What's so simple about simplified texts? A computational and psycholinguistic investigation of text comprehension and text processing

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Abstract

This study uses a moving windows self-paced reading task to assess both text comprehension and processing time of authentic texts and these same texts simplified to beginning and intermediate levels. Forty-eight second language learners each read 9 texts (3 different authentic, beginning, and intermediate level texts). Repeated measures ANOVAs reported linear effects of text type on reading time (normalized for text length) and true/false comprehension scores indicating that beginning level texts were processed faster and were more comprehensible than intermediate level and authentic texts. The linear effect of text type on comprehension remained significant within an ANCOVA controlling for language proficiency (i.e., TOEFL scores), reading proficiency (i.e., Gates-MacGinitie scores), and background knowledge, but not for reading time. Implications of these findings for materials design, reading pedagogy, and text processing and comprehension are discussed.

Keywords: second language reading, text simplification, computational linguistics, corpus linguistics, psycholinguistics, text processing, text comprehension.

The role of spoken and written input is an important element of second language acquisition (Gass, 1988; Hatch, 1978) because it provides second language (L2) learners with language data from which to develop a lexicon, acquire the grammatical and syntactic structures of a language, and understand how the language conveys connections between ideas. The input that L2 learners receive is often simplified to make it more comprehensible. In spoken speech, L2 learners receive simplified input that is modified at the lexical, phonological, and syntactic level (Gaies, 1983). Written L2 texts are also modified in a variety of ways to make the text more comprehensible. Such modifications generally occur at the syntactic and lexical level (Hill, 1997). Written texts may also be simplified through a process of elaboration, which clarifies message content and structure through repetition of key ideas and the paraphrasing of difficult terms (Yano, Long, & Ross, 1994), although such elaboration can lead to decreased readability

(Long & Ross, 1993).

A number of studies indicate that compared to authentic texts (i.e., unmodified texts that were originally created to fulfill a social purpose in a first language [L1] community; Little, Devitt, & Singleton, 1989), simplified texts lead to better text comprehension (Long & Ross, 1993; Oh, 2001; Tweissi, 1998; Yano, et al., 1994). However, many of these studies have not statistically controlled for potential linguistic differences between text conditions (Tweissi, 1998) or have relied on traditional readability formulas, which are limited in the number of linguistic features they measure (i.e., word and sentence length; Long & Ross, 1993; Yano et al., 1994). Additionally, many of these previous studies did not control for language proficiency (Tweissi, 1998; Yano et al., 1994), reading proficiency (Long & Ross, 1993; Oh, 2001; Tweissi, 1998; Yano et al., 1994), or background knowledge (Long & Ross, 1993; Oh, 2001; Tweissi, 1998; Yano et al., 1994) when assessing text comprehension. Moreover, many of the studies focused only on comprehension and not on text processing speed (Oh, 2001; Tweissi, 1998; Yano et al., 1994), which is a common metric of reading performance in neuroscience, education, and psychology studies (Legge, 2006). Lastly, many previous studies have not compared comprehension at various levels of simplification (i.e., beginning and intermediate simplified texts) as compared to authentic texts (e.g., Long & Ross, 1993; Oh, 2001; Tweissi, 1998; Yano et al., 1994).

This study addresses many of these issues within an experiment that recorded reading processing speeds and comprehension scores using a moving windows paradigm. The study examines reading processing and comprehension scores comparing texts simplified at the beginning level, at the intermediate level, and authentic texts. These texts differed linguistically at the level of lexical sophistication, syntactic complexity, and cohesion. The participants in this study were assessed for language proficiency, reading proficiency, and background knowledge, all of which were included as covariates in the statistical analyses. The primary research question that this proposed study seeks to answer is:

> 1. Are there differences in text readability and comprehension for L2 readers among texts simplified to the beginning and intermediate level and authentic texts?
> 2. To what degree do linguistic modifications in a text aid in text readability and comprehension for L2 readers when background knowledge, language proficiency, and reading proficiency are included as covariates?

Text Simplification

Texts simplified for L2 readers come in a variety of forms. They can be adapted or abridged versions of original texts, or texts written for teaching a specific grammar or linguistic form. However, all simplified texts share the same goal: increased comprehensibility and reduced cognitive load on the part of the L2 reader. The primary methods of attaining this comprehensibility are in the modification of the lexicon and the syntax (Hill, 1997). Generally, material developers have two approaches they can follow when simplifying a text: a structural approach or an intuitive approach (Allen, 2009).

Intuitive approaches to text simplification are the most common of the two (Crossley, Allen, &

McNamara, 2012; Simensen, 1987). Following an intuitive approach, authors' experiences as a language learner, language teacher, or materials developer (or any combination of these) guide the process of simplification. The intuition that is derived from such experiences allows the authors to rely on subjective approximations of what learners at a particular level should be able to read and comprehend (Allen, 2009). Such approximations obviate the need for structural manipulations.

Under a structural approach to simplification, writers generally depend on pre-defined word and structure lists. Such approaches are commonly used in graded reader schemes that are aimed at advancing learners' language acquisition through extensive reading. Another approach subsumed under the structural approach is text simplification guided by the use of traditional readability formulas. Traditional readability formulas are simple algorithms that measure text readability based on sentence length and word length. They have found success in predicting L1 text readability, but have been widely criticized by discourse analysts (Davison & Kantor, 1982) and L2 researchers (Carrell, 1987; Crossley, Greenfield & McNamara, 2008) as being weak indicators of comprehensibility. Traditional readability formulas have also been demonstrated to be less effective at predicting text difficulty than readability formulas derived from indices that tap into cognitive processing (e.g., decoding, syntactic processing, and meaning construction; Crossley et al., 2008).

Text Simplification and Text Structure

Until recently, the effects of text simplification on the actual linguistic features contained in simplified text were not clear, especially in comparison to authentic texts or in comparison of text simplification levels (i.e., differences in texts simplified at to beginning, intermediate, and advanced levels). This gap in the research was addressed in a series of studies by Crossley and his colleagues that compared differences in the linguistic features found in authentic and simplified texts (Crossley, Louwerse, McCarthy, & McNamara, 2007; Crossley & McNamara, 2008) and differences between levels of simplification (Crossley, Allen, & McNamara, 2011; 2012).

In reference to differences between simplified and authentic texts, Crossley et al. (2011, 2012) used the computational tool Coh-Metrix (Graesser, McNamara, Louwerse, & Cai, 2004; McNamara & Graesser, 2012) to examine a wide range of linguistic features in authentic and simplified texts at the beginning and intermediate level. These studies have indicated that at the intermediate level, authentic texts are syntactically more complex and contain a greater density of logical connectors. Simplified texts, on the other hand, have significantly higher levels of cohesion (e.g., lexical co-reference and semantic overlap) and lower levels of lexical sophistication (e.g., word frequency, word hypernymy, word polysemy, and word familiarity). These findings are generally similar to those at the beginning level and suggest that simplified texts may be more cohesive than authentic texts and contain less sophisticated linguistic features. Thus, the findings from these studies support the notion that the process of simplification creates texts that contain more linguistic features that should lead to enhanced text comprehension and more rapid text processing.

Crossley et al. (2011, 2012) used Coh-Metrix to examine differences between intuitively

simplified texts at the beginning, intermediate, and advanced levels. In the 2011 study, Crossley et al. investigated the predictive accuracy of readability formulas to distinguish among the three levels. They used two traditional readability formulas (Flesch Reading Ease, Flesch, 1948; Flesch-Kincaid Grade Level, Kincaid, Fishburne, Rogers, & Chissom, 1975) that measure word and sentence length and a more cognition-based readability formula (the Coh-Metrix L2 Reading Index, Crossley et al., 2008) that measures word frequency, syntactic similarity, and content word overlap. The results demonstrated that the Coh-Metrix L2 Readability Index predicted with greater precision the reading level of the texts as compared to traditional readability indices. The findings indicated that beginning level simplified texts contained more frequent words, higher syntactic similarity between sentences, and greater word overlap, all of which should lead to enhanced text comprehension and faster processing. The findings also raised concerns about the use of traditional readability formulas for assessing L2 text readability in that they were less predictive of simplification level and thus demonstrated lower correspondence with intuitive simplification approaches.

In the 2012 study, Crossley et al. examined a variety of linguistic features related to lexical sophistication, syntactic complexity, and cohesion to predict simplified text level. The findings from this study indicated that beginning level simplified texts as compared to advanced texts are less complex lexically (e.g., contain lower lexical diversity, more frequent words, more familiar words, and more concrete words) and syntactically (e.g., have greater syntactic similarity and fewer words before the main verb). In addition, beginning level simplified texts contain a greater number of cohesive cues (e.g., more given information, greater semantic co-referentiality, and more noun overlap). These findings imply that beginning level simplified texts should be easier to process and lead to enhanced comprehension than advanced level simplified texts.

Simplification and Text Comprehension

Material designers and researchers have considerable interest in the benefits of text simplification for L2 learners. Generally, the effects of text simplification are measured in terms of increased text comprehension, with supporters of text simplification arguing that the process of simplification increases the reader's ability to understand and interact with a text (Goodman & Freeman, 1993). Detractors, on the other hand, maintain that the removal of linguistic forms in favor of more simplified and frequent forms deny learners the opportunity to interact with and acquire the natural forms of language (Long & Ross, 1993). Generalizations about comprehension effects that result from authentic or simplified texts are difficult because of differences in research designs. However, the research that has been conducted generally supports the facilitative effects of text simplification for text comprehension.

For instance, Long and Ross (1993) found that L2 students who read texts linguistically simplified using traditional readability formulas scored significantly higher on multiple-choice items intended to assess comprehension than did those that read authentic texts. Long and Ross also found a strong relationship between readers' English proficiency level and reading comprehension scores with more proficient readers exhibiting better comprehension. This finding was supported in a follow up study (Yano et al., 1994) using the same texts. This study similarly demonstrated that the simplified texts increased text comprehension in comparison to the authentic texts. More recent studies by Tweissi (1998) and Oh (2001) also found that

simplification positively affected L2 students' overall reading comprehension. In addition, Tweissi reported differences in comprehension comparing texts modified both lexically and syntactically as compared to texts just modified lexically (with lexical modifications only leading to increased comprehension). This finding was interpreted as indicating that excessive simplification may reduce reading comprehension. However, Tweissi did not statistically control for linguistic differences in the text conditions, rendering interpretations of this finding potentially spurious. Similar to the studies reported by Tweissi, Long and Ross, and Yano et al., the study reported by Oh also found that simplified texts showed significant comprehension gains over authentic texts for high proficiency readers, but not for low proficiency readers. However, like Tweissi, Oh did not statistically control for linguistic differences between the text conditions.

Methods

As discussed in the previous section, a number of studies indicate that text simplification leads to increased text comprehension when compared to authentic texts. However, many of these studies did not statistically control for linguistic differences in text conditions (the exceptions being those studies that relied on readability formulas). Additionally, many of the studies did not control for participants' language proficiency, reading proficiency, or background knowledge when assessing text comprehension. Previous studies have also focused only on comprehension and not on text processing speed, which is an important indicator of reading performance (Legge, 2006). Lastly, previous studies have compared simplified text to authentic texts but have not controlled the level of simplification. This study addresses these limitations by using a self-paced moving window reading task to assess text processing speeds and true/false comprehension questions to assess text based levels of comprehension for authentic texts and texts simplified to the beginning and intermediate level. In addition, language proficiency, reading proficiency, and background knowledge scores were collected from the participants in this study.

Participants

Forty-eight non-native speakers of English enrolled at the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM) campus in San Luis Potosi, Mexico participated in this study. All participants were native speakers of Spanish and were studying at either the high school or college level. Of these 48 participants, 19 were female and 29 were male. All participants had normal or corrected to normal vision. The participants ranged in age from 15 to 24. All participants had taken a paper-based institutional TOEFL 1 month before the data collection. The average TOEFL score for the participants was 520. Descriptive statistics for the participants are presented in Table 1.

Table 1. *Descriptive statistics for participants in study*

Item	Minimum	Maximum	Mean	SD
Age	15	24	17.71	2.153
Grade level	10	13	11.58	1.164
Grade point average (100 scale)	73	97	84.81	6.271
TOEFL scores	420	597	519.60	30.741

Procedure

Data collection occurred in three different sessions. The first session involved an on-line questionnaire that collected demographic information for the participants followed by a background knowledge survey that assessed participants' knowledge of the topics covered with the reading passages. One week later, in the second session, the participants were administered the Gates-MacGinitie reading proficiency test (GMRT, MacGinitie & MacGinitie, 1989). On the following day, during the third session, the students participated in an on-line reading experiment that assessed their ability to read simplified and authentic texts using a self-paced, non-cumulative, moving window reading task similar to that used by Just, Carpenter, and Woolley (1982). Comprehension of these texts was assessed using true/false questions. Moving window reading tasks are common in studies of second language syntactic acquisition research (SLA, Felser, Roberts, Gross, & Marinis, 2003; Juffs & Harrington, 1995), but not L2 reading research to date. Moving windows tasks simulate eye movement data, but at a fraction of the cost (Just, Carpenter, & Woolley, 1982).

Three text groupings were developed for the moving window reading task such that each grouping included three authentic texts, three texts simplified to the intermediate level, and three texts simplified to the beginning level ($n = 9$). There was no overlap between the texts in each grouping and the texts in each grouping were on different topics. The texts were presented in random order. Participants were randomly, but evenly assigned to a grouping so that each text at each level and each text was read by at least 16 participants. Thus, each participant read nine texts (three beginning level simplified texts, three intermediate level simplified texts, and three authentic texts) on nine different topics.

Each text was presented one word at a time and the participants advanced through a text by pushing the spacebar on a computer keyboard. The words were presented sequentially and in the same location as in a normal text. Participants were not allowed to revisit text that had already been read. Such an approach allows a processing time measure (i.e., response times between spacebar presses) to be associated with each individual word (similar to word fixation rates). Participants were given instructions on the tasks and a practice trial to familiarize themselves with the task. Comparisons between self-paced reading tasks and normal reading tasks have demonstrated similar results across a number of studies (Juola, Ward, & McNamara, 1982; Rubin & Turano, 1992); however, this is not always the case (cf. Kennedy & Murray, 1984; Magliano, Graesser, Eymard, Haberlandt, & Gholson, 1993). In addition, self-paced reading tasks such as moving windows tasks slow down the reading time (Rayner, 1998).

When participants reached the end of the text, they were prompted to answer yes/no comprehension questions about the text they had just read (see Comprehension Question section below for more detail). The experiment was developed using E-Prime software. A font size of 14 was selected to ensure that visual factors did not affect reading speed (Legge, Rubin, Pelli, & Schleske, 1985).

Materials

Texts. The reading samples used for this study were selected from a corpus of 100 simplified news texts. Thus, unlike previous studies (Long & Ross, 1993; Oh, 2001; Tweissi, 1998; Yano et al., 1994), we did not modify the texts specifically for this study, but rather selected pre-existing texts modified by experts (see below for details). The texts were taken from an English teaching website (www.onestopenglish.com). The website offers simplified news texts and accompanying learning activities. The news texts were originally taken from the *Guardian Weekly*, a British-based publication with a wide international readership. The articles in the corpus were originally selected by the website editors for their topicality and interest value and typically center on world affairs. The texts are, therefore, non-academic in nature.

The news texts were simplified by a small, independent team of authors, into three levels of simplification: advanced, intermediate and beginning. The method of simplification employed by the authors was intuitive, that is, without recourse to word lists, structural grading schemes, or readability formulas (Allen, 2009). As reported by Allen, the authors did provide certain indications regarding their approach to simplification. First, the authors followed the motto 'grade the task, not the text,' showing a tendency to only simplify when absolutely necessary. Second, a number of general strategies were employed, such as modifying idiomatic language at the intermediate level and removing it completely from the elementary level, while removing all passive structures and phrasal verbs from elementary level texts. The texts have been used in a number of studies examining text simplification in L2 reading (Allen, 2009; Crossley et al., 2011, 2012).

From this corpus, we selected the initial paragraph from nine texts to use in the moving windows experiment. For each text we had three versions: the authentic text, a text simplified to the intermediate level, and a text simplified to the beginning level. We did not select texts from the advanced level because these texts were generally unmodified from the authentic texts (Allen, 2009). All texts contained the same main propositional information. While rarely necessary, we changed all spelling in the texts from British English to American English, which was the English of instruction for our participants.

In the process of text selection, we selected only those texts that differed in linguistic features related to L2 text simplification, comprehension, and readability. We examined the linguistic features in the text by first collecting linguistic information for each text using the computational tool Coh-Metrix (Graesser et al., 2004; McNamara & Graesser, 2012). We then used the linguistic information from each text to assess differences between levels using a Multivariate Analysis of Variance (MANOVA). The linguistic features we selected were related to meaning construction (i.e., cohesion), lexical recognition (i.e., lexical sophistication), and syntactic parsing (i.e., syntactic complexity). These features were selected from previous Coh-Metrix research that examined linguistic differences between simplified and authentic texts (Crossley et al., 2007; Crossley & McNamara, 2008), differences between levels of simplified texts (Crossley et al., 2012), and L2 text comprehensibility (Crossley et al., 2008). All indices demonstrated significant differences for the selected features between the text levels (see Table 2). The selected indices are discussed below. We also ensured that text conditions did not significantly differ based on number of words.

Table 2. *Multivariate results for linguistic differences between text levels*

Linguistic features	Beginning level text mean (*SD*)		Intermediate level text mean (*SD*)		Authentic text mean (*SD*)		*f*	*p*	*hp2*
Noun overlap	0.55	(0.13)	0.27	(0.13)	0.15	(0.14)	21.371	< .001	0.640
Lexical diversity D	65.89	(14.85)	91.00	(14.93)	112.67	(24.65)	14.081	< .001	0.540
CELEX content word frequency	2.43	(0.17)	2.20	(0.20)	2.01	(0.16)	12.449	< .001	0.509
Sentence syntax similarity	0.13	(0.03)	0.10	(0.03)	0.07	(0.03)	8.707	< .001	0.420
Word familiarity	580.55	(8.97)	568.74	(10.70)	563.16	(9.63)	7.389	< .010	0.381
Word Meaningfulness	368.12	(14.06)	352.70	(14.14)	346.89	(15.82)	5.989	< .010	0.333
Number of causal verbs and particles	44.12	(18.84)	32.87	(12.65)	23.70	(8.84)	4.761	< .050	0.284
LSA Sentence to Sentence mean	0.23	(0.07)	0.18	(0.05)	0.14	(0.07)	4.352	< .050	0.266
Number of words	150.11	(29.80)	125.22	(21.93)	128.89	(28.25)	2.250	> .050	0.158

Cohesion. Cohesion is an important feature of text readability that is strongly related to enhanced comprehension and processing (Gernsbacher, 1997; McNamara, Kintsch, Songer, & Kintsch, 1996). Coh-Metrix calculates a number of indices related to text cohesion including word overlap, semantic similarity, and causality. Word overlap indices measure how often words overlap between adjacent sentences. Semantic similarity indices use Latent Semantic Analysis (Landauer, McNamara, Dennis, & Kintsch, 2007) to assess similarity between words at the sentence and paragraph level. Word and semantic overlap indices help to facilitate meaning construction and improve text comprehension and reading speed (Douglas, 1981; Kintsch & van Dijk, 1978; Rashotte & Torgesen, 1985). Greater lexical overlap also leads to enhanced text readability for L2 readers (Crossley et al., 2008). Causal indices in Coh-Metrix are measured by calculating the ratio of causal verbs to causal particles in a text, which relates to the conveyance of causal content and causal relations between events and actions. Past studies have demonstrated that beginning level simplified texts have greater word overlap, greater semantic similarity, and less causality than intermediate and advanced simplified texts (Crossley et al., 2012) and authentic texts (Crossley & McNamara, 2008).

Lexical sophistication. The level of lexical sophistication found in a text also relates to text processing and comprehension and is an important feature of word decoding (Just & Carpenter, 1987; Perfetti, 1985; Rayner & Pollatsek, 1994). In reference to lexical sophistication, Coh-Metrix calculates the word frequency, word familiarity, word meaningfulness, and lexical diversity for the words in a text. Coh-Metrix calculates word frequency using the CELEX database (Baayen, Piepenbrock, & Gulikers, 1995), which consists of word frequencies taken from the 17.9 million word COBUILD corpus. Coh-Metrix calculates word familiarity and word meaningfulness using the MRC Psycholinguistic Database (Coltheart, 1981). Word familiarity indices assess the likelihood of word exposure while word meaningfulness indices measure how strongly words associate with other words. Coh-Metrix calculates lexical diversity using a variety of indices that control for text length including *D* (Malvern, Richards, Chipere, & Durán, 2004), which was used in this study. Word frequency is a strong predictor of L2 reading performance (Crossley et al., 2008) while word familiarity, meaningfulness, and lexical diversity are important elements of the text simplification process (Crossley et al., 2012; Crossley &

McNamara, 2008). More details on these indices can be found in McCarthy and Jarvis (2010) and Salsbury, Crossley, and McNamara (2011).

Syntactic Complexity. Syntactic complexity indices relates to the difficulty of syntactic parsing (Just & Carpenter, 1987; Rayner & Pollatsek, 1994), which is an important element of text readability and comprehension. From Coh-Metrix, we selected an index that measures semantic similarity by assessing the uniformity and consistency of parallel syntactic constructions in text. More uniform syntactic constructions result in less complex syntax that is easier for the L2 reader to process (Crossley et al., 2008). Greater syntactic similarity is also a feature of beginning level L2 simplified text (Crossley et al., 2012).

Number of words in the text. We also included a measure of text length because text length can correlate to the number of propositions contained in a text. The number of propositions found in text relates to text comprehension because multiple propositions strain working memory (Kintsch & Keenan, 1973). We used this measure to ensure that the conditions did not differ as a function of text length.

Background knowledge tests. Background knowledge is an important predictor of readability and text comprehension (McNamara et al., 1996; Shapiro, 2004). Thus, we developed an assessment of background knowledge specific to the reading texts used in this study. Following Bellissens, Jeuniaux, Duran, and McNamara (2010), we developed prior knowledge questions for each of the sets of texts. These questions broadly covered the main themes shared in the same set of beginning simplified, intermediate simplified, and authentic texts. The questions were multiple-choice questions that included the correct answer and three distracters. The distracters were near-miss (incorrect in general), thematic (same theme but incorrect), and unrelated (different theme and incorrect). We developed five text-based questions for each text ($N = 45$) where the question and answer were in the same sentence. We piloted these questions with 25 undergraduate students in order to examine item performance. Twenty-seven questions (three for each set of texts) were selected based on the item performance such that no questions had either a ceiling ($r > .900$) or a floor effect ($r < .250$). We used these 27 questions to assess the background knowledge of the participants for the text topics used in this experiment.

Reading proficiency tests. Participants in this experiment were administered the Gates-MacGinitie Reading Test (GMRT, MacGinitie & MacGinitie, 1989), which is a multiple-choice reading test that lasts 55 minutes. The participants were all administered the Level 10/12 GMRT. The tests were scored by the researchers. Controlling for reading proficiency is an important element of reading research, especially research that considers reading time because word fixation will decrease as a function of increasing reading skill (Buswell, 1922).

Comprehension questions. After participants finished reading a text in the moving windows experiment, they answered four true/false questions that corresponded to the main ideas and important details of the text. The comprehension questions associated with each text were identical regardless of level (i.e., text simplified to beginning or intermediate level and authentic texts). In this way, the questions were text specific. Such comprehension questions are a common approach to assessing reading for understanding (Carver, 1990).

Statistical Analyses. Statistical analyses of the data (i.e., reading times and comprehension scores) were conducted to examine the effects of linguistic simplification on text readability and comprehension. Analyses of variance (ANOVAs) followed by analyses of covariance (ANCOVA) were conducted to examine differences in reading times and comprehension scores between beginning, intermediate, and authentic texts alone and by using TOEFL, background knowledge, and reading proficiency (GMRT) scores as covariates.

Results

Correlations Between Covariates

Pearson correlations were conducted among the covariates selected for this analysis (i.e., TOEFL, background knowledge, and GMRT scores) to examine potential multicollinearity. None of the covariates demonstrated strong multicollinearity (defined as $r > .70$) with each other (see Table 3).

Table 3. *Correlations between selected covariates*

	Background knowledge score	GMRT score
TOEFL score	-0.035	0.559
Background knowledge score		0.068

Reading Time ANOVA

A within-subjects ANOVA revealed a significant effect of text level (beginning, intermediate, authentic texts) on reading time (normed for text length and reported as milliseconds per word), $F(2, 94) = 3.688$, $p < .050$, $\eta_p^2 = .073$. A significant linear trend, $F(1, 47) = 6.523$, $p < .001$, $\eta_p^2 = .122$, confirmed the expectation that texts simplified to the beginning level result in the shortest reading times followed by texts simplified to intermediate and authentic levels (see Table 4). Follow-up pairwise comparisons were conducted to evaluate differences among the means. Beginning level texts took less time to read than authentic texts ($p < .050$), but not intermediate texts. No differences in reading times were found between authentic texts and intermediate texts.

Table 4. *Descriptive statistics for reading time (ms per word): Mean (SD)*

Text level	Reading time
Beginning	603.20 (185.09)
Intermediate	624.00 (166.42)
Authentic	635.44 (162.49)

Tests for Homogeneity of Regression Slopes: Reading Time

Prior to conducting an ANCOVA, regression slopes for each of the covariates were plotted against the reading times for the participants by condition. The regression slopes were used to assess homogeneity between the covariates in the prediction of the dependent variable (i.e., reading time scores) across the conditions. If the regression slopes for the conditions are similar (i.e., demonstrate homogeneity in their slopes), then the dependent variable likely does not vary

as a function of the covariates and the covariates can be used in the subsequent ANCOVA. If the regression slopes for the conditions are dissimilar (i.e., demonstrate heterogeneity in their slopes), then the differences in the dependent variable among conditions likely vary as a function of the covariate and the results from the ANCOVA may not be meaningful because the findings will not represent all the conditions. The regression plots for the reading time covariates showed homogeneity across the conditions (see Figure 1) and thus all covariates were used in the ANCOVA.
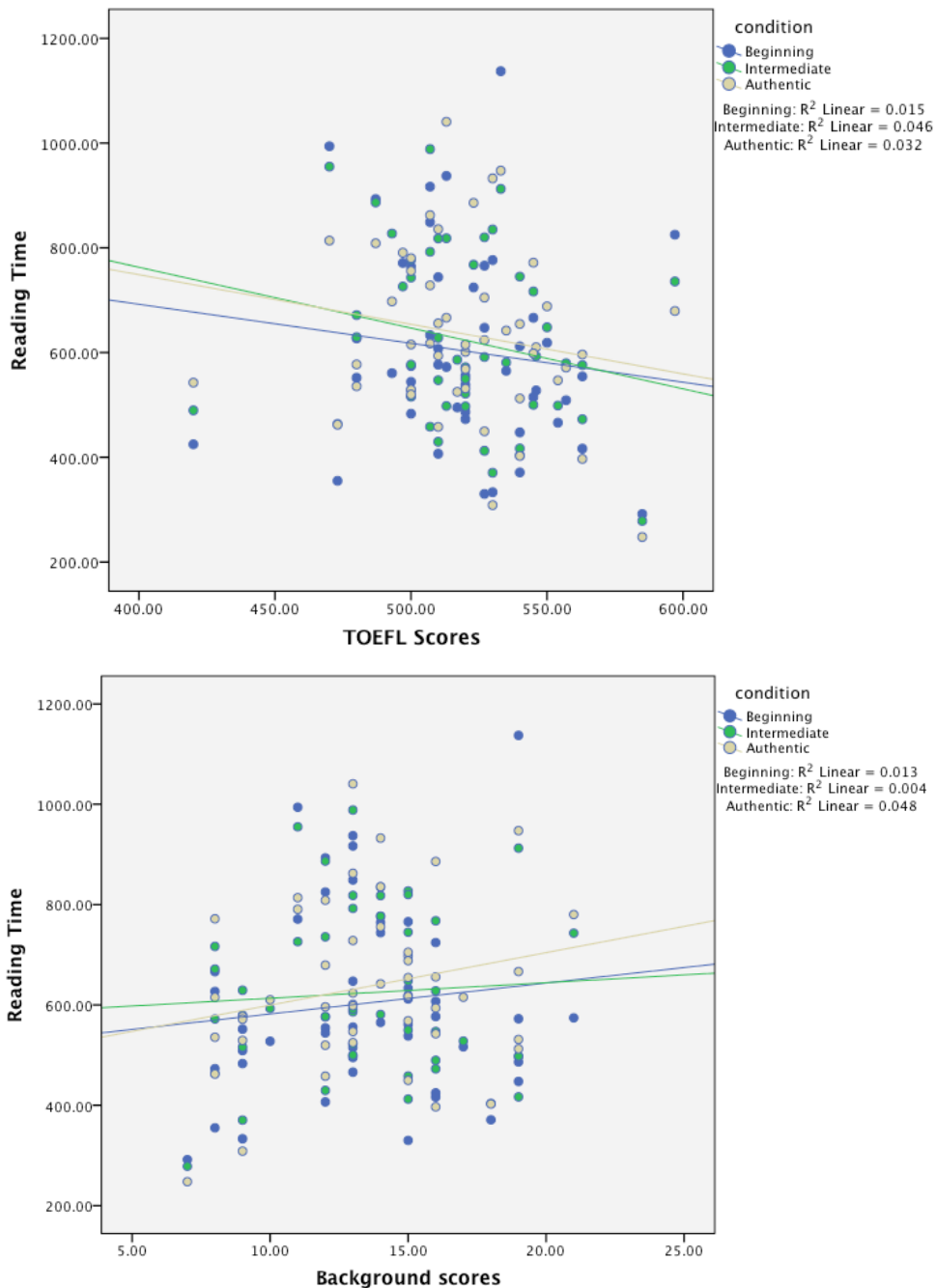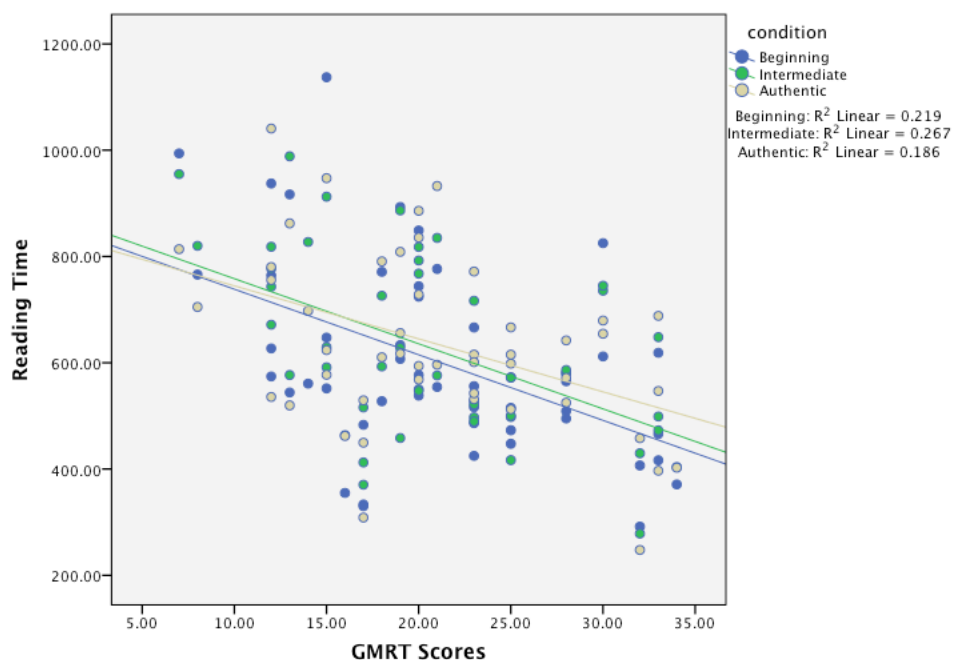
Figure 1. Regression slopes for reading time and covariates

Reading Time ANCOVA

The within-subjects ANCOVA on reading time including the covariates (i.e., TOEFL, GMRT, background knowledge) was not significant, $F(2, 88) = 1.373$, $p > .050$, $\eta_p^2 = .030$. The effects of language proficiency ($F < 2$) and background knowledge [$F(1,44)=2.002$] were not significant. However, reading proficiency as measured by GMRT had a substantial relation with participants' reading times, $F(1, 44) = 14.779$, $p < .001$, $\eta_p^2 = .251$. Therefore, when reading proficiency was entered as a covariate, the differences in reading time as a function of text level were no longer significant.
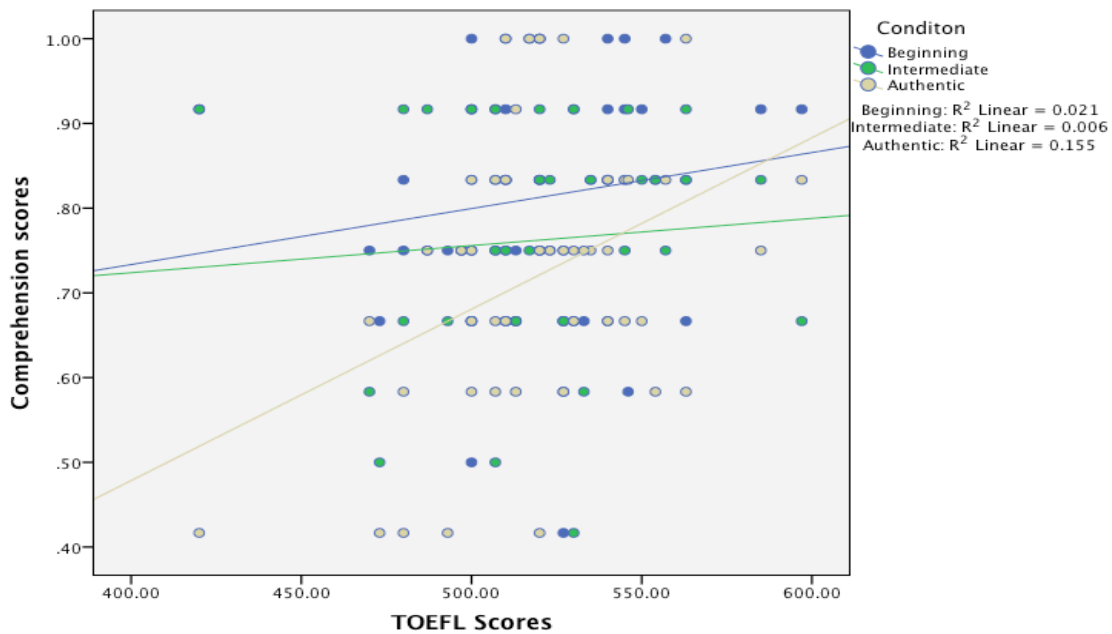
Comprehension Score ANOVA

The within-subjects ANOVA revealed a significant effect of text level (beginning, intermediate, authentic texts) on comprehension scores, $F(2, 94) = 5.732$, $p < .001$, $\eta_p^2 = .109$. A significant linear trend, $F(1, 47) = 9.093$, $p < .001$, $\eta_p^2 = .162$, confirmed expectations that the beginning level texts produce the highest comprehension scores followed by intermediate and authentic texts (see Table 5). Follow-up pairwise comparisons demonstrated that beginning simplified texts result in higher comprehension scores than intermediate simplified texts ($p < .050$) and authentic texts ($p < .010$), with no differences between intermediate and authentic texts ($p > .050$).

Table 5. *Descriptive statistics for comprehension scores: Mean (SD)*

Text level	Comprehension score
Beginning	.81 (.14)
Intermediate	.76 (.13)
Authentic	.72 (.16)

Tests for Homogeneity of Regression Slopes: Comprehension Scores

Regression slopes were plotted for each of the covariates against the comprehension scores for the participants by condition. The regression plots for the background scores showed heterogeneity across the conditions suggesting that differences in the dependent variable among the conditions varied as a function of the covariate (see Figure 2). Specifically, Figure 2 illustrates that background knowledge had a greater effect (i.e., steeper slope) for authentic texts than for simplified or intermediate texts. Thus, this covariate was not used in the ANCOVA. The TOEFL scores and reading proficiency scores demonstrated similarities across the conditions and were thus included in the ANCOVA
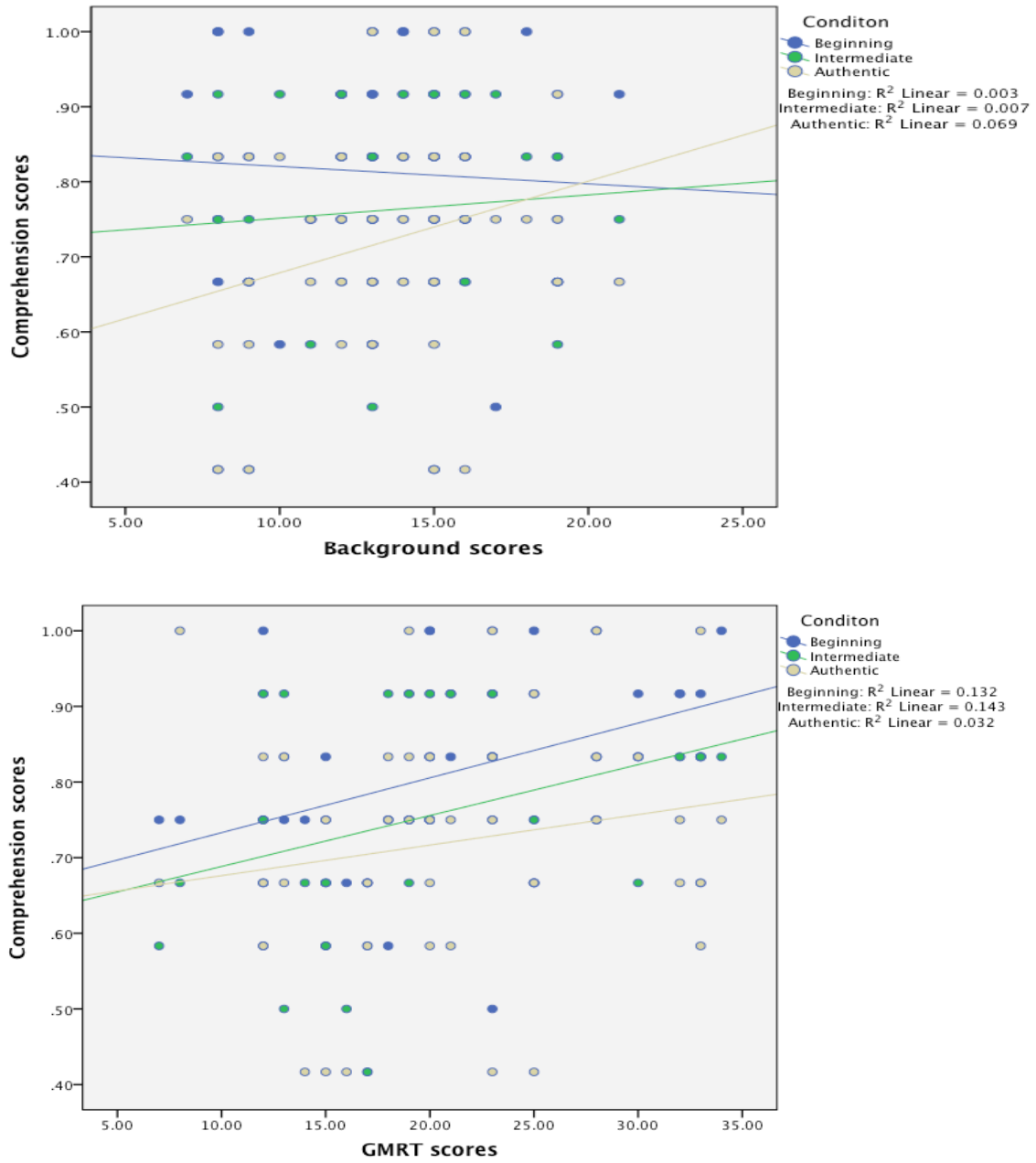
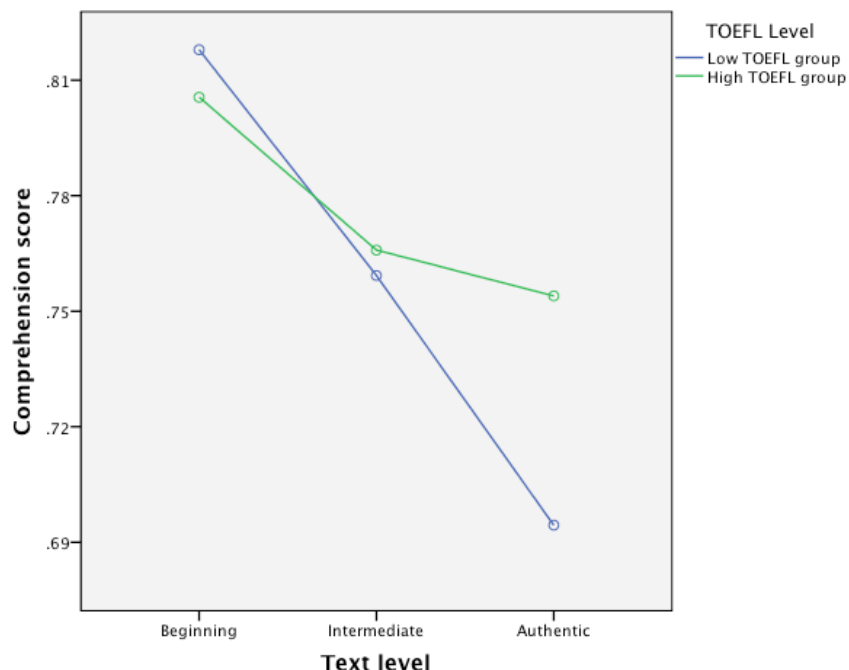**Figure 2.** Regression slopes for comprehension scores and covariates

Figure 3. Reading comprehension as a function of TOEFL score (high, low)

Comprehension Score ANCOVA

The within-subjects ANCOVA on comprehension scores including the covariates (i.e., TOEFL, GMRT) was significant, $F(2, 90) = 4.661$, $p < .050$, $\eta_p^2 = .094$, confirming a significant linear effect of text level, $F(1, 45) = 4.927$, $p < .050$, $\eta_p^2 = .099$. Therefore, when the effects of language proficiency as measured by TOEFL (F<1) and reading proficiency as measured by GMRT [$F(1, 45) = 6.386$, $p < .050$, $\eta_p^2 = .124$] were removed statistically, the effects of text level on comprehension remain significant.

In addition, there was a significant interaction between text level and TOEFL score, $F(2, 90) = 4.790$, $p < .050$, $\eta_p^2 = .096$. To illustrate this interaction, participants were categorized as high or low TOEFL using a mean split (TOEFL M = 520). Figure 3 displays comprehension scores as a function of TOEFL score group (high, low) and text level. Whereas there was little effect of language proficiency according to TOEFL for the simple and intermediate texts (both F < 2), there was a significant effect for authentic texts, $F(1, 46) = 5.065$, $p < .050$, $\eta_p^2 = .100$, demonstrating that authentic texts were comprehended better by participants with higher TOEFL scores than by participants with lower TOEFL scores (see Figure 3).

Discussion

A primary goal of this study was to examine the effects of text simplification on reading times and comprehension scores for L2 readers. We were also interested in assessing these differences while also statistically accounting for participants' reading proficiency, language proficiency, and background knowledge.

As expected, we found a linear trend such that authentic texts were read more slowly than were simplified texts. The reported effect size indicated that simplification explained about 12% of the variance in reading time. The reading time differences assumedly emerge from the linguistic differences between the texts, where simplified texts are characterized by more familiar words and text that is more cohesive and syntactically less complex. In essence, simplified text can be characterized as being more readable and as using language that is more accessible.

One qualification to the reading time results arises from the ANCOVA results. When reading proficiency was included as a covariate, the differences in reading time as a function of text level were no longer significant. Hence, reading proficiency tended to drive the reading times for the L2 readers, more so than the nature of the text. These findings collectively indicate that for these L2 readers there are significant effects of text simplification on reading time (especially between beginning simplified texts and authentic texts), but the variance associated with reading times is better explained by individual differences in reading proficiency (which explain about 25% of the variance in reading time). These findings are not surprising in that reading proficiency measures such as GMRT were explicitly developed to detect differences in reading processes and outcomes, such as reading time, whereas the differences between texts as a function of simplification for L2 readers are likely more subtle. In addition, text simplification is typically intended to facilitate comprehension as opposed to reading speed.

Similar to the effects on reading time, there was a linear effect of text simplification on comprehension. These results confirm that the beginning level simplified texts were comprehended better than authentic texts. Hence the ease in processing was not traded off with comprehension: simplified texts were read more quickly and they were better understood.

This effect of text simplification on comprehension remained when reading proficiency and language proficiency were included as covariates. However, one qualification to this finding emerged from an interaction between text level and language proficiency (i.e., TOEFL scores). Namely, the effect of text simplification on comprehension crucially depended on language proficiency. L2 readers with stronger language proficiency were better able to cope with the linguistic challenges of authentic text. By contrast, participants with lower English proficiency were significantly challenged by the authentic texts. Hence, the disadvantages of the authentic texts were augmented for those L2 readers with lower language abilities.

Authentic texts were also particularly challenging for low-knowledge readers, but appeared to be more beneficial to the readers with higher background knowledge. Looking at the comprehension score regression slopes in Figure 2, we see that comprehension differences as a function of text level further depended on the participants' background knowledge. Specifically, participants with higher background knowledge better comprehended authentic texts than those with less background knowledge. At the same time, high knowledge participants comprehended beginning simplified texts to a lesser degree than low background knowledge readers. These findings mirror reverse cohesion effects reported with L1 readers (McNamara, 2001; McNamara & Kintsch, 1996; McNamara et al., 1996; O'Reilly & McNamara, 2007). Accordingly, low background knowledge readers show better understanding of high cohesion (e.g., simplified) texts because the cohesion cues help the readers bridge gaps in their background knowledge. By contrast, high knowledge readers show comprehension gains for texts with lower cohesion (e.g.,

authentic texts). The predominate explanations for this reverse cohesion effect is that the lower cohesion texts induce the high knowledge readers to generate inferences that connect ideas in the text and also connect the text with prior knowledge. This interpretation is bolstered in the current study by the reading time results. Looking at the reading time regression slopes in Figure 1, we see that participants with more background knowledge take longer to read authentic texts than participants with less background knowledge. This increase in reading time is likely attributable to the increased effort needed to bridge cohesion gaps. The gaps induce inference generation (which takes more time), and the high knowledge readers are more able to engage in these gap-filling processes. In turn, these readers showed higher comprehension for these texts, because they were more actively engaged in the comprehension process. Nonetheless, the potential advantages of authentic texts are offset by their negative effects for lower knowledge readers, who depend on the higher cohesion in the simplified texts to scaffold their understanding.

Overall, the comprehension findings provide support for previous studies that have indicated that text simplification enhance text comprehension (Long & Ross, 1993; Oh, 2001; Tweissi, 1998; Yano et al., 1994). The reported effect size from the comprehension ANOVA indicated that simplification explained about 16% of the variance in comprehension scores. This relation between text simplification and comprehension seems to hold when reading proficiency and language proficiency are held constant with the reported effect size indicating that simplification explained about 10% of the variance in comprehension scores in the ANCOVA. Moreover, the advantages of simplified text are amplified for readers with lower language proficiency (low TOEFL scores). However, it is not unambiguously the case that simplifying a text will lead to better comprehension. The background knowledge of the reader is an important consideration. If a reader has higher background knowledge of the text's topic, authentic text enhances inference generation, which in turn improves comprehension. Conversely, if a reader has low background knowledge, beginning level texts enhance comprehension in comparison to authentic texts.

Pedagogically, these findings have important implications for L2 reading, classroom applications, and L2 acquisition. These results collectively confirm what might seem obvious post hoc. *Language teachers selecting texts should consider the aims of the reading task and the reading proficiency of the students.* Clearly, simplification at the beginning level is beneficial for L2 readers' text comprehension regardless of reading and language proficiency. Nonetheless, depending on the pedagogical objectives, the reading instructor may do better to consider the attributes of the students rather than to rely solely on text simplification. For example, high ability L2 readers (with higher language proficiency or higher background knowledge) seemed less intimidated by the authentic texts and potentially gained from the active processing induced by the lower cohesion. Hence, authentic texts may be particularly useful if the content is relatively familiar to the students and when the instructional goal is to emphasize active comprehension of the material.

Interestingly, it is important to note that across all of the results the intermediate texts sat squarely in the middle, with few differences between either authentic or simplified texts. Simplification seems to make little difference for comprehension at the intermediate level for L2 readers and leads to comprehension scores that are similar to those found for authentic texts. This (null) result implies that the intermediate texts offer a compromise between the two, and this compromise may have few negative consequences.

Linguistically, these findings demonstrate that texts that are more cohesive (i.e., more noun overlap, more causality, and more semantic similarity) can lead to increased text comprehension, further indicating that cohesive features that link sections of text together help to promote comprehension. Lexically, texts that have lower lexical diversity, more infrequent words, more familiar words, and more meaningful words can enhance comprehension, likely as a result of simplified propositional information. Lastly, texts that are syntactically simpler also facilitate text comprehension. This benefit is likely attributable to the greater ease in parsing the texts which opens the door to understanding them at a more global level. Such claims clearly necessitate a more fine-grained analysis, but the findings of this study nevertheless bolster claims that linguistic modifications at the cohesion, lexical, and syntactic level do increase text comprehension for L2 readers.

Conclusion

This study generally supports the use of simplified texts for L2 readers because such texts promote reading comprehension. However, text simplification does not always lead to decreased reading times or enhanced comprehension. These findings indicate that the use of simplified texts for L2 learning comes with caveats. First, text simplification does appear to lead to increased text comprehension, but may only do so if the L2 reader does not have strong background knowledge of the topic. In addition, the use of authentic texts seems to benefit advanced L2 learners to a greater degree than beginning L2 learners. Second, text simplification can lead to decreased reading times, but reading ability is potentially a more important consideration in that regard.

The research paradigm used in this study has provided valuable information about text processing and reading speed. However, it is not without its drawbacks. Assessing reading comprehension and cognitive processing in general is complex matter and no one technique can address the reading process as a whole. Thus follow-up studies using a variety of other research techniques (i.e., eye tracking and event-related brain potentials) would prove beneficial (Ditman, Holcomb, & Kuperberg, 2007; Rayner, 1998). Such techniques would be helpful in reassessing the reading time results reported in this study because moving windows techniques, such as the one used in this study, do not allow for multiple fixations of a single word or the skipping of words, both of which are common for readers. Also, moving windows techniques have been criticized because the task slows down the reading rate (i.e., the fingers move slower than the eyes); hence, generalizations taken from this study should be taken with caution (Rayner, 1998). As is always the case following an experimental study, follow-up studies are clearly warranted.

Acknowledgments

Monterrey (ITESM) campus in San Luis Potosi, Mexico. Specifically, we are indebted to our ITESM colleagues Samuel Clark, Gary Lundin, and Marisa Romero.

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