efficiently (Crossley, Allen & McNamara, 2012; Vössing, Stamov-Roßnagel & Heinitz, 2017).

There are two main approaches to text simplification aimed at L2 users: structural and intuitive (Crossley et al., 2012). Under the structural approach, text simplification is guided by the use of traditional readability formulas and mainly involves replacing rare words with the words of higher frequency of use in the language, as well as shortening sentences (Fry, 1968; Chall & Dale, 1995). The structural approach is commonly used in graded reader schemes aimed at facilitating language acquisition (Long, 2020). The second approach is an intuitive simplification. Crossley et al. (2012), and Crossley and McNamara (2016) report that this approach has become the most common type of text simplification aimed at L2 users performed in the classroom. It is based on the intuition of the person, mostly an English teacher,

[1] The term 'English L2 user' refers to anyone who knows more than one language, and for whom English is not their mother tongue. Adopted from Cook and Singleton (2014, p. 4), this term allows to include all English L2 users irrespective of their frequency of use or level of mastery of English.

performing simplification, and on their beliefs concerning what makes a text more comprehensible to the target group of learners. In light of its popularity with teachers, it is paramount to understand to what extent this technique can be successfully used in online educational settings.

Although there is emerging research supporting the effectiveness of intuitive simplification, the existing studies have some methodological shortcomings. First, previous research has generally not taken into account readers' individual differences, such as language proficiency (LP), background knowledge of the topic (BK), and topic interest (TI). These are important moderating factors when examining text comprehension (Boscolo & Mason, 2003; Davis, Huang & Yi, 2017; Catrysse, Gijbels & Donche, 2018). Secondly, it is unclear whether the effect of simplification remains significant across texts with different organisational structure (narrative and expository). Finally, the way the effect of text simplification is commonly measured has a substantial impact on the results. The vast majority of previous research reassures this effect only through traditional comprehension tests (Crossley, Yang & McNamara, 2014; Crossley & McNamara, 2016), which do not index text processing or inform about the parts of the text that the reader pays attention to in simplified texts.

This study aims to address the limitations of the previous research and to further enhance our understanding of the effects of intuitively simplifying online academic materials, such as OER, on English L2 users. This study examines both text comprehension through comprehension scores and text processing through eye-fixation measures, while separating the effect of text simplification from the effects of text organisational structure and individual differences.

Text Modification and Text Comprehension

Previous research generally supports the facilitative effect of text simplification on text comprehension of English L2 users. In simplification research, this effect has been mainly assessed through multiple-choice (MC) comprehension tests (e.g., Long & Ross, 1993; Yano, Long & Ross, 1994; Tweissi, 1998) and free recall of the text (Crossley & McNamara, 2016). Long and Ross (1993) found that L2 students who read texts simplified using structural approaches (replacing rare words and using shorter sentences), scored significantly higher on the MC comprehension test than did those that read authentic unmodified texts. This finding was supported in a follow-up study conducted by Yano et al. (1994) who used the same texts. The results of their study also demonstrated that the simplified texts increased text

comprehension in comparison to authentic texts. Tweissi (1998) in their study with 200 intermediate proficiency English L2 users also confirmed that the structurally simplified texts received higher scores on the MC comprehension test than the authentic texts.

The facilitative effect of text simplification can be explained using the premises of the automatic information processing theory (LaBerge & Samuels, 1974). This theory studies how visual information in the text is transformed and processed by the reader through a series of stages until it is comprehended. LaBerge & Samuels's theory postulates that individuals have a limited amount of attention available for any cognitive task, including the task of reading. Automatic word recognition, defined in the theory as quick and effortless identification of words out of context, leaves more available attention for text comprehension. Since simplified texts contain the words more familiar to the reader, shorter sentences, and increased text cohesion, more cognitive resources are available to the reader to comprehend the text better and pay attention to comprehending what the author has to say, i.e., the main themes of the text.

While previous research (Long & Ross, 1993; Yano et al., 1994; Tweissi, 1998) demonstrated the benefits of simplification for general text comprehension in relation to English L2 users, simplification in these studies was based on the structural approaches, which are aimed at enhancing language acquisition, rather than increasing access to the academic learning content. Furthermore, none of these studies controlled for individual predispositions and text-related (narrativity and exposition) factors when investigating the effect of text simplification, while these factors have been shown to also impact text comprehension.

Among such individual predispositions are BK and TI. Reading the information in the text that fits the knowledge about the topic the reader already possesses results in superior comprehension and learning of that information (Anderson, Spiro & Anderson, 1978; Boscolo & Mason, 2003). Likewise, interest induced by the characteristics of the text or by the reader's habitual interest in a specific topic domain has a positive influence on text comprehension, and particularly on text recall (Schiefele, 2009; Catrysse et al., 2018). Studies with adults showed that BK and TI tend to correlate: people have more BK about topics in which they are interested, or they are interested in the things they know more about (e.g., Boscolo & Mason, 2003).

Another individual factor shown to have a strong influence on text comprehension particularly in L2 is LP (e.g., Davis et al., 2017; Conklin, Pellicer-Sánchez & Carrol, 2018). More proficient L2 users exhibit better comprehension (e.g., Brunfaut & McCray, 2015; Davis et al., 2017). Simplified texts seem to be best suited for lower-proficiency L2 users (e.g.,

Crossley et al., 2014; Crossley & McNamara, 2016). However, Oh (2001) provided counter-evidence that simplified texts were understood significantly better than the authentic texts by high English LP users and not by low English LP users.

Finally, among the text factors that affect text comprehension is the organisational structure of the text, namely narrativity, and exposition (Sáenz & Fuchs, 2002; Kraal, Koornneef, Saab & van den Broek, 2018). Narrative and expository texts differ in the degree of causal coherence of information. Texts with narrative structure unfold as a story and feature characters with goals and motives, have event sequences, and themes (Berman & Slobin, 1994; Primor, Pierce & Katzir, 2011). In contrast, expository texts are more topic-oriented and deal with more abstract concepts and ideas that are linked through implicit logical relations (Berman & Katzenberger, 2004). Research has found that while text processing, as measured by reading time, is not significantly different between narrative and expository texts, expository texts are significantly harder to recall (Ehrlich, 1991; Sáenz & Fuchs, 2002). This finding can be interpreted using Kintsch and van Dijk's model of reading comprehension (1978): stronger cohesive links in the narrative texts make it easier to remember the local relations that constitute the micro- and macrostructure of the text. Thus, it has been recommended to account for text organisational structure when examining text comprehension (Clinton et al., 2020).

Among the few simplification studies that investigated the effect of intuitive text simplification, while controlling for some of the aforementioned factors are Crossley et al. (2014) and Crossley and McNamara (2016). In these studies, 49 English L2 users were randomly assigned to reading authentic and intuitively simplified texts. Participants also completed a BK survey, reading proficiency test, and answered yes/no comprehension questions (in Crossley et al., 2014), or completed a text retelling task (in Crossley & McNamara, 2016). It was found that the effect of intuitive simplification on text comprehension (true/false comprehension scores, text recall) remained significant when accounting for LP and BK. Participants comprehended simplified texts significantly better than their authentic versions. However, Crossley et al. (2014) reported that this effect did not remain significant on reading time, as measured by the word-by-word moving window technique when including all individual factors as covariates in the analyses.

While providing empirical evidence on the importance of controlling for these factors, Crossley et al. (2014), and Crossley and McNamara (2016) fell short of controlling for other aforementioned factors that were shown to influence reading, such as TI and text organisational structure. Controlling for more individual and text factors might provide a more refined understanding of the extent to which intuitive simplification facilitates text comprehension.

Another limitation of previous research concerns the fact that text simplification has been mainly measured through comprehension tests. To obtain a more well-rounded understanding of intuitive text simplification more studies that use a variety of measures to investigate its effect are needed.

Text Modification and Text Processing

Text simplification studies that looked at text processing (e.g., Crossley et al., 2014; Crossley & McNamara, 2016) have so far explored its effect on reading time using the word-by-word moving windows technique. A recognised limitation of this methodology is the reader's limited natural engagement with the text (Crossley et al., 2014).

A methodology commended for its higher ecological validity is eye-tracking, defined as the real-time registration of an individual's eye movements (Conklin et al., 2018). Other advantages of using eye-tracking include the rich quantitative data it provides and the possibility to tap into the time course of processing by separating the initial reading of the text (measured by first pass reading measures) from later reprocessing efforts (second pass reading measures or text re-inspection) (Ariasi, Hyönä, Kaakinen & Mason, 2017; Catrysse et al., 2018). When eye movement data are combined with comprehension assessment and self-report questionnaires that capture individuals' BK, TI, and LP it can provide a more comprehensive picture of text processing (Catrysse et al., 2018).

While the exploration of the effect of text simplification on text processing is very limited, some previous reading studies focused on the effect of other types of text modifications. Hyönä and Lorch (2004) used eye-tracking to investigate the effect of adding topic-headings to multi-topic texts on text comprehension and text processing. Ariasi et al. (2017) explored the refutation effect in a scientific text. In both studies participants read two texts on different topics – one text modified in a certain way (e.g., with or without headings in Hyönä & Lorch, 2004) and one authentic text. The eye-tracker was used to capture participants' eye movements followed by a text recall task. The authors analysed the eye movement records for three types of sentences: a) topic-introducing; b) last sentences of each paragraph (end); and c) all intervening sentences (medial). In both studies, the eye-tracking analyses revealed the facilitative effect of text modifications. Hyönä and Lorch (2004) found reduced processing difference between topic-introducing and medial sentences in that modified texts, suggesting that the modified texts made fewer inference demands on participants. Ariasi et al. (2017) found a longer fixation time for topic-final sentences in the modified texts. The integration of new information seemed to occur when participants were reading topic-final sentences that

summarised the key points unlike when reading the authentic texts. In both studies, the analyses of comprehension scores showed that participants recalled more information from the modified texts.

Mason, Pluchino, Tornatora and Ariasi (2013) explored the effect of adding illustrations to scientific texts on text processing and comprehension of English L2 users. Their study showed that at the immediate comprehension post-test, readers of the illustrated texts outperformed the readers of the non-illustrated texts. Eye-tracking provided further evidence for the support of using pictures to facilitate text processing. This efficiency effect of illustrations was found in a shorter re-inspection (second pass fixation time) of the overall text for wrap-up processing.

Conclusively, Hyönä and Lorch (2004), Ariasi et al. (2017) and Mason et al. (2013) showed that eye-tracking can provide new insights into the effect of text modification. Eye-tracking can supplement traditional comprehension check methods in a way that it allows to measure cognitive processes of an individual throughout the whole reading of the text, rather than in recall, as captured by comprehension tests (Godfroid, 2019).

Research Questions (RQs) and Hypotheses (Hs)

The present study aims to address the current gap in understanding what effect intuitive simplification of online academic texts (OER) has on text comprehension and text processing of English L2 users. To address the limitations of previous research on simplification, this study accounts for the organisational structure of the text, statistically controls for a number of individual factors, and combines comprehension assessment with the eye-tracking methodology. The three main RQs and Hs of this study are:

RQ1. What is the relation between individual factors, such as LP, BK, and TI and participants' text comprehension scores and text processing patterns?

H1. The higher BK, TI and LP, the better participants will understand the text, and the less time they will take to re-inspect it.

RQ2. Are there differences in text comprehension scores for English L2 users among simplified versions and authentic versions of narrative and expository texts, when controlling for LP, BK, and TI?

H2. Simplified texts will be comprehended better than the authentic texts, and simplified narrative texts will have the highest scores for recall among the texts used in the study.

RQ3. Is there an effect of text simplification on the initial reading of the text (first pass fixation duration) and later text reprocessing (second pass fixation duration) when controlling for LP, BK, and TI?

H3. Participants will be able to process simplified texts more effectively during the initial reading and, thus, will spend less time re-inspecting them. Participants will focus on the topic-final sentences in the simplified texts.

Methodology

Participants

Initially, 50 participants were recruited for the study, however, the data of 13 participants were removed from the analyses due to the poor quality of the eye-tracking data. This is a common issue in eye-tracking research (Holmqvist et al., 2011; Jarodzka & Brand-Gruwel, 2017). Thus, the final sample comprised of 37 participants (11 male, M_{age} = 33.05, *SD* = 10.33), who were adult English L2 users. Participants' L1s varied; the sample was selected to reflect the diversity of the population of OER learners. Participants were recruited from local English learning programmes at community learning centres and English language training centres from two universities in the UK. Most participants were university graduates (*n* = 33), 19 participants indicated they had educational degrees in sciences (e.g., engineering, medicine), and 14 participants – in humanities (e.g., arts, literature), four participants were high school leavers. All participants had a normal or corrected-to-normal vision, reported having no learning disorders.

Materials and Apparatus

Language proficiency (LP)

In line with Jung and Révész (2018), we used an adapted version of the 'Use of English' section of a practice Cambridge Proficiency (CPE) Test in this study to determine participants' LP. Cronbach's alpha for the CPE scores was α = 0.80. Using the test scores, we were able to categorise participants as high or low English L2 proficiency by using the average CPE score across the sample of 16.24 (SD = 4.64) as the mean split. The effectiveness of the mean split for the group formation was tested using the independent sample t-test, where the groups were examined on their LP. Overall, the split was successful, as there was a significant difference between the groups with the large effect size t (35) = 9.954, $p<0.001$, $d > 0.8$.

Texts

Texts with two different types of organisational structure were used: Text 1 was a narrative text about the discovery of vitamins (299 words, four paragraphs) and Text 2 was an expository text about the role of social workers (282 words, two paragraphs). As the focus of the study was on OER texts, both texts were selected from two introductory courses on the OpenLearn platform (2020). Each text was then intuitively simplified by 24 English teachers to the level of intermediate English proficiency in the earlier study of the first author (Rets, Astruc, Coughlan, Astruc & Stickler, Submitted). The final versions were based on the approaches to text simplification commonly used across the sample of teachers, and their complexity was also checked with the Textinspector online readability tool (Rets et al., 2020). Simplified texts mainly differed linguistically from their authentic versions at the level of lexical sophistication, syntactic complexity, and cohesion. The global structure and the content of the authentic texts were kept intact in simplification. Simplified Text 1 contained 293 words, and simplified Text 2 – 268 words. Thus, a total of four texts were used. All text versions were displayed in Times New Roman 14.5 black font on a white background and were presented 1.5-spaced on the screen.

Background Knowledge (BK)

Participants' BK was measured with a 5-item self-report questionnaire adapted from Khabbazbashi (2015). The same questions were used for Text 1 and Text 2. Participants' responses were recorded on a seven-point Likert scale ranging from 0 to 6 (e.g., *'I had a clear idea about this topic before reading the text'* – '0', '*strongly disagree'*; '6', *'strongly agree'*). The BK score for each participant was computed by averaging out responses to all five questions. Reliability scores for the four texts ranged between $\alpha = 0.6$ and $\alpha = 0.79$.

Topic Interest (TI)

Participants' TI was measured with a 7-item self-report questionnaire (Schiefele & Krapp, 1996; Catrysse et al., 2018). Similarly to the BK questionnaire, the same questions were used for Text 1 and Text 2. Participants' responses were recorded on a seven-point Likert scale ranging from 0 to 6 (e.g., *'While reading the text I felt stimulated'* – *'*0' *'strongly disagree'; '*6' *'strongly agree'*). For each participant, the TI score was calculated by adding the scores for each question. Reliability scores for the four texts ranged between $\alpha = 0.7$ and $\alpha = 0.89$.

Comprehension Assessment

Free recall

Participants were asked to write in English the ideas they remembered from the text they had read as part of the research session. The retelling was self-paced. Participants were provided with the following instructions: *Please retell the text you just read. Write as many ideas as you can remember, and do not worry about spelling mistakes. Please, do not state your opinion about the text.* Retellings were typed into a word document on the laptop from which they had read the text. Participants could see their retelling as they typed but did not have access to the text they had read.

In line with Chen (2016), the first author and one independent rater first separately identified the idea units recalled correctly in each participant's retelling. The inter-rater reliability was 0.95. They then discussed the disagreements on the idea units until a consensus was reached. One point was awarded for each idea unit in which all the main elements were recalled correctly, and half a point was given if some of the elements in the idea unit were recalled correctly. The maximum possible score on the summaries for the narrative text was 34, and the total score for the expository text was 28.

Multiple choice (MC) comprehension test

Two MC comprehension tests were designed for Text 1 and Text 2. Each test had ten questions. The questions included the correct answer and three distracters that were thematically related (same theme but incorrect). Two independent experienced language teachers tested the initial design of the tests and provided suggestions, after which four independent English L1 users provided further feedback on the design of the test. Reliability score for Text 1 authentic was $\alpha = 0.67$, Text 1 simplified $\alpha = 0.69$, Text 2 authentic $\alpha = 0.7$ and Text 2 simplified $\alpha = 0.63$.

Besides cross-checking participants' comprehension, the advantage of employing multiple comprehension assessment techniques is that they can complement each other's inherent weaknesses (Ariasi et al., 2017). An MC test covers a smaller number of ideas from the text, however, it does not involve other production skills, such as the participant's writing ability, as compared to free recall (Heinz, 2004).

Eye-tracking

Eye-tracking equipment

The Tobii Pro X3-120 (dark pupil tracking) eye-tracker, manufactured by Tobii Technology (Stockholm, Sweden) was used to collect participants' eye movements data. The eye-tracking component was integrated into a 17.3-inch laptop screen with a maximum resolution of 1920 × 1080 pixels. The sampling frequency was 120 Hz. Tobii Technology reported a gaze accuracy of 0.4°, and gaze precision of 0.20° for this eye-tracker. The eye movements were recorded with Tobii-Studio (3.2) software.

Eye movement data

We used the Tobii fixation filter for fixation identification (Olsson, 2007). For each sentence in all four texts, an area of interest (AOI) was defined. In line with Hyönä and Lorch (2004), the sentences that introduced the ideas in the text were coded as topic-introducing (e.g., *'It can be argued that social workers very often deal with some of the most complex problems in society'* in Text 2). The sentences that elaborated these ideas were coded as topic-medial (e.g., *'For example, many young people who need social work service may already be known to teachers'* in Text 2) or topic-final (e.g., *'However, it is also important to see the complexity of the wider picture'* in Text 2), depending on their position in the paragraph. Following Hyönä and Lorch (2004) and Ariasi et al. (2017) we separated topic-medial and topic-final sentences in the analyses, as topic-final sentences are likely to be where individuals carry out an integrative wrap-up processing before moving on to the next topic in the text.

First pass and second pass fixation duration were calculated per AOI. First pass fixation duration is the summed duration of fixations that land on unread regions of the sentence during the first encounter. Second pass fixation duration is the summed duration of fixations returning to a sentence that has already been processed (Ariasi et al., 2017; Mason et al., 2020). The first measure reflects participant's unconscious processing of the text (Catrysse et al., 2018). The second measure reflects participant's conscious, strategic behaviour and 'captures reanalysis following an initial processing difficulty' (Godfroid, 2019, p. 224).

There were several motivations for choosing these eye-tracking measures in the study. First, the analysis was based on a multi-word AOI (a sentence) and a finer distinction between additional fixation measures was less important for the study's RQs. When combined, first pass and second pass fixation duration capture most of the viewing activity on the AOI and can provide converging evidence on the presence or absence of text simplification effect. Secondly, these two measures do not overlap in their temporal properties, which safeguards the independence of the statistical tests during the analysis (Godfroid, 2019). Comparing multiple

measures can increase statistical error (Type I error), as in such cases researchers essentially test the same hypothesis multiple times (Von der Malsburg & Angele, 2017; Godfroid, 2019).

To control for the length of AOIs, the eye-tracking measures were converted to time-per-character measures (ms/char) and were then logarithmically transformed to normalize the distributions (Godfroid, 2019). Since simplified texts had more sentences due to the sentence split, we calculated mean fixation durations for each sentence type for the two eye-tracking measures.

Procedure

The ethical clearance for this study was obtained from the research ethics committee at the first author's institution. The session started with participants filling out a consent form, completing a demographic background questionnaire, and an LP test. All participants were then randomly allocated to one of the study conditions i.e., four OER texts read from the screen. Participants were informed that they would need to read a text for comprehension, and there would be two comprehension tests at the end of the session. Participants were seated about 60 cm from the screen for the eye-tracking calibration. Reading was self-paced, and participants were asked to press the escape button on the keyboard when they felt they understood the text.

After reading the text, participants completed BK and TI questionnaires. They were then asked to first complete a free recall task for the text they had read, and then to complete an MC comprehension test. This order of the comprehension measures allowed us to avoid the carry-over effect from seeing MC answer options to free recall. The entire experimental session lasted approximately 60 min. Participants were debriefed at the end of the session and received £20 Amazon vouchers.

Data Analysis

The distribution of the dependent variables in this study was tested. Comprehension via MC scores and comprehension via free recall all showed to be relatively normally distributed. The first and second pass fixation duration variables across three sentence types were skewed and therefore were log transformed (see section 2.2.6). The transformed variables met the assumption of being relatively normally distributed. Thus, overall the distribution of the residuals for each level of a factor, homogeneity of variances, linear relationship of covariates to the dependent variable at each level of the factor, homoscedasticity, and homogeneity of

regression slopes were tested for each of the ANCOVA described below and they were all met to a satisfactory standard.

RQ1 aimed to examine the relation between individual factors, such as LP, BK, and TI, and the variables that concerned participants' text comprehension and text processing in the study. To answer RQ1, Pearson correlation was conducted with all study variables.

RQ2 aimed to examine whether there is a difference in text comprehension between simplified versions and authentic versions of narrative and expository texts when controlling for LP, BK, and TI. To answer RQ2 between participants 2x2 Univariate ANCOVA was used. The first factor was condition with two levels (i.e., authentic vs. simplified). The second factor was text organisational structure with two levels (i.e., narrative text vs. expository text). The covariates in this analysis were LP, BK, and TI scores. The test was performed twice for each of the dependent variables i.e., 1) comprehension via MC; and 2) comprehension via free recall.

RQ3 aimed to examine whether there is an effect of text simplification on text processing as measured by first pass and second pass fixation duration. To answer RQ3, mixed effects 3x2x2 ANCOVA was used. The within-participants factor was sentence type with three levels (i.e., topic-introducing, medial, and final sentences). Between-participants factors were condition with two levels (i.e., authentic vs. simplified) and text organisational structure with two levels (i.e., narrative text vs. expository text). Similarly to the analysis in RQ2, to answer RQ3, LP, BK, and TI scores were entered in the model as covariates. In the first analysis the dependent variable was first pass fixation duration, and in the second analysis – second pass fixation duration.

Results

RQ1

To get an overview of the relation between the participant-related variables used in this study, correlations were computed. The correlations among the variables are presented in Table 1.

----------Table 1 about here ----------

As expected, BK strongly positively correlated with TI. LP moderately positively correlated with the free recall and moderately negatively correlated with the second pass fixation duration for the topic-introducing and medial sentences. TI strongly positively

correlated with free recall. BK and TI related positively to the first pass fixation duration for the medial sentences. In addition, TI negatively correlated with the second pass fixation duration for the final sentences. There were also significant relations between the eye-tracking measures: for first pass fixation duration between topic-introducing and topic-final sentences. The second pass fixation duration measure intercorrelated positively, i.e., topic-introducing sentences with medial, and medial with final sentences.

RQ2

The descriptive statistics for MC comprehension scores and free recall scores presented in Table 2 showed that on average, the comprehension scores for both MC and free recall were higher for the simplified condition than the authentic condition.

----------Table 2 about here ----------

The 2x2 Univariate ANCOVA was used to analyse the data and the results are presented in Table 3.

----------Table 3 about here ----------

As can be seen from Table 3, there are two important results. Firstly, whether text was simplified or not had an effect but only when comprehension was measured by the MC. In addition, LP had a significant effect on MC comprehension scores, F (1, 30) = 5.26, p = .03, η^2 = .15. To further explore this effect, participants were categorised as high (> 16.24, n = 16) or low LP group using a mean split (M = 16.24). ANCOVA (controlling now only for BK and TI) for the two proficiency groups showed that condition (simplified vs. authentic texts) only had a significant effect on comprehension MC in the low LP group, F (1, 15) = 11.09, p = .01, η^2 = .43 with the moderate effect size.

Secondly, for the comprehension measured by the free recall, text organisational structure had a significant effect i.e., whether it was narrative or expository when controlling for LP, BK, and TI scores. As with the comprehension MC, the analysis was run separately for the low and high LP groups. ANCOVA (controlling now only for BK and TI) for the two proficiency groups showed that for the low proficiency group both condition (simplified vs. authentic texts), F (1, 15) = 5.17, p = .04, η^2 = .24 and text organisational structure (narrative

vs. expository texts), F (1, 15) = 5.34, p = .04, η^2 = .25 had a significant effect on recall scores. These results demonstrate that participants with low proficiency scores were able to recall significantly more ideas from the simplified text that had a narrative structure, than from the simplified expository texts or authentic texts. Thus, simplification and text organisational structure had an effect on comprehension with simplification being important for MC comprehension, and narrativity of the text being important for free recall. In both cases, the low LP group benefited the most from text simplification.

RQ3

The means and standard deviations of the two eye-tracking measures in the authentic and simplified condition for the two texts are presented in Table 4.

----------Table 4 about here ----------

First Pass Fixation Duration

3x2x2 Mixed ANCOVA analysis of the first pass fixation duration revealed the main effect of condition (simplified vs. authentic texts), F (1, 30) = 13.4, p = .001, η^2 = .32 when controlling for LP, BK, and TI. Participants focused the most on topic-introducing sentences in the authentic condition, and – on topic-final sentences in the simplified condition. In addition, the initial text processing was longer in the simplified condition, as compared to the authentic condition. There was also a significant interaction effect between sentence type and text organisational structure, F (2, 60) = 3.79, p = .028. In the narrative texts participants focused mostly on topic-introducing sentences, and in expository texts – on topic-final sentences.

Conclusively, in relation to first pass fixation duration, the analysis of RQ3 showed that text simplification induced different initial processing of the text. Participants processed all three sentence types significantly longer in the simplified condition. Our analysis revealed that participants processed topic-introducing sentences most extensively in the authentic condition, and topic-final sentences – in the simplified condition, with medial sentences receiving the least processing time in both conditions. Furthermore, the time difference in processing of all three sentence types during the initial reading was reduced in the simplified condition. Since text organisational structure yielded interaction with sentence type, when accounting for this

factor separately, our data showed that in the narrative texts participants focused mostly on topic-introducing sentences, and in expository texts – on topic-final sentences.

Second Pass Fixation Duration

Similarly to first pass fixation duration, 3x2x2 Mixed ANCOVA was used. The results revealed the main effect of condition (simplified vs. authentic texts) on second pass fixation duration, F (1, 29) = 5.02, p = .033, η^2 = .15. As can be seen in Table 4, simplified texts received shorter re-inspection time in all three sentence types than the authentic texts. The results also showed a significant interaction between sentence type and condition, F (1, 58) = 9.46, $p < .001$, η^2 = .25 and a significant three-way interaction between sentence type, condition and text organisational structure, F (2, 58) = 5.16, p = .009, η^2 = .15. The three-way interaction is demonstrated in Figure 1 a, b and c.

----------Figure 1 a, b and c about here ----------

As can be seen from Figure 1 a, b and c, all three sentence types received shorter re-inspection times in the simplified condition for both narrative and expository texts. However, topic-introducing sentences received much shorter re-inspection times in the simplified expository texts, as compared to simplified narrative or authentic texts, while this difference in re-inspection times was less pronounced for the medial sentences. Second pass fixation duration was longer for topic-final sentences in the simplified narrative texts, as compared to simplified expository texts.

In addition to the main findings, LP had a significant effect on second pass fixation duration, F (1, 29) = .6.94, p = .031 and had significant interaction with sentence type F (1, 58) = 6.37, p = .003, η^2 = .18. To explore this effect further the analysis was performed separately for high and low LP participants (similarly to the analysis of comprehension scores). ANCOVA (now only using BK and TI as covariates) showed that participants in the high English LP group spent significantly less time rereading the texts, as compared to participants in the lower English LP group. Moreover, condition (simplified vs. authentic texts) only had a significant effect on second pass fixation duration in the high LP group, F (1, 10) = 17.75, p = .002, η^2 = .64.

To sum up, in relation to second pass fixation duration, the analysis of RQ3 showed that text simplification also induced different re-inspection processing of the text. Participants spent less time rereading simplified texts in all three sentence types in both expository and narrative texts. In contrast to their initial reading, where topic-medial sentences were viewed the shortest when rereading the texts participants spent more time rereading the medial sentences in both conditions. However, in the simplified condition participants focused on both medial and final sentences, and final sentences seemed to be particularly important in the narrative simplified text. In general, second pass fixation duration demonstrated higher sensitivity to individual and text factors than first pass fixation duration. One additional variable, LP, had a main effect on this eye-tracking measure with text simplification having significance only in the high LP group.

Discussion

The lack of research on the effects of intuitive text simplification that controlled for participants' individual factors and used diverse behavioural measures, coupled with the relevance of this topic for learning with Open Educational Resources (OER), inspired this study. To that end, this study examined the effect that intuitive simplification of OER reading materials has on text comprehension and text processing of English L2 users from diverse language and educational backgrounds.

RQ1 in this study was concerned with the relation between the different variables used in the study. Our study showed there was intercorrelation between background knowledge (BK) and topic interest (TI) in line with Boscolo and Mason (2003), between multiple-choice (MC) and free recall measures of the text comprehension assessment, as well as between the different sentence types in the two eye-tracking measures. The results supported our hypothesis that LP, BK, and TI have a positive effect on text comprehension, and participants with higher scores for these variables took less time to re-inspect the text. This finding might indicate that these participants were more efficient in capturing information from the text during the initial reading than participants with lower scores for these variables. Although our study showed that LP and TI have a significant effect on text recall and re-inspection than BK, all three individual factors that this study controlled for correlated with some of the variables related to participants' text comprehension and text processing. First pass fixation duration demonstrated positive relations with individual factors (BK, TI), while second pass fixation duration correlated negatively with individual factors (LP, TI). This finding provides additional

supporting evidence on the importance of controlling for these factors when exploring the effect of text simplification.

RQ2 in this study was concerned with the effect intuitive simplification of narrative and expository texts has on text comprehension of English L2 users when controlling for BK, TI, and LP. The analysis showed that across the sample simplification mainly facilitated comprehension as measured by MC, while narrativity of the text facilitated text recall. Our results supported our initial hypothesis: simplified texts were understood better than the authentic texts, and simplified narrative texts had significantly higher scores in free recall. These findings are partly in line with the previous text simplification research, which showed that participants who read simplified texts scored significantly higher on MC comprehension tests (Long & Ross, 1993; Yano et al., 1994; Tweissi, 1998; and Oh, 2001) and on free recall (Crossley & McNamara, 2016). In addition, our results are in line with some earlier studies that showed that narrative texts are better retained in memory than expository or descriptive texts. Narrative texts are more cohesively organised by causal relationships, whereas exposition is organised more loosely, which makes it more difficult to recollect the micro- and macrostructure of the latter type of texts (Kintsch & van Dijk, 1978; Sáenz & Fuchs, 2002).

Our data showed that LP had a significant effect on both MC and free recall scores, which is in line with the previous research (Oh, 2001; Crossley & McNamara, 2016). However, the results of the previous research have been inconsistent concerning whether text simplification has a significant facilitative effect on low, high, or both groups of English L2 proficiency users (Oh, 2001; Crossley et al., 2014; Crossley & McNamara, 2016). The further analysis we conducted with high and low English L2 proficiency groups separately showed that 1) it was the low proficiency group that benefited the most from intuitive text simplification exhibiting significantly higher scores on the MC comprehension test, and 2) there were higher scores on free recall for the narrative texts. The high proficiency group also had higher scores on simplified texts, but their scores were not significantly different from their reading of authentic and/or expository texts.

Finally, RQ3 in the study was concerned with the effect of text simplification on text processing as measured by first pass and second pass fixation duration. Since very few studies explored the effect of text simplification on text processing, it was difficult to hypothesise the moment-to-moment text processing in simplification. This study relied on the premises of the automatic information processing theory (LaBerge & Samuels, 1974) that informed this research, as well as on the evidence from previous research that used eye-tracking to explore the effect of other types of text modifications.

The findings supported our hypothesis for RQ3 concerning the facilitative effect of text simplification on participants' text processing. Our results showed that text simplification had a main effect on both first and second pass fixation duration. Text simplification slowed down processing for all three sentence types during the initial reading of the text and sped up processing during text re-inspection. In line with the automatic information processing theory (LaBerge & Samuels, 1974), shorter look-backs in this study might indicate that participants were able to process simplified texts more effectively during the initial reading and, thus, had fewer comprehension difficulties they needed to resolve during the look-backs in the text.

Furthermore, in line with Hyönä and Lorch (2004), we found that topic-introducing sentences were processed longer during initial reading in the authentic texts, as these were the likely locations that imposed extra inference demand on participants. In the simplified condition, however, we found a reduced time difference in processing of topic-introducing, medial, and final sentences, and participants moved more smoothly through the simplified texts during initial reading. This is in line with Hyönä and Lorch (2004), who linked the facilitative effect of text modification to the reduced processing difference between topic-introducing and medial sentences. Furthermore, this study found an extended overall processing time for final sentences in the simplified condition, when looking at both eye-tracking measures. The final sentences were the likely locations for the integration of the information participants read in the texts, and increased focus on this type of sentences is additional evidence of the facilitative effect of text simplification (Hyönä & Lorch, 2004; Ariasi et al., 2017; Mason et al., 2013). Using once again the premises of the automatic information processing theory (LaBerge & Samuels, 1974), this finding may indicate that as participants had fewer comprehension difficulties in simplification and they were able to direct their attention towards the text's main themes (topic-final sentences). Taking into account the findings from RQ2 in this study, which showed that comprehension and text retention scores were higher in the simplified condition, our study supports that text simplification facilitates effective text processing. As eye-tracking enables a nuanced investigation of the moment-to-moment processing, this study provided a fuller picture of the reading processes involved in simplification.

Similarly to text comprehension analysis, our data showed that LP also played an important role in text processing. Our data revealed both the main effect of LP on second pass fixation duration and a significant interaction between sentence type and LP in relation to this eye-tracking measure. When analysing second pass fixation duration separately for low and high LP groups, our results showed it was participants at high levels of English L2 proficiency that spent significantly less time re-inspecting the simplified texts than participants at low

proficiency levels. This is in line with the eye-tracking research literature that reports that as LP decreases, the fixation duration increases (Brunfaut & McCray, 2015; Conklin et al., 2018). Since eye-tracking enables an exploration of the initial reading of the text separately from later reprocessing efforts, our study further showed LP had a bigger influence on re-inspection time than on initial text processing duration.

Our analysis revealed that text organisational structure had a main effect on text recall and had significant interactions with sentence type in both initial reading and text reinspection. Thus, as has been shown in this study, it is important to account for this factor when exploring the effect of text simplification, which has not been done in earlier studies (Long & Ross, 1993; Yano, et al., 1994; Tweissi, 1998; Oh, 2001; Crossley et al., 2014; Crossley & McNamara, 2016).

Implications and Applications

The study also has a number of practical applications for the educational sector. First, it is evident from this study that the linguistic complexity of an academic OER text and its organisational structure play an essential role in understanding the text. The present evidence highlights that simplification of an OER text where possible – using higher frequency lexis, splitting long sentences, increasing text cohesion – benefits English L2 users, particularly at lower proficiency levels. Such practice has the potential to improve English L2 users' comprehension of an academic text and direct their focus to the sentences that are likely to summarise and wrap up the information in the text. Our study also showed that text narrativity has a positive impact on text retention. Since cohesion is not featured in structural text simplification practices, this study provided further evidence on the importance of introducing narrative elements and cohesive links within and between sentences in the academic texts, as these structures seem to be retained in participants' memory longer. Tools that can support the person performing simplification are online readability tools, such as Textinspector (Rets et al., 2020).

Secondly, this study focused on intuitive text simplification performed by English teachers and showed the efficiency of this approach for English L2 users' text comprehension and processing. This study demonstrated that English teachers represent an expert population on text simplification and have the necessary skills to increase access to the learning content. Thus, it is advisable for OER and academic material writers to collaborate with English teachers when editing or simplifying their reading materials. A similar recommendation can be applied to university teacher training programmes that prepare subject teachers who go on to

teach in English Medium Instruction (EMI) settings. It has been documented that many educators who teach their subjects through English felt they taught English L2 users in a 'trial and error' fashion. Educators pointed out that existing teacher training programmes did not offer courses aimed at equipping teachers with strategies for adequate language support in their future classes (Farrell, 2020; Yuan, 2020). Thus, training pre-service teachers on how to simplify academic texts might enable them to support their future learners with academic materials comprehension.

Limitations

This study intended to overcome the limitations of previous research on text simplification by controlling for individual factors, accounting for text organisational structure, using diverse methods of data collection, and multiple measures of text comprehension assessment. However, this study also has some limitations. First, the group sizes in the study were relatively small. It was possible to overcome this limitation in the eye-tracking analysis, as it was performed on the sentence level, which yielded more data points per participant. The issue of small sample size is still a concern for the comprehension test data collected in this study. However, assumptions for the selected statistical method were sustained and the model tested using this data was kept comparatively simple (two-way ANCOVA). This would somewhat elevate the strain on the data, although the power of the test with this sample size is lower than what we would hope for. Therefore, our results can be considered exploratory in nature and a first step to unpacking the effects of intuitive simplification. Future research should aim to replicate the results of this study using a bigger sample to gain higher statistical power.

Secondly, it would be interesting to further analyse the association between text re-inspection time, as measured by second pass fixation duration, and long-term retention of the information in the text. Participants in this study spent a significantly shorter amount of time re-reading the simplified texts. While this suggests ease of processing, it is not known if they learnt less from the text in the long-term perspective, as longer second pass fixation durations are associated with more deliberate text processing (e.g., Godfroid, 2019). Since it was beyond the scope of the present study to explore the effect of text simplification on learning from the text, a future study that adds a delayed post comprehension test might provide a further understanding of the effect of text simplification on learning.

Conclusion

The present study adds to our understanding of the effect of intuitive text simplification on text comprehension and text processing of English L2 users. The results converge to show that simplification leads to better text comprehension, reduces the processing difference between the different sentence types in the initial reading of the text, leads to shorter re-inspection time of the text, and directs individuals' focus to the text's final sentences. The group of English L2 users that benefited from text simplification the most were individuals with low English language proficiency. As such, academic materials that are developed for international use and which ignore the level of language difficulty in these materials can be excluding these learners. In light of the present finding, OER publishers and material designers should be motivated to include the possibility for OER learners to access a simplified version of the OER materials. Such practice has the potential to reduce the gap between many potential OER learners' language abilities and the learning materials they are provided with.

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