Exploring the impact of word order asymmetry on cognitive load during Chinese–English sight translation: Evidence from eye-movement data

Xingcheng Ma[1], Dechao Li[2] and Yu-Yin Hsu[2]

[1] Southeast University | [2] The Hong Kong Polytechnic University

This paper explores the impact of word order asymmetry between source language and target language on cognitive load during Chinese–English sight translation. Twenty-five MA students of translation from a Hong Kong university were asked to sight translate sentences with different degrees of between-language structural asymmetry from Chinese into English, in both single-sentence and discourse context conditions. Their eye movements were recorded to examine cognitive load during sight translation. The results show: (1) There was a significant effect of word order asymmetry on overall cognitive load as indicated by the considerably longer dwell times and more frequent fixations for the asymmetric sentences, but it was only during the later-processing stage that structural asymmetry exerted a strong influence on local processing in terms of first fixation duration and regression path duration; (2) the role of context in offsetting the asymmetry effect was very limited; and (3) although reordering may place a greater burden on working memory, most participants preferred reordering over segmentation to cope with the asymmetric structures. The empirical data point to the need to consider word order asymmetry as a variable in theoretical accounts of the interpreting process, especially for interpreting between languages that are structurally very different.

Keywords: sight translation, word order asymmetry, eye movements, cognitive load

1. Introduction

1.1 The effect of word order asymmetry on Chinese–English interpreting

The extent to which language specificity imposes additional difficulties on interpreting has been an issue of ongoing debate (Setton 1999; Donato 2003). Language specificity refers to language-specific factors, such as differences in language structures and cultural conceptualization between source language (SL) and target language (TL) (Gile 2002).

Conflicting views have emerged with regard to the impact of language specificity on interpreting. Supporters of the Universality Hypothesis, represented by the Paris School, deny the relevance of language-specific factors in interpreting and believe that interpreting is not fundamentally different from monolingual speaking because all language-specific difficulties can be avoided through *deverbalization* – a widely taught strategy that prioritizes sense over language forms (Seleskovitch 1978; Lederer 1998). In contrast, Information Processing theorists consider language specificity to be a major obstacle in interpreting that requires specific strategies (Donato 2003; Gile 2005). One prominent indicator of language specificity is the difference between the SL and TL in syntax or word order (Gile 2005; Li 2015). Interpreters dealing with syntactically different language pairs may experience greater cognitive constraints as a result of syntactic disambiguation, heavy memory load and coordination (Gile 2002; Christoffels, De Groot, and Kroll 2006). To examine the effect of language specificity on interpreting performance, studies of different language combinations have been conducted and have provided empirical evidence for a negative impact of word order asymmetry on interpreting performance (Gile 2011b; Seeber and Kerzel 2012).

One language pair that merits attention because of typological differences is English/Chinese. Interpreting between languages with striking differences in morphosyntactic structures is supposed to increase the "memory effort's processing capacity requirements because of the waiting involved before being able to reformulate the SL segment into TL segment" (Gile 2002, 170). In China, it is a market reality that conference interpreters perform retour (A–B) interpreting (i.e., interpreting from one's dominant language (A language) into one's weaker language (B language) [Wu and Liao 2018]). For these interpreters, interpreting into their B language, especially if the B language is a European language such as English, poses additional challenges because of the structural differences between the SL and TL. Despite its wide application, Chinese–English interpreting has seldom been examined for the potential impact of syntactic differences between the two languages. An initial investigation by Dawrant (1996) found that during Chinese–English simultaneous interpreting (SI), professional interpreters are more likely to encounter problems when dealing with Chinese-specific structures (i.e., 的 *de* structure and locative phrases) and have to render these structures by using anticipation or preserving linearity. More recently, Guo (2011) compared word order patterns in the target rendition with their corresponding patterns in the SL and found that in Chinese–English SI, 75% of Chinese front-loaded structures are interpreted into English back-loaded structures. The results of these two empirical explorations are aligned with the findings

from a recent corpus-based study: Wang and Zou (2018) examined how attributive modifying structures in Chinese, which are consistently located before the head noun, are interpreted during consecutive interpreting (CI) by professional interpreters into English, a typical back-loaded language. Their analysis shows that most pre-loaded modifying structures in Chinese are rendered into back-loaded structures or a mixture of front- and back-loaded structures in English. This preference for reordering, which the authors corroborate by comparing the interpreted texts with a comparable corpus of original English texts, suggests that additional cognitive load may be required to cope with word order asymmetry.

Two major findings can be summarized from the studies by Dawrant (1996), Guo (2011), and Wang and Zou (2018). First, language-pair specific factors, in particular word order differences, constitute a prominent source of difficulty in Chinese–English interpreting; and second, reordering and preserving linearity are the primary strategies used by professional interpreters to deal with asymmetric structures. There is thus empirical evidence to confirm the strong impact of language specificity on interpreting, which highlights the importance of considering structural asymmetry as a critical component in interpreter training and in theories of interpreters' cognitive processing. However, these studies draw on data from the product of Chinese–English interpreting and do not investigate the interpreter's mental processing in response to asymmetric structures. There is thus a need for cognitive, process-based systematic investigations of into-B language interpreting.

1.2 Mode-specific features of sight translation

Sight translation (STR) generally refers to the oral translation of a written text (Čeňková 2015), and is considered to be a hybrid between translation and interpreting (Agrifoglio 2004). However, STR seems to have more in common with SI since it has to be done in real time with little possibility of a global perspective of the text (Viaggio 1995). One prominent feature of STR is that the SL is in written form and the constant visibility of the written information may increase mental load (Lee 2012). As compared with spoken language, which is more loosely organized and contains simpler words and structures, written language tends to exhibit higher information density with more diversified vocabulary and more complex sentence structures (Chafe and Danielewicz 1987). Additionally, extra-linguistic features, such as intonation and gestures, which facilitate comprehension, are not available in STR (Gile 2010a, 168). Therefore, the inherent complexities of written language and the continuing presence of written information (Gile 2010a) may increase the difficulty of STR. According to Agrifoglio (2004),

listeners generally pay more attention to the gist, while readers are bound to concentrate on individual words and surface structures. During STR, interpreters may run greater risk of cognitive overload due to constant linguistic interference, which may take the form of complex grammatical or syntactic structures in the SL. This interference may be stronger when the SL and TL are structurally distant (Gile 2010a). These mode-specific features of STR may increase the interpreter's mental load. To examine mode-induced differences in cognitive processing, Ho (2017) compared cognitive load during reading for comprehension, reading aloud and STR by means of eye-tracking. Eye movement data showed that the cognitive load in reading for comprehension and STR were similar during the first pass of reading but exhibited significant differences in the second pass. Ho (2017) attributed the greater cognitive load in STR at the later stage of processing to the coordination between the reading and speaking modality. Similarly, Bóna and Bakti (2020) investigated the effect of cognitive load on temporal and disfluency patterns of speech by comparing the output across four speech production tasks: STR, consecutive interpreting, spontaneous speech and extemporaneous speech. The analysis of temporal characteristics and disfluency markers demonstrated that STR generated the most cognitive load as measured by the greatest production time and the highest frequency of pauses, suggesting a negative effect of the written modality in STR. The studies above have offered a glimpse into the mode-specific processing patterns of STR.

1.3 Measuring cognitive load during sight translation using eye-tracking

Cognitive load constitutes the conceptual basis for cognitive approaches to the study of interpreting (Seeber 2011; Chen 2017). The construct of cognitive load was first discussed in psychology with the underlying assumption that cognitive resources for processing certain tasks in the human brain are limited (Miller 1956). In the context of interpreting, cognitive load is understood as the amount of processing capacity spent on an interpreting task in an inherently capacity-limited system (Seeber 2013). Process-oriented investigations of European language pairs have demonstrated that morphosyntactic differences between the SL and TL influence cognitive load during SI (Seeber and Kerzel 2012). Coping with structural incongruences during interpreting may elicit a considerable increase in the cognitive load associated with the coordination of online memory storage and syntactic integration. However, the potential effect of word order asymmetry on cognitive load during Chinese–English interpreting is unclear since it has seldom been systematically investigated.

In this study, we make use of eye-tracking to measure cognitive load during Chinese–English STR. Eye-tracking is a widely used data elicitation method for observing real-time processing during translation and interpreting (Hvelplund 2014; O'Brien 2009). Eye-tracking measures are reliable indicators of the cognitive load associated with language-processing tasks, such as reading, syntactic processing, and translation (Hvelplund 2017; Rayner 1998; Staub 2010;). By using eye-tracking, researchers gain access to multidimensional data on cognitive load: different eye-tracking measures reflect a combination of initial and later stages of processing (see Henderson and Ferreira 1990; Rayner 2009; Yan et al. 2013) and provide information on comprehension as well as other sub-tasks at both sentence and word level.

2. The current study

We designed an experimental study to investigate the effect of word order asymmetry on Chinese–English STR and its relation to interpreting strategies. Eye-tracking serves as the primary data elicitation method to measure cognitive load during STR in order to identify to what degree interpreters' cognitive processing is influenced by word order asymmetry.

Relying primarily on eye-movement data, we explore the following questions:

1. To what extent does word order asymmetry impact cognitive load during Chinese–English STR, as reflected in eye-movement data?

2. In what way and to what extent can the effects of word order asymmetry be modulated by the amount of contextual information?

3. What strategies do trainee interpreters use to manage word order asymmetry during Chinese–English STR, and what are possible reasons for their use of these strategies?

In this study, asymmetric sentences are assumed to generate significantly greater cognitive load than sentences that are structurally similar with the TL. We thus formulate the following hypotheses:

1. A significant effect of word order asymmetry exists for both sentence-based processing and word-based processing irrespective of task conditions. In other words, cognitive load will be consistently higher for asymmetric sentences than for the symmetric sentences at both sentence and word levels.

2. Contextual information alleviates the asymmetry-induced burden as evidenced by significantly lower cognitive load for STR in discourse contexts. In other words,

cognitive load in discourse conditions will be lower than in single-sentence conditions at both sentence and word levels.

3. To cope with word order asymmetry, the interpreter trainees make use of segmentation far more frequently than reordering to relieve the processing load due to the repositioning of the asymmetric sentence segments.

3. Design

3.1 Participants

Thirty postgraduate students (twenty-eight females and two males) majoring in translation and interpreting at a university in Hong Kong were recruited. The students, aged between 22 and 25 years ($M = 23$, $SD = 1.07$), were native speakers of Chinese with English as their first foreign language. The participants provided written informed consent before the experiment. The experiment took place just prior to the completion of the participants' training in interpreting for twelve weeks for their first semester. Furthermore, they had attended an STR course that included six hours of classroom instruction per week (for a consecutive twelve weeks). To ensure that all participants were proficient in written and spoken English, only those who had scored seven or higher on the International English Language Testing System (IELTS) exam and who had obtained a TEM-8 certificate were invited to take part in the experiment. IELTS is an internationally recognized English test (see Chalhoub-Deville and Turner 2000) and TEM-8 is the highest-level test for English major students in Mainland China (see Jin and Fan 2011). Through the use of a background questionnaire, twenty-five students were identified as suitable to participate in the study.

3.2 Structures analyzed

Two structures that are supposed to increase cognitive load when interpreted from Chinese into English are investigated in this study: the relative clause (RC) and the preposition phrase (PP).

The RC is a frequently discussed structure in the literature on structural asymmetry between Chinese and English (Setton 1999; Wang and Gu 2016; Wang and Zou 2018). The two languages differ in their use of RCs. First, in terms of its location in a sentence, Chinese RCs consistently take a prenominal position, preceding the head noun, whereas RCs always follow the head noun in English. Second, unlike English RCs, Chinese RCs do not contain a

relative pronoun such as *who*, *which* and *that*, or relative adverbs such as *where* and *when*; instead, RCs and head nouns are linked by the particle 的 *de*. For example, in Chinese a relativized noun phrase is formed as follows: RC + 的 *de* + noun.

As shown in Example (1), in the source text, the RC (reflected in segment **2**) is located before the head noun (in segment **3**) to express the purpose of 'the important route'. Here, 的 *de* at the end of the RC is used as a modification marker to connect the modifying clause with the head noun. To interpret the original sentence into the most natural English, it is necessary to reorder the segments from **123** to **132**. Greater mental processing load may therefore be involved in interpreting this sentence since the long RC has to be kept in short-term memory until its integration with the head noun.

(1)

Source text

丝绸之路自古以来就是

sī choú zhī lù zì gǔ yǐ laí jiù shì

'the Silk Road since the ancient time has been' **1**

中国与中亚、西亚、乃至欧洲各国友好往来的

zhōng guó yǔ zhōng yà, xī yà, naǐ zhì oū zhōu gè guó yǒu hǎo wǎng laí de

'China and Middle Asia, Western Asia, even European countries' friendly exchange' **2**

重要通道

zhòng yào tōng dào

'important route' **3**

Target text

the Silk Road since the ancient time has been **1**

an important route **3**

which promotes friendly exchanges between China and countries in Middle Asia, Western Asia and Europe **2**

The other structure that warrants attention is the PP. The preposition, also called the "coverb" (Li and Thompson 1981, 356), refers to a class of morphemes in Chinese that include

words such as 从 *cóng* 'from', 朝 *cháo* 'towards', 在 *zài* 'at' and 对于 *duìyú* 'as for' to express meanings associated with time, space, conditions, directions, and reference. Prepositions need to be followed by their objects, which are generally nominal phrases (NPs). A PP, which is composed of a preposition and its object, can be used to modify a verb. When PPs are located before verbs in Chinese, a change in word order is always required to render them into English. Example (2) illustrates how a PP structure is processed in Chinese–English STR to comply with the syntactic rules of English.

(2)
Source text
我们亚洲各国
wǒ mén yà zhōu gè guó
'we Asian countries' **1**

在贸易、投资和环保等多个领域
zài mào yì, tóu zī hé huán bǎo děng duō gè lǐng yù
'in trade, investment and environment protection, etc., various fields' **2**

开展了卓有成效的合作
kaī zhǎn le zhuó yǒu chéng xiào de hé zuò
'have effective cooperation' **3**

Target text
we Asian countries **1**
have effective cooperation **3**
in trade, investment and environment protection, etc., various fields **2**

As Example (2) shows, a natural English translation calls for the PP (segment **2** in the source text) to be moved to the sentence-final position in the target text and additional cognitive load may be required as a result of this reordering.

In this study, Chinese sentences containing RCs or PPs form the focus of analysis because they can be regarded as examples of asymmetric sentences and are assumed to generate significantly greater cognitive load than sentences that are structurally similar to the TL.

3.3 Materials

The Chinese–English STR experiment had a 2x2 within-subject design: The first independent variable was the level of asymmetry (with two levels: asymmetric sentences and symmetric sentences). Each asymmetric sentence contained one RC as pre-nominal modifier or a PP structure. In contrast, each symmetric sentence was syntactically similar with English and could be interpreted by following the SL word order. Only long RCs and PPs that contained at least six characters were used (see Sung et al. 2016). According to Inhoff and Liu (1998), readers of Chinese have a perceptual span extending from one character to the left of a fixation to three characters to the right of a fixation. Thus, if the asymmetric segment is not long enough, it is likely to be easily recognized within one fixation and processed as a single meaning unit. The second independent variable was task condition, which refers to the amount of contextual information available, with two levels: single-sentence and discourse context. In the single-sentence condition, the experimental sentences were presented in isolation (i.e., they were interpreted individually). In the discourse context, the sentences were embedded in surrounding texts and the participants interpreted two different texts that contained the experimental sentences. Previous studies have confirmed that a supportive context during reading facilitates word recognition and processing (Rayner 1998): words are recognized more quickly when preceded by a related word or sentence than when processed in isolation or in a neutral sentence (Fischler and Bloom 1985). Contexts with strong semantic associations support the integration of the current word into a reader's discourse representation (Schustack, Ehrlich, and Rayner 1987). Additionally, contextual support is critical for inference processing: contextual information helps activate readers' world knowledge, establishes logical links between individual parts, and facilitates online anticipation, which alleviates cognitive load during reading (Johnson-Laird 1983; Van Dijk and Kintsch 1983). In this study, it was thus expected that the presence of discourse context would, to some degree, offset the disruption caused by structural asymmetry and alleviate cognitive load.

Twenty-four experimental sentences were used in the single-sentence condition: twelve were asymmetric sentences (six containing RCs and six containing PPs) and the remaining twelve were symmetric. All sentences were adapted from speeches from authentic interpreting settings and dealt with topics that the interpreting trainees would be familiar with (e.g., economic cooperation). For the STR task in the single sentence condition, the experimental

sentences were intermixed with filler sentences in a randomized order. The use of fillers prevents the participants from discerning the pattern of experimental materials or the research purpose. For the STR task in discourse context condition, two source texts of similar length were constructed to obtain an equal number of appropriate experimental sentences. Each text contained three RC sentences, three PP sentences and six symmetric sentences respectively. Consecutive asymmetric sentences were separated by at least one filler clause to avoid a spill-over effect.

All forty-eight experimental sentences were matched in terms of length, word frequency and word familiarity. Most of the words in the sentences were included in a list of the 8000 most frequent words in contemporary Chinese (see Liu 2000). Prior to the experiment, a list of all the content words in the asymmetric and symmetric sentences was provided to ten interpreting students from a university in Mainland China, who were asked to identify any Chinese words they felt unfamiliar with or had trouble interpreting into English. 98.5% of the words in the asymmetric sentences and 99.23% of words in the symmetric sentences were rated by the students as familiar words, indicating a high and comparable level of word familiarity between the two types of sentences. A list of the words marked as difficult to interpret by the students (nine words in total), along with their English translations, were offered to the participants before the experiment to mitigate problems in word-meaning retrieval or semantic transfer during online processing. Ideally, the texts used in the discourse context should have been extracted from an existing corpus of real interpreting settings to ensure ecological validity. However, the use of fully authentic materials was deemed impracticable because the study required sentences that met specific criteria. To ensure that this manipulation in the discourse condition did not affect textual coherence, three interpreting teachers assessed the coherence of the two source texts using a five-point scale (1: very low coherence; 5: very high coherence). The average level of coherence was 4.67 for Text A and 5 for Text B, with an inter-rater agreement of 67%.

3.4 Apparatus

The source materials were presented on an LCD display monitor (1024 x 768 pixels) with text displayed in black against a light gray background. Participants' eye movements were recorded using the Eyelink® 1000 Plus eye tracker (SR Research, Canada). The sampling rate adopted in this study was 1000 Hz. The experiment was created using Experiment Builder 2.1.140 (SR

Research Experiment Builder 2.1.140 2017) and the eye-tracking data gathered were analyzed using Data Viewer 3.1.97 (Eyelink Data Viewer 3.1.97 2017).

3.5 Procedures

A pilot study was first conducted with five interpreting students who did not participate in the STR experiment, which took place several weeks after the pilot study. The experiment procedure is described below.

1. All the participants were tested individually. They were briefed about the task and the general procedures by the experimenter.
2. During the experiment, the participants were seated 60–65 cm away from the LCD monitor. All texts in Chinese were displayed in SimSun, font size 11 and with 1.5 line spacing to maximize the chance of linking fixations to specific words.
3. STR for both task conditions began with a warm-up practice and thirteen-point calibration. In the single-sentence condition, the participants sight translated the twenty-four experimental sentences along with the filler sentences that were presented in an individually randomized order. In the discourse condition, the participants sight translated the two texts, the order of which was alternated per participant. There was a ten-minute break between the single-sentence STR and discourse context STR, and the order of the two tasks was randomized across participants.
4. The participants could interpret at their own pace and there was no time limit. Their eye movements and TL output were recorded synchronically.

3.6 Data analysis

Twenty-five participants took part in the experiment but one had to be excluded due to repeated failures in the pre-task calibration and validation. Of the remaining twenty-four participants, two participants' production lagged far behind the reading comprehension and they were thus excluded as they were supposed to read and interpret in a near-simultaneous mode instead of a consecutive one. The quality of the eye-movement data for overall analysis was assessed using the fixation durations. According to Rayner and Sereno (1994), average fixations during normal reading range between 200 ms and 250 ms, which served as one of our criteria for data trimming. Drawing upon the practices of earlier studies (Pavlović and Jensen 2009; Hvelplund

2011), we applied a minimum threshold of 200 ms and excluded participants from analysis when half of their fixations were shorter than 200 ms. In addition, we cleaned the data of the remaining participants by removing fixations shorter than 80 ms and longer than 1 200 ms since abnormally short or long fixations may indicate measurement errors (Drieghe et al. 2008; White 2008). As for the quality of the data for local analysis, we examined both fixation duration and the degree of fixation drift, because a serious drift makes it difficult for fixation-to-word mappings. After the data filtering, the data from seventeen participants qualified for sentence-based analysis and the data from thirteen participants for word-based analysis.

We analyzed all eye movement data by means of linear mixed-effects models in the R statistical environment (R Core Team 2016) with the package lme4 (Bates et al. 2015). For the sentence-based analysis, dwell time and fixation count are calculated as dependent variables; as for the word-based analysis, the dependent variables include first fixation duration and regression path duration. The fixed effects include two predictors: COMPLEXITY (with two levels: Asymmetric and Symmetric) as well as CONDITION (with two levels: Single-sentence and Discourse Context). To account for between-participant and between-sentence variation, intercepts were added for the variables PARTICIPANT and SENTENCE as random effects. The *p*-values in the models were estimated by using Satterthwaite approximations in the lmerTest package (Kuznetsova, Brockhoff, and Christensen 2017). For model selection, we adopted a forward selection approach, starting with a null model, and then gradually adding the fixed effects, ending with the interaction item between fixed effects.

As for the analysis of the use of strategy, we identified two major approaches (segmentation vs reordering) to word order asymmetry. The essential difference between segmentation and reordering is whether or not the original word order of the asymmetric structure is changed – which served as the basis for classifying the strategies by listening to the audio recordings of all the participants. The recordings showed that few participants changed their strategy during online processing: for example, one participant attempted to reorder the sentence but soon decided to chunk it instead. In this case, the strategy classification was based upon the final production.

4.   Results

4.1 Overall cognitive load

We first report on the results for global processing, with each experimental sentence as one Area of Interest (AOI). Dwell time and fixation count were employed as indicators of overall cognitive load (i.e, the cognitive load for processing a whole experimental sentence). Dwell time includes all fixations and saccades on the experimental sentence, irrespective of when they take place (Yan et al. 2013). Fixation count refers to the total number of fixations on one single sentence (Hvelplund 2014). Two linear mixed-effects models were fitted for dwell time and fixation count, respectively. Values for dwell time were logarithmically transformed due to their skewed distribution, but their means are reported as non-transformed for ease of interpretation. Table 1 presents the means of the two measures and Table 2 presents the summary of the models.

INSERT TABLE 1 HERE

Table 1. Means and (SD) of eye measures for overall cognitive load

	Asymmetric sentences	**Symmetric sentences**
Dwell time in ms		
Single-sentence	27 192 (7780)	23 438 (7139)
Discourse context	17 760 (5978)	15 187 (4796)
Fixation count		
Single-sentence	68 (22)	58 (17)
Discourse context	71 (22)	60 (21)

INSERT TABLE 2 HERE

Table 2. Analysis of overall cognitive load (significant p-values at the level of $p < 0.05$ are marked with *)

Measure	Effect	Estimate	Standard error	t-value	p
Dwell time	COMPLEXITY	-0.06	0.03	-2.21	< 0.001*
	CONDITION	-0.19	0.01	-13.75	< 0.001*
	COMPLEXITY X	0.02	0.03	0.75	0.45

	CONDITION				
Fixation count	COMPLEXITY	-11.3	2.1	-5.34	< 0.001*
	CONDITION	4.4	2.03	2.16	0.03*
	COMPLEXITY X CONDITION	4.1	3.9	1.03	0.3

There was a significant effect of word-order complexity on dwell time ($t = -2.21$, $p < 0.001$) with considerably longer viewing time spent on asymmetric sentences than on symmetric sentences in both conditions. A significant effect for CONDITION was also detected ($t = -13.75$, $p < 0.001$) with longer dwell times in the single-sentence than in the discourse context condition.

Significantly more fixations were devoted to the asymmetric sentences than to the symmetric sentences across both conditions ($t = -5.34$, $p < 0.001$). Processing both types of sentences in the discourse context generated significantly more fixations than in the single-sentence condition ($t = 2.16$, $p = 0.03$).

4.2 Local cognitive load

To examine cognitive load in word-based processing, we report on data for each word of an experimental sentence as one AOI. To provide sufficient inferences regarding moment-to-moment changes in processing, we examined word-based processing using two local eye measures: first fixation duration and regression path duration. First fixation duration is the duration of the first fixation made upon a word, which is considered an indicator of early processing (Rayner 1998) that reflects lexical access and automatic processing (Yan et al. 2013). Regression path duration is the total time of all fixations made on the word and also the fixations occurring to the left of the word, from the first fixation on the word to the first fixation to the right of the word (Rayner and Liversedge 2004). It includes the sum of all fixations related to regressions, and is thus often taken as an indicator of problem detection, reanalysis and integration at later stages (Yan et al. 2013). To avoid the "sentence wrap-up" effect (Just and Carpenter 1980, 336; Tessa, White and Reichle 2009, 132), whereby more time is spent on the final word for meaning integration across the whole sentence but not for the comprehension of the word itself, we considered the last word of a sentence a poor region for local analysis and excluded it from the calculation. Two linear mixed-effects models were fitted for first

fixation duration and regression path duration, respectively. The participants' regression path durations were logarithmically transformed because of their skewed distribution but the means are reported without transformation for ease of interpretation. Table 3 presents the means of the two measures and Table 4 the summary of the models.

INSERT TABLE 3 HERE

Table 3. Means and (SD) of eye measures for local cognitive load

	Asymmetric sentences	**Symmetric sentences**
First fixation duration in ms		
Single-sentence	234 (42)	233 (43)
Discourse context	238 (39)	240 (45)
Regression path duration in ms		
Single-sentence	1296 (585)	1061 (429)
Discourse context	1617 (698)	1065 (545)

INSERT TABLE 4 HERE

Table 4. Analysis of local cognitive load (significant *p*-values at the level of $p < 0.05$ are marked with *)

Measure	**Effect**	**Estimate**	**Standard error**	**_t_-value**	***p***
First fixation duration	COMPLEXITY	1.38	3.37	0.41	0.82
	CONDITION	6.1	3.24	1.88	0.07
	COMPLEXITY X CONDITION	3.1	6.48	0.48	0.63
Regression path duration	COMPLEXITY	-0.09	0.02	-5.56	< 0.001*
	CONDITION	0.02	0.02	1	0.32
	COMPLEXITY X CONDITION	-0.05	0.03	-1.4	0.16

There were no significant differences in first fixation duration between asymmetric sentences and symmetric sentences ($t = 0.41$, $p = 0.82$). In the discourse context condition, first fixation duration was marginally longer than in single-sentence condition but there were no significant differences between the two ($t = 1.88$, $p = 0.07$).

Word-based processing in asymmetric sentences generated significantly longer regression path durations than in symmetric sentences, irrespective of task condition ($t = -5.56$, $p < 0.001$). There was no effect of task condition for either type of sentence ($t = 1$, $p = 0.32$).

4.3 Strategies for addressing word order asymmetry

Our last question addresses how interpreting trainees address word order asymmetry. To cope with word-order divergences, interpreters either chunk the sentence and render the segments in a linear manner or reorder the source sentence structure (Gile 1990).

Segmentation, also known as chunking, is a linear strategy for dealing with word order asymmetry. By means of segmentation, interpreters divide a sentence sequentially into several shorter segments and reproduce them according to the source word order (Jones 2014; Ahrens 2017). Thus, this strategy is often termed "linearity" (Dawrant 1996, 46) and is believed to reduce working memory load during SI. In contrast, reordering, another strategy frequently adopted to address word order asymmetry (Donato 2003), refers to making changes to the original word order, such as placing the prenominal Chinese RC after the head noun in the corresponding English. Reordering is assumed to increase difficulty in the coordination between storage and integration. Figure 1 demonstrates the distribution of reordering and segmentation for each participant under both conditions, with the frequency of reordering specified.

In the single-sentence condition, reordering was used far more frequently than segmentation by almost all of the participants. Among twelve participants (71%) who reordered ten or more sentences, five participants (S3, S4, S13, S14, and S17) reordered all asymmetric sentences. The only exception was S10 who used the two strategies with equal frequency. Similarly, the distribution of strategies in the discourse context revealed an overall preference for reordering to cope with asymmetric structures. However, the preference for changing word order was slightly lower in the discourse condition, compared to the single-sentence condition. For example, the five participants who reordered all sentences in the single-sentence condition increased their use of segmentation in the discourse context. Moreover, a near-even distribution of the two strategies was observed for S1, S7 and S11.
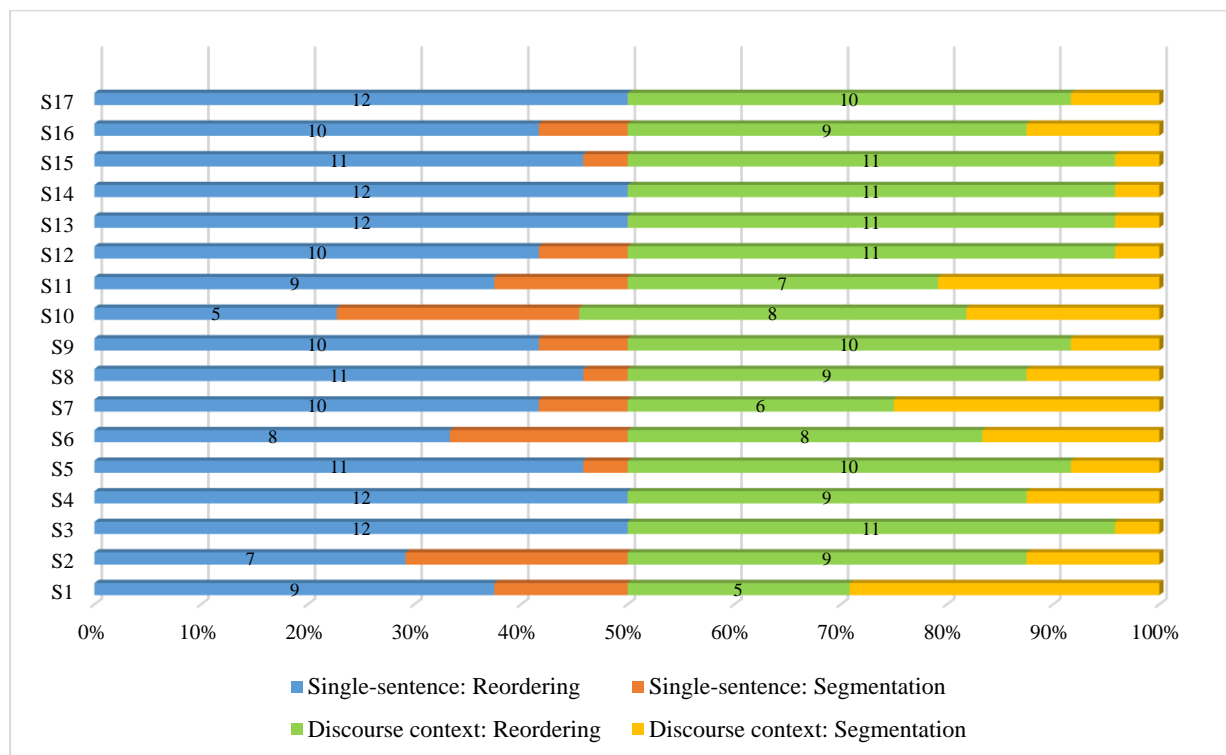
Figure 1. Distribution of strategies for asymmetric sentences

Example (3) provides two target text versions of the same source text sentence with a PP structure. This illustrates how segmentation and reordering were used by two participants for the same sentence.

(3)

Source text

这项政策为促成经济复苏、资本流动、科技创新和技术进步提供了强劲动力。

zhè xiàng zhèng cè weì cù chéng jīng jì fù sū, zī běn líu dòng, kē jì chuàng xīn hé jì shù jìn bù tí gòng le qiáng jìng dòng lì.

'This policy for stimulating economic recovery, capital flow, science innovation and technology progress provides strong impetus.'

Target text A

17

This policy <u>is to promote the economic recovery, capital flow, science innovation and technology advances</u> and this policy has provided strong forces.

Target text B

This policy has offered impetus <u>for economy recovery, capital flow, science innovation and technological progress.</u>

In version A, the participant preferred a linear approach by following the source text's word order. The Verb Phrase (VP) 提供了强劲动力 *tí gòng le qiáng jìng dòng lì* 'provided strong impetus' at the sentence-final position in the source text constitutes a separate clause with the added subject 'This policy' and the coordinator 'and' in the target text. In contrast, in version B, the word order is changed by placing the long PP after the VP to adhere to the grammatical rules of English and to produce a more complete and natural translation.

The consistent preference for reordering seems to contradict our expectation that the participants would avoid changes of word order, as reordering may increase the constraints on coordination capacity. It is believed that segmentation, rather than reordering, plays a critical role in rendering long and complex sentences, in particular when language pairs are structurally very different (Donato 2003). Thus, the consistent preference during Chinese–English STR needs be investigated further so as to determine the possible reasons for the strong preference for reordering.

Further analyses suggest that the participants may have encountered more problems during segmentation, as demonstrated in Example (4).

(4)

Source text A

<u>这项政策为促成经济复苏、资本流动、 科技创新和技术进步</u>提供了强劲动力。

zhè xiàng zhèng cè weì cù chéng jīng jì fù sū, zī běn líu dòng, kē jì chuàng xīn hé jì shù jìn bù tí gòng le qiáng jìng dòng lì.

'This policy <u>for stimulating economic recovery, capital flow, science innovation and technology progress</u> provides strong impetus.'

Target text A

This policy to <u>promote economy development, capital flow, scientific innovation and technology improvement</u>.

Source text B

该机制已经成为亚洲<u>结构最完善、 影响最广泛、 成果最显著</u>的合作机制。

gāi jī zhì yǐ jīng chéng wéi yà zhōu jié gòu zuì wán shàn, yǐ ng xi ǎ ng zuì gu ǎ ng fà n, chéng gu ǒ zuì xi ǎ n zhù de hé zuò jī zhì.

'This has become Asia <u>structures most optimal, influence most widespread and achievement most remarkable</u> *de* cooperation mechanism.'

Target text B

This mechanism has become Asia's <u>most comprehensive in the broadest influence and most remarkable achievement</u> cooperation mechanism.

Both source text sentences were segmented but the corresponding target texts are quite problematic. In target text A, the original sentence is chunked into two parts: the subject and the infinitive VP. But there is no connection between the two, which is ungrammatical in English. In addition, the VP element of the source sentence, 提供了强劲动力 *tí gòng le qiáng jìng dòng lì* 'provided strong impetus', was omitted in the translation, leaving the target text sentence unfinished. For target text B, the participant tries to chunk the sentence, but has difficulties integrating the different segments. The segments are merely piled up one after another without any cohesive devices, which constitutes a grammatically unacceptable delivery.

5. Discussion

5.1 The effect of word order asymmetry on cognitive load in sight translation

This study attempted to address the impact of word order asymmetry as a factor in the cognitive processing of Chinese–English STR. The focus of our exploration was to identify to what extent cognitive load during STR is affected by asymmetric structures. To explore this issue, eye measures indicative of different processing levels and processing stages were investigated to compare the cognitive load associated with sight translating asymmetric and symmetric sentences under the two task conditions.

5.1.1 *The influence of word order asymmetry on cognitive processing*

Our first question enquired into the impact of word order asymmetry on Chinese–English STR. The data analysis of overall cognitive load revealed a significant effect for word order asymmetry. The striking effect of structural asymmetry, irrespective of the presence of contextual information, highlights the impact of language-pair specificity on interpreting and offers empirical evidence to refute the language-independent view: although deverbalization or the sense-based approach is encouraged in interpreting teaching and practice, linguistic factors such as the structural differences between languages still present considerable difficulty for interpreters.

The effect of asymmetry can be attributed to structural priming, a frequently mentioned concept in psycholinguistic investigations. Priming refers to the tendency to reuse a structural pattern similar to one previously comprehended or produced (Bock 1986; Bock et al. 2007). It thus describes the effect of earlier processed items on subsequent processing (Schaeffer et al. 2017). Several studies have demonstrated that priming exists between languages and the effect can be similar to within-language priming (Schoonbaert, Hartsuiker, and Pickering 2007; Kantola and Van Gompel 2011). STR can thus be understood, at least in part, as a process of cross-linguistic priming in which SL syntactic features tend to be transferred to the TL. When word orders were shared between Chinese and English, the participants, who were primed by the SL structure, produced similarly structured translations. This priming provided cognitive relief for the participants, who could adopt a syntactically linear approach instead of searching for different TL structures. However, if the SL structures were not similar with the TL structures, the benefit of priming disappeared. The participants had to make greater effort to resist the natural tendency of being primed and resolve the structural differences through specific strategies.

Different patterns were identified for word-based processing, as suggested by the two word-based eye measures. The first fixation durations for the asymmetric sentences were similar to those for the symmetric sentences, but a significant asymmetry effect was found for regression path durations. In eye-tracking based studies, eye-movement measures at word level are generally categorized into 'early' measures and 'late' measures to indicate stage-specific processing activities (Staub et al. 2007). First fixation duration is regarded as a measure of early processing that taps into automatic and lower-level activities such as word meaning retrieval during reading (Dussias 2010). Thus, considering that the word frequency and

familiarity in all the experimental sentences had been controlled for, it may be inferred that there are no fundamental differences in cognitive processing during the participants' early encounter with individual words, and that the participants were primarily engaged with word retrieval during the early stage. It was only during the later stage that word order asymmetry began to exert a strong impact, as seen by the significant main effect of asymmetry on regression path durations. Regression path duration, an eye measure associated with later-stage processing, is associated with strategic processing such as integration and reanalysis (Conklin and Pellicer-Sánchez 2016). It comes as no surprise that later-stage processing was significantly affected by word order asymmetry. The difficulty of syntactic processing is related to the degree to which the initially anticipated structures and their target forms accord with the actual sentence structures (Levy 2008). During STR, the expectation of the upcoming structures is established incrementally as SL reading continues, and it is natural to expect TL production that is structurally similar to the SL sentence. Therefore, during the process of interpreting symmetric sentences, the parallel word orders facilitated online parsing and there was little need for reprocessing. However, the initial expectation was violated by the SL asymmetric structures, which did not conform to the conventional syntactic rules of the TL. This violation and subsequent correction process resulted in a dramatic increase in the regression path durations. Additionally, the need to establish syntactic links between segments or syntactically incorporate incoming parts into earlier words may also increase later-stage processing effort.

5.1.2 *The role of context in modulating asymmetry-induced effort*

Our second question focused on the influence of contextual information on modulating asymmetry-induced effort. The participants sight translated the pre-controlled materials under two task conditions: single-sentence and discourse context. It was expected that a greater amount of contextual information would facilitate processing by enhancing comprehension proficiency and lowering linguistic interference.

The results indicate that context plays a limited role in compensating for asymmetry-induced effort. The significant effect of task condition was only partly confirmed, as evidenced by the significant between-condition differences in dwell time. Evidence from previous studies points to the beneficial role of context in increasing word predictability during reading (Ehrlich and Rayner 1981): words in a highly constrained context are generally read faster and fixated less often (Altarriba et al. 1996). This may account for the quicker processing in the discourse

context condition. However, the pattern for fixation count was reversed in the discourse context, which generated more frequent fixations. If the pattern for dwell time is interpreted in combination with that of fixation count, it may be inferred that STR in the discourse context is characterized by a high frequency of very short fixations. Although contextual information greatly shortened the amount of time spent interpreting a whole sentence, the online processing was not less effortful and the participants had to quickly move their eyes between words or lines in service of better comprehension, meaning integration, reanalysis and production.

The effect of context was negligible with regard to processing at word level, as reflected by the results. No context benefit was found for word-level processing, which may be accounted for by two factors. First, visual interference, which tends to be stronger in discourse contexts than with single sentences, may offset the benefit of context. According to Agrifoglio (2004), visual interference in STR is induced by the constant presence of textual information. Shreve, Lacruz, and Angelone (2011) found that during STR, second paragraphs in source texts are more effortful than first paragraphs, suggesting an incremental increase in cognitive load in discourse contexts. In other words, effort increases due to visual interference as the discourse unfolds. Second, frequent online search for contextual cues may increase cognitive load. According to Ito, Corley, and Pickering (2018) readers tend to make use of prior textual information to direct their eye movements when encountering a new or difficult message. In the discourse context condition, there may be more frequent visual search for contextual cues to improve comprehension efficiency or prediction. Taken together, it may therefore be that a greater amount of contextual information did not facilitate word-based processing because the supposed context benefit was offset by the extra effort due to language interference and/or visual search.

5.2 Strategies for addressing word order asymmetry

Our third question dealt with the participants' online solutions to word order asymmetry. To address the asymmetric structures under investigation, two general approaches are available: reordering the original sentence to produce a natural and complete translation or chunking the source sentence into smaller segments and reformulating these elements in their original order. It is believed that reordering is less efficient because it imposes additional load on working memory: certain parts of the original sentence have to be stored in short-term memory for later integration with upcoming words. We assumed that most participants would use segmentation more frequently to alleviate mental load.

In contrast to the prediction, the results demonstrated a consistent preference for reordering by most participants, irrespective of task condition. However, the frequency of reordering in the discourse context was slightly lower than in the single-sentence condition. One possible reason for this is that the participants needed to spare effort in seeking contextual support and had to increase the use of segmentation to save working memory resources. The overwhelming preference for reordering corroborates findings by Wang and Zou (2018) who investigated professional interpreters' online strategies for rendering front-loaded attributive clauses in Chinese–English consecutive interpreting. Their analysis showed that the majority of the rendering tactics involved reordering the front-loaded Chinese structures into back-loaded structures or a mixture of front- and back-loaded structures in the TL.

Despite the fact that it is cognitively taxing, reordering was used far more frequently than segmentation. This unexpected result is in contrast to the findings of an ongoing project by Ma (2019) which addresses word order asymmetry in English–Chinese STR. According to Ma (2019), the rendering of asymmetric English sentences into Chinese involves significantly more frequent use of segmentation irrespective of task condition. For most participants in Ma (2019), the linear approach was preferred over changing the source word order. Framed against the findings of this study, the divergent results in Ma (2019) raise questions about language availability and directionality in shaping interpreters' decision-making processes. It is widely held that the degree of language availability is of critical importance in target production. On average, language availability is higher in one's A language, and allows for richer linguistic choices (Gile 2010a, 223). In contrast, lower availability in one's B language may increase the effort required for lexical selection, planning and articulation, making B-language production less automatic and more likely to involve conscious monitoring (Ullman 2001). Therefore, the processing capacity requirement in segmentation may differ between interpretation into an A language and a B language.

Successful segmentation calls for the ability to establish coherence by linking different meaning units in a logical manner (Jones 2014). When working into their A language, interpreters enjoy a cognitive advantage because retrieving A language words and structures from long-term memory is nearly automatic and effortless. They have a variety of choices available for logical connection between chunks. However, cohesive chunking in their B language is more cognitively taxing. A lack of B-language robustness and resourcefulness may restrict language availability in production and reduce the power of expression. Consequently, linking the segments and reconstructing coherence during segmentation may turn out to be

more effortful and entail greater risk of unusual collocations, grammatical mistakes and illogical delivery (Donovan 2005).

6. Summary and conclusion

This study examined cognitive load during Chinese–English STR and confirmed the strong impact of word order asymmetry on real-time processing. Three major findings are derived from eye-movement data and product analysis. First, the cognitive process of STR is seriously disrupted by word order asymmetry as indicated by a significant increase in dwell time and fixation count; however, at word level, the effect of asymmetry only occurs during later-stage processing, as evidenced by regression path duration. Second, contextual information plays a very limited role in modulating asymmetry-induced effort and does not necessarily contribute to less effortful processing. Third, although both reordering and segmentation strategies are available for word order asymmetry, the former is used far more frequently. A lack of B-language robustness and resourcefulness may discourage interpreters from making use of segmentation which requires additional effort in maintaining coherence.

The eye-movement data and real-time processing findings in this study support the findings of previous product-based investigations and further confirm the impact of language specificity on interpreting. The data also show that a greater amount of contextual information is not likely to guarantee more capacity-efficient processing, which points to the prevalence of asymmetry-induced difficulty irrespective of interpreting setting. Given that a wider context may be more burdensome during STR, future training should include long and coherent texts obtained from authentic interpreting settings to better prepare trainees for the contextual constraints in real working conditions.

Although the interpreting trainee participants in this study had been taught sense-based interpreting to cope with language-specific factors, they still encountered difficulties in overcoming word-order differences. It is thus of pedagogical importance to enhance students' awareness of structural asymmetry between SL and TL. Students with deeper syntactic knowledge of both languages will have a cognitive advantage in terms of structure anticipation, identification of primary information and syntactic integration. With regard to word-order issues, the predominant use of reordering and the issues that arose in some segmented sentences demonstrate that the lack of robustness and resourcefulness in the B-language may have conditioned the students' choice of strategy. For interpreters working into their B language, segmentation, which is conventionally seen as less effortful, may involve greater cognitive load.

This finding points to the relevance of directionality in shaping interpreting strategies and also highlights the need to strengthen B language skills in interpreting curricula.

In future research, professional interpreters could be recruited for a comparative study of syntactic processing between experts and novices (e.g., Chmiel and Lijewska 2019). It would be of more pedagogical relevance to see how and to what extent professionals differ from novices and to identify behavior patterns that lead to successful renditions of asymmetric sentences. In addition, a closer examination of online reading behavior during segmentation and reordering could generate more intriguing data on cognitive processing and strategy selection during STR. Finally, research needs to be done on cognitive behavior and strategy use for interpreting into different language directions.

References

Agrifoglio, Marjorie. 2004. "Sight Translation and Interpretation: A Comparative Analysis of Constraints and Failure." *Interpreting* 6 (1): 43–67.

Ahrens, Barbara. 2017. "Interpretation and Cognition." In *The Handbook of Translation and Cognition*, edited by John W. Schwieter and Aline Ferreira, 445–460. Hoboken: Wiley-Blackwell.

Altarriba, Jeanette, Judith F. Kroll, Alexandra Sholl, and Keith Rayner. 1996. "The Influence of Lexical and Conceptual Constraints on Reading Mixed-language Sentences: Evidence from Eye Fixations and Naming Times." *Memory & Cognition* 24 (4): 477–492.

Bates, Douglas, Martin Mächler, Ben Bolker, and Steve Walker. 2015. "Fitting Linear Mixed-effects Models Using lme4." *Journal of Statistical Software* 67 (1):1–48.

Bock, Kathryn. 1986. "Syntactic Persistence in Language Production." *Cognitive Psychology* 18 (3): 355–387.

Bock, Kathryn, Gary S. Dell, Franklin Chang, and Kristine H. Onishi. 2007. "Persistent Structural Priming from Language Comprehension to Language Production." *Cognition* 104 (3): 437–58.

Bóna, Judit, and Mária Bakti. 2020. "The Effect of Cognitive Load on Temporal and Disfluency Patterns of Speech: Evidence from Consecutive Interpreting and Sight Translation." *Target* 32 (3): 126–150.

Chafe, Wallace, and Jane Danielewicz. 1987. "Properties of Spoken and Written Language." In *Comprehending Oral and Written Language*, edited by Rosalind Horowitz and S. Jay Samuels, 83–113. London: Academic Press.

Chalhoub-Deville, Micheline, and Carolyn E. Turner. 2000. "What to Look for in ESL Admission Tests: Cambridge Certificate Exams, IELTS, and TOEFL." *System* 28: 523–539.

Chen, Sijia. 2017. "The Construct of Cognitive Load in Interpreting and its Measurement." *Perspectives* 25 (4): 640–657.

Chmiel, Agnieszka, and Agnieszka Lijewska. 2019. "Syntactic Processing in Sight Translation by Professional and Trainee Interpreters: Professionals are More Time-efficient While Trainees View the Source Text Less." *Target* 31 (3): 378–397.

Christoffels, Ingrid K., Annette M. B. de Groot, and Judith F. Kroll. 2006. "Memory and Language Skills in Simultaneous Interpreters: The Role of Expertise and Language Proficiency." *Journal of Memory and Language* 54 (3): 324–345.

Conklin, Kathy, and Ana Pellicer-Sánchez. 2016. "Using Eye-tracking in Applied Linguistics and Second Language Research." *Second Language Research* 32 (3): 453–467.

Čeňková, Ivana. 2015. "Sight Interpreting/Translation." In *Routledge Encyclopedia of Interpreting Studies*, edited by Franz Pöchhacker, 374–375. Abingdon: Routledge.

Dawrant, Andrew. 1996. *Word Order in Chinese–English Simultaneous Interpretation: An Initial Exploration*. MA diss. Fu-Jen Catholic University.

Donato, Valentina. 2003. "Strategies Adopted by Student Interpreters in SI: A Comparison between the English–Italian and the German–Italian Language-Pairs." *The Interpreters' Newsletter* 12: 101–134.

Donovan, Clare. 2005. "Teaching Simultaneous Interpretation into B: A Challenge for Responsible Interpreter Training." *Communication & Cognition: Monographies* 38 (1–2): 147–166.

Drieghe, Denis, Alexander Pollatsek, Adrian Staub, and Keith Rayner. 2008. "The Word Grouping Hypothesis and Eye Movements During Reading." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 34 (6): 1552–1560.

Dussias, Paola E. 2010. "Uses of Eye-tracking Data in Second Language Sentence Processing Research." *Annual Review of Applied Linguistics* 30: 149–166.

Ehrlich, Susan F., and Keith Rayner. 1981. "Contextual Effects on Word Perception and Eye Movements During Reading." *Journal of Verbal Learning and Verbal Behavior* 20 (6): 641–655.

Eyelink Data Viewer 3.1.97 [Computer Software]. (2017). *Mississauga*, *Ontario*, Canada: SR Research Ltd.

Fischler, Ira S., and Paul A. Bloom. 1985. "Effects of Constraint and Validity of Sentence

Contexts on Lexical Decisions." *Memory & Cognition* 13 (2): 128–139.

Gile, Daniel. 1990. "The Processing Capacity Issue in Conference Interpretation." *Babel* 37 (1): 15–27.

Gile, Daniel. 2002. "Conference Interpreting as a Cognitive Management Problem." In *The Interpreting Studies Reader*, edited by Franz Pöchhacker and Miriam Shlesinger, 162–177. London: Routledge.

Gile, Daniel. 2005. "Teaching Conference Interpreting: A Contribution." In *Training for the New Millennium: Pedagogies for Translation and Interpreting*, edited by Martha Tennent, 127–152. Amsterdam: John Benjamins.

Gile, Daniel. 2011a. *Basic Concepts and Models of Interpreter and Translator Training*. Shanghai: Shanghai Foreign Language Education Press.

Gile, Daniel. 2011b. "Errors, Omissions and Infelicities in Broadcast Interpreting: Preliminary Findings from a Case Study." In *Methods and Strategies of Process Research: Integrative Approaches in Translation Studies*, edited by Cecilia Alvstad, Adelina Hild, and Elisabet Tiselius, 201–218. Amsterdam: John Benjamins.

Guo, Liangliang. 2011. *An Analysis of the Word Order Pattern in the SI Target Language and its Underlying Reasons in the Language Combination of English and Chinese* (中英文同传语序处理方式的选择与原因研究—基于职业译员体现语序差异的名词性片段译语表现的实证研究). PhD diss. Shanghai International Studies University.

Henderson, John M., and Fernanda Ferreira. 1990. "Effects of Foveal Processing Difficulty on the Perceptual Span in Reading: Implications for Attention and Eye Movement Control." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 16 (3): 417–429.

Ho, Chen-En. 2017. *An Integrated Eye-tracking Study into the Cognitive Process of English-Chinese Sight Translation: Impacts of Training and Experience*. PhD diss. National Taiwan Normal University.

Hvelplund, Kristian T. 2011. *Allocation of Cognitive Resources in Translation: An Eye-tracking and Key-logging Study*. PhD diss. Copenhagen Business School.

Hvelplund, Kristian T. 2014. "Eye Tracking and the Translation Process: Reflections on the Analysis and Interpretation of Eye-tracking Data." In *Minding Translation / With Translation in Mind*, edited by Ricardo Muñoz Martín, special issue of *MonTI: Monographs in Translation and Interpreting* 1: 201–223.

Hvelplund, Kristian T. 2017. "Eye-tracking in Translation Process Research." In *The Handbook of Translation and Cognition*, edited by John W. Schwieter and Aline Ferreira, 248–264.

Hoboken: Wiley Blackwell.

Inhoff, Albrecht Werner, and Weimin Liu. 1998. "The Perceptual Span and Oculomotor Activity during the Reading of Chinese Sentences." *Journal of Experimental Psychology: Human Perception and Performance* 24 (1): 20–34.

Ito, Aine, Martin Corley, and Martin J. Pickering. 2018. "A Cognitive Load Delays Predictive Eye Movements Similarly during L1 and L2 Comprehension." *Bilingualism: Language and Cognition* 21 (2): 251–264.

Jin, Yan, and Jinsong Fan. 2011. "Test for English Majors (TEM) in China." *Language Testing* 28 (4): 589–596.

Johnson-Laird, Philip Nicholas. 1983. *Mental Models: Towards a Cognitive Science of Language, Inference, and Consciousness.* Cambridge, MA: Harvard University Press.

Jones, Roderick. 2014. *Conference Interpreting Explained*. Abingdon: Routledge.

Just, Marcel Adam, and Patricia Ann Carpenter. 1987. *The Psychology of Reading and Language Comprehension*. Boston: Allyn & Bacon.

Kantola, Leila, and Roger P. G. van Gompel. 2011. "Between-and Within-language Priming is the Same: Evidence for Shared Bilingual Syntactic Representations." *Memory & Cognition* 39 (2): 276–290.

Kuznetsova, Alexander, Per Bruun Brockhoff, and Rune Haubo Bojesen Christensen. 2017. "lmerTest Package: Tests in Linear Mixed Effects Models." *Journal of Statistical Software* 82 (13): 1–26.

Lederer, Marianne. 1998. "The Interpretive Theory of Translation: A Brief Survey." *Academic Journal of the College of Sworn Translators of the City of Buenos Aires* (El Lenguaraz: Revista Académica del Colegio de Traductores Públicos de la Ciudad de Buenos Aires) 1: 35–43.

Lee, Jieun. 2012. "What Skills do Student Interpreters Need to Learn in Sight Translation?" *Meta* 57 (3): 695–714.

Levy, Roger. 2008. "Expectation-based Syntactic Comprehension." *Cognition* 106 (3): 1126–1177.

Li, Charles N., and Sandra A. Thompson. 1981. *Mandarin Chinese: A Functional Reference Grammar*. Berkeley: University of California Press.

Li, Xiangdong. 2015. "Putting Interpreting Strategies in their Place: Justifications for Teaching Strategies in Interpreter Training." *Babel* 61 (2): 170–192.

Liu, Lianli. 2000. *HSK A Dictionary of Chinese Usage: 8000 Words* (汉语 8000 词词典). Beijing: Beijing Language and Culture University Press.

Ma, Xingcheng. 2019. *Effect of Word Order Asymmetry on Cognitive Process of English–Chinese Sight Translation by Interpreting Trainees: Evidence from Eye-tracking*. PhD diss. The Hong Kong Polytechnic University.

Miller, George. A. 1956. "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." *Psychological Review* 63 (2): 81–97.

O'Brien, Sharon. 2009. "Eye Tracking in Translation Process Research: Methodological Challenges and Solutions." In *Methodology, Technology and Innovation in Translation Process Research: A Tribute to Arnt Lykke Jakobsen*, edited by Inger M. Mees, Fabio Alves, and Susanne Göpferich, 251–266. Copenhagen: Samfundslitteratur.

Pavlović, Nataša, and Kristian T. H. Jensen. 2009. "Eye Tracking Translation Directionality." In *Translation Research Projects 2,* edited by Anthony Pym and Alexander Perekrestenko, 93–109. Tarragona: Intercultural Studies Group.

R Core Team. 2016. *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.

Rayner, Keith. 1998. "Eye Movements in Reading and Information Processing: 20 Years of Research." *Psychological Bulletin* 124 (3): 372–422.

Rayner, Keith. 2009. "Eye Movements and Attention in Reading, Scene Perception, and Visual Search." *The Quarterly Journal of Experimental Psychology* 62 (8):1457–1506.

Rayner, Keith, and Sara C. Sereno. 1994. "Regressive Eye Movements and Sentence Parsing: On the Use of Regression-Contingent Analyses." *Memory & Cognition* 22 (3): 281–285.

Rayner, Keith, and Simon P. Liversedge. 2004. "Visual and Linguistic Processing during Eye Fixations in Reading." In *The Interface of Language, Vision, and Action: Eye Movements and the Visual World*, edited by John M. Henderson and Fernanda Ferreira, 59–104. New York: Psychology Press.

Schaeffer, Moritz J., Kevin B. Paterson, Victoria A. McGowan, Sarah J. White, and Kirsten Malmkjær. 2017. "Reading for Translation." In *Translation in Transition: Between Cognition, Computing and Technology*, edited by Arnt Lykke Jakobsen and Bartolomé Mesa-Lao, 18–54. Amsterdam: John Benjamins.

Schoonbaert, Sofie, Robert J. Hartsuiker, and Martin J. Pickering. 2007. "The Representation of Lexical and Syntactic Information in Bilinguals: Evidence from Syntactic Priming." *Journal of Memory and Language* 56 (2): 153–171.

Schustack, Miriam W., Susan F. Ehrlich, and Keith Rayner. 1987. "Local and Global Sources of Contextual Facilitation in Reading." *Journal of Memory and Language* 26 (3): 322–340.

Seeber, Kilian G. 2011. "Cognitive Load in Simultaneous Interpreting: Existing Theories — New Models." *Interpreting* 13 (2): 176–204.

Seeber, Kilian G. 2013. "Cognitive Load in Simultaneous Interpreting: Measures and Methods." *Target* 25 (1): 18–32.

Seeber, Kilian G., and Dirk Kerzel. 2012. "Cognitive Load in Simultaneous Interpreting: Model Meets Data." *International Journal of Bilingualism* 16 (2): 228–242.

Seleskovitch, Danica. 1978. *Interpreting for International Conferences: Problems of Language and Communication*. Washington, DC: Pen & Booth.

Setton, Robin. 1999. *Simultaneous Interpretation: A Cognitive-Pragmatic Analysis*. Amsterdam: John Benjamins.

Shlesinger, Miriam. 2003. "Effects of Presentation Rate on Working Memory in Simultaneous Interpreting." *The Interpreters' Newsletter* 12: 37–49.

Shreve, Gregory M., Isabel Lacruz, and Erik Angelone. 2011. "Sight Translation and Speech Disfluency: Performance Analysis as a Window to Cognitive Translation Processes." In *Methods and Strategies of Process Research*, edited by Cecilia Alvstad, Adelina Hild, and Elisabet Tiselius, 93–120. Amsterdam: John Benjamins.

SR Research Experiment Builder 2.1.140[Computer Software]. (2017). *Mississauga, Ontario*, Canada: SR Research Ltd.

Staub, Adrian. 2010. "Eye Movements and Processing Difficulty in Object Relative Clauses." *Cognition* 116 (1): 71–86.

Staub, Adrian, Keith Rayner, Alexander Pollatsek, Jukka Hyönä, and Helen Majewski. 2007. "The Time Course of Plausibility Effects on Eye Movements in Reading: Evidence from Noun-noun Compounds." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 33 (6): 1162–1169.

Sung, Yao-Ting, Jung-Yueh Tu, Jih-Ho Cha, and Ming-Da Wu. 2016. "Processing Preference Toward Object-extracted Relative Clauses in Mandarin Chinese by L1 and L2 Speakers: An Eye-tracking Study." *Frontiers in Psychology* 7 (4): 1–14.

Ullman, Michael T. 2001. "The Neural Basis of Lexicon and Grammar in First and Second Language: The Declarative/Procedural Model." *Bilingualism: Language and Cognition* 4 (2): 105–122.

Van Dijk, Teun Adrianus, and Walter Kintsch. 1983. *Strategies of Discourse Comprehension.* London: Academic Press.

Viaggio, Sergio. 1995. "The Praise of Sight Translation (and Squeezing the Last Drop Thereout of)." *The Interpreters' Newsletter* 6: 33–42.

Wang, Binhua, and Yukui Gu. 2016. "An Evidence-based Exploration into the Effect of Language-pair Specificity in English–Chinese Simultaneous Interpreting." *Asia Pacific Translation and Intercultural Studies* 3 (2): 146–160.

Wang, Binhua, and Bing Zou. 2018. "Exploring Language Specificity as a Variable in Chinese–English Interpreting: A Corpus-Based Investigation." In *Making Way in Corpus-based Interpreting Studies*, edited by Mariachiara Russo, Claudio Bendazzoli, and Bart Defrancq, 65–82. Singapore: Springer.

Warren, Tessa, White Sarah J., and Erik D. Reichle. 2009. "Investigating the Causes of Wrap-up Effects: Evidence from Eye Movements and E–Z Reader." *Cognition* 111: 132–137.

White, Sarah J. 2008. "Eye Movement Control during Reading: Effects of Word Frequency and Orthographic Familiarity." *Journal of Experimental Psychology: Human Perception and Performance* 34 (1): 205–223.

Wu, Yinyin, and Posen Liao. 2018. "Re-conceptualising Interpreting Strategies for Teaching Interpretation into a B Language." *The Interpreter and Translator Trainer* 12 (2): 188–206.

Yan, Guoli, Jianping Xiong, Chuanli Zang, Lili Yu, Lei Cui, and Xuejun Bai. 2013. " Review of Eye-Movement Measures in Reading Research (阅读研究中的主要眼动指标评述)." *Advances in Psychological Science* 21 (4): 589–605.

Address for correspondence

Xingcheng Ma

School of Foreign Languages

Southeast University

No. 2 SEU Road

211189 NANJING

China

Email: xingcheng.ma@hotmail.com

Co-author information

Dechao Li

Department of Chinese and Bilingual Studies

The Hong Kong Polytechnic University

Hong Kong

China

Email: dechao.li@polyu.edu.hk

Yu-Yin Hsu

Department of Chinese and Bilingual Studies

The Hong Kong Polytechnic University

Hong Kong

China

Email: yu-yin.hsu@polyu.edu.hk