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An eye-tracking based investigation into reading behavior during Chinese-English sight translation: The effect of word order asymmetry

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Abstract: The focus of this study is the reading behavior of student interpreters during the process of Chinese-English sight translation. Eye-tracking was adopted to examine whether and how student interpreters' real-time reading is affected by the degree of word order asymmetry and modulated by the amount of contextual information available. A group of interpreter trainees sight translated asymmetric sentences (sentences that are structurally asymmetric to the target language) and symmetric sentences (sentences that are similar to the structure of the target language). These sentences were presented in isolation and embedded in discourse. Their eye movements were recorded for an analysis of their rereading rate and reading ahead frequency. The results show that the rereading rate for the asymmetric sentences was significantly higher than that for the symmetric ones. There were no notable differences in the reading ahead frequency between the two types of sentences. The role of context was limited in modulating the asymmetry-induced effect. This study addresses real-time reading behavior at the word level during sight translation and deepens our understanding of the cognitive processing involved in interpretation, as well as the potential influencing factors.

Keywords: Reading; sight translation; word order asymmetry; rereading; reading ahead.

1. Exploring reading behavior in sight translation

1.1 Reading in sight translation

Sight translation (hereafter, STR) refers to the oral translation of a written text (Chen, 2015). It has been considered as a hybrid between translation and interpretation (Agrifoglio, 2004). However, STR seems to have more in common with simultaneous interpreting (SI), due to the time constraints and piecemeal processing involved. Gile (2010, p. 167) models the effort components of STR as follows: sight translation = reading effort + memory effort + speech production effort. In this model, reading effort is the precondition for the other components in STR. The quality of target expression primarily depends on reading comprehension, especially how source information is retrieved and analyzed via fast and efficient reading (Wan, 2005). Reading speed and comprehension accuracy exert a direct influence on STR quality in terms of accuracy and fluency (Nilsen & Monsrud, 2015). It is generally agreed that reading comprehension in sight translation is more complicated and involves more effort than normal reading, as a result of the stronger language interference and quasi-simultaneous working mode involved in STR. Studies have demonstrated that the continuing presence of written text intensifies the language interference in STR, which may take the form of undesirable influence from the syntactical structures of the source language (Agrifoglio, 2004; Shreve et al., 2010). Additionally, STR needs to be performed in a real-time mode, posing extra pressure in regard to reading: During normal reading, readers can pause for a long time, dwell upon certain words or sentences, or even reread the prior parts of the text in order to gain a better understanding of it. This is not possible in STR, due to the requirement of concurrent reading and speaking. Interpreters would lag too far behind if they began their delivery after completely reading a whole sentence; instead, they have to read in a piecemeal manner, which implies that meaning retrieval and analysis are incremental during STR. Furthermore, reading in STR is not only a matter of meaning identification, but also requires on-line anticipation and planning (Weber, 1990). To ensure a smooth delivery, interpreters sometimes need to read ahead to identify key words and translation units, by glancing through text structures or topic sentences so as to predict the upcoming words and facilitate on-line planning (e.g., Agrifoglio, 2004). When source texts contain long and complex sentences, extra mental effort may be required to read and conduct textual analysis. In particular, the greater the syntactic discrepancy between the source language (SL) and the target language (TL), the greater the cognitive load imposed upon the interpreters who perform STR (Gile, 2010; Lee, 2012).

1.2. Studying the process of reading in sight translation via eye-tracking

Reading is a fundamental component of STR and has become a gateway to uncovering the cognitive process of interpreters (Ma, 2017). Thanks to the increasing accessibility of eye-tracking (see Hvelplund, 2017), reading activity in the process of translation and interpreting can be recorded and analyzed based on eye movement measures (see Clifton et al., 2007; Hvelplund, 2014; Rayner, 1998), making it possible to capture the cognitive effort involved and the real-time reading pattern at work. According to the eye-mind assumption, there is an assumed link between observable and measurable eye movements and the underlying cognitive process in reading (Just & Carpenter, 1987; Hvelplund, 2017). Based on this relationship, eye-tracking can be adopted not only to measure the overall cognitive effort in reading activities in terms of fixation-based parameters, but also to depict the real-time reading patterns through gaze plots, heat maps, and fixation sequences (Dragsted & Hansen, 2009).

Although the eye-mind assumption often serves as an operational basis for reading and translation studies via eye-tracking, there is not always a perfectly straightforward link between visual focus and cognitive focus (Jakobsen, 2017). Eye-tracking reveals where the eyes look during language processing, but cannot identify the object of thought (Hvelplund, 2014). For instance, mind wandering or drifting may occur while reading (Smallwood & Schooler, 2006). Sometimes, the mind may be ahead of the eyes, processing words that the eyes have yet to fixate upon (McConkie & Yang, 2003). These potential limitations of eye-tracking require caution in data interpretation. Despite the weaknesses discussed above, the role of eye-tracking in capturing the cognitive process that occurs during translation should not be underestimated. Since interpreting is a cognitively demanding task, there is "little room for mind wandering" (Hvelplund, 2014, p. 211). Eye movement data indictive of the cognitive process in reading and translation have been successfully validated in previous studies.

Process-oriented studies approach reading from two major perspectives. One research focus is the effect of task purpose on reading. As reading is usually purposeful, readers do not merely read for the sake of reading (Koda, 2005, p. 205). Researchers are thus interested in discovering whether or not and how reading behaviors in STR differ from other similar language activities. Eye-tracking data have demonstrated that reading in STR requires a greater amount of cognitive resources. Jakobsen and Jensen (2008) found that eye movements in STR were substantially different from those in monolingual reading and reading in preparation for translating, as indicated by more and longer fixations during STR. Ho (2017) examined the effect of reading purposes on reading behaviors and how they were modulated by the reader's level of interpreting proficiency, by comparing eye movement patterns across three types of tasks: reading for comprehension, reading aloud, and sight translation. The second research focus is the effect of interpreting expertise or professional backgrounds on reading in STR. For instance, Dragsted and Hansen (2009) conducted a comparative study of reading patterns during STR between professional interpreters and professional translators. Their hotspot analysis revealed different gazing behaviors between the two groups. Chimel and Mazur (2013) used eye-tracking to examine whether or not first-year and second-year interpreting trainees exhibited different reading patterns during preparation for STR. Generally, eye movement visualization is used to supplement the statistical testing of eye movement measures for a more robust analysis of reading activity.

Two general findings can be summarized from these studies: (1) STR is cognitively more demanding than normal reading comprehension; and (2) reading behavior is modulated by a myriad of factors, such as reading purpose, professional background, and level of expertise. These empirical explorations offer a glimpse into the mental workings of reading in STR. However, it still remains largely unclear how reading is performed as the STR task progresses. Although eye movement data have confirmed that reading in STR involves more effort than that in other similar language tasks, such as reading comprehension, reading aloud, and reading for translation (e.g., Ho, 2017; Jakobsen & Jensen, 2008), few studies have examined specific reading behavior in STR. Eye movement measures applied in previous studies, such as gaze duration and average fixation duration, are global indices reflecting processing at the sentence or text level (see Yan et al., 2013). These measures, however, are unable to capture reading behavior and its underlying mental operation at the word level. Furthermore, reading behavior can be influenced not only by task mode, but also by specific language features, which have been neglected in STR-related studies. Results from studies on reading comprehension have confirmed the effects of a range of linguistic features on reading, such as word frequency, word predictability, syntactic structures, and contextual constraints (Clifton et al., 2007). Considering the overlapping components between general reading and STR, we infer that reading in STR may be impacted by the above language features in a similar way.

Based on the above, we can summarize the research gaps as follows. First, a more detailed investigation into the reading behavior of STR is required. In particular, word-based eye movement measures are expected to uncover cognitive activities related to reading; for example, coordination between SL comprehension, anticipation, textual analysis, and delivery. Second, potential factors that shape reading activity need to be considered, so that we can obtain a multidimensional view of the reading behavior in STR.

2. Word order asymmetry in Chinese/English interpreting

Word order asymmetry is a typical indicator of "language specificity" (Gile, 2010, p. 182) and is of particular concern in the present study. Language specificity generally refers to language-specific factors, such as differences in linguistic structures and cultural conceptualizations between SL and TL. Syntax or word order is a noteworthy aspect of language-pair specific factors in interpreting (Gile, 2005). The wider the syntactic gap involved in language pairs, the greater the risk of interpreting erroneously and cognitive overload. In this study, the notion of "word order asymmetry" is adopted to describe the divergences in syntactic structures between SL and TL. Mounting evidence from empirical studies on different language pairs (e.g., Gile, 2011; Uchiyama, 1991; Wliss, 1978) has lent support to the detrimental effect of word order asymmetry on interpreting performance.

One of the language combinations that merits special attention is English/Chinese interpreting. Chinese, one of the six official working languages of the United Nations, is a major non-European language widely adopted in interpreting practice. Striking differences between English and Chinese at lexical, syntactical, and discourse levels (Chen, 2015) may cause extra difficulties in interpreting. Data collected from real-time measurement and/or product analysis have demonstrated that word order asymmetry is a major obstacle during English/Chinese interpreting: The processing of asymmetric structures causes more frequent errors and disfluencies (Wang & Gu, 2016), a considerable increase in cognitive effort (Ma et al., 2021), and specific strategies (Dawrant, 1996; Guo, 2011). This asymmetry impact may be exacerbated in interpreting from Chinese into English. In China, it is a market reality for conference interpreters to perform retour (A-B) interpreting – i.e., interpreting from one's dominant language (A) into one's weaker language (B) (Wu & Liao, 2018). Interpreting into one's B language, especially into a European language such as English, poses additional challenges arising from structural differences between SL and TL. Despite its wide application, Chinese-English (C-E) interpreting has seldom been examined in regard to the impact of syntactic differences. In particular, studies on whether or not and how interpreters' reading behavior is related to word order asymmetry are still scarce.

Two specific structures in Chinese that exemplify word order asymmetry are believed to cause extra difficulty during C-E interpreting: relative clauses (RCs) and preposition phrases (PPs). RCs in Chinese and English conform to divergent branching directions: Chinese RCs consistently take a prenominal position, whereas, in English, a typical right-branching language, RCs are modifiers and always follow the head noun. Therefore, word order must be rearranged in order to achieve a natural target delivery. PPs, sometimes also called "coverbs" (Li & Thompson, 1981), refer to a class of morphemes in Chinese that include words such as *cong* (from), *chao* (toward), *zai* (at), and *duiyu* (as for). They express meanings associated with time, space, conditions, directions, and reference. When PPs are located before verbs in Chinese, a change of word order is required to render them in natural English, since English PPs generally appear after the verbs. Studies using experimental and corpus approaches have confirmed the negative impact of RCs and PPs on interpreting, as indicated by lower levels of accuracy (Dawrant, 1996), greater cognitive effort (Ma et al., 2021), and output disfluency (Wang & Zou, 2018).

3. Research questions and indicators of reading behavior in sight translation

The present study primarily relies on an eye-tracking method. It aims to collect data on interpreter trainees' reading processes in C-E STR and to identify whether or not and how their reading behavior is affected by degrees of syntactic asymmetry. The data for this study are part of a larger project (Ma et al., 2021) that examines the effect of word order asymmetry on the cognitive process of C-E STR. The primary data source for this article is the eye movement data associated with student interpreters' reading behavior during STR.

In the absence of sufficient knowledge on reading behavior in processing word order asymmetry during interpreting, this study attempts to answer the following two research questions (RQ):

RQ1: In what way and to what extent is the rereading rate during C-E STR affected by word order asymmetry? Is the rereading rate modulated by the amount of contextual information available?

RQ2: In what way and to what extent is the reading-ahead frequency during C-E STR affected by the degree of word order asymmetry? Is the reading-ahead frequency affected by the amount of contextual information available?

To quantify reading behavior during STR, two specific indicators based on eye movement data are adopted: rereading rate and reading-ahead frequency.

3.1. The rereading rate

Rereading rate, a word-based eye movement measure, refers to the probability of rereading the source word after the first-pass reading. It is calculated as the proportion of second-pass reading duration to the total reading duration on individual words. Second-pass reading time (also known as second run dwell time) is a local eye movement measure. It is generally associated with later-stage processing, such as reanalysis, problem detection, and meaning/structure integration (Titone et al., 2016). Previous studies demonstrate that second-pass reading or rereading is sensitive to linguistic and contextual factors (Rayner, 1998, 2009). Thus, the higher the rereading rate, the greater the processing difficulty involved. In this study, interpreter trainees engaged in STR are hypothesized to reread more frequently when encountering sentences containing asymmetric structures, but the differences between asymmetric and symmetric sentences in rereading will become less obvious when more contextual information is provided.

3.2 Reading-ahead frequency

The temporal constraints of interpreting reveal two extreme conditions in STR: the concurrent nature of reading comprehension and speech production, and the need to begin reformulation before the comprehension of a whole sentence is completed (see Chernov, 2004). This mode-specific feature implies a strong need for reading ahead during sight translation. To avoid long pauses or hesitations, interpreters sometimes have to read ahead, taking a quick look at upcoming words or segments, in order to effectively anticipate and plan target expression (Agrifoglio, 2004). It is assumed that processing asymmetric sentences will force the interpreters to read ahead more frequently for syntactic anticipation, syntactic analysis, and integration. In the present study, reading ahead refers to the condition in which the interpreter is orally producing word N but is already fixating on the word to the right of word N (e.g., word N+1, word N+2) for the first time. In other words, when a certain word is first being fixated upon, the interpreter is also engaged in reformulating the prior word(s). Pausing during the first fixation on a word or producing the word(s) that are currently being fixated on are not considered as reading ahead.

4. Experimental design

4.1 Participants

A total of 30 postgraduates (28 women and two men) majoring in translation and interpreting at one college were recruited. All students, aged between 22 and 25 years old (mean = 23, SD = 1.07), were native speakers of Chinese, with English as their first foreign language. The students had been trained in interpreting skills for at least one semester and were quite familiar with STR. All claimed Mandarin Chinese as their A language and English as their B language. To ensure that all subjects had acquired a high level of proficiency in English, only those who scored seven or higher on the International English Language Testing System (IELTS) exam were invited to participate in the experiment. According to the background questionnaires, 25 of the 30 postgraduates were qualified to participate in the study.

4.2 Design

The C-E STR experiment has a 2 x 2 within-subject design. The independent variables include sentence type (asymmetric sentences vs symmetric sentences) and task conditions (single sentence context vs discourse context). All asymmetric sentences contain RCs as prenominal modifiers or PPs, which requires restructuring to occur in order to make the sentences comply with the grammatical rules of English. All symmetric sentences are syntactically similar to TL. In other words, there is no need to change the word order to render them in English. Table 1 presents sample experimental sentences.

Table 1. Sample experimental sentences

Asymmetric sentences	Symmetric sentence
Sentence with RC: 这一系列重要文件向国际社会释放了我们共同维护东亚和平稳定的强烈信号。 (*These important documents have sent a strong message to the international community that we are committed to maintaining peace and stability in East Asia.*) Sentence with PP: 丝绸之路为加强中国与各国的政治关系、贸易往来、民间友好发挥了重要作用。 (*The Silk Road has played a vital role in strengthening the political relations, trade exchange, and people-to-people friendship between China and all other countries.)*	各国政府应该视经济全球化为积极力量，加强对话 与合作，以完善国际经济秩序。 (*All governments should consider economic globalization as a stimulus and strengthen dialogue, as well as cooperation, so as to update global economic orders.*)

In addition to sentence type, task condition was introduced as the potential modulating factor in STR. In the single sentence context, a set of experimental sentences was presented and processed in isolation. In the discourse context, the experimental sentences were embedded in the surrounding text. The participants in the discourse condition interpreted two flowing texts that contained the experimental sentences. It is assumed that processing the experimental sentences within the surrounding text offered more contextual information and thus facilitated sense-based interpreting. The participants could draw on contextual clues to establish relationships between segments, anticipate upcoming words, and improve efficiency, instead of dwelling on the surface language and becoming trapped in syntactic complexity. Therefore, the discourse context could, to some degree, offset the negative impact of structural discrepancy and alleviate the readers' cognitive effort. With respect to reading pattern, participants reread less frequently, owing to the contextual benefits of the discourse condition.

The tasks in the single sentence context comprised 24 experimental sentences: 12 asymmetric sentences (six with RCs and six with PPs) and 12 symmetric sentences. To imitate a real-life interpreting condition as closely as possible, all sentences were selected and adapted from authentic speeches. Most sentences were related to the topic of the economy (a topic the interpreting trainees were quite familiar with) and some were more general in nature. The same number of experimental sentences was used for the tasks in the discourse context: 24 experimental sentences, 12 of which were asymmetric (six with RCs and six with PPs) and 12 of which were symmetric sentences. However, these sentences were embedded in two coherent texts and participants were required to interpret the whole text. Two source texts of comparable length (around 300 characters) were selected from speeches made at international conferences. They were written for oral purposes. Some of the original sentences were rewritten so that each text contained six asymmetric sentences (three with RCs and three with PPs) and six symmetric sentences. To ensure that the manipulation did not affect textual coherence, two professional interpreting teachers, who are also native speakers of Chinese, assessed the coherency of the two texts on a five-point scale (1: very low coherence; 5: very high coherence). Both texts were considered to be fairly coherent with satisfactory interrater agreement (*K* =. 65 for Text A; *K* = .72 for Text B). All 48 experimental sentences were matched in length (around 17 Chinese words). Most words in the stimulus were included in the list of the 8000 most frequently occurring words in contemporary Chinese. English translations of those not included in this list were offered as background information before the experiment, to guarantee that difficulty arising from word comprehension was kept at a minimum level.

4.3 Apparatus

All source materials were presented in black against a light gray background on an LCD display monitor (1024 x 768 pixels). Participants were tested individually, and their eye movements were recorded by an Eyelink 1000 Plus (SR Research, Canada) eye tracker. The sampling rate adopted in this study was 1000 HZ. The original eye-tracking program was created using *Experiment Builder* 2.1.140 and eye-tracking data were analyzed with *Data Viewer* 3.1.97. During the experiment, a forehead rest was used. This was to avoid the impact of head or body movement on recording and to improve data accuracy, which is crucial to eye movement analysis at the word level.

4.4 Procedure

Each participant was individually tested in a sound-proof room with artificial light. They first read the instructions for the task. Each participant sat 60-65 cm from the front of the display PC screen. All texts in Chinese were displayed in SimSun, font size 11, with 1.5 line spacing, to maximize the chance of linking fixations to specific words. In the STR task under the single sentence condition, the 24 experimental sentences were intermixed with a set of fillers and presented in an individually randomized order. In the STR task under the discourse condition, the orders of the two source texts were randomized across the participants. Both tasks began with a 13-point calibration and a warm-up task, which lasted about five minutes. During the warm-up practice, the participants sight translated a set of individual sentences or short paragraphs from Chinese to English. The stimuli for the warm-up were similar to the experimental materials in topic and genre, containing no asymmetrical structures.

Under both conditions, participants were required to perform on-the-spot STR of the stimuli, bearing in mind the usual time constraints. No specific time limit was imposed; these participants were familiar with the STR procedures and aware of the importance of concurrent input and output during interpreting. During the experiment, the participants' eye movements and oral output were recorded synchronically for further analysis, using the Eyelink program.

4.5 Eye-tracking data analysis

A total of 25 participants took part in the study, but two of them had to drop out due to failures in pre-task calibration and validation. Among the remaining 23 participants, those whose production lagged far behind the reading comprehension were excluded (n=1), since they were supposed to read and interpret in a near-simultaneous mode, instead of a consecutive one. As a result, data regarding another participant were abandoned. The analysis of reading behavior requires highly stable and accurate eye-recording; thus, data regarding the participants with fixation drifts were not employed. Data regarding 15 participants were identified as suitable for local reading analysis. In addition, fixations shorter than 80 *ms* or longer than 1200 *ms* were eliminated from the final analysis for each participant, since abnormally short or long fixations may indicate measurement errors (Drieghe et al., 2008; White, 2008).

The reading ahead frequency in this study is calculated on the basis of two-character Chinese words that are frequently used in modern Chinese. Each two-character word in the experimental sentences, excerpt for words in final positions, was analyzed as a single area of interest (AOI) and numbered sequentially. We identified the onset and offset of the target production for each source word in *Praat*, a computer software package for speech analysis. Reading ahead takes place only when the onset of the first fixation on word N+1 falls within the duration of the oral production of word N, which suggests that the reading of the later words and the production of the prior words are performed concurrently. Based on this criterion, we counted how frequently each participant read ahead in each experimental sentence.

5. Results

5.1 Rereading rate

Table 2 demonstrates the mean value and standard variation (SD) of the rereading rate for the two types of sentences in both conditions. According to the descriptive statistics, the average rereading rate for the asymmetric sentences is consistently higher than that for the symmetric ones. STR in the single sentence context elicited a slightly higher rereading rate than in the discourse context, irrespective of sentence type. It appears that the participants' reading was influenced by the degree of word order differences and the amount of contextual information available. A two-way repeated measures ANOVA test was conducted on the rereading rate. The results indicate a significant effect of asymmetry [F (1, 14) = 115.91, p < .001]: The rereading rate for the asymmetric sentences is considerably higher than that for the symmetric sentences under both conditions. However, there was no significant effect of task condition [F (1, 14) = .59, p = .46]. Additionally, no significant interaction between sentence type and task condition was found [F (1, 14) = .03, p=.87].

Table 2. Mean (SD) values of the rereading rate

	Asymmetric sentences	**Symmetric sentences**
Rereading rate		
Single sentence context	71% (1%)	63% (11%)
Discourse context	69% (8%)	61% (9%)

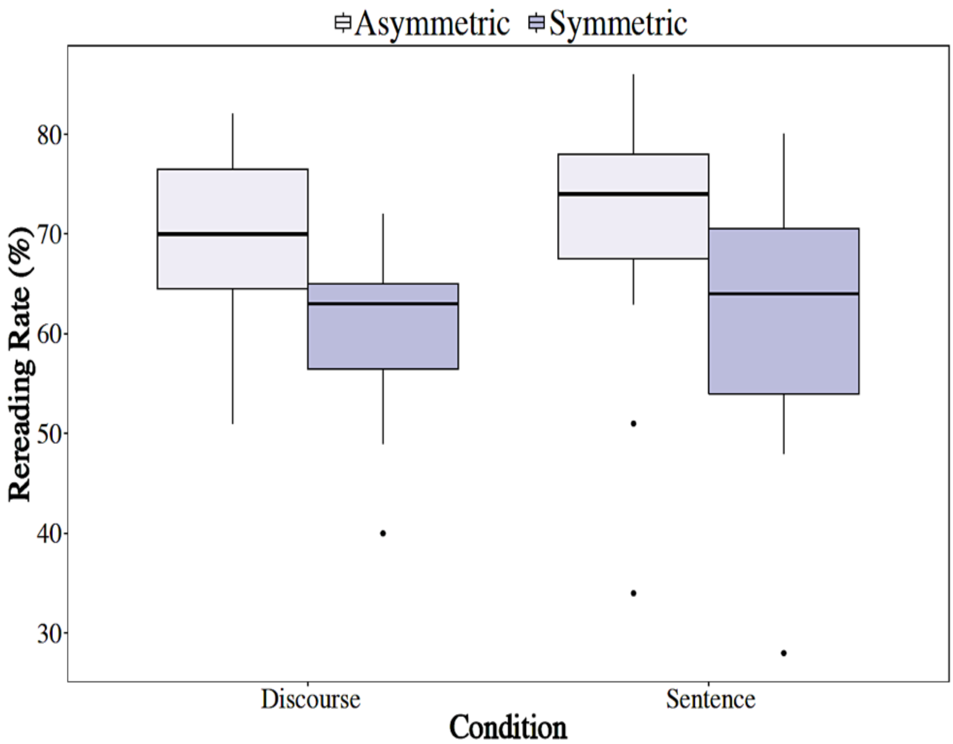

Figure 1. Boxplot of the rereading rate

5.2 Reading ahead frequency

Representing the timing of eye movements and the target output on one single timeline is crucial to identifying reading ahead and inferring the associated cognitive activity. Although participants' eye movements and their outputs were synchronically recorded by the *Experiment Builder* program, the timing of these two events was marked on different clocks. When marked on the same timeline, the action of the sound recordings was actually triggered later than the start of the eye movement recordings, with a temporal gap ranging from dozens of milliseconds to hundreds of milliseconds. Therefore, to minimize the effect of this mismatch, we first calculated the temporal gap for each recording trial so as to synchronize the recording of eye movements and oral production. The timestamps for the eye-tracking data were based on the host PC, while those of the audio recordings were marked on the display PC.

This section reports the mean frequencies of the reading ahead per experimental sentence. Table 3 presents the mean frequencies of reading ahead and the values of the standard variation under both conditions. As demonstrated by the two-way repeated measures ANOVA test, neither a significant asymmetry effect [F (1, 14) = 1.23, p = .28] nor a significant condition effect was found [F (1, 14) = 2.94, p = .11]. In the single sentence context, an asymmetric sentence generated a slightly higher frequency of reading ahead than a symmetric sentence. In the context of discourse, reading ahead occurred at almost the same frequency in both types of sentences. The mean value reveals a higher frequency of reading ahead in the single sentence context, irrespective of sentence type. However, the differences were not statistically significant. Additionally, no notable interaction between sentence type and task condition was detected [F (1, 14) = 1.63, p = .22].

Table 3. Mean (SD) values of reading ahead frequency

	Asymmetric sentences	**Symmetric sentences**
Reading ahead frequency		
Single sentence context	5.82 (1.74)	5.3 (1.8)
Discourse context	5 (1.22)	5.1 (0.84)

Table 4 illustrates how one participant's initial reading of certain source words was ahead of the oral production when processing an asymmetric sentence in the single sentence context. In an experimental sentence, each two-character Chinese word is analyzed as one single area of interest (AOI) and is numbered sequentially.

Table 4. Identifying reading ahead based on mapping fixation and oral production

Source sentence:

过去 20 年里， 我们和亚洲各国， 在贸易、投资、环保等多个领域开展了卓有成效的合作。

In the past two decades, we and Asian countries, in trade, investment, environmental protection, and many other fields have conducted fruitful cooperation.

	Onset of first fixation	Onset of corresponding production	Offset of corresponding production	The AOI being read ahead
....				
AOI 3: 我们 *we*	1848 ms	2926 ms	4620 ms	AOI 5, 6
AOI 4: 亚洲 *Asia*	1425 ms	5730 ms	7100 ms	
AOI 5: 各国 *all countries*	3438 ms	7130 ms	7612 ms	AOI 12
AOI 6: 贸易 *trade*	4100 ms	12600 ms	13625 ms	
……				
AOI 11: 开展(了) *establish*	7494 ms	7813 ms	9185 ms	

Target production:

In the past two decades, we and other Asian countries have established efficient cooperation in trade, investment, environment protection, and other areas.

As shown in Table 4, the reading ahead during sight translation was identified by mapping the first fixation on individual AOI and the duration of the corresponding target production. The onset of the first fixation time was exported from the eye-tracking data and the production duration was identified in *Praat*. According to the table, when the participant was producing the third AOI ("我们 *we*") from 2926 to 4620 *ms* from the beginning of the trial, two later AOIs (AOI 5 and 6) were being initially fixated on during that period. Similarly, another reading-ahead behavior was identified: When AOI 11 was being read for the first time, the participant was concurrently translating AOI 5, indicating that the eyes were ahead of the production. It can be seen from the target output that the participant reordered the original sentence by locating the PP at the sentence's final position to conform to English grammatical rules. This restructuring may be attributed to the reading ahead. The strategy for rendering the asymmetric structure might have been envisaged when AOI 6 ("贸易 *trade*"), the first content word of the original front-loaded PP, was initially processed during the production of AOI 3. Bearing this in mind, the participant continued to read ahead by fixating on AOI 11, which may have prompted her to reorder the original sentence by first producing the verb "开展(了) *establish*". It appears that reading ahead is closely related to real-time coordination and anticipation, as well as the selection of interpretation strategy.

6. Discussion

This article addresses the impact of word order asymmetry on reading behavior during Chinese-English sight translation. Two specific parameters on a single sentence basis (namely, the rereading rate and reading ahead frequency) were adopted to measure the real-time reading. We aim to identify whether or not and how student interpreters' reading behaviors during STR are influenced by the degree of word order differences. We also intend to explore the role of context in modulating the asymmetry-induced effect.

6.1 Word order asymmetry increases the probability of rereading

The statistical analysis reveals a considerable effect of word order asymmetry, as shown by the significantly higher rereading rate for the asymmetric sentences across both conditions. The results indicate that reading during C-E STR was influenced by word order differences to a remarkable extent. Rereading, a late-stage eye parameter, is generally reflective of integration and reanalysis (Conklin & Pellicer-Sánchez, 2016). It can thus be inferred that the student interpreters encountered greater difficulties in regard to syntactic analysis or integration when they processed asymmetric structures. According to Ito, Corley, and Pickering (2018), readers tend to process sentences incrementally and integrate information extracted from each word to predict the forthcoming words. It was thus possible that the interpreting trainees were constantly making predictions while reading, which entails the risk of correcting or revising their initial predictions as the STR task progressed. Problems related to syntactic processing are often associated with the degree to which the previously predicted structures conform to the actual structures (Levy, 2008). For unbalanced bilingual speakers, vocabulary and syntax in L1 are more accessible and more difficult to suppress than their counterparts in L2 (Bergmann et al., 2015). Thus, for the participants, predicting upcoming structures and their target syntactic representations based on their L1 (Chinese) linguistic system would be more natural than doing so based on their L2 (English) linguistic system. When processing sentences that were structurally similar to SL, their L1, the participants enjoyed a facilitation effect, since the L1-based predictions were consistent with TL structures. In contrast, during the processing of the asymmetric sentences, the previous prediction about the target structures was more likely to be revised as the marker(s) of asymmetric structures were encountered. This need for the constant revision of syntactic expectations may generate a significant increase in rereading, which can be taken as evidence for a more effortful reading pattern, due to word order differences. In addition, more frequent rereading may also be accounted for by greater coordination efforts in rendering the asymmetric sentences. It has been widely held that syntactic discrepancies between SL and TL call for structure-specific strategies, such as chunking and restructuring (Donato, 2003; Li, 2015).

6.2 Generally stable reading behavior as indicated by reading ahead frequency

In sight translation, oral delivery practically overlaps with the comprehension of source texts (Sampaio, 2007), which implies that interpreters have to begin their production before the comprehension of a full sentence is completed. To better coordinate input and output, reading ahead what is being orally produced has been taught as an interpreting-specific reading skill (Weber, 1990). We hypothesized that reading ahead would be applied strategically and flexibly when the participants addressed varying degrees of word order differences. They would read ahead more frequently when dealing with asymmetric sentences, in order to obtain more syntactic cues for quicker comprehension and efficient prediction. However, the data revealed no significant differences in terms of reading ahead frequency between asymmetric and symmetric sentences under both conditions, indicating a generally stable and consistent reading pattern that is not strongly related to the degree of syntactic difficulty.

This result runs contrary to our previous assumption that the participants, who had been trained in interpreting skills systematically, would have a strong awareness of reading ahead when processing the asymmetric sentences. This is because frequent reading ahead is supposed to help identify syntactic cues as early as possible, which facilitates syntactic analysis and anticipation. One possible reason for the generally stable reading behavior may be the frequent use of chunking during STR, a widely taught interpreting strategy for structure-specific difficulties (Yang, 2010). Chunking is a coping tactic that divides a sentence sequentially into several shorter segments during interpreting (Ahrens, 2017; Jones, 2014), which is believed to alleviate cognitive load on the interpreters. Chunking enables a syntactically linear approach to source sentences (i.e., the participants do not have to frequently move their eyes back and forth to restructure a sentence; they can instead concentrate on the word(s) being fixated upon).

Another possible explanation is that reading or identifying forthcoming information as early as possible is not the most crucial component for sight translation. These participants, who are non-native speakers of English, might have been constrained by their limited L2 language resources and may have struggled with searching for appropriate target expressions. Interpreting into one's B language (L2) has long been considered inferior to interpreting into one's A language (L1) (Pokorn, 2011). During simultaneous interpreting, although both languages are activated (Christoffels & De Groot, 2009), the level of activation depends on the interpreter's language proficiency in the languages in question (Dong & Li, 2019). Psycholinguistic research demonstrates that, for late bilingual speakers, representations in L2 are weaker and more difficult to access than those in L1 (Bergmann et al., 2015). This lower availability in L2 may increase the efforts required for lexical selection, planning, and articulation (Gile, 2008; Wu & Liao, 2018), making target production in C-E interpreting less automatic; it involves more conscious monitoring. Therefore, irrespective of the degree of structural asymmetry, the participants may devote large amounts cognitive resources to producing the word(s) being currently read. They thus cannot expend extra effort when reading the forthcoming parts. It can thus be inferred that, when interpreting from A (Chinese) to B (English), language proficiency in their B language plays a greater part in shaping real-time processing of the student interpreters.

6.3 The unclear role of context in modulating the effect of word order asymmetry

Some of the research questions focus on the function of contextual information in modulating asymmetry-induced disruption. Pre-controlled materials were sight translated under two conditions: a single sentence context and a discourse context. When the experimental sentences were embedded in a coherent text, it was assumed that the greater amount of contextual information available would facilitate parsing and predictive reading. Processing in discourse condition is supposed to encourage sense-based interpreting, thereby reducing dependence on linguistic forms and the frequency of structural reanalysis. Previous studies on sentence processing demonstrate that prediction is a natural part of language comprehension (Otten & Van Berkum, 2008). It occurs when assimilated prior contexts and world knowledge, which have been activated by the context, are progressively matched to incoming information being processed locally. It is this context and activated world knowledge that form the basis of expectations about the forthcoming semantic or syntactic elements (e.g., Chernov, 1994; Frisson et al., 2005; Van Berkum et al., 2005). Therefore, a sufficiently constraining context is conducive to making predictive inferences during language processing (Hodzik & Williams, 2017).

As shown by the ANOVA test, the mean rereading rate and reading ahead frequency in the discourse context are slightly lower than in the single sentence context, but the differences fail to achieve statistical significance. Although a greater amount of contextual information can facilitate recognition, comprehension, or prediction, its benefits were overwhelmed by the effect of structural complexity. The complexity was so disruptive that a wider context could not compensate for the cognitive difficulty of overcoming word order differences. The very limited role of context in modulating reading behavior can be accounted for by two factors. First, visual interference from the constant presence of written information in STR (Agrifoglio, 2004) tended to increase incrementally in the discourse context, as the translation progressed. As a hybrid of interpreting and translation, STR requires extra efforts in coordinating processing in the auditory and written modalities (Martin, 1993). This cross-modal processing is responsible for the visual interference in STR. The source information presented in written form may conflict with the oral delivery and increase the cognitive burden (Agrifoglio, 2004). Shreve, Lacruz, and Angelone (2011) found that, during STR, all second paragraphs in source texts were apparently required more effort to interpret than the first paragraphs, suggesting that visual interference seems to increase as the discourse unfolds. Therefore, the participants in the discourse context had to devote extra efforts to resisting interference. Second, frequent searches for contextual cues in discourse may increase the frequency of rereading and reading ahead. Readers tend to make use of textual information to direct their eye movements when encountering new or difficult messages (Ito et al., 2018). In context conditions, there may be more frequent visual searches for contextual cues, to improve comprehension efficiency or predictions.

7. Conclusion

Based on eye-tracking data, this study explores whether or not and how interpreter trainees' reading behaviors during C-E STR are influenced by the degree of word order asymmetry. It also attempts to identify the function of contextual information in modulating the asymmetry effect. The data have demonstrated a considerable impact of asymmetry on rereading. Frequent reanalysis was required to repair misunderstandings or syntactic integration. However, there was virtually no conceivable effect of asymmetry on the frequency of reading ahead. A similar reading ahead pattern was found across the two types of sentences. According to the data analysis, the function of contextual information in offsetting the asymmetry-induced disruption was not as clear as expected.

Several limitations need to be addressed in future studies. First, the present study was limited to a laboratory setting, in which the source stimuli were carefully controlled. To improve the ecological validity of the research, it is necessary to explore reading behavior in authentic interpreting settings. Second, reading behaviors by professional interpreters were not investigated. A comparison of reading patterns between experts and novices is expected to shed light on the training effects on cognitive processing during STR, which helps identify whether and to what extent student interpreters' reading processing differs from their professional counterparts. Additionally, from a pedagogical point of view, an analysis of the performance by expert interpreters will offer practical guidelines for interpreter trainees, who might enhance their reading efficiency by acquainting themselves with the reading behaviors and practices of those professionals. Finally, most of the conclusions were derived from eye movement data. Triangulation based on multiple sources of data, for example, target output and retrospective interviews, is required to further validate the current findings.

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